Submission to the Productivity Commission Review of: *Public Support for Science and Innovation*

By

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Introduction

The Australian Government has identified science and innovation as one of its strategic priorities, recognising its contribution to Australia's economic and social prosperity. The Government has provided significant support for science and innovation, which it has augmented since 2001 through Backing Australia's Ability (BAA), and funding now exceeds $5 billion per annum. In light of this investment, the Government considers that a study of public support for science and innovation is warranted. This study – to be conducted by the Productivity Commission and completed by March 2007 – will complement the ongoing and planned reviews of BAA programmes. The main issues outlined in the Productivity Commission's review span three areas:

- The economic, social and environmental impacts of public support;
- Impediments to the effective functioning of Australia's innovation system; and
- Evaluation of decision making principles and program design.

The following is in response to the Productivity Commmission's call for submissions. As part of our research programme at the Melbourne Institute of Applied Economic and Social Research (which is a major stakeholder in the Intellectual Property Research Institute of Australia, IPRIA, along with the Melbourne Business School and the Melbourne Law School), we have conducted research which has an important bearing on the study of public funding of science and innovation. This submission is a summary of the key findings of this research. We first present a primer on the basics of the economics of innovation and then explore some of the pertinent results from our research on public policies relating to innovation in science and innovation. In particular, this submission draws heavily from Webster and Jensen (2006); Jensen, Palangkaraya and Webster (2006); Dent, Jensen et *al*. (2006); Jensen and Webster (2006); Jensen and Webster (2004); Webster (1999); Palangkaraya, Jensen and Webster (2005); and Buddelmeyer, Jensen and Webster (2006). In this submission, we address the following key issues:

1. **Optimal Policy Settings for Patent Rights.** Patents provide incentives for innovation investment, but in doing so inhibit knowledge spillovers. We analyse whether the current policy settings optimally balance the tension between these competing effects.

2. **Research Exemptions from Patent Law.** Universities and other public research institutions have long considered themselves to be exempt from patent law. But this assumption has recently been questioned. We analyse the pros and cons of research exemptions.
3. **Disharmony in International Patent Examination Decisions.** Although there has been much pressure to harmonise international patent laws and procedures, we show that there is substantial disharmony in examination outcomes – in particular, Japan, Europe and the US often disgaree about which applications to grant patents to. We attempt to understand the determinants of this observed effect.
4. **Accounting for Innovation Investments.** Unlike tangible capital, investments in intangible capital are poorly dealt with by the accounting profession. Without consistent way of accounting for intangible capital, it is difficult to examine the effects of investment on firm performance. We consider ways in which this could be remedied.
5. **Usage of Intellectual Property by SMEs.** Much concern has been expressed about the role of SMEs in innovation and whether they are disadvantaged in their ability to use IP rights. We examine the evidence for this in Australia and demonstrate that large and small firms apply for IP rights at the same rate.
6. **Innovation and the Determinants of Firm Survival.** Innovation is a risky enterprise and it would be naive to expect that innovative activity has no effect on firm survival. We examine firm survival while distinguishing between innovation investments and innovation capital and find that current innovation investments increase the probability of death while innovation capital lowers it.

Simple Economics of Innovation

Since the amount of tangible matter in the world is fixed, innovation is the sole source of productivity growth and thus our ability to enhance the (material) quality of life. In recent times, it has been argued that innovation is playing an increasingly important role in modern capitalist economies: academics, policymakers and the popular press talk about the emergence of a "new economy" dominated by investments in human capital and "knowledge workers". There is some evidence of this: in Australia, for instance, the growth of intangible capital relative to tangible capital in enterprises over the last 50 years has been 1¼ per cent per annum.[1]

Innovation is subject to market failure, which may occur along two dimensions: either firms may not allocate sufficient resources for the creation of the asset, or society may under- (or over-) use an asset. These market failures are directly attributable to the properties of non-excludability and non-rivalry.[2] A good is non-excludable if it is impossible to prevent theft, imitation or uninhibited access to the services of the good. Non-rivalry occurs when capital consumption does not detract from the ability of others to simultaneously consume the same capital service. Non-excludability leads to a sub-optimal level of investment into the creation of capital goods and non-rivalry leads to a sub-optimal consumption of capital goods. Many, but not all, types of innovation has non-rivalry properties due to the ability to copy without loss of service to other users. As a consequence, the amount of innovative activity in an unfettered market is generally regarded as being less than socially optimal.

Excludability and rivalry also influence the manner in which innovation is transmitted and the ways firms seek to appropriate returns. Specifically, there is the classic tension between incentives and diffusion. On one hand, diffusion through the spread of successful ideas and methods is fundamental to improving the material standard of living of a society. At the same time, however, diffusion (or learning and imitation) undermines firm's ability to appropriate the returns from the innovation and thus attenuates the incentive to invest in innovation. Intellectual property (IP) such as patents, trade marks and copyright attenuate the under-investment problem in the production of knowledge, but they exacerbate the diffusion problem.[3] However, even with the support of the patent system, the appropriation of economic rents generated by innovation is not perfect. There is uncertainty regarding the validity of granted intellectual property rights, imitation by rival firms is difficult to detect, and enforcement through the courts is costly. Empirical analysis indicates that

[1] Webster (2000).

[2] This is in addition to the standard market failure that arises from "…the inability of individuals to buy protection against uncertainty…" (Arrow 1962, p.612).

