The Value of Intellectual Property Rights to Firms

by Christine Greenhalgh and Mark Rogers[1]

Oxford Intellectual Property Research Centre,
St Peter's College, Oxford,
May 2007

Comments please to christine.greenhalgh@economics.ox.ac.uk, or
mark.rogers@hmc.ox.ac.uk

Abstract

Economists view intellectual property rights (IPRs) as policy tools for encouraging

innovation, but they recognize that they can also inhibit competition. There are many types of

IPRs and of institutions concerned with their administration. We begin by outlining how these

complex and varied rights are supposed to work and how they interact with other

characteristics of firms and markets. We then survey the available literature on patents, trade

marks and copyright to assess the value of these IPRs to firms and the costs to firms of

acquiring and defending their rights. The paper concludes with suggestions for topics

requiring further research to better inform public policy in this field.

---

[1] Some parts of this article draw on an earlier review by Dixon and Greenhalgh (2002) and thus the authors wish
to acknowledge the helpful contribution of Padraig Dixon.

I. INTRODUCTION

Intellectual Property Rights (IPRs) are one category of intangible assets that may be owned by a firm, some others being customer goodwill, human skills embodied in their workers, and good management practice. IPRs are seen by economists as a policy tool to ensure adequate private returns to innovation and creative activities. Firms invest in R&D and new product design in order to gain profitable outcomes by launching new products and using more efficient processes of production. Once the plans of product or process innovations have been made, firms can often use IPRs to protect the returns from their investment from being depleted by imitation. If the eventual returns to innovation are generally too low, then the firm will not achieve its required rate of return on investment, so then R&D and design investment will be reduced. This paper examines the ways that economists have sought to evaluate the value of IPRs to private firms and present a survey of the available evidence. Then we question whether IPRs are rewarding firms too much or too little and whether firms in some sectors are advantaged compared with other sectors, raising issues for further research that would provide crucial information for IPR policy.

There is both a multiplicity of types of IPRs and a web of UK, EU and international bodies overseeing the design and implementation of each type of intellectual property. If we neglect the minor categories of rights, such as plant varieties or semi-conductor design, that are specific to particular branches of economic activity, there are four main types of IPR: patents, copyright, trade marks and design rights. These IPRs are deemed to be of high importance in the protection of innovation by a significant share of firms (especially by large firms).[2] Each of these rights protects different aspects of a firm's products and, in some instances, a single product can be protected by a combination of rights.

---

[2] See details in Table 1.1 on page 20 of Gowers Review of Intellectual Property, HM Treasury 2006.

Firms have to make a variety of outlays of expenditure to acquire and protect their IPRs. Some IPRs, such as patents, are registered and awarded by the state after a lengthy process of scrutiny by experts, while others, such as copyright, are acquired automatically by the act of creation with no official register being kept. A further complication is that firms that are trading internationally have to seek protection for their creations in a variety of jurisdictions, as many IPRs are country specific, or geographically delineated within a limited territory such as the European Community. Firms can also use other methods to protect their knowledge, such as trade secrets, including making confidentiality agreements with their employees and other firms with which they trade. Given this complex set of registered and unregistered rights in many countries, it is hardly surprising that the assessment of the value of IPRs to firms is fraught with empirical difficulties. Economic studies have focused largely on the value of patents in the US and the EU countries, with fewer studies of trade marks and almost none of design rights. There is very little firm-level statistical evidence on the value of copyright, although there are many vociferous advocates of the need to strengthen and extend the term of copyright on sound recordings, a proposal rejected by the Gowers Review (HM Treasury, 2006).

Figures 1 and 2 show the trends in patent and trade mark applications by domestic residents since 1970. US and Japanese applications are much larger and their values are shown on the right hand axis.[3] Figure 1 shows that patent applications started to rise in Japan and the US in the 1980s, but not in other countries. Whereas Japan's growth petered out in the 1990s, US patenting activity accelerated in the 1990s. The rapid rise in US patenting has led to much debate other whether the US system is functioning properly (Jaffe and Lerner, 2004). Germany is the only other country to show significant growth in the 1990s. Figure 2 shows trade mark applications by domestic residents. Overall, these series appear more volatile,

---

[3] In addition, the Japanese patent applications have been scaled down by a factor of three since each Japanese patent is commonly thought to represent around one third of a US patent (i.e. the Japanese system breaks down an invention into more discrete stages).

which may reflect that trade marks are an indicator of innovative and marketing activity and not inventive effort. Most of the countries show strong growth in the 1990s, with a sudden correction in 2000. Japan was the exception, showing much earlier strength, but declining during the depression of its economy.

II REWARDING INNOVATION IN THEORY

(i) Why are intellectual property rights awarded?

IPRs give people an incentive to produce socially desirable new innovations. They assist the creators of a non-rival good (the innovative knowledge or design) to appropriate the returns of their innovation for themselves alone. But since IPRs make a non-rival good excludable, they introduce inefficiency for the duration of the right. The IPR, in effect, gives the creator a monopoly right and this causes the price of the good to be above the marginal cost of its production. Even with IPRs there are sub-optimal incentives to commit resources to investment, since the temporary monopoly profits are less than the overall benefit to society. (For example consumers will gain from the lower price of the innovation after the IPR expires.) A rational investor will only invest in an amount of research that will earn it the monopoly profit, and such behaviour will not achieve the maximal benefit to society that would obtain if production were undertaken in a competitive market. Consumers lose because monopolists restrict output to boost price, and therefore lose out by not enough of the monopoly good being sold (see Shavell and Van Ypersele, 2001). Economists are then left to adjudicate as to the desirability of using IPR as a spur to innovation, given that it acts as an instigator of monopolistic inefficiency. This trade-off between encouraging innovation to benefit society and suffering the consequences of temporary monopoly was noted by many writers and was formally analysed in a modern way by Nordhaus (1969).

(ii) How exactly do firms benefit from IPRs?

When firms hold some monopoly power during the period of their IPR, and in the geographical territory of the jurisdiction under which the right is protected, the gains may arrive via different routes depending on the innovation type and the use made of the IPR. With p*rocess innovation* the firm gains profits via lower costs of production if they continue to sell at the same price. Alternatively the firm can sell at a lower price and increase its market share by driving out competitors, leading to later returns from increased product monopoly. With *product innovation* the firm gains profitability from increasing its market share and gaining customer loyalty due to product novelty; also relatively higher prices can be charged for a higher quality product. In both cases, the firm will effectively steal some profits from rival firms (often called a business stealing effect). On its own this business stealing effect could indicate that firms were investing too much in IPRs. Nevertheless, acquiring IPRs does not always imply a one way movement in market share; rather there are 'two faces' to the way in which firms may be affected by IPRs obtained by their rivals. For example, McGahan and Silverman (2006) contrast 'market stealing' where a rival's patent gives them an advantaged position to the detriment of the focal firm, with 'spillover' effects, when a breakthrough by a rival firm triggers greater technological opportunity and provides information on which the focal firm can build.

A third route to obtaining value from IPRs is that of *licensing* the use of their IPRs to other firms, which brings in direct revenues without necessarily having to engage in production. Baumol (2002) argues that competition and the pursuit of profits drive many firms to disseminate their technology, using both single deals and broader technology exchange agreements between large firms, also known as 'patent pools'. He argues that such technology sharing agreements between incumbent firms saves wasteful costs of reverse engineering, or

inventing around a rival's patent, and provides them with a degree of protection against firms outside the technology agreement.

However, recently the issue of patent licensing has become more controversial, especially in the US. The most extreme case of this is specialist firms dealing only in IPRs, particularly patents. Such firms have been termed pejoratively as 'patent trolls', as they are seen to be searching for and acquiring patents in order to enforce these against potential or actual infringers, and to pursue opportunities for licensing, without having been involved in the relevant R&D or producing any products using the patent. This activity is quite legal and might be seen as improving the liquidity of the market in intellectual property, but the level of licence fees is not subject to any restraint in the US, leading to allegations of excessive profiteering. Even within firms that are actively using their IPRs, there can be allegations that they acquire extra related IPR in order to create a 'patent thicket', giving them the power to deny access to potential rivals of necessary technology. However, in the UK, patent law contains provisions that require a patent holder to grant a license on reasonable terms and, in the event that this is denied, a compulsory licence may be granted by the Patent Office. This limits the incentive to act aggressively via either patent thickets or trolls. This said, the transaction costs associated with negotiating a raft of license agreements may act as a barrier, something that has attracted concerns in biomedical research - Heller and Eisenberg (1998) call this 'the tragedy of the anticommons'.

