Attachment to Submission to PC Compulsory Licensing Inquiry

Patent Policy and Innovation:

Do Legal Rules Deliver Effective Economic Outcomes?

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forthcoming (probably March 2013)

Cheltenham, UK and Northampton, MA, US: Edward Elgar

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Abbreviations etc.

ACIP	Australian Council on Intellectual Property
BIE	(Australian) Bureau of Industry Economics (became part of the Productivity Commission)
CAFC	Court of Appeals for the Federal Circuit (the US court which hears all patent appeal cases)
CBO	(US) Congressional Budget Office
CMS	Carnegie Mellon Survey (1994, US)
FTC	(US) Federal Trade Commission
G7	The seven industrialised nations of Canada, France, Germany, Italy, Japan, the United Kingdom and United States
IPAC	(Australian) Industrial Property Advisory Committee (replaced by ACIP)
IP Australia	Intellectual Property Australia (including the Australian Patent Office)
JSTOR	Journal Storage: an online archive of academic journals (www.jstor.org)
NAFTA	North American Free Trade Agreement
NBER	National Bureau of Economic Research (USA)
NOIE	(Australian) National Office for the Information Economy
R&D	Research and development
TRIPS	(Agreement on) Trade Related Aspects of Intellectual Property Rights
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
Yale survey	Yale University Survey of firms (1984, US)

Cited cases

Australia

Welcome	*Welcome Real-Time SA v. Catuity Inc*, [2001] FCA 445 (17 May 2001)

USA

State Street	*State Street Bank & Trust Co. v. Signature Financial Group, Inc.*, 149 F. 3d (1998)

2 The economics of patent policy: assumptions, paradoxes and evidence

2.1 Introduction

The principal economic argument supporting patent policy is founded on the assumption that copying knowledge is virtually free. Once an innovator has developed a new artefact or process, competitors are able to replicate this at very low cost, undercutting the original innovator in the market. They can price close to marginal cost as they do not have to recoup the overhead costs of developing the new knowledge. This argument also implies that very little time is needed to copy the new knowledge to the point of having a fully developed competing product in the market, so that the original innovator has little if any period of market exclusivity.[1]

An alternative view, derived from the information economics school of thought, considers that it takes both time and money to learn and use new knowledge. Indeed the cost of acquiring new knowledge is sufficiently high that it is a barrier to the diffusion of new technology. This alternative perspective draws the conclusion that many new industrial artefacts and processes will have a period of exclusivity in the market when there are no competing products. During this time the product can be priced above marginal cost so ensuring a return to its R&D investment. An exception may be where initial development costs are very large (e.g. aircraft, submarines, clinical trials). Here the initial period of market exclusivity may be insufficient to allow full recoupment of the R&D investment.

These two opposing perspectives have co-existed for many decades, with virtually no cross-over between the largely theoretical literature supporting the view that patents address a market failure and the quite separate literature on the challenges of technology diffusion. But empirical data are now available to test the assumptions on which these conflicting theories rest. These data provide insights into how industrial innovation works in practice and are reviewed in Section 2.2. If copying is fast and cheap innovation markets may frequently fail, except for very trivial innovations. But if copying is expensive and/or slow, then markets may fail only for the very largest and most expensive projects.

If innovation markets fail regularly then there will be less investment in innovation. Why is this a problem? Investors could simply put their money elsewhere. The reason a lower level of investment in innovation is assumed to be a problem for society is the view that the social returns to industrial innovation exceed the private returns. Thus if an innovation succeeds the innovator will profit, but so will society as there are net positive externalities from the innovation. If the investment does not take place, society is the poorer for the lack of these benefits.

The net positive externalities are the sum of all the impacts of the innovation on other parties. Thus if the consumer surplus from the new product exceeds the consumer surplus from any displaced products, there will be a benefit. Further if the new knowledge embodied in the innovation provides other producers with ideas which in turn lead to further new products or

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[1] These assumptions are more reasonable in commodity markets, particularly agricultural commodities. In such markets there is little differentiation between goods and the incentive structures for innovators and followers are different. But in markets for manufactured products there is substantial segmentation and differentiation so products can gain market share on the basis of quality as well as price. Such differentiated markets typically involve imperfect rather than perfect competition.

processes, there will be further benefits through faster innovation and so stronger economic growth. Section 2.3 considers the empirical evidence on net externalities from innovation.

From a policy perspective there is another important issue beyond determining whether these two critical assumptions are supported by the evidence. That is, are patents effective in inducing *additional* investment in innovation? Do patents *induce* innovation investment that would not otherwise occur? This question is partly related to the cost and speed of copying, but it provides an alternative approach to assessing the evidence on whether the first mover period of exclusivity is sufficient. The issue of the extent to which patents induce innovation – as opposed to providing a windfall transfer from consumers for innovation that would take place anyway – is addressed in Section 2.4.

If the above questions are all answered such that a patent system provides positive benefits, then the next important policy issue is at what cost? There is surprisingly little empirical evidence on the cost of patent systems, and what there is tends to focus on the private costs to users of the system rather than the policy question of the net cost to society. But there are a range of social costs, particularly higher prices during the period of patent exclusivity and additional costs imposed on innovators from having to invent around if they are not first to the patent office. The privileges awarded by a patent centre on exclusion and prevention of unauthorised use. This is a very strong form of monopoly – it goes beyond preventing copying. It allows the patent holder to prevent independently invented innovations from being sold in the marketplace. The available evidence on patent system costs is discussed in Section 2.5.

The chapter concludes by considering the evidence about the net economic balance from patent systems. Are there net benefits or net losses? Economists' answers to this question traditionally tended to be theoretical. As Cheung characterises the classical economists, Bentham considered patents provided something for nothing, Taussig that they provided nothing for nothing, Plant that they provided nothing for something, and Arrow that they are inferior to direct subsidies for research and development (R&D) (Cheung 1986). Now, however there are a range of useful empirical studies of industrial innovation. These data allow the choice between competing economic theories to be based on evidence: a great step forward from the earlier era when "[c]onviction was pitted against conviction, argument against argument, assumption against assumption" (Machlup and Penrose 1950: 28).

Unfortunately, it is no longer possible to conduct natural experiments about the impact of patent systems as the TRIPS Agreement requires a minimum standard system in exchange for World Trade Organization (WTO) membership. However in earlier times there was more variety particularly in respect of chemicals and pharmaceuticals. Historical evidence from nineteenth century trade fairs suggests that the existence of a patent system changes the focus of innovation but does not increase the level of innovative effort (Moser 2005). Italy provides empirical evidence that allowing patenting of chemical compositions does nothing to promote the chemical industry (Scherer and Weisburst 1995). There are also several heroic studies which attempt to isolate the impact of patent regimes on economic growth from all the other relevant variables.[2]

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[2] However these are very compromised by the questionable proxies available. In particular most use the Ginarte and Park index to measure patent system 'strength' (Ginarte and Park 1997). But as van Pottlesberghe has shown this is a measure of patent friendliness not patent 'strength' (van Pottelsberghe 2011). Boldrin and Levine (2008: 192-8) identify 23 such studies and summarize their results as showing weak or no evidence that stronger patent regimes increase innovation.