[3] Others argue that patents promote diffusion through disclosure since ideas that may otherwise be lost to society are recorded for posterity through the patent publication (Denicolo and Franzoni 2004). However, Machlup and Penrose (1950) dismiss this argument since they reason that '…concealable inventions remain concealed and only unconcealable inventions are patented' (p.27).

there exist significant differences across industries in the effectiveness and use of the various appropriation mechanisms (Levin et *al*. 1987; Cohen et *al*. 2000).

If the social costs of discovery and development are the same regardless of who pays, then the most desirable policy is the one that maximises diffusion, providing that this does not affect the quantity and quality of resources that are allocated to investment. Accordingly, the first-best policy is to publicly finance the production of under-produced intangible capital since this allows all public-good outputs which arise from its production to disperse without restraint (Arrow 1962). Such public-funding mechanisms may range from *ex ante* procurement through to ex post prizes.[4] However, in some circumstances second-best policies – such as IP laws – may be apt. In abstraction, these policies however are less efficient since the social welfare losses incurred through taxing a single market (via a monopoly price) are always greater than those incurred though broad-based taxation (Gallini and Scotchmer 2002).

Designing innovation policies which balance the tension between incentives and diffusion is difficult to do since all policy initiatives must deal with generic problems associated with rent-seeking behaviour. Provision of R&D grants by the government may be the first-best policy for encouraging diffusion of knowledge, for example, but it is subject to moral hazard problems since the government often provides complete insurance for research costs, thereby weakening the incentive to minimise production costs. Patents, on the other hand, provide strong incentives to invest in R&D but they also provide a means whereby firms can engage in undesirable anti-competitive behaviour such as the creation of patent thickets.

As a result, systems in most developed nations currently consist of a combination of both research grants and IP laws, albeit with incomplete and uneven coverage across industries and technology fields. For example, manufacturing and goods-based technologies tend to rely on patents, while copyright is most suited to media and communication industries, and public funding tends to be used almost exclusively for basic research in not-for-profit institutions. In addition, natural forms of appropriation, such as secrecy, organisational know-how and human resource management exist but are more effective for processes and complex production structures (Cohen et *al*. 2000).

[4] Government prizes were commonly used in the early 19th century and since then invention or innovation awards have continued to stimulate intangible investment in part by acting as signals to the market (Klette et *al*. 2000).

Policy Issues

Optimal Policy Settings for Patent Rights

Patents create deadweight social losses by temporarily blocking imitation and preventing others from using a non-rival resource. These deadweight losses arise because the patent system operates by creating a distortion (a monopoly right) to correct a distortion (non-rivalry). The size of these social costs varies according to the administration of the patent rights scheme. For instance, if a patent is granted too freely or too broadly, it may stifle future (incremental) inventions, create an anti-commons or induce excessive anti-competitive behaviour (see Heller and Eisenberg 1998, for example). Conversely, if it is granted too parsimoniously, it may inhibit firms' desire to invest in easily-copied inventions. Striking the right balance between these competing effects is about both rewarding the inventor and protecting the interests of the rest of society.

Achieving this balance is only half of the story since the value of a patent to its owner lies in its ability to prevent rivals from copying their invention. Once a patent has been granted, its owner has a right to take action against alleged infringers in a court of law. However, infringement of intellectual property rights is difficult to prove. The power to stop infringement is adversely affected by two factors. First, unlike titles to tangible property, patent rights are only granted if it can be demonstrated that they pass certain criteria. Since there will always be some mistakes made in the patent examination process, there exists a non-trivial probability that any given patent right will be found invalid if challenged in a court of law.[5] Secondly, articulating the boundary of a patent right is difficult to do since it requires that an idea be precisely conveyed in written form. As a consequence, disputes over ownership of patent titles are often difficult to resolve which results in wasteful expenditure on litigation. Taken together, these two factors may reduce the *ex ante* incentive to invest in inventive activity since they create uncertainty regarding the patent owner's ability to curb imitative behaviour.

In Jensen and Webster (2004), we argue that the power of a patent is determined in two stages: first, acquiring the title to the right (patent granting) and secondly, getting competitors to accede to

[5] See Lemley and Shapiro (2005) who argue that intellectual property rights should therefore be considered probabilistic in nature.

the right by modifying their behaviour (patent enforcement). Each stage is associated with varying administrative costs for processing the claim (or dispute) and wider social costs which arise from erroneous decisions or behaviours. Three main administrative criteria – novelty, inventive step (or non-obviousness) and utility – are used to form the patentability threshold. From a social welfare perspective, only inventions that would not have been made in the absence of a patent system should be patented since patenting all other inventions involves a deadweight loss. Since these inventions are hard to identify, the convention in practice is that these inventions require significant *ex ante* investment which subsequently constitutes a large inventive step. We expect that the higher is this examination threshold, the more certain it is that patents granted will be affirmed if challenged in a court of law.

In pursuit of the ultimate goal of optimising the rate of successful innovation, the patent system should aim to minimise first, the amount of desirable inventions that are not granted a patent; secondly, the amount of undesirable inventions that are granted a patent; thirdly, the uncertainty over the power of granted patent titles to stop infringement; and finally, the costs of administering the system. These intermediate objectives however involve trade-offs. To achieve the best mix of these objectives the government has three main policy instruments: the size of the inventive step; the rigour of the patent examination and opposition process; and the predisposition of the courts towards affirming the patent office's decision.