A final possibility for how firms benefit from IPRs is the *signalling* view (Long, 2002). This is based on the view that there is an informational asymmetry between firms and outsiders (investors, banks and potential employees). Given this, firms need to signal their expertise and use the IPR system to do this. Patents, in particular, are costly to acquire and undergo an external quality check, hence they act as good signal, allowing firms to raise finance or attract

talented employees. From this perspective, the signal value of IPRs is related to its 'quality', and any deterioration in standards within the IPR system could affect this value.

(iii) If IPRs are offered, should they be of uniform length?

If not, does economic theory offer a guide to varying the length of the right? A formal model to maximise social welfare (Stoneman, 1987, Chapter 9; Nordhaus, 1969) shows that uniformity in IPR duration is not likely to be optimal. The duration of protection should vary according to the nature of demand for the product, being short for elastic demand and longer for inelastic demand, so the IP system should reserve longer protection for items without close substitutes to minimise the welfare distortions. In addition, the duration of protection should vary with the marginal cost of the R&D required to make a breakthrough, so that reward is proportional to the marginal resource investment, being longer for the most costly. In practice we already see different durations for patents (20 years) and copyright (50 years or more), but theory would seem to suggest the former should be longer than the latter, rather than as now having longer duration of copyright than patents.

(iv) Are there alternative ways of providing incentives to innovate?

The most frequently used alternative instrument is that of an R&D subsidy. Does the IP policy agency need to offer incentives via both IP rights and R&D subsidy? Griffith et al. (2004) have argued there are 'two faces of R&D'. R&D produces innovations that can be either genuinely novel innovation likely to attract an IPR, or incremental innovation, building on recent breakthroughs but not attracting any patents. In addition, the second face, R&D supports the firm's ability to keep up with the field in 'best practice' technology and 'state of the art' product design via adoption and learning from others. So even if the firm never gets to the front as an innovator, it can benefit both itself and the wider economy if it undertakes R&D. This suggests that R&D subsidy and patents can be complementary incentive policies,

as R&D covers a wider range of socially beneficial activity. Even this policy combination of patents with an R&D subsidy may not reach all the parts of the economy engaging in innovative activity. Service sector firms report few patents and very little classified R&D, but have become increasingly innovative if judged by their applications for new trade marks (Greenhalgh and Rogers, 2006a).

(v) Do IPRs interact with market structure and impinge on competition policy?

Schumpeter (1942) asserted that large firms operating in concentrated industries constitute the engine of technological progress. He argued that monopolistic firms were more able to conduct meaningful R&D because they can use funds earned from monopoly profits to fund R&D. Schumpeter's work suggests an important role for IPR, which may be understood by revealing the central role Schumpeter accorded to the entrepreneur. The entrepreneur was seen as a pivotal figure that controls and directs the other factors of production (land, labour and capital) towards their most productive use. Any successful new product introduced leads to imitation and ultimately profit is eroded. There is therefore a fundamental incompatibility between perfect price competition and modern entrepreneurial activity since such immediate imitation reduces incentives to innovate. Schumpeter argued that oligopolistic market structures, with their perceived intensity of product and factor cost competition will achieve more for social welfare than the severe price competition exhibited by perfectly competitive market structures.

Many reasons have been advanced since Schumpeter's (1942) work as to why large firms may be the engine of technological and innovative progress, and these have been subsequently been formulated as two hypotheses (Symeonidis, 1996). The first hypothesis postulates a positive relationship between innovation and market share or power. Large market share implies more certainty that a new product will also gain market share and

generate profits. Higher profit margins due to market power yields finance for R&D. The reinvestment of these profits, together with the advantages of scale in investment in risky R&D, so that all research eggs are not in one basket, yields commercially viable innovation. The second hypothesis states that large firm size and innovation are correlated. This hypothesis was based on Schumpeter's belief that a large diversified firm would be better able to reap the benefits of innovation, regardless of where in the industry's product range innovation happened to occur. Furthermore, indivisibility in cost-reducing innovations makes innovations more profitable for large firms.

Nevertheless, Arrow's (1962) analysis countered the Schumpeterian view of the relative returns to innovation for a competitive firm as opposed to a monopoly. Arrow's (1962) model argues that, when IPRs exist, competitive producers have bigger incentives to innovate than a monopoly. The monopolist already enjoys excess profits due to existing barriers to entry and thus the returns to innovation offer only a small extra profit. However, in a competitive industry, IPRs offer the opportunity for a competitor to become a temporary monopolist using the IPRs gained following innovation. But this model ignores the financial constraints on R&D investment for smaller competitive firms with zero excess profits, as borrowing to undertake R&D with its uncertain outcomes will command a high risk premium.

These opposing views lead to the idea that there is potentially a non-monotonic relationship between competition and innovation performance, which has quite a long history in economics (see Scherer, 1992). Aghion and Griffith (2005) develop a model in which the two contrasting forces in the relationship between innovation and competition vie to create an inverted U shape: with rising competition, innovation provides the opportunity to enhance profit in sectors with low variation in costs and profits; against this is the Schumpeterian

effect whereby higher competition reduces the differential rents of innovation in sectors with some degree of technology and profit variation.

(vi) What is the role of complementary assets in deriving value from IPRs?

The factors enabling firms to profit from innovation were examined in Teece (1986). He put forward the view that the ability to capture the returns from innovation was related to the complementary asset structure of the innovator, to market entry timing decisions, and to the contractual structures employed by managers to access missing complementary assets. This paper turned attention away from the Schumpeterian notions of market share and firm size as success factors and towards the analysis of heterogeneous industries, to explore what are the relevant sets of complementary assets and how might a firm's management strategy determine its ability to retain rewards from innovation. The list of major complementary assets includes the capacity to manufacture using related technology, aspects of distribution and after sales service, as well as factors quite specific to the industry. Twenty years after this article appeared the current edition of Research Policy is entirely devoted to articles considering the impact of this shift of focus, (see Nelson, 2006; Pisano, 2006; Teece, 2006; Winter, 2006). In this framework, intellectual property is just one of a set of opportunities within which firms have to construct their strategy for appropriation of returns, albeit still an important one.

(vii) Does innovation occur in the absence of IPRs?

Recent analysis has even questioned the need for any IPRs. Boldrin and Levine (2002) believe that the optimal length of a patent/copyright may be zero. They make a distinction between the 'right of first sale' when an item is placed on the market and the 'downstream licensing' of intellectual property arising from continued protection under IP law. In their view, ownership of the first is necessary but the second is not. They argue that there is sufficient profit available to innovators from the advantages of being the first to bring their

innovative product to market, without the need for continued protection, which causes much of the distortion leading to welfare losses from IP assets. Their model neglects issues of uncertainty and risk aversion in R&D investment and ignores the impossibility of recouping all expenses from first sale in most fields of scientific invention e.g. pharmaceuticals, where the crucial inventions can precede the bringing to market of the product by anything up to a decade or more, due to the high level of product testing required in this field. More generally, there is the inherent difficulty of establishing the value of a knowledge-based invention without revealing its properties, and once the knowledge is revealed no-one will bid anything if there is no IPR protection.

A strong argument against the view that IPRs are justified by market failure in knowledge generation is advanced by Dosi et al. (2006). They make three criticisms of the standard view: markets are not just devices for allocating resources, but are dynamic instruments (albeit imperfect) for the production and testing of "novelty"; markets are embedded and depend on a whole ensemble of non-market institutions, such as the public science community; thirdly there is a misleading identification of knowledge with information, which neglects the processes generating useful knowledge, which includes much that is tacit. As Nelson (2006) warns, there is not always a sharp division between the interests of firms and the interest of the public in the design of IPRs. He quotes examples where producers in sectors as varied as pharmaceuticals and software can have a preference for an IPR system that does not block progress by imposing too high a cost on the use of others' technology.

III EMPIRICAL EVIDENCE ON THE VALUE OF IPRs

(i) Evidence of returns to patents

(a) Market value studies

In a well-functioning market economy, the private economic value of a good may be inferred from its price. However, intellectual property rights are often not traded and this makes it difficult to determine private returns to intellectual property. One popular approach to determining the value of such rights is to infer the value of IPR from the prices of shares in publicly quoted companies, which are highly traded assets. In this section, we review some recent studies that have examined the relationship between IPR and market value.

The share price of a quoted company represents the market's best valuation of the expected future dividends (or share repurchase payments) likely to be made by the company. The maintained assumption (Hall, Jaffe, and Trajtenberg, 2005) in the literature on IPR and market value is that investors have "rational expectations", so that financial markets are assumed to price shares "correctly". Investors' estimates of the future dividend payments will be a function of the stock of tangible and intangible assets owned by the company. IPR are one component of a firm's intangible assets, and evidence that measures of knowledge assets such as patent statistics are correlated with market values constitutes evidence, argue Hall et al (2005), that such statistics are good proxies for the (private) economic value of a firm's knowledge stock. An advantage of this approach is that it is inherently forward looking, which distinguishes it from the costs and productivity approaches described below. But as Hall (2000) notes, intellectual property assets are usually embedded within a particular product, and evaluating the separate contribution made by these and other types of assets is difficult.