One major conclusion from the available evidence is that balance is critical if patent systems are to deliver net economic benefits. The threshold for grant of a patent must be such that there is genuine new knowledge contributed so that there is at least some chance of a sufficient quantum of spillover benefits to offset the costs of allowing monopolies. The quantum of inventiveness required for a patent is therefore critical in determining net balance in patent system outcomes.

As social benefits flow only from induced innovation, a critical question is whether inventiveness works as a proxy for induced innovation. The answer of course is that it is very imperfect on this account as it is the absolute size, or lumpiness, of the innovation investment compared to the period of natural exclusivity that is important here. But benefits are also related to whether there are net externalities from the induced innovations, and in this regard there is a closer relationship with inventiveness. If inventiveness works as an effective proxy for the contribution of new knowledge or know-how and is set at a level where a reasonable quantum is required, then granted patents are more likely to confer net external benefits through knowledge spillovers and the patent system overall is more likely to confer net economic benefits. If, however, the inventiveness standard is very low, then many granted patents will confer no external benefits and patent systems are more likely to confer net economic losses.

2.2 Copying: is it free and fast?

2.2.1 Direct evidence on copying

The earliest of the empirical studies on industrial imitation was of manufacturing firms in the north-eastern part of the USA. Mansfield and colleagues found that on average imitating an industrial artefact cost 65 per cent of the original innovation cost, and took 70 per cent of the original time (Mansfield et al. 1981). For one in seven innovations, imitation costs were as high as the original innovation costs, largely due to the innovator's greater technological capacity. There was considerable variation around the reported averages. High relative imitation costs were associated with high relative time costs (and vice versa).

These results provide very striking evidence that in general copying takes time and money and that the more complex and expensive the innovation the more money and time is needed for copying. Thus it is likely that more expensive innovations will have a longer period of market exclusivity. While minor innovations may have only a very short period of first-mover advantage, it may well be possible to recoup their development costs during this time. This would, of course, need to include the relevant risk-adjusted profit margin.

The Mansfield study also investigated whether patenting made a difference to imitation, and found that about 60 per cent of patented products were imitated within four years. Patenting increased both the time and the cost of successful imitation: the median increase in cost was 11 per cent, but for pharmaceuticals was 30 per cent.

Further data on imitation were provided in the 1983 Yale Survey, covering 650 large US firms in 130 industries. This again found substantial variability in time and cost of imitation, but variations in the imitation cost ratio were greater within than between industries. In general, imitation saved around 50 per cent of the cost of the original R&D. Major innovations were more expensive to replicate, and replication took longer – sometimes over three years; most often at least six to 12 months (Levin et al. 1987). These results are significantly different from the assumption that copying is fast and free.

Surprisingly there have been few further studies about the cost of copying industrial innovations. A search of all citations for Mansfield's original study yielded no further empirical work.[3] Attention in the field turned to another aspect of the Yale survey – data on the role of alternative mechanisms to appropriate returns to innovation. These data are explored in Section 2.2.2. But first it is useful to consider why copying new knowledge should take time and effort. This is important given the contrast with the dominant view that, despite the evidence, copying is virtually free and instantaneous.

Knowledge is a prime input into inventive activity and builds over time. Its use in industrial innovation involves a complex chain of feedbacks and interdependencies: "a collective, social, learning, evolutionary process" (Mandeville 1998: 49). Because new knowledge is not yet codified – not yet reduced to a clear written description – it is costly to acquire. At this stage it resides in the minds of researchers and inventors. It is expensive to turn tacit into codified knowledge, but only the latter can be exchanged easily in the market and relatively cheaply absorbed. But both language and learning are needed to absorb, interpret and use codified knowledge: one cannot readily absorb codified knowledge unless one has the requisite language and sufficient learning (Saviotti 1998). As a result the number of people who can appropriate new knowledge can be quite small. Those who can readily access such new knowledge can do so because of earlier expensive investments in their own learning.

But even for such knowledgeable researchers it is not always easy to extract the relevant knowledge from innovations and use this to generate a competing product. A new product embodying new knowledge does not necessarily disclose the underlying technology (Monk 1992). It takes time and resources to move from the artefact to understanding the technology, to being able to use it to replicate the artefact, let alone to improving it. Of course, the relative ease or difficulty of accessing such underlying technology will vary along a number of dimensions. Students of innovation have developed classifications of industries and technologies to understand better different patterns in the creation and diffusion of innovation (for example Pavitt 1984; Merges and Nelson 1990).

Imitation is an important element of learning but requires investment (Cohen and Levinthal 1989). Indeed imitation and adaptation (further incremental innovation) are essential parts of the process of building the stock of knowledge, and Mandeville (1996) suggests that there is no clear distinction between innovation and imitation. Radical breakthroughs can occur on the back of a process of incremental innovation (Magee 2002). Knowledge grows through use, and there is a multiplicative effect when new knowledge is added to old knowledge as different users take different perspectives, so adding to the body of underlying knowledge (Mandeville 1996). Most innovation takes place in the realm of uncodified knowledge, and mechanisms for the diffusion of uncodified knowledge – such as well-functioning labour markets – are critical to an effective innovation system.[4]

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[3] JSTOR yielded 61 citations of Mansfield's 1981 study and google scholar yielded 1047 (but displayed only 1000 of these). None referred to any subsequent empirical work on the cost of imitation. A search for citations of Cohen and Levinthal's 1989 study on the importance of R&D for imitation and learning yielded 105 citations in JSTOR. This included one theoretical piece assuming imitation took time, but no empirical studies on imitation costs or time.

[4] The interesting literature on the role of labour movement in the diffusion of innovation and on barriers to such diffusion through anti-competitive laws is a diversion from the theme of this book. But this line of research provides very useful material that innovation policy-makers might well review. A starting point is Boldrin and Levine's report of research by Gibson finding that the differential success of Silicon Valley compared to Route 128 is likely due to differences in labour laws. Post-employment non-compete covenants are unlawful in California but not in Massachusetts (Boldrin and Levine 2008: 198-200).

Once attention is turned to the inventor as a recipient as well as a creator of new knowledge, issues around the diversity of local knowledge emerge. Differences in local knowledge or mind-sets underlie the high value placed on team-work in many areas. Individual and firm differences in local knowledge mean that imitation will often lead to a range of re-interpretations and improvements (Ricketson 1992).

Because the cost of developing new knowledge is independent of the scale on which it is later used, there can be considerable economic advantages in sharing knowledge widely.[5]

This depth of perspective about knowledge flows derived from the information economics school of thought (Lamberton 1999) contrasts sharply with a small number of assumptions about knowledge flows made in neo-classical economics. The theoretical economics literature on patents generally assumes that any innovation can be discretely identified and is independent of and un-related to most other innovations. The substantial mathematical literature on 'first' and subsequent innovations, takes the initial innovation to have no intellectual history, though the subsequent innovation derives from the earlier one. The analysis then focuses on appropriate incentives to ensure the right returns at each stage (see, for example, Scotchmer 1991, 1996; Gallini and Scotchmer 2002). Such analyses fall far short of the real-world complexity of how knowledge is used in industrial innovation.