An economically desirable or 'good' patent has three properties: it must represent an invention which incurred significant costs to create since a costless invention would have been invented in the absence of a patent system; it must create social benefits when used; and it must be able to be defined without trespassing on existing property rights. An undesirable or 'bad' patent does not possess all of these attributes. Given the difficulty of precisely identifying good and bad patents, there will always be some positive rate of rejection of good patents (Type I errors) and acceptance of bad patents (Type II errors).

Allocating more resources to the examination (and opposition) process should reduce both Type I and Type II errors since it reduces the random error associated with examination. Of more importance is the interaction between the size of the inventive step and the quality of the examination process. In order to analyse this, Table 1 presents a typology of the effects of different patent granting regimes. The weak regime consists of a cursory examination process and small inventive step and results in a low Type I error rate and a high Type II error rate. By contrast, a strong regime is where examinations are rigorous and the inventive step is large, which results in low Type I and Type II error rates. However, it is unclear which of the weak and strong regimes has lower Type I errors since the random error arising from the cursory examination process in the weak regime is not necessarily larger or smaller than the error produced by the large inventive step in the strong regime. There is some evidence to suggest that at least errors exist since the patent grant rates across the US, Japan and the European patent offices are different (see Quillen et *al*. 2001).

Table 1: A typology for the extent of Type I and Type II errors in the patent granting process

Quality of examination	**Size of required inventive step**	
	Small	Large
Cursory (high random error)	WEAK Low Type I error High Type II error	SEMI-STRONG Medium Type I error Medium Type II error
Rigorous (low random error)		STRONG Low Type I error Low Type II error

The regime involving a high inventive step, a rigorous examination procedure and courts predisposed to affirm the patent office decision involves the lowest Type I and Type II errors and the most certainty for firms. Accordingly, it maximises the incentive to inventors and innovators by giving them the best *ex ante* chance that their investment in an inventive activity will be rewarded with a patent that has a high probability of recognition by rival firms. It also minimises the unfair use of patents by firms to lock other firms out of their technology space. However, this regime may also be more expensive since it requires an expensive examination and opposition process. Counterbalancing this is the fact that this regime probably results in lower enforcement costs since it should be easier to prove infringement given the certainty over the validity of the patent right.

At the other extreme, the worst regime appears to involve a small inventive step, a cursory examination system and a court system that is predisposed to affirm patents. Such a system may be inexpensive to administer but is potentially deleterious to the incentive to invent since it heightens unfair competition by affirming numerous bad patents and results in long-running, costly legal disputes. This scenario seems to bear some resemblance to the current patent system in the United States, where some have recently expressed concerns about the effects of bad patents and unfair competition on inventive activity (see Federal Trade Commission 2003). Whether it is socially beneficial to change the existing settings for the policy instruments identified here ultimately depends on estimates of behavioural responsiveness to the proposed changes. For example, how responsive is the rate of Type I and Type II errors to changes in the inventive step and increases in resources spent on the examination and opposition process? At present, we have little empirical evidence to guide us on these issues: we do not know what the elasticity of supply of bad patents is, nor do we know whether there are diminishing returns from examination.

Research Exemptions from Patent Law

A research exemption for patented inventions allows researchers to use an invention without infringing the rights of the patent-holder of the invention. Such exemptions attenuate the deadweight losses associated with the public grant of a monopoly right over inventions. In Dent et *al*. (2006), we provide an overview of evidence for/against research exemptions. Historically, most industrialised countries have not deemed university research on a patented invention as an infringement of the rights of the patent-holder. However, the *Madey v Duke* case in 2002 changed the perception of this. Without an exemption, it is possible that scientists and universities may be sued for infringement when the work they are doing is for scientific progress generally. As a result, there is now widespread concern that the absence of a research exemption in patent law may have serious long-term effects on scientific progress.

Concern over the effect of patents on scientific enquiry has escalated in recent years because of:

- increased pressure on public research organisations to patent inventions arising from their research;[6]
- increased use of the patent system;[7]
- the effect of the *Madey v Duke* decision in the United States which narrowed the scope of research exemptions; and
- increased propensity of patent owners to enforce their rights.[8]

Concern over the existence (or absence) of research exemptions is part of a wider concern that the patent system is privatising knowledge. Nelson (2004) argues that as universities push for greater commercialization of output, there is greater pressure on university researchers to keep their research a secret (in order to fulfil the patenting criteria) and to turn research output into proprietary knowledge. This has increasingly resulted in the privatisation of the scientific commons and the creation of an anti-commons, where knowledge is under-used relative to the social optimum (Heller and Eisenberg 1998). Such a strategy may temper the rate of technological progress or change the direction of technological progress since if science is guided by the hand of commercial interests, it will focus primarily on puzzles that have commercial significance.

Advocates of research exemptions argue that since much research is cumulative in nature, there may be multiple licensing arrangements that need to be negotiated separately before any actual research can take place. These will probably involve significant transaction costs. These payments are deadweight losses from society's point of view and do not augment the incentive to invest for either party. Negotiating your way through a minefield of contracts (or cross-licensing arrangements) can also lead to well-known contractual problems such as hold-up. As a consequence, research will only be conducted up until the point where the transaction costs imposed are less than the total expected value of the research itself. Moreover, the more basic and fundamental the level of research, the more uncertain and unpredictable the social uses for the new knowledge and accordingly the greater the deterrence effect of an explicit price for investors. For this reason, scientists have long advocated the free and wide communication of ideas (Nelson

[6] In the US, this originally occurred as a result of the Bayh-Dole Act 1980 which allowed universities to patent inventions in order to promote technology transfer.
[7] OECD (2004).
[8] Bessen and Meurer (2005) show that patent litigation has escalated in recent years.