The starting point for many empirical studies on innovation and market value is Griliches (1981). This assumes that the market value (V) of the firm is given by

$$V = q(A + \gamma K)^{\sigma} \qquad\qquad [1]$$

where A is the book value of total tangible assets of the firm, K is the stock of intangible assets not included in the balance sheet, q is the 'current market valuation coefficient' of the firm's assets, σ allows for the possibility of non-constant returns to scale, and γ is the ratio of shadow values of intangible assets and tangible assets (i.e. $\frac{\partial V}{\partial K} \Big/ \frac{\partial V}{\partial A}$). Taking natural logarithms of [1], and using the approximation $\ln(1+K/A) \approx K/A$, [1] can be rearranged to

$$\ln V = \ln q + \sigma \ln A + \sigma\gamma \frac{K}{A} \qquad\qquad [2]$$

Note that the approximation becomes poorer the larger the value of K/A. The difficult problem for empirical studies is how to proxy K – the stock of intangible assets accumulated by the firm. Interpreted broadly, 'intangibles' can be related to brand names, process or product innovations, advertising, managerial skill, human capital in the workforce and other aspects of the firm. Although balance sheet data do, at times, contain a book (accounting) value for intangible assets, there is widespread agreement that this vastly underestimates the true stock of intangible assets of the firm.

One important recent contribution to this literature is the work of Hall, Jaffe, and Trajtenberg (2005). These authors construct a variable representing citation-weighted stocks of patents as a proxy for the firm's stock of knowledge. The sample consists of over six thousand publicly traded manufacturing firms with data from 1965 to 1995, although data are only available for patent citations from 1976. Their specification of the firm's market value function is a standard one: the value of the firm is defined as the value of equity plus debt, and this is related to the value of tangible and intangible assets. The Hall et al. (2005) empirical analysis replicates a familiar result from this literature: the R&D stock is more closely correlated with

market value than either patents or citations, see for example the early work of Cockburn and Griliches, (1988).

Hall et al. show that citation weighted patent stocks are more highly correlated with the firm's value than unweighted patent stocks.[4] Even after controlling for firms' R&D, the citation variable is associated with increased market value. Firms with very heavily cited patents exhibit what the authors describe as "almost implausibly" large market value differences of 50% higher than a firm with the same R&D and patent stocks, but with only the median citation intensity. However the benefit of hindsight, as to which have been the most cited patents, was not available to the stock market at the time of share valuation. This suggests that the citations are a proxy for innovation quality that is already known to the stock market. Another novel result is that firms with a higher share of self-citations enjoy a higher market value, other things equal. A self-citation is simply a citation made by a company to a patent already owned by that same company. Although self-citations may be strategic, Hall et al. note that such citations may mean the firm is successfully protecting positive downstream impacts and successfully appropriating benefits for itself.

The work of Bloom and van Reenen (2002) examines the role that patents play in determining the market value of large UK firms. Their sample is 236 firms who had taken out at least one patent in the US between 1968 and 1996. They examine the impact of the patents registered in the US by these firms on their stock market value, arguing that these will be the more significant patents as compared with those registered in the UK or the EU. Bloom and Van Reenen report three different specifications for the patent variable: patent stocks estimated

---

[4] In common with many other econometric studies, these authors do not use patent renewals data (unlike the costs approach to patent value) to construct actual patent stocks; rather they use an assumed depreciation rate. Clearly citation weights pose further problems in that the importance of any patent is revealed slowly throughout its duration and some citations may be as yet to come, necessitating either the estimation of unobserved future citations or the adoption of a fixed time cut-off.

using a fixed 30% depreciation rate, and two variants of citation-weighted patent stocks, using an imputation of future citations for one measure and a five year cut-off for the other. They find that any one of these three measures of patents positively affects market value; furthermore the three measures are highly correlated (above 0.9) in their sample. Patents also affect market value much more quickly than they affect productivity measures, which they also analyse (see below), a result that is likely to be due to the time it takes to embody new innovations in work processes and to adjust physical capital to the new innovation.

McGahan and Silverman (2006) examine the direct impact of the firm's own IPR on its market value, but they also explore the interactions between IPRs in rival firms. Their database builds on that of Hall et al. (2005) for US stock market listed companies, by containing observations for non-manufacturing firms and covering a longer time period. They distinguish between firms that currently compete in the same industry, as well as exploring the impact of relevant IPRs acquired by 'outside inventors', who are potential competitors but not currently producing in the same product markets. They also distinguish between industrial sectors according to the Teece (1986) framework, whereby the presence of complementary assets can affect the degree to which a firm can appropriate the returns from its own and others innovations. They make a further distinction between patent stocks based on counts and citation rates per patent, which identify important patents.

In this study, positive spillover effects dominate negative market-stealing effects in the IPR competition between rivals in the same industry (in this case patents). However, if highly-cited patents are acquired by a firm or inventor outside the sector, then market stealing dominates. This suggests that firms are better able to respond to important innovation by rivals with which it may share absorptive capacity, but is consistent with the ability of new entrants to exploit radical innovation to unseat successful incumbents. Nevertheless when

complementary assets are introduced the picture changes: in the effect of highly cited patents by outsiders the spillover effects now dominate, suggesting that those incumbent firms with complementary assets are well-situated to bargain with outside innovators to license innovations on favourable terms.

(b) Productivity analysis for patents

Another approach to assessing the value of IPR and the innovation they embody is to assess the contribution such rights make to productivity. Productivity is perhaps the single most important statistic used by analysts interested in how firms and countries are performing. Griliches (1984) pioneered this approach using data for the US. Papers that have taken this approach using British data include Bloom and Van Reenen (2002) and Greenhalgh and Longland (2005). The advantage of the analysis in the previous section is that market value is a forward looking measure of performance. The disadvantage is that it relies on 'efficient markets' and can only be conducted on firms that are quoted on stock markets. This section investigates the link between IPRs and performance looking at estimates of firm production functions, in which these intangible assets can play a role in boosting productivity.

The production function, which is a relation between production capacity defined by inputs and output, can be specified as:

$$Y = AL^{\alpha_1} K^{\alpha_2}. \tag{3}$$

where Y is value added, L is labour (total employment), K is stock of tangible capital and A is a scalar representing knowledge. Many factors affect the level of knowledge in the firm. The most commonly used proxies in empirical analysis are expenditures on R&D, patenting activity, spending on training or human capital measures, and information technology

16

investment. The vast majority of analyses on production functions are conducted on firms in the production sector and, within this, focusing on manufacturing.

Bloom and Van Reenen (2002) study a database of over 200 UK firms for the period 1968-1996. Their proxies for knowledge include both simple patent counts and patents weighted by citations; the dependent variable in their regressions is based on firm sales, which the author's take as a measure of output, rather than the more appropriate value added.[5] The empirical results point to a significant and positive effect of the patent measures on total factor productivity (as measured by the real sales variable). Patent stocks, when estimated as the sole measure of knowledge in a firm, are highly significant and have an estimated elasticity of 0.03, implying that total factor productivity will rise 3% if total patent stocks are doubled. When both citations and raw patent stocks are included estimated jointly, the simple patent stock variable is no longer significant. This implies, as one would expect, that citations provide significant and important information concerning the effects of innovation and IPR on productivity. However there is little difference in the estimates depending on which approximation to citation weights is used.

Greenhalgh and Longland (2005) use a larger panel database for 1986-94 and they relate firms' net output (measured by value added) to the contribution made by intangible knowledge assets, as well as to the contribution made by capital and labour services. These authors also seek to widen the range of measures of IPR, arguing that while the acquisition of new patents may be reflective of more efficient production processes or improved product variety and quality, the launching of new products is also often associated with registration of trade marks. Consequently, they investigate gains from IPRs by measuring the number of

---

[5] There is thus a problem of mispecification in that Bloom and Van Reenen estimate a gross output production function (using real sales as their dependent variable), but do not include as regressors any variables related to the use of intermediate inputs.

new patents registered in three geographical domains, the UK, EU and US, and by trademarks registered in the UK.

Greenhalgh and Longland (2005) test for evidence of productivity gains in firms registering trademarks and patents, but also examine the size and duration of benefits to IP protection for the firms in their sample. This question is of interest since it would be useful to know if the economic gains to IP protection correspond to the length of protection enshrined in statute. A closely related question addressed by Greenhalgh and Longland relates to the non-depletability of knowledge assets. In theory, knowledge is not "used-up" by being applied (Arrow, 1962), so Greenhalgh and Longland assess whether the absolute amount of R&D, or the total amount of IP assets, is important for firm performance. They compare this idea of knowledge as a non-rival good with a contrasting hypothesis of knowledge as a depletable good, whereby the intensity of R&D and IP relative to firm size becomes important as each process or product only affects part of the range of the firm's output in a multi-product firm.