They also contrast sharply with the information economics focus on the role of market mechanisms in providing a return to R&D investment. Now that it is widely accepted that most markets are imperfect, the existence of temporary rents and excess profits (first mover advantages) is the accepted paradigm.[6] Other natural protections of new technology, such as knowledge imperfections, transaction costs and the need for complementary assets (Teece 1986), create at least temporary barriers to entry, and therefore opportunities for returns to innovation. Where the tacit component of knowledge is high, the cost of learning to use new products is also high. Such barriers apply to consumers as well as rival producers. Consumers who have incurred high learning costs, for example with computer software, are reluctant to switch between products, so there are great advantages to early market entrants. It is now also recognised that in markets with such network effects, early movers and dominant players have considerable market advantages. The first party to bring an innovation to market may thus reap a considerable on-going reward through this mechanism.

2.2.2 Indirect evidence on copying

Given the centrality of the free and costless copying assumption to the rationale for the patent intervention, it is somewhat astonishing that after the two early studies there has been no further empirical work directly addressing the subject. This is particularly surprising given that there is some anecdotal evidence suggesting that copying may have become faster and possibly cheaper in recent decades. Reasons for this include new technologies such as computer aided design and manufacture as well as the rise of firms specialising in the production of cheaper alternatives to high-priced products.

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[5] Mandeville (1996) discusses the conditions which will encourage such sharing, while Sena (2004) provides a review of recent literature on R&D cooperation.

[6] Though this argument (advanced by Schäffle, who called it head-start profits) was rejected during the 19th century Great Patent Debate, because at that time perfect markets were thought to be pervasive (Machlup and Penrose 1950).

One reason for this gap is that academic attention has been diverted to the related question of what mechanisms firms use to appropriate a return to innovation. The 1983 Yale survey not only provided direct evidence on copying, it also asked firms to assess a range of mechanisms for their effectiveness in ensuring profitable investment in innovation. Lead time (first in market), learning and sales/marketing were all seen as more important than patents in obtain a return from new products. For new processes, lead time, learning curves, sales/service, and secrecy were all reported as more important than patents (Levin et al. 1987). There were a small number of exceptions: those industries where new products are highly codified, principally fine chemicals and pharmaceuticals, relied more heavily on patents. While the Yale survey focused on larger firms the 1994 Carnegie-Mellon survey (CMS) covered 1478 firms, including smaller firms, and confirmed the findings of the Yale survey (Cohen et al. 2000). Both surveys presented strong evidence that, in general, patents are *one of the least effective mechanisms* for obtaining a return to investment in R&D. The high importance assigned to lead time provides indirect evidence that innovating firms rely on a period of market exclusivity to obtain a return on their fixed investment.

The combined analytical power of the Yale and Carnegie-Mellon surveys is enhanced by their relative timing. The Yale survey occurred before the 'strengthening' of the US patent system, generally dated from the creation of the CAFC in 1982, and the latter after this 'strengthening' had begun.[7] Cohen, Nelson and Walsh (2000) conclude that the major change in mechanisms to ensure profitable innovation is a considerable increase in the importance of secrecy.[8] They also suggest that patents may be more central for larger firms and that there may be a larger minority of industries where patents are counted as a major mechanism of appropriation (Cohen et al. 2000: 13). Given the significant increase in the value of patents as a result of decisions by the CAFC, such an increase is not surprising. It does, however, need to be interpreted in the light of the reasons given for patenting, which are discussed in Section 2.4. Overall, however, the data from the CMS confirm the findings of the earlier studies: except in a narrow range of industries patents are far less important than market mechanisms in ensuring a profitable return to R&D expenditure. That is, with a few exceptions, there is no market failure in innovation.

While these data do not directly address the question of copying, they provide complementary evidence that copying takes time. Firms in most industries confirm that being first in the market (lead time) is a critical mechanism for ensuring their innovation investments are profitable. These findings have been replicated in Japan, Canada, Switzerland, and in many European Union countries.[9] The overwhelming evidence from this wide range of empirical studies is well reviewed in López (2009).[10] The policy implications are significant.

The findings also raise the question of the so-called "patenting paradox". If patents are largely ineffective, why do firms take them out? The answer lies in the strength of the monopoly provided by patent – the ability to prevent use of independently invented innovations. Substantial data are

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[7] 'Strengthening' usually means extended patent coverage, either through reduced inventiveness standards or broader subject matter coverage. It can also incorporate more powerful regimes for enforcing patents. In contrast a 'weak' patent system is once which protects the public interest through a high inventive step and a narrower range of patentable subject matter.

[8] This does not mean that secrecy is a good alternative to patenting in a world with patents. As Quillen (2008) points out secrecy often needs to be reinforced by patents, especially since the creation of the CAFC.

[9] In Japan imitation lags are shorter than in the USA, but lead-time is still reported as a significant means for obtaining a return for innovation (Cohen et al. 2002).

[10] This review does not include any data from Australian innovation surveys. Data from the 2003 survey indicate that over half of new to the world innovators do not use patents (Australian Bureau of Statistics 2005) again confirming their relative lack of importance to innovating firms.

available on reasons for patenting, and these clearly indicate that a very large majority of patents are taken out as insurance against infringement suits or to participate in cross-licensing regimes. The evidence on reasons for patenting is considered further in Section 2.4 when attention is turned to the proportion of innovations induced by the patent system.

Overall these empirical studies show little evidence of market failure because of costless copying. The market for innovation only fails in very particular circumstances – where knowledge is highly codified and there are relatively large numbers of firms with the requisite knowledge. These features characterise the pharmaceutical industry but few others.

2.3 Net externalities

New technologies drive economic growth through the diffusion of new knowledge, which spills over to parties not involved in its production. Such spillovers are a very important factor in productivity growth. They are also frequently invoked by industry lobbyists as a reason for 'strong' patent 'protection' (e.g. Maddock 2002). The exclusion (monopoly) mechanism of patent policy is designed to reduce these spillovers and thus directly impedes economic growth. At the same time, if more investment in new technology is encouraged, this can drive a higher rate of economic growth.

Most theoretical expositions on knowledge spillovers are for closed economies. As spillover benefits (positive externalities) need paths to flow through, and can flow overseas, this is a major limit to their value to a nation. A number of analysts have noted that optimal patent policy in a technology-importing nation may well be very different from that in a technology-exporting nation (Penrose 1951; BIE 1994; Gruen et al. 1996). In smaller countries, or countries with little depth in their industrial base, the domestic social rate of return may not be much above the private return to R&D, due to cross-border spillovers (NOIE 2004). Very few countries are net exporters of technology. But even in a technology-exporting nation, the flow of spillover benefits to other countries may affect the net benefits of a patent system.

The social return to innovation includes the private return and any externalities. The externalities take two principal forms – increases in consumer surplus, and knowledge flows.[11] To the extent that an innovator can exercise monopoly power, consumer surplus benefits will be lower. To the extent that patents are effective in preventing imitation and adaptation, knowledge flows (spillovers) may be lower. The net positive externalities flowing from industrial innovation are thus likely to be higher when a patent regime has high inventiveness standards.