1959). The full social value comes often from unexpected quarters and cannot be predicted *a priori*.

A canonical example of the type of problem that researchers face as a result of increased patenting in the public domain is the story of the OncoMouse.[9] In the early 1980s, researchers at the Harvard Medical School inserted a gene into a mouse embryo which made the mouse highly susceptible to cancer. The result was a research tool useful for all researchers looking to understand the onset of cancer. Realising the potential commercial value of their discovery, Harvard patented the OncoMouse and licensed it to DuPont who then aggressively marketed the research tool and enforced their property rights. Many scientists expressed their opposition to this development, since it goes against the fundamental tenets of "open science", where information is disseminated and diffused openly and freely.[10]

Given that the decision is fairly recent, there is very little empirical work examining whether *Madey v Duke* has had any material effect on the level or quality of research undertaken in universities in the US. But there has been a lot of discussion about its potential effects (and the effects of stronger IP rights in general) on university research.[11] Much of this work examines whether the increased rate of patenting has had an effect on the quantity, quality or direction of scientific progress. An example is Murray and Stern (2005) who take advantage of the fact that many new scientific discoveries are both patented and published in scientific journals and use this to construct a set of 169 patent-paper pairs from the US. They then compare the pattern of forward citations to scientific articles of the patent-paper pairs with the pattern of forward citations from a control group made of non patent-paper pairs. Their main finding is a small but statistically significant anti-commons effect: the citation rate for articles published and then patented falls by 9 to 17 per cent after the patent has been granted.

On balance, there is reasonably strong evidence suggesting that patents may have some deleterious effects on scientific research. A research exemption may therefore be an effective safety

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[9] As described in Murray and Stern (2005).

[10] After considerable opposition to DuPont's strategy, the National Institutes of Health brokered a deal whereby non-profit research institutions were able to use the OncoMouse without the imposition of licenses. For-profit research organizations, however, were still required to enter into commercial arrangements with DuPont.

[11] See David (2004), Cohen (2005) and National Research Council (2004), for example.

mechanism to minimise the chance that patents will adversely affect future research. There is, however, insufficient empirical data at this stage to demonstrate that any particular form of the exemption will be more effective than others in guarding against future restrictions on scientific work. The strongest argument may, therefore, be to introduce statutory exemptions in those nations that do not have them in order to further harmonise patent laws.

Disharmony in International Patent Examination Decisions

There has recently been much debate about the merits of harmonizing international patent laws (see Duffy 2002; Barton 2004). Bilateral and multilateral trade agreements and treaties—such as the Agreement on Trade Related Aspects of Intellectual Property (TRIPS)—which promote consensus on issues such as copyright term extension and patent coverage, have flourished. Moreover, it is a condition of TRIPS that all signatories to the agreement apply the same criteria—novelty, non-obviousness and utility—to determine whether an invention is eligible to be protected by a patent. Despite this, there are substantial procedural differences in the way in which different patent offices search for prior art and interpret non-obviousness. The Trilateral Patent Offices—the United States Patent Office (the USPTO), the Japanese Patent Office (the JPO) and the European Patent Office (the EPO)—have recognized the importance of consensus in patent examination procedures and have considered ways in which these differences can be attenuated.

In Jensen et *al*. (2006), we analyzed one aspect of the patent harmonization debate: whether there are systematic differences in patent application outcomes—which we define as withdrawn, pending, rejected or granted—across the trilateral patent offices. Recent evidence suggests that despite the fact that all three offices have been working towards a consistent interpretation of patentability thresholds, such disharmony in patent application outcomes may exist. For example, a recent study compared the aggregate grant rates in the USPTO, the EPO, the JPO and Germany and found that the proportion of patent applications which are approved as patents varies between 47% (Germany) and 95-97% (USPTO) (Quillen and Webster 2001). However, this comparison is based on aggregate statistics from each of the offices and therefore it is not possible to determine whether the difference in observed granting rates is caused by the quality of the patent application or differences in the outcome of the examination process. To determine how much disharmony exists, we are interested in whether the patent offices make consistent decisions for a given invention.

To achieve this, we analyze patent applications that have been submitted to all three offices and have a single common priority application—and should therefore cover the same invention specifications.[12] We constructed a dataset consisting of the population of 70,000 non-Patent Cooperation Treaty (PCT) single, common priority patent applications (unit records) with priority years inclusive of the period 1990 and 1995. Data on applications from the U.S. are not available for this period, so our dataset consists of all U.S.-granted patents which were also the subject of patent applications in the EPO and the JPO. Since estimates of the grant rates at the USPTO are as high as 95-97%, the degree of bias caused by omitting rejected USPTO applications in our dataset should be small.

The current state of play with regard to international patenting is that an inventor who wants legal protection in different countries must apply for a patent in each jurisdiction. Once a patent application has been lodged at the relevant patent offices, each office then undertakes its own examination of the application. Although the same patentability threshold applies, each office conducts its own search for prior art and uses different tests to examine the size of the inventive step involved in the invention (see Howlett and Christie 2003). Thus, it is possible that a single invention that results in patent applications in multiple jurisdictions will be granted by one patent office and rejected by others.