The empirical analysis reveals that firms that register trademarks and patents, and who do R&D (for those firms who report R&D separately in their accounts) are more productive. Interestingly, the immediate productivity benefits revealed by panel data analysis appear to be fairly short-lived. Dividing their sample between firms which are located in high and low technology sectors shows that the dynamic returns for acquiring new IPR are non-significant for high technology firms, but significant for firms in low tech sectors. (These panel data estimates control for persistent differences between firms.) Even so, cross-section analysis reveals that persistent differences in productivity are associated with the presence of R&D and IP activity in both high and low tech firms and firms which do not participate in any of these innovative activities are persistent laggards. They also find that innovative firms do not possess the ability to use knowledge equally effectively in all areas of their activity, as the

intensity of R&D and IP matter. Hence Greenhalgh and Longland suggest that firms need to continually renew their intangible assets stocks to improve both their production technology and product offering.

This result is similar to conclusions of survey work on US firms in the high-tech semiconductor industry: Hall and Zeidonis (2001) conducted their own survey of 100 firms in the semiconductor industry. This industry is characterized by technological sophistication and extremely short product life cycles. Earlier surveys of many sectors report that managers regard patents as one of the least effective ways of extracting value from intellectual property. The authors note that firms in the semi-conductor industry tend to rely more on measures such as lead time, secrecy and design capability than on patents. This evidence is particularly surprising given the widespread and increasing use of patents in this industry.

Hall and Zeidonis conclude that many patents are registered so as to quickly allow individual firms to negotiate access to important external technologies. Thus, firms use large patent portfolios as "bargaining chips" to get around the problem of investment being delayed due to certain patents being held by external economic units. Such behaviour leads to "patent portfolio races" on the part of firms trying to amass, for strategic reasons, large numbers of patents. Hall and Zeidonis observe that such behaviour would not be observed if patent rights were awarded on a strictly "novel" basis, so that it would become very difficult to get a patent when a substantial body of "prior art" exists. This work is especially helpful in highlighting the need to explicitly take strategic factors into consideration when studying patent behaviour, as proposed by Teece (1986, 2006).

(ii) Variability of returns to patents

The above studies mainly focus on the average value of the firm's patent count. Such counts were widely used in empirical research concerned with the valuing of IP until the work of Schankerman and Pakes (1986), who convincingly argued that the simple patent counts are unlikely to be good measures of the amount of innovative output, since the value distribution of patents themselves is so skewed. In other words, most patents are worth very little to either their inventors or to society; instead, a very small minority of patents are of high value and are lucrative financially to their inventors and yield sizable benefits to the economy in terms of improved consumer welfare. Therefore, adding up the number of patents issued to a particular entity is an uninformative measure of innovative output and finding the average value of these patents is not a very accurate reflection of their economic value.

Schankerman and Pakes (1986) demonstrated the existence of a skewed value distribution for the United Kingdom, France and Germany. They improved on the patent count literature by confronting the problem of a skewed value distribution by basing their empirical analysis on the observation that in these three countries (and in most other countries), patentees must pay an annual fee to renew their patents. Schankerman and Pakes argue that it is reasonable to assume that firms, governments and other patent holders make renewal decisions on the basis of the value of the patent. These authors then exploit this fact by using data on renewals and renewal fee schedules for the three aforementioned countries to reveal information on the distribution of the value of patent rights. Forming this empirical distribution also facilitates estimation of the economic value of patents, albeit as a lower bound estimate, given that renewal only occurs if the anticipated value of the patent exceeds the renewal fees.

Their study covers all patents applied for in the UK, France and Germany for the period from 1950 to 1979, but with no breakdown for industrial sectors in any of the countries.

(Schankerman, 1998, presents estimates of the private value of patent protection amongst different technology fields.) Based on data obtained directly from national patent office, France and the UK share similar patterns of (institutionally imposed) slowly rising cost and falling rates of patent renewal with patent age. In Germany, renewal costs rise rapidly after the patent has been in force for six years and initially high renewal rates fall more sharply after this point. The distribution of renewals by countries appears consistent with the hypothesis that renewal fees influence the decision to renew. In each country the distribution of patents by duration (and thus by imputed value) is extremely skewed. In the UK and France roughly 60% of patents survive five years but only a quarter survive past age thirteen, which shows that the available legal maximum patent life is not relevant for the majority of patents because the value of the intellectual property falls to zero, either due to technological redundancy or to commercial non-viability. The small proportion of patents that are renewed to the limit are, of course, those with highest value.

Given the fact that the life of individual patents can vary so much, and that so many have short lives, the average value of all patents is not a particularly informative statistic. Because of this, Schankerman and Pakes also looked at the value of patents that survive to at least five years of age. Measures reveal similar values in France and the UK, but much higher values in Germany. This difference is probably reflective of the higher initial rejection rates in Germany (only about 30% of patent applications were accepted), which of course implies that any patents that are accepted in Germany are likely to be of a somewhat higher value than those in the other two countries. Hence it is to be expected that the five-year value will be highest in Germany.

Harhoff et al., (1997, 1999) studied another refinement of the patent renewal approach. Their work was inspired by the observation that work on application and renewal data was silent on

those patents that were renewed for the maximum possible duration. Since patents that are

renewed for the maximum possible statutory term are presumably the most valuable, Harhoff

et al. point out that the renewal studies will only uncover information on a small amount of

the total value of a national patent portfolio. Harhoff et al. (1997) confirm the skewed value

distribution found in many other studies, but present this result for the tail of the most

valuable patent applications made in 1977 (when the maximum patent duration in Germany

was 18 years) and expiring at full term in 1995. A novelty of the empirical approach in this

paper is that the value estimates were obtained directly from patent holders through the use of

a survey conducted in 1996, a year after the final year's fees. German data were used

because, as noted above, the German system of patent renewal is particularly rigorous in

rejecting applications of low inventive output and because of its highly progressive renewal

fee schedule (i.e. the fees that must be paid to the relevant patent office increase with each

year that the patent is in force.)

The survey asked the patent holders how much they would have been willing to sell the patent

for soon after it was granted, assuming they had perfect knowledge at this time of patent's

contribution to future profitability. This distinguishes the Harhoff et al. studies from other

renewal data papers, since responses to this survey question mean that patent values can be

measured relative to the counterfactual of being deprived of the use of the patent. This

method results in much higher extreme values; the estimated value levels are hundreds of

times higher than those in other studies that use renewal and application data. The results also

exhibit a high degree of skewness: the most valuable 5% of all German patent renewals

accounted for over 50% of total sample patent value, and in the US the most valuable 8.5% of

patents account for around 80% of total patent value. In related work, Harhoff et al. (1999)

showed that within the class of patents renewed to full term in both the US and Germany,

citations of the patent rise with estimated value, although this relationship is somewhat noisy.

(iii) Returns to trade marks

In Landes and Posner (1987), the basic argument is that trade marks have value since they help to solve the information asymmetry between seller and buyer, as firms use trade marks to signal to consumers that the product is of a certain, consistent quality. In this way the 'search costs' of customers are reduced, the firm can charge a higher price, and the firm's profits increases. In law the role of the trade mark is to provide a distinctive name or sign that can identify the origin of the product in question. Trade marks may also encourage firms to increase investment in improving the quality of their good(s). Thus, a second view of trade marks, that has been stressed by Mendonca et al (2004), is that they proxy innovative effort, in the same way that R&D or patent data also proxy innovative effort. Clearly, in this case it is the current trade mark activity (i.e. a 'flow'), rather than the stock of trade marks held by a firm that is the relevant proxy. There is a further possibility that stems from the theoretical industrial organisation literature on brands, entry and barriers to entry, where a traditional argument is that firms may use product or brand differentiation as a strategic barrier to entry by incumbents. From this perspective, the rapid rise in trade mark activity since the mid 1990s, although potentially beneficial to incumbent firms, may not be benign for society.

Seethamraju (2003) analyses the value of trade marks in 237 US firms from selected industries in 1993-97, finding a positive role for trade marking on sales and also market values. A more recent study of 300 Australian firms observed from 1989-2002 by Griffiths et al. (2005) found that the stock of trade marks was a significant determinant of profits, but with a smaller impact than either patents or registered designs; even so the value of a trade mark was rising over their data period.