There are two types of empirical studies on the externalities from industrial innovation. Econometric studies generally used highly aggregated data, for example national accounts data, stock market data, or linked company and patent databases. Case studies use more finely granulated data but are limited in their sample size. Both are plagued by measurement problems. There are massive problems in adequately measuring knowledge, changes in knowledge, own knowledge, public domain knowledge and knowledge appropriated from private owners. Nor is it

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[11] An excellent exposition of this is the review article by Dempster (1994). This study is hard to obtain, though the library at the Australian Commonwealth Department of Industry, Innovation, Science, Research and Tertiary Education has a copy. There are even broader definitions of spillovers from new technology (all benefits not captured by the originator of the new technology). Baumol considers Romer's view that if all externalities from new technology were captured by the innovator, there would have been no increase in the standard of living over the past several centuries (Baumol 2000: 124).

easy to separate knowledge from capital – indeed there are arguments as to whether *disembodied* knowledge can have any direct impact on economic output.

The seminal case study used as evidence of high social returns from industrial innovation is the 1977 study by Mansfield and colleagues which estimated the median social return to R&D at 56 per cent. This study is repeatedly cited to indicate than industrial innovation generates a high social return, though the authors themselves emphasised the care that was needed in interpreting their results, given the limitations created by the assumptions in their model (Mansfield et al. 1977). What is rarely reported is that this study is based on only 17 innovations (13 products and four processes). Nor is it always noted that the methodology is based on estimated consumer surplus, and does not attempt to measure knowledge spillovers. The estimates are gross consumer surplus not net surplus after taking account of products displaced by the innovations. The estimates therefore need to be reduced by such offsets if they are to be used to estimate *net* consumer surplus benefits from innovation.

A further finding of the study that is rarely referred to is that six of the 17 innovations had both high private and high social returns so may well have occurred without the patent incentive. Another five had low or negative social returns so it would not be rational to encourage these. Only six of the 17 had both a high social return and a low private return (Mansfield et al. 1977: 233). That is only about one-third fell into the category that would be targeted by rational patent policy – innovations with high gross social returns but where the private return might be too low for the investment to take place. A core policy question is whether today's pervasive R&D support programs would, alone, be sufficient to induce such innovations.

Also available, but less widely quoted, is the Bureau of Industry Economics (BIE) study of spillovers, which usefully considers both consumer surplus and knowledge spillovers (BIE 1994). Benefits frequently flow along the value chain, ie between parties in a market relationship with each other: suppliers and customers. Where there is such a relationship benefits are measured as a change in consumer or producer surplus, rather than as spillover benefits. The study also emphasises two factors that are critical for benefits to eventuate: in regard to knowledge spillovers, *market depth*, i.e. a sufficiency of other firms, is necessary for there to be high social returns. In regard to firms in market relationships, *competition* is essential if the innovator is to pass benefits to users of the innovation.

Turning now to the econometric studies, two review articles reach somewhat different conclusions, but are useful in marshalling the available evidence. Sena (2004) reviews four types of econometric studies and concludes that sizeable intra- and inter-industry spillovers exist. In contrast the US Congressional Budget Office (CBO) considers the evidence from three different types of studies is relatively speculative, largely because of severe measurement difficulties. The large econometric studies give very divergent estimates of the value of social returns to industrial innovation. In particular, estimated spillovers are much lower from time-series than cross-sectional studies (US CBO 2005). As the key policy issue is the impact over time of innovation spillovers on productivity and economic growth, the lower time-series estimates are of some concern.

There is consensus on more detailed aspects of knowledge spillovers. Such spillovers flow through a variety of channels (Sena 2004: 318); firms must invest in their own innovation capabilities if they wish to be able to benefit from spillovers (Cohen and Levinthal 1989); and they may be higher between firms in technological or geographic proximity (Jaffe 1986, 1988; Porter 1990). Differences in the magnitude of knowledge spillovers between industries are also reported, with some contributing a high level of knowledge spillover benefits, and others very little (Bernstein and Nadiri 1991). Clearly the magnitude of knowledge spillovers is variable and contingent.

Overall, then, there is still some doubt about the evidence that intervention in the innovation market is needed because of high positive externalities. Plant and Machlup both expressed considerable reservations that re-allocating resources to inventive activity through the patent system is welfare-enhancing. Plant pointed to the wide range of incremental improvements occurring outside research laboratories as being cumulatively more important to the development of technology than formal R&D (Plant 1934).[12] Machlup was unsure that industrial R&D had a higher pay-off, in terms of economic growth, than other major drivers of growth, such as education (Machlup 1958).

These empirical studies typically use R&D expenditure as a key independent variable. The relationship between R&D expenditure and patenting has changed significantly over the past two decades (Kortum and Lerner 1999; Jaffe 2000; Blind et al. 2003; Hall 2005). So they provide only very indirect evidence on the social return to the patent system. They do not begin to address whether the net social return for the whole set of patents granted in a year is positive. To date this question has been asked only in respect of private returns to patenting, and only in respect of US publicly listed firms (Bessen 2006). This study showed a negative private return, except for pharmaceutical firms.

2.4 Do patents induce innovation?

Some analysts take a theoretical view that the level of investment in innovation will be sub-optimal unless the innovator is able to capture the *full* benefits of each innovation (eg ACIP 2008: 7). Baumol shows that this is not a realistic position and that in practice benefits need to be shared between the innovator and society (Baumol 2000). This is well illustrated in an interesting study of private seed research. The alleged difficulties in appropriating a return to investment in innovation apply more strongly in agricultural than industrial markets. But Pray and colleagues have shown that both the innovator and the user can simultaneously benefit. In a study of the private seed industry in India they find that the private return to R&D was 17 per cent while farmers, distributors and dealers received between 61 and 86 per cent of the total benefits from the seed research (Pray et al. 1991: 321). A delightful win-win outcome.

From a policy viewpoint, the critical question is whether the patents *which are induced by the patent system* create sufficient social benefits to offset the social costs attributable to all granted patents. It is wasteful from a policy perspective to provide the innovator with a return greater than that needed to induce the invention. This, of course, would include a risk-adjusted profit on the capital invested. Effectively there is an exchange of society's power to create an artificial monopoly for an adequate share of the consequent economic benefits. Spillover benefits from innovations which were not induced by the patent incentive – which would have happened anyway – cannot be regarded as benefits from the patent system.

The substantial empirical research on appropriability and reasons for patenting can be used to develop rough estimates of the proportion of patented inventions that might be induced by patent policy.

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[12] Recent Canadian research indicates that 32 per cent of innovations occur in firms which neither fund nor undertake any formal R&D (Hanel 2008: 294). Pavitt (1984) has pointed to the importance of production engineering departments and undifferentiated design and development inputs in small specialised firms.

The 1994 CMS asked R&D performing firms why they patented their most recent patented innovations. Firms were asked to choose from a list of seven reasons and multiple choices were allowed (Cohen et al. 2000: 17). Naturally most firms reported prevention of copying as a reason.[13] The next most frequently given reason was to block rivals. Blocking involves the use of patents to prevent other firms patenting related inventions (Cohen et al. 2000: 17).[14] The next most frequently reported reason was to prevent infringement suits. This was followed by reputation and use in negotiating access to other firms' patented technologies. Reputation was particularly often reported by smaller firms (Cohen et al. 2000: 24).