There are several apparent problems with the existing state of affairs; problems which are at the center of the push for harmonizing international patent procedures. First, the fact that an invention could be granted protection in one market but denied protection in others creates uncertainty for firms interested in launching new products in multiple markets. From a welfare perspective, either it attenuates the *ex ante* incentive to invest in innovation by permitting copying in one jurisdiction

[12] Given that there is considerable interaction between the applicant and the office during the course of the examination process, it is possible that patents with common single priority date do not have identical claims (and therefore the scope of the patent is different). However, we cannot compare the detail of the claims in each patent office as it is not directly observable from the data sources we use.

or it implies an unwarranted grant of a monopoly patent right in the other jurisdiction.[13] Second, the existence of independent patent examinations in each patent office is inefficient: the duplication of examination costs has been conservatively estimated to be in the order of US$150 million for filing a patent in two jurisdictions (see Barton 2004).

Do the trilateral offices make consistent decisions regarding patent examinations? To determine this, Table 2 shows a cross-tabulation of the EPO and JPO patent application outcomes—conditioned on the patent being granted by the USPTO. It reveals that 37.7% of U.S. grant decisions are being affirmed by both of the other offices and that 0.6% of applications are being rejected by both offices. Moreover, it shows that 10.0% of those patents granted by both the USPTO and the EPO are rejected by the JPO, while only 1.0% of those patents granted by the by the USPTO and the JPO are rejected by the EPO.

Table 2. Cross-Tabulation of Patent Application Outcomes, Priority Years 1990–1995

	EPO				
JPO	Withdrawn	Pending	Rejected	Granted	Total
Withdrawn	7,064	1,024	1,403	11,304	20,795
(%)	*10.1*	*1.5*	*2.0*	*16.1*	*29.6*
Pending	698	914	142	6,174	7,928
(%)	*1.0*	*1.3*	*0.2*	*8.8*	*11.3*
Rejected	2,361	406	439	7,024	10,230
(%)	*3.4*	*0.6*	*0.6*	*10.0*	*14.6*
Granted	2,892	1,261	688	26,456	31,297
(%)	*4.1*	*1.8*	*1.0*	*37.7*	*44.6*
Total	13,015	3,605	2,672	50,958	70,250[a]
(%)	*18.5*	*5.1*	*3.8*	*72.5*	*100*

Notes: [a] There were 223 "missing" observations which have been removed.

The other striking feature of Table 2 relates to the high proportion of patents granted by the USPTO which were either withdrawn or still awaiting a decision at either of the other offices. Specifically, of those patent applications granted by the USPTO, 29.6% were withdrawn at the JPO while 18.5% were withdrawn at the EPO. Moreover, 10.1% of all patents granted by the

[13] Assuming that patents are intended to act as an incentive to invest in innovation, a patent granted in one country but not another means that either: (a) the incentive is necessary, but is reduced by the grant in one country and not another; or (b) the incentive is not necessary, and hence the monopoly represents a simple deadweight loss.

USPTO were withdrawn at both the JPO and the EPO. This is an important, and often overlooked, dimension of the patent harmonization debate: it provides further evidence that patents are being granted by the USPTO that are not being granted elsewhere. While there are many reasons why such applications are withdrawn, a substantial proportion has presumably been abandoned by applicants who have realized that the marginal cost of continuing with the application is greater than the marginal benefit. Some of these may have been granted if the examination had proceeded, but no doubt many would have been rejected or modified substantially.

The number of applications where a decision was still pending at the EPO or the JPO is also of concern. Specifically, 11.3% of patent applications at the JPO still had decisions pending and 5.1% of all patent applications were still pending at the EPO. The lack of a decision in these instances is a concern for economists because of the uncertainty that it creates for investment decisions. Although there is an ongoing debate about the optimal length of patent examination,[14] the fact that some decisions are still pending after 10 years is troublesome. One possible explanation for the high rate of pending applications at the JPO is that it is a result of the 7-year window allowed to request (and examine) an application.

The main conclusion to be drawn from this is that there is a substantial amount of disharmony across the trilateral offices: from our matched sample, only 37.7% of the patent applications granted by the USPTO were also granted by the EPO and the JPO. The remaining applications (62.3%) were either rejected outright, were withdrawn (or deemed withdrawn) or were still awaiting a final decision. Although much of the disharmony appears to be centered in the JPO, this is not to say that the JPO is making mistakes in its patent examination procedures.[15] In fact, it is difficult to determine whether the JPO was "correct" in rejecting the 7,024 patents that were granted by the USPTO and EPO since we cannot observe the reasons for the rejection, nor do we have perfect knowledge of the patentability threshold. Nevertheless, it is a matter of fact that it is the JPO that seems to be in disagreement with the other two offices about which patent

[14] See for example, Harhoff and Wagner (2005) and; Regibeau and Rockett (2003).

[15] Differences in patent examination outcomes across patent offices can be thought of as either a Type I or a Type II error. If a patent is granted by the USPTO and the EPO but rejected by the JPO, either the JPO has rejected a patent application that should have been granted (a Type I error), or the USPTO and the EPO have granted patents that should not have been granted (a Type II error). It is the Type II errors that many commentators have argued have contributed to the proliferation of patent thickets in the US.

applications to grant and which to reject. Moreover, many of the patents granted by the USPTO were withdrawn or are still pending at the JPO and the EPO.

We then examine whether national strategic trade factors are a determinant of patent examination decisions at the trilateral patent offices. In particular, we compare the pattern of examination decisions at the EPO and the JPO across inventor nationality, area of technological specialization and patent value. The results also suggest that – despite the fact that the JPO rejects a lot more patent applications than the EPO – it consistently grants patents which have economic value. However, we find strong evidence that examination decisions at both the EPO and the JPO do depend on strategic trade factors. While both offices give preferential treatment to local inventors, ceteris paribus, the advantage is greatest for applications in their strongest areas of technological specialization, especially in Japan. The converse of this is that it is harder for foreign applicants to get a patent in each jurisdiction's dominant R&D areas. Such discrimination provides assistance to local researchers and manufacturers since they are able to use these inventions without licensing from the patent owners.