Greenhalgh and Rogers (2007) analyse a large sample of publicly quoted UK firms from 1996-2000, with both manufacturing and services firms being analysed. They explore the impact of undertaking any trade mark activity in these firms and also the effects of increasing trade mark intensity among those that do. The results indicate that stock market values are positively associated with R&D, patents and trade mark activity by firms. They find larger differences between firms with and without trade marks for firms in the services sector than for manufacturing. They also find bigger differences in Tobin's q when the services firm is applying for European Community marks, rather than just applying for UK marks. Increasing the intensity of Community trade marking appears to raise market value for both manufacturing and services, but this relationship weakened over their data period.

In the same paper, Greenhalgh and Rogers (2007) investigate the relationship between trade marks and productivity levels and growth rates for both quoted and unquoted firms, using a value added production function. The results indicate that firms that trade mark have significantly higher value added than non-trade markers (by between 10% and 30% across all firms). Their interpretation is that trade mark activity proxies a range of other, unobservable, firm-level characteristics including innovation that raise productivity and product unit values. They also analyse whether greater trade mark intensity raises productivity growth. Higher trade mark intensity has some positive association with productivity growth in services, but the results are relatively weak for manufacturing firms. These results for the relationship between productivity and trade marks were broadly consistent with those derived for their quoted firm sample using the market value approach, suggesting that stock markets are efficient in estimating the likely benefits of new intangible assets, and that managers are not just seeking trade marks to follow a management fad, but could expect to receive real returns from innovative activity leading to new products requiring trade marks. Even so, the marginal returns to extra trade marks per firm were diminishing quite rapidly over the period, as

indicated by exploration of the interaction of time trends with trade mark intensity, suggesting decreasing returns to further proliferation of product variety.

Greenhalgh and Rogers (2007) also investigate the interactions between firms to determine if there are spillovers from trade mark activity of the type detected by McGahan and Silverman (2006) for patents in US firms. They find that, in the short run, higher trade mark activity by rivals in the industry reduces the firm's value added, presumably by putting downward pressure on prices and profit margins through the 'market stealing' effect. However, in their analysis of subsequent productivity growth and of current stock market values, which incorporate the expectations of future performance, the results are that positive spillovers negate the market stealing effects to give a net positive impact of rivals' trade marks on the firm's productivity and of rival's patents on the firm's market value.

(iv) Returns to copyright

The first copyright laws were developed in the 18th century to protect the authors and publishers of books for up to a period of 28 years (after which free access and copying was allowed). As with patents, the basic rationale for copyright is that without legal protection the incentives to produce creative work would be lessened. Since its inception, the length and breadth of copyright has expanded considerably. Copyright now covers a wide range of creative work, including music, film, photographs, architecture and software. The length of coverage for literary work is now the author's life plus 70 years and the other categories have long periods of protection (e.g. in the UK, movies and sound recordings are protected for 50 years).

There has been considerable debate over the role of copyright protection in recent years (Corrigan and Rogers, 2005). While this is not the central focus of this paper, it is worth

outlining the key elements of the debate. First, changes in technology that increase the ability to copy and distribute creative work have raised concerns that copyright infringement is increasing. A famous court case that illustrates this concerns the Napster's file sharing software (which at its peak had around 70 million users). In 2001 the large music companies accused Napster of massive copyright infringement – specifically by enabling others to commit infringements. The end result was that Napster was effectively closed down by the courts (although the software was bought by Bertelsmann). Second, the large music, software and movie companies that rely on copyright protection are concerned that there is persistent, large scale infringement by developing countries.[6] The companies refer to such infringement as 'piracy' and claim that it causes substantial lost revenues. Third, industries that rely on copyright are an expanding share of GDP: it is estimated that such industries account for 6% of US GDP and 7.3% of UK GDP (WIPO, 2005; HM Treasury 2006).

It is clear from the various legal cases about copyright, and industry complaints over increasing 'piracy', that copyright has substantial private value. For example, the International Federation of the Phonographic Industry in its *Piracy Report* 2006 estimates that unauthorized CD sales represented US$4.6bn dollars of lost sales (or around 14% of total worldwide sales). There is, however, debate over these numbers since 'pirate' sales may not represent lost legal sales. Academic papers have analysed the impact of unauthorized downloads on music sales, finding varying impacts on legal sales from 'no effect' (Oberholzer and Strumpf, 2004) to 'substantial' (Blackburn, 2004). The conceptual reason why unauthorized sales may not reduce legal sales is that 'sampling' can occur, whereby a consumer finds out about new types of music (and subsequently does buy a legal copy).

---

[6] This is not a new issue; for example, in the 19th century, US book publishers were quick to copy new Charles Dickens' books since the US was not a signature to international copyright agreements until 1891 (Khan, 2004).

Empirical analysis of the value of copyright is hampered by the fact that there is (currently) no legal requirement to register creative work. Nevertheless, there are a few studies that generate some information on the economic role of copyright. A study for the US in a period when copyright did require registering and renewal concluded that around 80% of copyright had little economic value (see Landes and Posner, 2003, who looked at the 1910-1991 period). Png and Wang (2006) look at the impact of copyright extensions on the production of movies in OECD countries, finding that extension from 50 to 70 years after author's life did increase production by around 10%. This is a surprising result, since the net present value of such a 20 year increase is very low (if a standard discount rate is used), but the result appears robust to a range of checks. Another approach is to use data on court actions. Baker and Cunningham (2006) look at the effect of US federal court decisions that broadened copyright on the market value of firms. They find that one ruling raised the market value of firms by around 0.2 to 0.45% (or $4 to 8 million). In a similar type of study, Mazeh and Rogers (2006) find that plaintiffs in copyright disputes have higher market values than a peer group of similar firms. Overall, however, the empirical evidence on the value of copyright is very sparse.

(v) The interface between IPRs and market structure

Schumpeter's provocative claims about the beneficial role of large firms operating in concentrated markets sparked a huge empirical literature. If his claims are true, then the traditional preoccupation of the competition authorities with opposing mergers leading to concentration and preserving opportunities for entry of smaller new firms might be shown to have negative trade-offs for the rate of innovation.

With very few exceptions, most of the literature concerned with testing the second Schumpeterian hypothesis, about the relationship between firm size and innovation, regressed some measure of innovative output or input on a measure of size, usually using cross-

sectional data of firms from one or many industries (see Symeonidis, 1996). Studies in this tradition, starting with the work of Scherer (1965) have been criticized as failing to recognise or deal with numerous methodological problems.[7] Perhaps the most serious fault of much empirical work in this area is the implicit assumption that causality runs from firm size (and market structure) to innovation. In fact, it is now widely recognised that variables such as firm size, market structure and innovation are endogenous variables within systems in which the most important factors determining overall economic outcomes are technology, institutions, demand, strategic considerations and randomness (Symeonidis, 1996).

Cohen (1995) provides a summary of the empirical evidence, "The most robust finding from the empirical research relating R&D to firm size... is that there is a close, positive monotonic relationship between size and R&D which appears to be roughly proportional in the majority of industries... In addition, innovative output appears to increase *less than proportionately* than firm size and R&D productivity appears to decline with firm size...The consensus is that... size has little effect on innovation and that larger firms have no advantage in the conduct of R&D and perhaps a disadvantage." This statement is only partly borne out in the analysis of firm size as a determinant of patenting and trade mark activity for a large sample of UK firms by Greenhalgh and Rogers (2006a). In their analysis of both manufacturing and services firms, larger firms were significantly more likely to be IP active in any given year than smaller firms, but across the active firms the number of IPRs per employee was negatively associated with firm size.

---

[7] For example, there was a serious sample selection problem arising from the non-random nature of samples, since the sample of firms studied typically only included those firms that reported R&D. A further issue was the extent to which studies managed to successfully control for firm characteristics other than size. This creates problems for empirical work since the intensity of R&D varies across firms (Cohen, Levin, and Mowery, 1987). A related problem relates to the need to control for industry effects. Since firm size and innovation are likely to be affected by attributes of the overall industry such as the level of technological opportunity and regulatory considerations, studies that use inter- and intra-industry data need to control for the industry level effects in order to obtain unbiased estimates of the effect of the specific influence of firm size on innovation. Moreover, as Cohen (1995) notes, controlling for industry effects in firm level data can be extremely difficult given that many large firms are often composed of smaller units that operate in and across several industry categories.

This takes us on to the literature concerned with testing the first of Schumpeter's two hypotheses, which postulated the existence of a positive correlation between innovation and market share. Again, interpreting the empirical literature in this area gives rise to several difficulties. Most work has regressed a measure of innovative activity on a measure of industry concentration. This assumes that concentration unidirectionally causes innovative activity, whereas in practice it is almost certainly the case that there is two-way causality. The problems noted above of the difficulties of controlling for firm and industry effects also contaminate much of the research on innovation and market structure. Two early reviews of this literature (Scherer, 1992 and Geroski, 1994) agree that Schumpeter was wrong to believe that large monopolistic corporations are the driving forces of technological innovation. Scherer (1992) notes that there is no evidence to suggest that countries should seek to "re-allocate innovative activity away from venture firms to the well-established giants lauded in Schumpeter's (1942) book". Instead, industry characteristics such as technological opportunity and appropriability conditions may be more important in determining innovation.