Once the data are weighted by the number of patent applications, the results change appreciably only for two reasons: prevention of infringement suits and use in negotiations (Cohen et al. 2000: 18). Both increase in importance, with 79 per cent of product patents taken to prevent infringement suits (63 per cent for process patents). Comparable figures for access to cross-licensing are 58 and 49 per cent. These data indicate that firms which patent frequently are particularly concerned to protect themselves against litigation, and to participate in cross-licensing negotiations. Thus in terms of patent applications, very many are filed for reasons that are dysfunctional in terms of overall economic welfare (blocking rivals) or because of the very existence of the patent system (preventing infringement suits or participating in negotiations for access to complementary or overlapping technologies).

Such strategic reasons for patenting are confirmed by Blind and colleagues, who review a small number of studies on this topic, and add new 2002 data from German firms which actively use the patent system (Blind et al. 2006). They suggest that the motives for patenting are becoming increasingly uncoupled from the need for protection from imitation. Their review of mainly European surveys systematically confirms that important reasons for patenting are defensive and offensive blocking and negotiations for exchange of technologies. One of the most interesting surveys they report investigates changes in motives to patent among very large firms over a ten-year period. The most important change influencing increased patenting is patenting by other market participants.[15]

These data suggest that a major factor underlying patenting activity is simply the existence of the patent system (Merges 1997: 129). This is not surprising when one considers that the patent system can inhibit independent invention. As the level of patenting rises, so does the risk that a firm will be found to infringe another firm's patents. The rational response is to insure against this by taking out one's own patents.[16] The only firms at risk of facing a patent infringement suit are innovating firms (Bessen and Meurer 2008).

This is a long way from the goal of inducing more innovative activity. It is not – or should not be – the objective of patent policy to induce more patent applications.

In industries where few firms report patents as important, it seems unlikely that many innovations are induced by the patent system. Mansfield specifically asked what innovations would not have been commercially introduced or developed in the absence of patents. Outside the chemical

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[13] Oppenheim (2000), reports that while 97 per cent of a sample of UK SMEs say a purpose of patenting is to stop copying only 40 per cent report this as the *sole* reason for patenting.

[14] It uses the patent right of prevention to exclude firms from alternative products and processes thus extending the scope of the monopoly on the actually produced innovation. In earlier times this would have been considered an anti-competitive use of the patent system.

[15] 2003 OECD survey by the Committee for Scientific and Technological Policy (Blind et al. 2006: 658).

[16] As noted above this also explains why firms that emphasize secrecy also take out patents (Quillen Jr. 2008: 73)

industries the highest reported percentage was for machinery, where 15 to 17 per cent of innovations would not have occurred.[17] In contrast a small number of firms, particularly those in the pharmaceuticals and fine chemicals industries report that patents are an important appropriation mechanism. For these firms a high proportion of innovations may well be induced by the patent system. Again Mansfield provides data on this issue. He reports that, absent patents, 60 to 65 per cent of pharmaceutical innovations would not have been developed or commercially introduced (Mansfield 1986: 175). So even in the pharmaceutical industry some 35 to 40 per cent of innovations may have occurred in the absence of patents.[18] Mansfield's data suggest that up to 65 per cent of pharmaceutical and somewhat less than 15 to 20 per cent of other innovations may be induced by the patent system.

Drawing on data on defensive patenting from the Carnegie-Mellon survey, between 63 and 74 per cent of innovations are reported as patented to protect against infringement suits. The corollary is that some 26 to 37 per cent may be required for other than defensive purposes.[19] A generous assumption about induced inventions is therefore that between 25 and 40 per cent are induced by the patent system.

Two dimensions are used to develop some fairly rough estimates of innovations induced by the patent system. Firstly inducement rates are estimated separately for pharmaceuticals compared to all other industries. Secondly market size issues are considered as a basis for estimating whether a national patent system induces innovation in foreign firms.

Considering first the industry dimension, granted patents are separated into a group where a very high proportion of patents may be induced and a group where a much lower proportion are likely to be induced. The first group is the pharmaceutical and fine chemicals industries, as the survey data show unambiguously that these firms systematically report patents as important in ensuring a return to innovation. I assume that *all* patented inventions in these fields are induced by the patent system. This substantially over-estimates induced patents in this group, as the survey data (and real world experience) show that some pharmaceutical and chemical innovation would occur absent patents.[20]

In most countries, the bulk of patents are owned by overseas-based companies (Bates 2003). So in making estimates of induced innovation in any specific country, it is important to consider whether the patent system in one country will induce innovation overseas. The probability will vary with the size of the market where the innovation is being patented, in comparison to the size of the market in the innovator's home country. The size of the US market may well mean that US patents induce innovation in overseas firms. In smaller markets such as Australia it seems unlikely that the patent system induces foreign innovation except in even smaller countries. If an innovator's domestic market is sufficiently large for the full investment (including a risk-adjusted profit margin) to be recouped domestically, obtaining monopoly prices from overseas consumers does nothing to induce the investment, it simply provides a rental stream from overseas.[21]

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[17] Fabricated metal products followed with 12 per cent, then electrical equipment at 11 per cent, primary metals 1 per cent, and instruments at 1 per cent. For four industries the figure was zero (Mansfield 1986: 175).

[18] This result is supported by the evidence on pharmaceuticals assembled by Boldrin and Levine (2008: 212-42)

[19] In fact the proportion not taken out for defensive purposes cannot be calculated directly from these data as firms reported multiple reasons for patenting. But as these estimates still exceed the direct estimates of the proportion that would not occur provided by Mansfield, they provide a reasonable upper estimate of induced patents.

[20] For a summary of the real world experience see Boldrin and Levine (2008: chapter 9).

[21] Where 'rent' is used in the classical economic sense of above-normal returns (excess profit).

In making estimates of induced patents in Australia, it seems improbable that Australian patents would offer much of an inducement effect for innovators from the North American, Japanese or UK/European markets – the Australian market is only 2 per cent of the OECD market.[22] The small proportion of additional sales in Australia is unlikely to make a critical difference to the investment decision except in unusual circumstances. I assume no innovations patented in Australia by innovators resident in the G7 countries are induced by the Australian patent system. In contrast, a New Zealand innovator might take into account the possibility of an Australian patent monopoly in determining whether to proceed with a costly innovation, as the Australian market is much larger. In estimating what patents in Australia are induced from firms' resident outside the G7 countries, I treat all these in the same way as domestic patenters. That is, I assume that all pharmaceutical patents are induced and that in all other technology areas between 25 and 40 per cent of patents are induced by the Australian patent system – again clearly over-estimates.

Combining these two sets of assumptions provides an estimate that between 10 030 and 13 090 of the 203 815 patents granted in Australia between 1990 and 2006 may have been induced by the patent system. This is some 4.9 to 6.4 per cent of granted patents (Table 2.1). This low figure should not surprise. It has long been clear that a patent system is unlikely to induce much innovation in a small economy, especially where the proportion of activity in high-technology areas is low (Penrose 1951).

In contrast, given the size of the US market, US patents might well induce innovations from innovators firms in many other countries, including those with large domestic markets. Here I assume innovation is induced for 50 per cent of US patented innovations from innovators in the five large G7 economies outside North America (Japan, France, Italy, Germany and the UK),[23] and for 100 per cent of patents from other countries. These figures are then modified by technology-specific inducement factors. I again assume that for pharmaceutical and fine chemical patents,[24] 100 per cent of patents might be induced. For all other classes I assume that between 25 and 40 per cent of patents are induced.