Accounting for Innovation Investments

Currently, there is no standardised and consistent firm- or economy-wide measure of investment into the creation of enterprise intangible capital, either as a whole or by component (Lamberton 2003). Over the last decade, there has been a minor explosion in the intangible capital metrics industry (for an overview see Rodov and Leliaert 2002, Hunter et al. 2005). Most of the recommended metrics are indicators (i.e. not expenditure-based) and cannot therefore form the basis of a rate of return calculation. They involve systems of records separate from the financial accounts. Given that an estimate of the rate of return is a prime responsibility of management accounts, the ideal measure should be denoted in monetary terms. Such monetary measures can take either a backward-cost or forward-value perspective: a distinction often confused in the literature. However, the difference between them – being the rate of return to the investment – is one of the prime functions of measurement.

In Webster and Jensen (2006), we argue that the first-best metric is a backward (or cost-based) measure which reflects how much and what type of intangible capital investments firms are making. Without this elementary data, the basis for estimating forward-value measures is tenuous. Furthermore, the most efficient, straight-forward and functional intangible metric is one that is created within the accounting system in a manner analogous to 'gross fixed capital expenditure'. Currently, intangible investment expenditures are not classified as capital but are expensed as intermediate inputs in company accounts, and correcting this requires serious reform to international accounting standards. Reforming accounting standards will have positive follow-on benefits for economic research since most firm-level data is derived from company accounts. While there is some call for greater inclusion of intangible assets on company balance sheets primarily from academics and managers; this is being resisted by the accounting profession (see Lev and Zarowin 1999; Canibano et *al*. 2000; and Hunter et *al*. 2005).

The primary source of accountants' reticence is that intangible assets typically lack one or more of the following attributes: identifiable (i.e. it is capable of either being separated from the entity and sold, transferred etc or arising from legal rights); controllable (i.e. access and use of the asset can be controlled by the 'owner'); beneficial (i.e. it is probable that economic benefits embodied in the asset will eventuate); and measurable (i.e. it can be reliably traced to a measured cost or value). While the absence of the last attribute is an artefact of the accounting standards, the first three attributes are strict and limiting criteria that cause accountants to make Type I errors (not classifying true investments as investment expenditures) while minimising Type II errors (classifying expenses as investment expenditures). It is not clear however whether the errors involved in being conservative about what to admit as a capital item (Type II) are of smaller import than the errors committed by expensing capital items (Type I).

Given the paucity of regular expenditure data, economists have reverted to three kinds of second-best measures: direct survey questions on new inventions (or innovations), staff training, R&D, workplace organisation and marketing (such as the European Community Innovation Survey); official R&D expenditures from accounting data[16]; and administrative intellectual property (IP) data (patents, trade marks and designs). Patents are considered to be reasonable aggregate

[16] However, these are generally poorly reported. For example, Griffiths and Webster (2004) find that 12.3 per cent of large Australian companies are patenting but not reporting any R&D expenditure.

measures of inventive output of manufacturing industries (Griliches 1990) but trade marks have been found to have broader application across all industries (Posner 2005; Greenhalgh and Rogers (2006); and Jensen and Webster 2004).

None of these substitute variables are without flaws. Users of these data must deal with three problems: the heterogeneity of the artefact being measured, the tension between using static measures to capture dynamic processes and biases in the coverage of activities or firms. Although heterogeneity complications are endemic in economic measurement, they may be particularly acute in innovation analysis where it is well-known that the vast majority of patents have no economic value (see Harhoff et *al*. 1999 for example). Compounding this problem is the fact that, relative to commonplace production systems, innovation is a continual process in which products and processes are in a constant state of flux. The innovation process follows a complex pathway which involves changing and irregular feedback loops generated by on-the-job learning, trial-and-error and other discontinuities. In attempting to make innovation measurement tractable, some assumptions about the beginning and end of the innovation pathway have to be made (either implicitly or explicitly). The further we progress down the innovation pathway, the more we are defining outcomes rather than the process itself.

It is also well-known that there are biases in each indicator's coverage by type of intangible capital and type of firm.[17] R&D and patent data, for example, are known to be biased towards production capital and probably have no relevance to organisational, marketing or human capital investments. Similarly, patents may be a poor proxy in fields not well covered by patent laws (e.g. services), where appropriation can be more effectively achieved by other methods (e.g. secrecy, copyright or keeping-ahead), where inventions are hard to imitate, and where firms do not have the resources to support litigation and enforce intellectual property rights (see Griliches 1990; Arundel and Kabla 1998).

[17] Patenting rates vary across process and product lines and accordingly, patenting rates are a biased indicator of intangible investment.

Usage of Intellectual Property by SMEs

Since IP rights are both costly to acquire and to enforce, it is often argued that small-medium sized enterprises (SMEs)[18] are disadvantaged vis-à-vis large firms in their ability to use IP rights to appropriate returns from their innovative efforts (Cordes, Hertzfeld and Vonortas 1999; WIPO 2003; Macdonald 2004). While this view is largely based on casual empiricism, Arundel and Kabla (1998) recently provided some confirmatory evidence in a study that demonstrated that small European firms have a lower propensity to patent their innovations than large firms.