Even so, explorations of the role of market structure have continued: Aghion and Griffith (2005) have offered empirical evidence to support their hypothesis of an inverted U-shaped relationship between the degree of competition and the rate of innovation. In their study, using large quoted UK companies that obtained patents in the US between 1968-1997, there is first a rising rate of patented innovation as the index of product market competition falls and then a falling off of patent rates as concentration rises further. Greenhalgh and Rogers (2006b) explore the interaction between market share and the value of intellectual property, as seen through variations in the stock market value of the firm. They find that the stock market assigns higher values to both patents and trade marks when these are obtained by firms with higher market shares, although there is considerable variability in the size and significance of this interaction across different technology groups.

Several papers have focused on one specific industry, which can reveal details of the innovation process, in the manner suggested by Teece (1986, 2006), where complementary factors play a role in the distribution of returns. For example, Gambardella's (1995) study of the biotechnology industry showed that small firms often come up with radical new innovations and discoveries, but are unable to take the commercialisation of the product much further. He notes that the "result has been a new division of labour, with smaller firms specializing in early research and larger firms conducting clinical development and distribution". This conclusion suggests a much more subtle process of technological innovation than the one postulated by Schumpeter. As another example, Gruber's (1992, 1995) studies reveal the importance of "first mover advantage" in determining market share and innovative output in the semi-conductor memory chip industry. Firm specific learning is important in this industry because an early innovator is more capable of learning how to improve product quality in the face of rapid overall industry quality improvement than a late entrant to the industry who will have less time to learn how to improve quality. These examples of detailed work on particular industries reveal just some of the subtlety of the mechanisms relating innovation, firm size and market share.

(vi) Costs of obtaining and enforcing Intellectual Property Rights

While gross returns to IPRs have been demonstrated in many of the above studies, the net rate of return can only be assessed after consideration of the costs of acquiring and defending these rights. As with the returns, the issue of firm size is again relevant to the ability to pay both the initial fees to register assets and the legal costs arising when an IPR is challenged by a competitor. Some evidence on these costs is presented in Table 1. These estimates indicate a wide variation in the costs of litigation across countries. They also show considerable variation within countries according to which legal route is taken and how far up the

hierarchy of the courts it is pursued (for example from County Court to High Court in the UK).

Table 1 - Patent costs

	UK	Germany	France	US
Application & renewal fees	£3500	£9000	£4000	£5500
Litigation costs	£ 0.2 to 1 million	£35,000 plus	£35,000 plus	£1 to 2 million

Note: Data are from IPAC (2003) and Gowers Review (HM Treasury 2006) and are rough estimates only.

Lanjouw and Schankerman (2001) study the determinants and outcomes of patent infringement and declaratory judgment suits, using a sample of all patent suits reported by US Federal courts over the period 1978-1999. They find that the threat of court action is very important: most settlement occurs soon after the suit is filed, and sometimes before pre-trial hearings take place. Lanjouw and Schankerman conclude that this aspect of the enforcement process is desirable, since it implies that the use of judicial resources is minimized. However, individuals and smaller companies are much more likely to be engaged in a suit, conditional on the characteristics of their patents. Interestingly and importantly, what is significant for settlements is that firms have a portfolio of intellectual property to trade, or that firms have some other means of encouraging cooperative behaviour. Again, this puts small firms and individuals, with their small intellectual property portfolios, at a disadvantage. Nevertheless, the authors do suggest that patent litigation insurance would be a plausible proposition.

In related work, Lanjouw and Lerner (1996) study the use of preliminary injunctive relief in patent litigation. Preliminary injunctive grants prevent alleged infringers from using the infringed patent during the period of the trial. They investigate whether small firms, who are weaker financially than larger firms, would be unable to compensate the patentee for damage occurring during a trial if found guilty, or might not be able to sustain even an injunction. In other words, they test whether the possibility of increasing legal costs and the possibility of

going out of business may lead defendants to settle on unfavourable terms; this issue is relevant to financially constrained smaller firms since such firms would probably be worse off when faced with a preliminary injunction. They find a positive relationship between plaintiff size and the likelihood they will request an injunction. Interestingly, the difference between plaintiff and defendant size is also important, which Lanjouw and Lerner argue may be due to strong firms preying upon smaller and weaker firms in an effort to drive up the costs of their smaller competitors. They also cite unpublished work by Lerner, which shows that patent cases involving smaller firms display a disproportionate concern with trade secrets, which Lerner concludes is due to high costs, both direct and indirect, of patenting for these firms.

In other work, Lerner (1995) studies the patenting behaviour of 49 new American biotechnology firms. He finds that firms with the highest litigation costs are more likely to patent in patent subclasses with no rival awards, although he does not consider the possibility that unobserved characteristics of such firms may be driving this result. He also finds that firms with high litigation costs face a lower likelihood of patenting in areas where there are firms who have a lower cost of litigation. Again, it is possible that new firms do not make this decision purely on the basis of legal costs, but instead are driven to patent in areas where there are few older, established competitors.

IV ASSESSMENT AND QUESTIONS FOR FUTURE RESEARCH

There is a large and longstanding literature indicating the presence of significant gross returns to firms from acquiring patents. A more recent and narrower range of literature has demonstrated that trade marks work similarly for firms in sustaining their current and future profitability. The eventual returns to individual patents or trade marks can vary enormously: most returns are very small, but a few generate huge returns. Overall these variable returns are not very precisely predictable by stock markets, although it seems that markets do obtain

early indications of which will be the most highly cited patents and revise share values accordingly.

The areas of copyright and design are less well served by the empirical literature on valuation than those of patents and trade marks. It is also difficult to be very precise about the net returns to various IPRs, as there is a paucity of evidence about how much firms have to spend to enforce their rights via legislative activity. However the benefit of copyrights to media and music firms and individual authors can be inferred from the lobbying pressure to extend terms of protection. Whether and to what extent these systems of IPRs are in need of reform is a difficult question recently reviewed by Gowers (HM Treasury, 2006), which made a lengthy set of recommendations, but did not endorse the extension of copyright in sound recordings. We venture to pose four questions here that require continued examination:

(i) Are IPRs rewarding firms by too much or too little?
Implicit in this question is the idea that there may be some ideal system of IPRs that produces the socially optimal rate of innovation. Evidence of the impact of the current system on the incentives to innovate, which is acceptable to social scientists, is very hard to obtain. There is a lack of variety across advanced countries in IPR systems due to international agreements seeking to establish 'level playing fields' and there are slow changes in these systems through time, which leads to a lack of evidence about counterfactual situations. There are quite considerable differences across industries in the relevance and availability of the IPR regime, given the nature of their products, but due to the myriad of factors differentially affecting industry growth rates again it is hard to assess the impact of the IPR system.

Dosi et al. (2006) cite a considerable range of examples of new technologies forming the core of the ICT revolution that evolved rapidly with no patent regime, or a very weak one,

including semiconductors, computer software, and mobile telephones (until the late 1980s). They argue that evidence supports the view that the recent patent explosion is due to changes both in the legal and institutional framework and in firms' strategy, with little relation to the underlying innovative activities. Surveys of US firms (Levin et al., 1987; Cohen et al. 2000) show that learning curve advantages and lead times are ranked ahead of patents in the majority of manufacturing sectors. The UK Innovation Survey 2005, quoted in the Gowers Review (UK Treasury, 2006), similarly ranks lead time and confidentiality agreements well ahead of patents, copyright or trade marks for all firms of any size; however in larger firms IPRs are rated relatively more highly.

(ii) Are smaller firms disadvantaged by their size in the use of IPRs?

A constant theme in both policy and academic debates is the extent to which the IPR system provides support to small and medium sized firms. The existing empirical research on the value of IPRs has generally neglected to include information about the smallest sized firms (i.e. those with less than 50 employees). In the papers cited above we have found some indications that medium sized firms that are IPR active can be more IP intensive than larger firms. Nevertheless there is concern that many smaller firms are unaware of the IPR system and even those that appreciate its possibilities are reluctant to use the system because of its high costs, particularly in respect of enforcement costs. The UK Patent Office has made efforts to reach these firms and is further encouraged to do this by the Gowers Review, but more research to assess the interaction between smaller firms and the IP enforcement system appears vital.

(iii) Are services firms being helped as much as manufacturing by IPR systems?