These rather brave assumptions (set out in the top block of Table 2.1) provide an estimate that between 238 150 and 325 880 of the 810 487 patents granted in the USA between 2001 and 2005 are induced by the US patent system.[25] In other words some 29 to 40 per cent of US patents may reflect induced innovation.

It is these induced innovations which are responsible for any positive benefit attributable to a patent system. Such positive externalities and dynamic efficiency gains flow from the patent-induced re-allocation of resources. But if an induced patented product is imported, the resource

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[22] Using GDP as a measure of market size and 2009 data (the most recent year available) from the OECD (http://stats.oecd.org/Index.aspx?datasetcode=SNA_TABLE1 accessed 4 August 2012)..

[23] While Canada is also a member of the G7, its proximity to the USA and its membership of NAFTA create a different dynamic. It is assumed here that Canadian firms consider the joint Canada/USA market when making investment decisions. They are thus treated in the same manner as US firms.

[24] Of course, patent data are not available by industry classification. The two classes selected (see Table 2.1) seem to come closest to covering the drugs and fine chemicals industries, though it is clear from the classification descriptions that these are in fact quite heterogeneous classes. To that extent, use of these classes as approximations will over-estimate induced innovation.

[25] As the relevant Australian data are no longer provided on IP Australia's website and therefore cannot be updated, my original US estimates have also not been updated. Given the "back-of-the-envelope" nature of the estimates the results are illustrative only.

Table 2.1 Estimated induced patents USA and Australia

	USA, 2001-2005		Australia, 1990-2006	
	lower estimate	upper estimate	lower estimate	upper estimate
	Assumed % of patents induced			
Pharmaceuticals				
G5/G7 countries	50	50	0	0
Other countries	100	100	100	100
Other industries				
G5/G7 countries	12.5	20	0	0
Other countries	25	40	25	40
	Estimated induced patents			
Number induced	238 150	325 880	10 030	13 090
% of total granted	29.4%	40.2%	4.9%	6.4%
Induced patents:	Induced patents providing domestic spillovers			
Owned by residents	89 000	122 000		
Owned by non-residents but produced in USA	104 680	143 000		
Total with domestic spillovers	193 680	265 030	6 750	8 810
% of total granted	23.9%	32.7%	3.3%	4.3%

Notes:

USA: Total grants for 2001-05 are 810 487. Calculated from USPTO data for 'Life and Agricultural Sciences and Testing Method' and 'Compositions and Synthetic Resins; Chemical Compounds' classes are as described in the U.S. Classification System (Arranged by Related Subjects) June 2006 version from http://www.uspto.gov/web/offices/opc/documents/classescombined.pdf, and http://www.uspto.gov/web/offices/ac/ido/oeip/taf/tecstc/classes.htm (accessed 5 March 2007).

Australia: Total grants for 1990-2006 are 203 815. Calculated from data formerly available on IPAustralia website (accessed 19 July 2008): (http://www.ipaustralia.gov.au/about/statistics.shtml, Table P31 (Feb08) Countries of Origin of Granted and Certified Patents). Pharmaceutical patents are taken to be those from technology groups 'organic fine chemicals' and 'pharmaceuticals, cosmetics' (from http://www.ipaustralia.gov.au/about/statistics.shtml, Table P61 (Oct07) Standard Applications by Technology Real standard patent applications).

re-allocation will be in the country of origin. And so will most spillover benefits. Where knowledge spillovers depend on local working for the transfer of the important associated know-how, then knowledge spillovers will not flow from that proportion of patented goods which are imported, even where they are induced by the patent system.

There are, of course, few data on the proportion of patented products locally produced.[26] But it is only these locally produced induced patents that provide spillover benefits to offset any costs of the patent system. Given Australia's small market size and low tariff barriers many products patented in Australia are imported. A rough proxy has been adopted for locally produced patented goods: those where the patent is owned by an Australian innovator.[27] On this basis some 6750 to 8810 patents granted between 1990 and 2006 are induced inventions owned by Australian residents (3.3 to 4.3 per cent of all patents). It is this set of patents which must generate the dynamic efficiency gains to offset any social costs created by the 203 815 patents granted in the same period. Each of these domestically produced induced patents must generate sufficient benefits to offset the costs of between 23 and 30 granted patents. This implies a need for quite large average knowledge spillovers for the Australian patent system to confer a positive economic outcome.

In the USA about 37 per cent of induced patents are owned by non-residents of the USA. But it may well be rational for overseas firms to locate production in this large market. This effect is enhanced by US buying practices which can make it difficult for overseas producers to sell into US markets. Consequently some overseas owned induced patents will be produced in the USA generating spillover benefits there. In the absence of any direct information on the proportion of overseas-owned patents made in the USA (rather than imported) I assume that 50 per cent are manufactured in the USA. This gives a final guesstimate of the number of patents which might generate dynamic efficiency gains for the US economy of between 24 and 33 per cent of granted patents. The non-induced granted patents may generate static welfare losses, but cannot generate any benefit attributable to the patent system. Each domestically produced induced innovation needs to produce benefits to offset the costs of only between three and four granted patents.

2.5 What are the costs of granting patents?

While the percentage of granted patents which might give rise to dynamic benefits in the USA is ten times the magnitude in Australia, to conclude that the net impact of the patent system in the USA is positive would be to make some important assumptions about costs. The idea that patent policy is the most efficient available mechanism for inducing a higher level of innovation is at least partly based on the assumption that the costs of a patent system are trivial (Andersen 2003). In fact there are few data on the costs of patent systems, particularly the social costs. There are certainly no empirical data to support the standard assumption of low costs.

Indeed there is very little literature on patent system costs and what there is focuses on the private costs incurred by patent holders (Macdonald 2002: 31). Even here it has been extremely difficult to quantify costs, as demonstrated by Mooney and Oppenheim (1994a, 1994b) in their work on the British patent system. Taking an indirect approach, Bessen has estimated the net private cost of patents for publicly listed US firms and finds a net private loss among US publicly

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[26] Firestone's study of the economic utility and disutility of patents in Canada is one of very few studies of patent use. The focus was on whether patents were worked (used in production). Only 15 per cent were worked in Canada, though 50 per cent were worked in at least one country (Firestone 1971: 347).

[27] Including the subsidiaries of overseas companies, where these subsidiaries give Australia as their address.

listed firms, once pharmaceutical firms are excluded (Bessen 2006). Indeed Bessen and Meurer estimate that over two-thirds of the private return from global patents systems flows to chemical and pharmaceutical firms. They further estimate that over half of the private return from global patents systems is highly concentrated, flowing to a small number of large pharmaceutical firms (Bessen and Meurer 2008: 108). There is a reasonable academic literature on patent litigation (for example Lanjouw and Lerner 1997; Graham and Somaya 2003; Bessen and Meurer 2007), but there do not appear to be any good data on the payments made. There are however a number of well-known stories about specific cases. The E-Data case involved a point of sales kiosk. Some 16 years after this invention the CAFC reinterpreted "point of sales" kiosks to include the internet – not in existence when the invention was made. E-Data successfully sued more than 100 parties including small businesses and individuals (Bessen and Meurer 2008: 1-9). Kodak's 1976 instant photography products were found to have infringed Polaroid's patents and the final payment was $US 873.1 million (Quillen Jr. 2008).