In Jensen and Webster (2006), we examined whether firm size affects the intensity of IP usage in Australia. In particular, we examined whether applications per employment for commonly-used types of IP rights such as patents, trade marks and registered designs varies across firms of different size. Although firms often rely on other non-legal appropriability mechanisms such as secrecy and first-mover advantages, we argue that any diminution in the effectiveness of one type of appropriability mechanism should affect the overall incentive to innovate, ceteris paribus. In order to analyse this issue, we used data from IP Australia on the application rates for patents, trade marks and designs by individual firms in Australia and data from the Australian Bureau of Statistics (ABS) on industry characteristics. These data are then match-merged with data from IBISWorld and Australia On-Disc which contain data on firm characteristics.

The potential under-investment in innovative activity by SMEs is an important policy issue since it suggests that an important source of creative potential in the economy may be neglected. In Australia, SMEs account for 62 per cent of total employment and almost half of value-added (ABS 2001). If the potential contribution of the SME sector is being constrained by impediments to the use of the IP system – such as the lack of access to financial assistance to acquire a patent or enforce the patent once granted – then there may be a strong case for government intervention. In fact, the Australian government has been active in the creation of special programs to encourage SME innovation. For example, the Federal Government announced in May 2004 an injection of an additional $200 million per annum across a range of programs in support of innovation by SMEs.

Observed differences between large firms and SMEs in their use of the IP system could be caused by a couple of factors. On the one hand, they could be due to differences in the actual level of

[18] We define a small firm refers to an independent business that employs up to 20 people, while a medium size business is one that employs between 20 and 200 people and has assets under $200m.

innovation. That is, large firms might patent more because they actually do more innovation. Alternatively, large firms and SMEs might innovate at the same rate but SMEs might be less able, for instance, to access the finance necessary to apply for a patent (which is costly once registration fees and patent attorney fees are considered).

The first of these effects – the relationship between firm size and innovation – is well-researched in the economics literature. Schumpeter (1934), for example, argued that large firms are more innovative since they have the retained earnings with which to re-invest in risky innovative activities. There may also be an advantage to being large if there are economies of scale in R&D production and the innovative process more broadly. If true, this implies that the marginal cost of innovation will be lower for large firms. However, the current consensus in the empirical literature is that this only holds consistently across different industries: within an industry, size does not matter. Innovation may also be more cost efficient when firms are able to amortise the fixed innovation costs over larger production runs (Schumpeter 1976; Cohen and Levinthal 1989). Given that large firms typically have larger production runs (and therefore revenues) than SMEs, this suggests that large firms will be more able to spread the fixed costs of innovation thereby lowering the average total cost of a given innovation.

However, a contrary argument is that SMEs may have some distinct advantages in innovation since they may have better information about the function that relates expected profitability of an innovation to development expenditure (see Arrow 1983), that they better protect and reward the innovator (Acs et *al.* 1997) and that they may have less inertia than large firms and are therefore able to recognise (and take advantage of) market niches (see Rogers 2004). It is perhaps not surprising therefore that the empirical literature on the relationship between firm size and innovative activity is inconclusive. Compounding the analysis is the scarcity of evidence on the *intensity* of innovative activity by firm size. Most empirical studies measure innovation as a binary variable, thus providing the tautological result that the larger is the firm, the more likely it is to have had at least one incidence of innovative activity over the relevant time period. What is of interest, however, is innovative activity per employment.

The second effect – the relationship between firm size and IP usage – is less well-researched. The small number of studies which have studied this effect includes Iversen (2002) and Hanel (2004). Often, however, these studies have analysed the firm size/IP usage relationship by simply comparing the number of IP rights held by large and small firms. Such an approach is flawed since it fails to take account of the fact that it is the *intensity* of usage not the *absolute level* of usage that is of interest: in absolute terms, large firms do more of everything by virtue of their size, so it should not surprise (or concern) us if empirical evidence confirms this. What is of interest is whether there are systematic differences in the number of IP rights held by SMEs and large firms after adjusting for their innovative potential.

Our results indicate that SMEs are more likely to apply for patents, trade marks and designs given their innovative potential, than large enterprises. Thus, there is no strong positive evidence supporting the contention that SMEs are disadvantaged. There are a number of different ways to interpret these results. First, it may indicate that the SME sector may actually have a higher rate of innovation intensity than large firms. In other words, we may observe that SMEs use the IP system more than large firms because SMEs actually do more innovation than large firms. This may be intrinsic or an outcome of government SME programs. Second, it may reflect the fact that SMEs have greater incentives than large firms to obtain IP protection. For example, it has often been noted in the literature that SMEs have a greater need for strategic alliances for production and marketing, or more generally, that more of their transactions occur through the external market rather than within the firm. In these cases, the lower level of trust between transacting parties makes legal contracts – such as those offered by patents – more attractive to both parties. Thirdly, it is also possible that many of the anecdotally-cited disadvantages of using the IP system claimed by the SME sector apply equally to large firms. Therefore, their comparable usage rates may belie their intrinsic disadvantages in IP usage.

Two caveats must accompany our findings. The first is that we cannot distinguish industries and sectors where market failure problems are known to be acute from those where it is less severe. Clearly, differential rates of IP usage in the latter industries are of less concern than the former. If the marginal cost of producing items with embodied intellectual capital is close to the average cost, and subsequently the social benefits are equivalent to private benefits at the margin, then there is little welfare-enhancing role for a legally-based IP appropriation mechanism. As such, we would not be duly concerned about low rates of patenting and trademarking in these industries and sectors. Secondly, our analysis of the mechanisms to correct for market failure is limited to IP rights since comprehensive data on the use of other forms of appropriation are not available.