Many services activities have historically fallen outside of the realm of patentable items, but this does not mean that they have remained stationary in terms of innovation. Recent evidence

shows services firms in many sectors catching up with manufacturing firms in their propensity to register trade marks for new products (Greenhalgh and Rogers 2006a). One issue that might affect services firms more than manufacturing is that of whether there should be an opportunity to apply for business method patents in the EU as now exists in the US. Hart and Pitkethly (2003) investigated the experiences of operating in the US under a regime including business method patents. They concluded that there was very little evidence that business method patents increased the rate of innovation as opposed to the level of patent activity. Their recommendation was that, providing companies are made aware of the current US legislation, there was no compelling need for change to the patent regime in Europe.

Other service sectors are heavily dependent on copyright. The Gowers Review identified a number of areas where copyright was not working optimally at present, because of uncertainty about the domain of copyright and whether particular instances of copying are legal. Although there are also differences between the US and the EU in the treatment of software patents, to date there is very little evidence of the real impact of this on innovation and growth in the related industries. This points to the opportunity for new research into the growth of services in US versus the UK and Europe to try to identify the impact of the different IPR systems.

(iv) Should IPRs seek to influence the direction of innovation?

Here the issue is how to ensure that what is invented is socially desirable. At present the requirements for the award of a patent are that the inventive step should be novel, non-obvious even to experts, and capable of industrial application. The patent examiner has to judge if the proposed patent meets these three conditions, with very little reference to the nature of the invention (other than it cannot be 'contrary to public policy or morality', i.e. positively harmful to society).

The issue of what is a sufficient contribution to merit a patent could be adapted to fit with a more socially determined incentive structure, a proposal made in Greenhalgh (2005). Suppose that it was decided that the twin goals were those of satisfying basic needs, not luxuries, and of preserving scarce environmental resources. To obtain patent protection, the inventor would have to demonstrate either an improvement in the supply of goods and services meeting basic needs, or the offer of a new technique for greener production or distribution technology. R&D and innovation might then become more concentrated in these product and process fields, slowing the development of luxury goods for rich consumers in favour of such things as cures for the diseases of the poor and the achievement of environmental goals. This may appear to be a provocative suggestion, but there is every reason to expect the IPR system to serve a wider set of social objectives than the promotion of innovation.

REFERENCES

Aghion, P. and Griffith, R. (2005), *Competition and Growth: Reconciling Theory and Evidence*, Cambridge, MA: MIT Press.

Arrow, K. (1962), 'The economic implications of learning by doing' *Review of Economic Studies*, **29**(1), 155-173.

Baker, M. and Cunningham, B. (2006), 'Court decisions and equity markets: Estimating the value of copyright protection', *The Journal of Law and Economics*, **49**, 567–596.

Baumol, W. (2002), *The Free-Market Innovation Machine*, Princeton, NJ: Princeton University Press.

Blackburn, D. (2004). 'On-line piracy and recorded music sales', Mimeo, Harvard University.

Bloom, N. and van Reenen, J. (2002), 'Patents, real options and firm performance', *Economic Journal*, **112**, C97-116.

Boldrin, M. and Levine, D. (2002), 'The case against intellectual property' *American Economic Review*, **92**(2), 209-212.

Cockburn, I. and Griliches, Z. (1988), 'Industry effects and appropriability measures in the stock market's valuation of R&D and patents', *American Economic Review*, **78**(2), 419-23.

Cohen, W. (1995), 'Empirical studies of innovative activity' in P. Stoneman (ed.) *Handbook of the Economics of Innovation and Technological Change*, Oxford: Blackwell.

Cohen, W., Nelson, R., and Walsh, J. (2000), 'Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent or not', NBER Discussion Paper 7552.

Cornish, W. (1999), *Intellectual Property: Patents, Copyright, Trade Marks and Allied Rights*, 4th edition, London: Sweet and Maxwell.

Corrigan, R. and Rogers, M. (2005), 'The economics of copyright', *World Economics: The Journal of Current Economic Analysis and Policy*, **6**(3), 53-174.

Dixon, P. and Greenhalgh, C. A. (2002), *The Economics of Intellectual Property: A review to Identify Themes for Future Research*, paper for the Intellectual Property Advisory Committee of the UK Patent Office.

Dosi, G., Marengo, L. and Pasquali, C. (2006), 'How much should society fuel the greed of innovators? On the relations between appropriability, opportunities and rates of innovation', *Research Policy*, **35**(8), 1110-1121.

Firth, A., (1995), *Trade Marks: The New Law*, Bristol: Jordan Publishing Ltd.

Gambardella, A. (1995), *Science and Innovation: The U.S. Pharmaceutical Industry During the 1980s.* Cambridge, UK: Cambridge University Press.

Geroski, P. (1994), *Market Structure, Corporate Performance and Innovative Activity*, Oxford: Clarendon Press.

Greenhalgh, C.A. (2005), 'Why does market capitalism fail to deliver a sustainable environment and greater equality of incomes?' *Cambridge Journal of Economics*, **29** (6), Special Issue on Economics for the Future.

Greenhalgh, C. A. and Longland, M. (2005), 'Running to stand still? The value of R&D, patents and trade marks in innovating manufacturing firms', *International Journal of the Economics of Business*, **12**(3), 307-328.

Greenhalgh, C. A. and Rogers, M. (2006a), 'Intellectual property activity by service sector and manufacturing firms in the UK, 1996-2000', forthcoming in H. Scarbrough (ed.) *The Evolution of Business Knowledge,* Oxford: Oxford University Press.

Greenhalgh, C. A. and Rogers, M. (2006b), 'The value of innovation: The interaction of competition, R&D and IP', *Research Policy*, **35**(4), 562-580.

Greenhalgh, C. A. and Rogers, M. (2007), 'Trade marks and performance in UK Firms: Evidence of Schumpeterian competition through innovation', University of Oxford, Department of Economics, Working Paper 300.

Griffiths, W., Jensen, P. and Webster, E. (2005), 'The effects on firm profits of the stock of intellectual property rights', Melbourne Institute Working Paper 4/05.

Griffith, R., Redding, S. and Van Reenen, J. (2004), 'Mapping the two faces of R&D: Productivity growth in a panel of OECD countries', *Review of Economic Statistics*, **86**(4), 883-895.

Griliches, Z. (1981), 'Market value, R&D, and patents', *Economic Letters*, **7**, 183-187.

Griliches, Z. (ed.) (1984), *R&D, patents and productivity*, Chicago: University of Chicago Press.

Gruber, H. (1992) 'Persistence of leadership in product innovation', *Journal of Industrial Economics*, **40**(4), 359-375.

Gruber, H. (1995) 'Market structure, learning and product innovation: The EPROM market', *The International Journal of the Economics of Business*, Vol. 2, No. 1 pp. 87-101.

Hall, B. (2000), 'Innovation and market value' in *Productivity, innovation and economic performance*' in R. Barrell, G. Mason and M. O'Mahoney. Cambridge UK, Cambridge University Press.

Hall, B., Jaffe, A. and Trajtenberg, M. (2005), 'Market value and patent citations' *Rand Journal of Economics* **36,** 16-38.

Hall, B. and Ziedonis, R. (2001), 'The effects of strengthening patent rights on firms engaged in cumulative innovation: insights from the semiconductor industry' in Libecap, G. (ed.), *Entrepreneurial Inputs and Outcomes: New Studies of Entrepreneurship in the United States,* Vol. 13 of Advances in the Study of Entrepreneurship, Innovation, and Economic Growth, Amsterdam**:** Elsevier Science**.**

Harhoff, D., Narin, F., Scherer, F.M., and Vopel, K. (1999), 'Citation frequency and the value of patented innovation', *Review of Economics and Statistics*, **81**(3), 511-515.

Harhoff, D., Scherer, F.M., and Vopel, K. (1997) 'Exploring the tail of the patent value distribution', Working paper 92-27, Wissenschaftszentrum Berlin (WZB).

Hart, R. and Pitkethly, R. (2003) *Business Implications of Business Method Patents*, London: IP Institute.

Heller, M. A. and Eisenberg, R. (1998), 'Can patents deter innovation? The anticommons in biomedical research', *Science* **280**, 698-701.

HM Treasury (2006), *Gowers Review of Intellectual Property*, Norwich: The Stationery Office.

IPAC (2003), 'The enforcement of patent rights', The Intellectual Property Advisory Committee of the UK Patent Office, http://www.intellectual-property.gov.uk/ipac/pdf/enforce.pdf.

Jaffe, A. and Lerner, J. (2004), *Innovation and its discontents : How our broken patent system is endangering innovation and progress, and what to do about it,* Princeton University Press.

Khan, B. Z. (2004), 'Does copyright piracy pay? The effects of US international copyright laws on the market for books, 1790-1920', NBER Working Paper 10271.