A few authors discuss the social costs of patent system but tend to the view that detailed empirical estimates are impossible (for example Machlup 1958; Cole 2001). Other authors note positive or negative impacts, generally with no empirical support other than anecdotes. Moir (2009a) makes an initial attempt to codify the types of social cost imposed by a patent system and to bring together the available information on the social costs (and benefits) of patent systems.

Of course, apart from noise, information search costs and the potentially questionable efficiency of resources allocated to obtaining patents, patents that are not used are unlikely to impose significant external costs. So the issue of the proportion of patents used becomes central to the question of the social costs of patent systems.

Some argue that very few patents are used – perhaps as few as 5 per cent (see, for example, Lemley 2001; Blonder 2005). But neither cites any evidence to support this figure. Likewise a European Union study on small firms and patent enforcement provides no supporting evidence or citations for the statement that it "is well known that the majority of patented inventions are never used in practice, either because they are overtaken by further advances, or they are seen by their owners to be uneconomic, or for some other reason" (European Union 2000: 30).

These claims of very low use run counter to the empirical data. Firestone found that 50 per cent of Canadian patents were used to support production. He also reported figures from the UK and the USA: in the UK 30 per cent of patents were worked (Firestone 1971: 14), while in the USA large firms worked 49 per cent of their patents and small firms 71 per cent (Firestone 1971: 149). These estimates are consistent with reports from a 1957 US study that 41 to 55 per cent of patents were used commercially, with up to 71 per cent used among small firms (Griliches 1990: 1679). While this evidence is dated, it does suggest that at least a substantial minority of patents are used in commercial production.

Patent renewal data suggest that many patents continue to have value for their owners, implying some form of use. Griliches (1990: 1679-80) summarises the early evidence as indicating that about half of granted patents are renewed beyond year ten and about 10 per cent to the maximum limit.[28] Renewal rates in the USA do not show the smooth curves evident in other

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[28] Patent renewal data are mostly used to calculate the private value of patents. There are marked inter-country differences in renewals, but these largely disappear once industry is controlled. There are also differences in renewal rates by patent cohort and by residence, with renewal rates being much lower for domestic than for foreign patent owners. There are no single effective summary measures of renewal rates, and they are usually shown graphically. Neither Schankerman and Pakes (1986) nor Pakes and colleagues (Pakes et al. 1989) give summary measures of

countries as US renewal fees are payable at only three points over the 20 year potential life. The percentage of US patents renewed to their full term is estimated at nearly 40 per cent (Thomas 1999). These data show that while many patents lose any value quickly, a substantial minority retain value for some time – their private value at least appears to exceed the costs of renewal.

The concept of patent use has changed radically since Firestone's study. Since the success of the patent lobby in eliminating local working as a condition of patent grant, interest in the use of patents to support product production has waned. However as the CMS data cited above show, patents are now used for a variety of purposes, many involving strategic uses. These include enhancing reputation, a use which likely has little impact on third parties, and insuring against infringement suits, where the main use may well be passive. In contrast blocking patents may impose substantial costs on other firms. And in industries where whole portfolios of patents are exchanged to gain access to essential and closely related technology, high costs are imposed on all parties.

Some of the literature presumes that because of the existence of close substitutes, very few patents have any real degree of monopoly power and so argue that they impose few costs (for example Gans et al. 2004). If this is the case then very few patents can be induced by the patent system: if the patent holder cannot achieve higher prices there is no incentive to increase investment. A brief review of legal cases shows that many apparently obvious patents – the kind of innovations that might have many close substitutes – can impose significant costs on other innovators. Amazon's one-click case is well known and initially imposed substantial costs on competitors. The patent was issued in September 1999 and Amazon obtained an injunction preventing barnesandnoble.com from using their independently invented system over the end of year major shopping season. The injunction was lifted 14 months later because of doubts about the patent's validity. Amazon settled an out-of-court, presumably compensating barnesandnoble.com for their losses. The patent remained on the books until late 2007 when, after an independent request for re-examination, the USPTO rejected 22 of the 26 claims. Amazon then amended claims 1 and 11, restricting them to a shopping cart model of commerce and the revised patent was confirmed in March 2010.[29] There is no process to recompense any other party for any license fees extracted during the decade when the invalid claims held sway.

In the Australian *Welcome* case, the core inventive concept in the consumer loyalty card was agreed by all parties to be well known. Despite this the judge upheld its validity. The respondent, who had independently developed a similar smart card use, has gone out of business. It would be preferable to have systematic data on the outcomes of patent litigation rather than such individual stories. But in the absence of systematic data such individual cases show that it cannot reasonably be presumed that obvious patents cannot do real economic damage to competitors. The very real possibility that patents impose substantial social costs should not be dismissed without proper investigation. Indeed a cursory consideration of the impact of high pharmaceutical prices in low-income countries makes it evident that the costs can include preventable deaths. A very high price for those so affected.

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renewal rates.

[29] There is a very extensive literature on US patent 5729594, both academic and popular (Lesavich 2001; Stern 2001, http://en.wikipedia.org/wiki/1-Click) Although it simply computerises the well known process of running an account and despite the public outcry about obviousness nothing happened until mid 2006 when the USPTO agreed to New Zealander Peter Calveley's request for re-examination based on lack of novelty. Amazon lodged 167 documents (weighing 7 kg) in defence of their monopoly (http://igdmlgd.blogspot.com/, accessed 25 July 2012).

Even if a patent is not used it adds to noise in the system. Most patent infringement cases involve inadvertent trespass (Bessen and Meurer 2008), and this is in part due to the difficulty in determining what has already been patented. Patent applicants play strategic games, where the key objective of a patent specification seems to be to hide rather than disclose information. Stallman (2001) provides an interesting case for a method of recalculating the values in spreadsheets where the essential technical terms were completely missing from the specification. Large volumes of potentially trivial patents make the search for those that involve genuine technological advances more difficult and expensive. This imposes higher costs on other innovating firms who need to know what grants and applications are close to their own technology.

Where patents are used, one of the most important social costs is any negative impact on subsequent innovation (see for example David 1993; Macdonald 2004). Decades ago Penrose suggested "[b]oth within and between countries the greatest social cost of patents arises from the restrictions they put on the right to imitate new ideas" (Penrose 1951: 99). Cohen provides one of the more detailed assessments of the technological hold-up problem, discussing the negative impact of the patent system on airplane development and radio technology. He concludes that "[i]f the technology in question is sufficiently important, only one or a few instances of [restricted access or an anticommons] may impose considerable social cost" (Cohen 2005: 63). As noted above, there is a fine line between imitation and improvement and consequently subsequent innovation. Not only can negative impacts on subsequent innovation create direct losses, but also – because innovation is cumulative, evolutionary and path-dependent – it can change the direction of future technological development.