Accordingly, we cannot determine whether firms with lower IP rates compensate by using other forms of appropriability – such as trade secrecy – or simply have lower total appropriability. While it is only the latter case that gives rise to public concern, we must unfortunately treat the two as synonymous here.

Innovation and Firm Survival

It has often been argued that innovation is the essence of firm survival since only those firms that are able to successfully innovate are able to establish and maintain a competitive advantage in the market (Bruderl, Preisendorfer and Ziegler 1992; Wagner 1999; Audretsch and Mahmood 1995). However, this line of argument ignores the well-known fact that innovation, especially new-to-the-world innovation, is subject to fundamental uncertainty. Consequently, studies of firm survival using measures of innovation based on "successful" innovation often erroneously infer a positive causal relationship between innovation and firm survival.

To correct for this confusion, we use two measures of innovation – capital and investment – in order to examine their affects on firm survival whilst controlling for observable industry and macroeconomic factors. We collated data at the firm-level (e.g. intellectual property [IP] stocks and flows), the industry-level (e.g. gross entry rate) and the economy-level (e.g. change in GDP growth). Firm-level data were collected on an unbalanced panel of approximately 290,000 Australian companies per annum over the period 1997-2003. Given this data, a flexible age-death relation is then estimated using a piecewise-constant exponential hazard rate model (Lancaster 1979).

As expected, we find that new-to-the-world innovation investments and innovation capital have disparate effects of a firm's chances of survival once other factors such as market conditions, cost and access to finance, and industry risk profile have been taken into account. The explanation of this result is that investment into innovation – as depicted by the company's current applications for patents – is a risky activity which lowers the likelihood of survival. However, this does not mean that average returns from innovation are negative, only that current innovative activity has a negative effect on the median firm, ceteris paribus. Conversely, past successful innovations have a clear positive effect on survival: firms that have patents which are worth renewing also possess the bundle of financial, management and economic capabilities that raises their chances of survival.

The result for trade marks was quite different, possibly because the presence of trade marks reflects the occurrence of imitation or new-to-the-firm innovations. Our finding that trade mark applications were associated with higher survival rate may indicate that trade marking investments are less risky than patented investments or that the innovative activity associated with the launch of a trade mark is a less risky form of innovation than patent related innovations. Aside from the role of innovation on firm survival, another noteworthy finding from a policy perspective is the large effects of macroeconomic conditions and interest rates on survival. Accordingly, policies designed to curb inflation through artificially depressing the macro-economy, have clear adverse effects on firm survival.

Conclusions and Policy Implications

Innovation is regarded by economists as the fountainhead of productivity and economic growth. Given the well-known market failure associated with the production and sale of knowledge, governments around the developed world have introduced various policies designed to enhance appropriability, including the creation of intellectual property rights. While IP rights induce investment in the creation of new knowledge, they also inhibit knowledge spillovers. In this submission, we distill the results from a number of our recent research projects which have an important bearing on contemporary policy issues associated with the use of IP rights. Much of these issues relate to balancing the inherent trade-off between incentives and spillovers.

There are a number of important innovation policy issues raised in our submission which the Australian Government should address. In particular:

1. There is mounting evidence that the quality of patents has fallen in recent years: examination standards have fallen and almost anything is inherently patentable (see FTC 2003; Jaffe and Lerner 2004, for example). This trend is alarming given the fact that patents can be used to create patent thickets, patent submarines and other

undesirable economic effects. Policy makers in Australia should heed these danger signs and consider ways in which the patent system can be improved.

2. Recent anecdotal evidence suggests that the *Madey v Duke* court decision in the US which narrowed the scope of research exemptions from patent law for university researchers may have serious consequences for the progress of science (see Nelson 2004 for an overview). Although more rigorous empirical work needs to be conducted on the potential effects of this issue, the Australian Government should be proactive and ensure that important public sector research is not unnecessarily impeded by patent laws.

3. Patents are designed to induce investment in innovation. Despite recent efforts to harmonize international IP laws and protocols, there is increased evidence that different countries do make different decisions with regard to patent examinations, part of which may be explained by strategic behaviour by national patent offices. Such a situation can only serve to undermine the *ex ante* incentive offered by patents by attenuating firms' ability to appropriate the economic rent in multiple jurisdictions from its investment.

4. Economic analysis of the effects of investment in innovation is constrained by the fact that the accounting system addresses intangible capital imperfectly – it is typically expensed rather than being treated as an investment. Until innovation investments are properly treated in accounting systems, the real effects of innovation on form performance and national prosperity will remain shrouded. Corporate and public policy makers should aim to correct this shortcoming.

5. SMEs play an important role in the Australian economy. Considerable attention and effort is taken by the Australian Government to ensure that commercialization opportunities for SMEs are not abandoned due to lack of funding opportunities. Our research shows that, in terms of usage of the IP system, SMEs do not lag behind large firms. This could either be because existing Government programs have been successful or because the perceived disadvantages for SMEs are not as great a hurdle as expected. Nevertheless, the Government should continue to monitor the efficacy of its numerous R&D support and commercialization programs.

6. There is evidence that current investments into innovative activities are risky enough to shorten firm expected median life-time. Firms however that have had some success in innovation have considerable longer life spans than those who do not. However, both these effects are dwarfed by macroeconomic factors which have the greatest affects on firm survival.

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