Landes, W. M. and Posner, R. A. (1987), 'Trademark law: An economic perspective', *Journal of Law and Economics* **30**(2), 265-309.

Landes, W. M. and Posner, R. A. (2003). *The economic structure of intellectual property law*, Boston: Belknap/Harvard University Press.

Lanjouw, J. (1998), 'Patent protection in the shadow of infringement: Simulation estimations of patent value', *Review of Economic Studies*, **65**(4), 671-710.

Lanjouw, J. and J. Lerner (1996), 'Preliminary Injunctive Relief: Theory and Evidence from Patent Litigation' National Bureau of Economic Research, Working Paper w.5689.

Lanjouw, J, Pakes, A. and Putnam, J. (1998), 'How to count patents and value intellectual property: Uses of patent renewal and application data', *Journal of Industrial Economics*, **46**(4), 405-432.

Lanjouw, J. and M. Schankerman (2001) 'Enforcing intellectual property rights' National Bureau of Economic Research, Working Paper w.8656.

Lerner, J. (1995) 'Patenting in the shadow of competitors' *Journal of Law and Economics*, **38**(3), 563-595.

Levin, R., Klevorick, A., Nelson, R., and Winter, S. (1987), 'Appropriating the returns from industrial R&D', *Brookings Papers on Economic Activity*, 783-820.

Long, C. (2002), 'Patent signals', *University of Chicago Law Review* 69(2): 625-679.

Mazeh, Y. and Rogers, M. (2006), 'The economic significance and extent of copyright cases: An analysis of large UK firms', *Intellectual Property Quarterly*, 2006(4) December, 404-420.

McGahan, A. and Silverman, B. (2006), 'Profiting from technological innovation by others: The effect of competitor patenting on firm value', *Research Policy*, **33**, 1222-1242.

Mendonca, S., Pereira, T. and Godinho, M. (2004), 'Trademarks as an indicator of innovation and industrial change', *Research Policy*, **33**, 1385-1404.

Nelson, R. R. (2006), 'Reflections of David Teece's "Profiting from technological innovation…" ', *Research Policy*, **35**(8), 1107-1109.

Nordhaus, W. (1969), *Invention, growth and welfare: A theoretical treatment of technological change*, Cambridge, MA.: MIT Press.

Oberholzer, F. and Strumpf, K. (2004). 'The effect of file sharing in record sales: An empirical analysis'. mimeo, Harvard University.

Pisano, G. (2006), 'Profiting from innovation and the intellectual property revolution', *Research Policy*, **35**(8), 1122-1130.

Png, I. P. L. and Wang, Q. (2006). 'Copyright duration and the supply of creative work'. mimeo, National University of Singapore.

Seethamraju, C. (2003), 'The value relevance of trademarks', in *Intangible assets: Values, measures, and risks*, J. Hand and B. Lev. (eds.), Oxford: Oxford University Press.

Schankerman, M. (1998), 'How valuable is patent protection? Estimates by technology field using patent renewal data', *Rand Journal of Economics*, **29**(1), 77-107.

Schankerman, M. and Pakes, A. (1986), 'Estimates of the value of patent rights in European countries during the post-1950 period', *Economic Journal*, **96**(384), 1052-1077.

Scherer, F.M. (1965), 'Firm size, market structure, opportunity and the output of patented inventions', *American Economic Review*, **55**, 1097-1125.

Scherer, F.M. (1992) 'Schumpeter and plausible capitalism' *Journal of Economic Literature*, **30**, 1416-1433.

Schumpeter, J. (1942), *Capitalism, socialism, and democracy,* Harper and Row; and London: Routledge (1992 reprinted version).

Shavell, S. and Van Ypersele, T. (2001), 'Rewards versus intellectual property rights', *The Journal of Law and Economics*, **XLIV**(2), 527-543.

Stoneman, P. (1987), *The Economic Analysis of Technology Policy*, Oxford: Oxford University Press.

Stoneman, P. (ed.) (1995), *Handbook of the Economics of Innovation and Technical Change*, Oxford: Basil Blackwell.

Symeonidis, G. (1996) 'Innovation, firm size and market structure: Schumpeterian hypotheses and some new themes' *OECD Economics Department* Working Paper No. 161.

Teece, D. J. (1986), 'Profiting from technological innovation', *Research Policy*, **15**(6), 285-305.

Teece, D. J. (2006), 'Reflections on "Profiting from innovation" ', *Research Policy*, **35**(8), 1131-1146.

Winter, S. G. (2006), 'The logic of appropriability: From Schumpeter to Arrow to Teece', *Research Policy*, **35**(8), 1100-1106.

WIPO (2005). 'Wipo magazine', *May/June* www.wipo.int.

Figure 1   **Patent applications by domestic residents in leading economies**
(Note: US and Japan/3 measured on right-hand scale; all others on left-hand scale. Data WIPO)
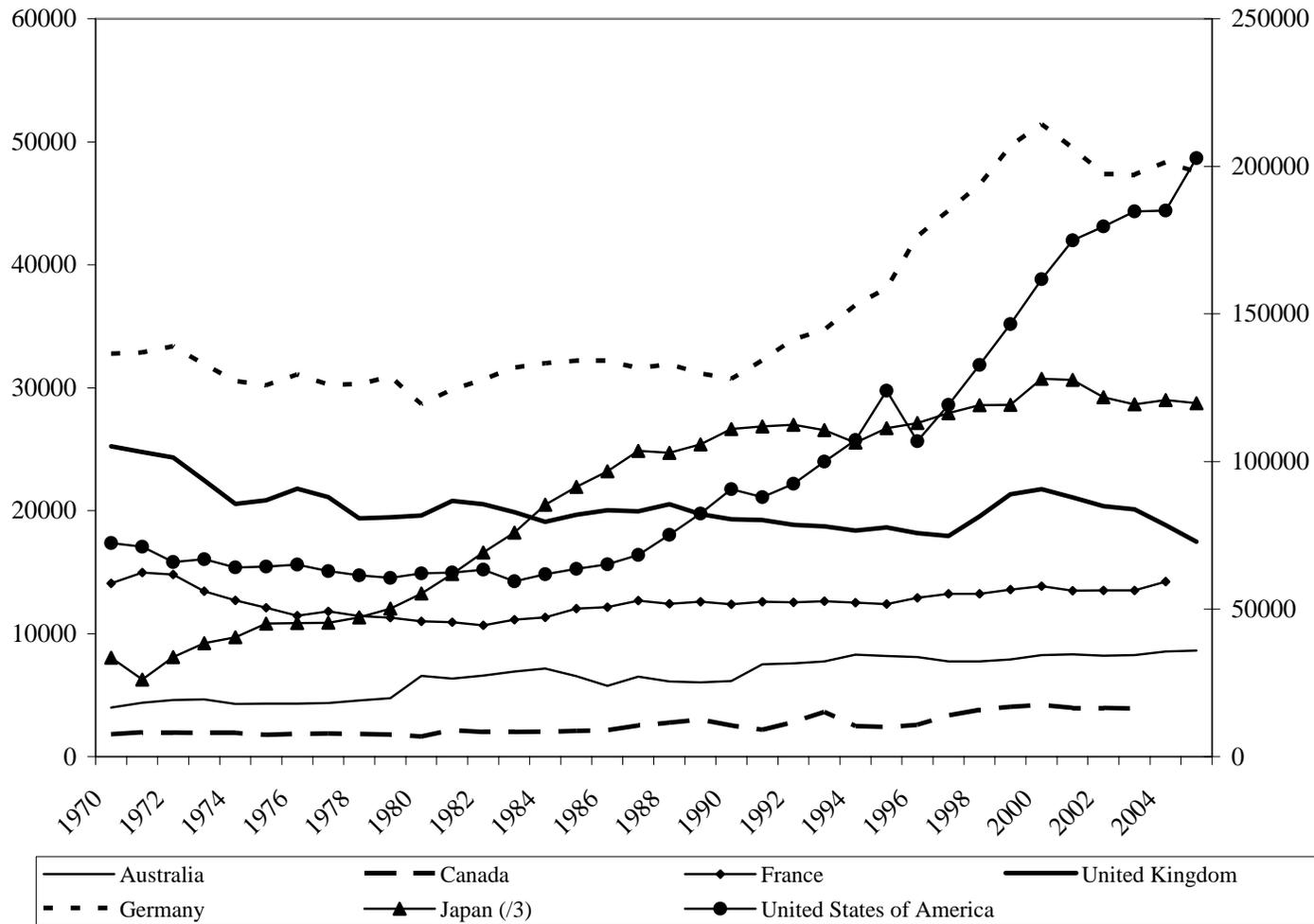
Figure 2 **Trade mark applications by domestic residents in leading economies**
(Note: US and Japan/3 measured on right-hand scale; all others on left-hand scale. Data WIPO)