Other social costs include the direct welfare losses due to reduced (monopoly) output and reduced competition. Investigating these issues is complex. Analysis of welfare losses from reduced output tend to be theoretical, but provide some useful insights into the quite different welfare impacts of alternative types of innovation (see, for example, Tisdell 1981; Deardorff 1992; Winter 1993). Cost-reducing innovations are most tractable for economic analysis, but their welfare implications are quite different from those of new product development, particularly radically new products. Few would question the strong positive externalities arising from the introduction of penicillin (which was not induced by patents) or the birth control pill (which probably was induced by patents).

From a national economic perspective a particularly concerning cost is where patents reduce market competition by excluding new entrants. Cockburn and MacGarvie (2006) have investigated the role of patents as barriers to or facilitators of entry in the software industry and find *direct* evidence hard to find. In their study of 27 narrowly-defined classes of software products they find that entry is lower in industries where there are more software patents, suggesting that patents do operate as a barrier to entry. But they also find that firms holding software patents are more likely to enter these markets, suggesting that patent ownership assists entry, at least in markets where patents are prevalent. The results are very sensitive to the assumptions (Cockburn and MacGarvie 2006: 35).

It is a matter of considerable concern to effective patent policy development that so few data are available to properly measure the costs, or benefits, of patent systems. In 1984 the committee reviewing Australia's patent system recommended that periodically, on patent renewal, the government ask for information on how the renewed patent is being used (IPAC 1984:10). This recommendation has never been implemented. Nowadays patent offices hand out tens of thousands of patent monopolies a year yet none collects any information on how these monopolies are used. This is the antithesis of evidence-based public policy. It suggests a blithe disregard for the public interest.

Indeed there appear to be some concerted efforts to prevent the collection of data on the impact of the US patent system. Kahin reports that, subsequent to the *State Street* case the White House Office of Science and Technology Policy commissioned the Science and Technology Policy Institute at RAND to undertake a study on software patent quality and business effects. He goes on to report that "it was suspended at the request of a U.S. multinational company concerned that the study would undercut efforts to secure greater international acceptance of software patents" (Kahin 2003). Bessen and Meurer comment that the FTC recommendation most prominently rejected by the Intellectual Property Owners Association (dominated by patent lawyers from large firms) was recommendation 10 "expand consideration of economic learning and competition policy concerns in patent law decisionmaking" (Bessen and Meurer 2008: 293-4).

2.6 Are there net benefits from patent systems?

This discussion confirms that patent policy is a very blunt instrument. The empirical data suggest that patents are effective in achieving a higher level of innovative activity only in a narrow range of circumstances. It is a minority of patented innovations that are induced by the patent system, though in the USA it may be a substantial minority. The owners of the majority of patents may therefore receive windfall profits. Spillover benefits are lower than often alleged, and are contingent on a number of factors including location of production and industry depth. While costs cannot be quantified, there are some potentially serious costs that incur high risks though hopefully with a low probability. History has shown, however, that technological development can be impeded by patent systems.

The conclusion that patent policy does not confer clear net economic benefits is similar to that reached, by different routes, by many others. Granstrand concluded that "the patent system … has been neither necessary nor sufficient for technical and/or economic progress at country and company level historically" (Granstrand 1999: 44). Encaoua and colleagues suggest that if the policy interest is the incentive to invest, then patents should not be the default policy choice (Encaoua et al. 2006). Boldrin and Levine (2004) suggest patents should be used only when the innovation investment is large and indivisible.[30] Winter, using an evolutionary model, demonstrated that both R&D investment and total surplus would be higher without patents (Winter 1993). Dutton (1984) and Mandeville (1996) both concluded that the most balanced (welfare-enhancing) patent policy was a 'weak' patent system. More recently, in a theoretical assessment of a situation where government has the opportunity to subsidise R&D and where imitation takes time, Bonatti and Comino (2011) find that social welfare is higher in the absence of patents.

Despite the lack of a sound and substantiated theoretical basis, and a complete lack of empirical evidence on its effectiveness, patent policy has been strengthened in ways that seem to reduce net positive externalities and increase social costs. Jaffe, for example reports "widespread unease that the costs of stronger patent protection may exceed the benefits" (Jaffe 2000: 555). In part, the strengthening has been due to decisions by individual judges, a story investigated in more detail in Chapter 3. In part it is due to successful lobbying by the small number of firms which are

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[30] Though Arrow considered that direct R&D subsidies would be more efficient for such large projects.

major beneficiaries of the patent system (Landes and Posner 2004).[31] In part it is due to a general shift in the pendulum towards viewing patents in a more positive light (Granstrand 1999).

How patent system balance works out in practice is an empirical question and the answer may vary depending on the industry structure of an economy and market size. Another very important factor in patent balance is the quantum of new knowledge required for a patent grant. All other things being equal a higher new knowledge requirement makes it more likely that there will be spillover benefits. This would also reduce the proportion of trivial patents, thus reducing noise and transaction costs.

The data presented above suggest that innovation markets are most likely to fail where relative imitation costs and the overall investment cost is large compared to the time taken to imitate. These conditions are found in the pharmaceutical industry, but in few others. In pharmaceuticals, innovations are highly codified, making imitation faster, and Phase III clinical trial costs are very high. Generic companies can avoid the full costs of Phase III trials, thus radically reducing their development costs. In most other industries patents are less relevant to obtaining a return on R&D investment and are much less likely to induce investment that would not otherwise occur. This brings the discussion full circle to Arrow's seminal article (Arrow 1962). He concluded that markets were most likely to fail where the innovation cost was large and lumpy and suggested that the appropriate response was public financing.

In the post-war period most industrialised countries have introduced substantial programs of public subsidy for industrial R&D investment. In addition in some countries there is substantial direct government investment in R&D. But there has been no simultaneous review of patent policy to consider whether in this new world of public subsidy to R&D patent monopolies continue to be effective economic policy.[32] It is apparent from the material presented above that the real-world existence of spillover benefits from patented innovations is both highly variable and contingent on the location of production and the depth of industry. Obviously it is also dependent on the height of the inventive step.

It is also apparent that, even in the best of circumstances, only a minority of patented innovations are induced by patent policy. At a minimum each induced innovation may need to generate spillovers that exceed the cost of three to four patents if the overall system is to generate benefits. While the costs of granted patents cannot be quantified, neither can they be dismissed as negligible, at least without some data to support this assumption. So on both the benefits and the costs side appropriate data are wanting. There has been more progress on the benefits side. The substantial data now available raises considerable doubts about the alleged benefits of patent systems. Further work is needed on patent system costs and a useful starting point would be for governments to collect data on how the monopolies they grant are used. This should be complemented by better data on the impact of patents held by one firm on other innovating firms. Such data could readily be collected through the National Innovation Surveys.

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[31] The USPTO website provides data on major users of their patent system annually since 1963. For patents filed in the years 1990 to 2001 there were 1 713 605 grants, of which 1 468 408 (86 per cent) were granted to organisations. Of these 45 per cent (656 974) are owned by just 300 companies who each owned 1000 or more patents granted between 1963 and 2006. The 100 most prolific patenters held 513 228 patents in aggregate, or 35 per cent of patents granted to organisations. In Australia 161 404 patents were granted from 1990 to 2001 applications, of which 141 584 (88 per cent) were to organisations. The 100 companies holding most patents held 34 per cent of patents granted to organisations (Moir 2009b: Table 2).

[32] Though Bonatti and Comino's (2011) theoretical work suggests it is very poor policy.

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