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Abstract

The effects of innovation on firm performance is conventionally analysed using R&D or patent applications as measures for innovation capital and market value as the measure of firm performance. We argue that such studies fall short in three important respects. First, the proxies used for innovation capital are flows not stocks as the theory suggests. Secondly, while they are derived from the theory of intangible capital, their estimations ignore other important intangible capital such as organisational and marketing capital; and thirdly, by using market value, the studies heroically assume that stock markets work efficiently. In this paper, we develop a model of the effects of intangible capital, including, but not limiting to, innovation capital, on firm profits, using new measures for the former. Our results indicate that profits vary, *ceteris paribus*, according to the type of IP rights held by the firm, the age of the firm, the size of the firm, and the lifespan of the IP right.

1 Introduction

Numerous studies have attempted to address the impact that innovation has on firm performance. The standard approach begins with an identity between market value and the firm's capital, and then assumes that the unmeasured intangible part of capital can be represented solely by innovation capital. In estimation, the latter is proxied by R&D, patent applications or new product launches.[1] In theory however, intangible capital also includes human, organisational and marketing capital and it is desirable that some attempt is made to capture their effects on firm performance as well. Ignoring these other forms of capital is likely to bias the estimated coefficients on innovation capital. Many difficulties are encountered measuring all forms of intangible capital, but given the policy interest in innovation, the focus of much effort has been on developing better measures of innovation capital activity using existing data on patent rights (see Griliches 1990, Jensen and Webster 2004, Hall, Jaffe and Trajtenberg 2005). In this paper, we devise and test a new approach which includes patents in force rather than patent applications and a limited number of other measures to proxy for intangible capital more broadly, such as trade marks and registered designs and company age. In addition, we use actual profits rather than the present value of expected profits to depict firm performance.

One limitation of our study is that we are unable to analyse the profitability of investments in innovation-related activities since data on the costs of these investments are not available. However, given that we use accounting data on realised profits, our model can be used to provide an estimate of the average contribution of intellectual property (IP) rights to current revenues or profits.[2] Our results indicate that profits vary, *ceteris paribus*, according to the type of IP rights held by the firm, the age of the firm, the size of the firm, and the lifespan of the IP right. In addition, there were clear trends in the effects of new IP applications on profits. Both trade marks and registered designs showed clear signs of rising value over time but somewhat surprisingly the pattern for patents is less clear.

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[1] There is a large literature here, including but not limiting to Griliches (1981), Pakes (1985), Jaffe (1986), Griliches, Hall and Pakes (1991), Blundell, Griffith and Van Reenen (1999), Hall and Kim (2000), Toivanen, Stoneman and Bosworth (2002), Bosworth and Rogers (2001).

[2] See Hunter, Webster and Wyatt (2005) for a discussion of this issue.

The findings from this study have obvious relevance for financial analysts, investment advisors and company managers. Unless they can adjust published company data for differences, over time and across companies, for investment in innovative activities, they cannot tell whether changes in the return on assets or equity are due to a profound difference in the actual rate of return to all investments or is a mirage caused by differences in the quality of innovation activity. Understanding what their accounting system is *not* telling them should be of major concern to managers. For economists and public policy makers, our findings relate mostly to the issue of monopoly pricing. What may at first sight appear as monopoly profits, based on returns to equity, may in fact represent quasi-rents, or 'normal'[3] returns to investment in innovative activities. Accordingly, analysts interested in monopoly pricing should at a minimum account for these unmeasured intangible investments.

This paper begins with some background on the empirical difficulties associated with the measurement of innovative activity, firm performance and the relationship between the two. We then develop a simple model of profits, discuss the data set used and, in particular, estimation issues that arise from the use of accounting and administrative enterprise data sets. Bearing these complications in mind, we then present estimates of the determinants of company profits.

2 Innovative activity and firm performance

2.1 Defining and measuring innovation

Innovation is defined in this paper as the introduction of new-to-the-firm ideas and methods into a workplace. While it is generally thought that innovation is the cornerstone of generating productivity gains and superior company performance, applied studies of the effects of investment in innovative activity are burdened by the problem of how to measure innovative activity. Typically, economists have used proxies for innovation activity such as R&D expenditure or counts of IP rights. However, these proxies are generally used cautiously since it is known that they are highly imperfect and that they are 'known' to favour one type of activity over another. There is evidence, for example,

[3] Clearly what is normal depends on the consensus over what is a normal premium for the risk associated with the particular investment in question – not an area of great consensus.

to suggest that patents are biased towards manufacturing firms and those that produce goods rather than services.[4] Patents are also known to be "noisy" indicators of innovative activity as a result of the fact that only a small proportion of all patents granted have any economic value.[5] Similarly, R&D expenditure suffers from the problem that it is generally reported only by large firms. Using it as a proxy for innovation, therefore, would erroneously lead one to conclude that small firms are less innovative than large firms.

There are several general characteristics of the innovation measurement problem. First, the innovation process follows a pathway that may take many years from start to finish: it is not a point in time. In order to measure innovative activity, therefore, some decisions must be made about what stage of the innovation pathway our indicators should come from. Secondly, by definition, innovation involves novelty which makes it virtually impossible to quantify all new products and processes in any meaningful way since each innovation is unique. As a consequence of this, both inputs (such as R&D) and outputs (such as patents) of the innovation production process are highly heterogeneous which makes quality-adjustment difficult and inter-temporal and cross-sectional comparisons of performance problematic. Thirdly, much of the activity that is categorised as innovation is largely unobservable because it occurs within organisations and is not reported in any conventional statistics.

Notwithstanding these problems, many previous studies have used flows of patent and other IP applications in each year as a proxy for innovative activity (Griliches, Pakes and Hall 1987, Lanjouw, Pakes and Putnam 1998, Hall 2000). More recent studies have weighted these flow measures by indices of value such as forward citations and renewal rates (Lanjouw *et al.* 1998, Schankerman and Pakes 1986, Hall, Jaffe and Trajtenberg 2005).[6] The main difficulty with the forward citation-adjusted and renewal-adjusted measures of patent applications is that there are significant truncation issues: recent patent applications have not had time to accrue many citations and do not yet qualify for renewal. Thus, weights for current and recent years are unusable or biased.

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[4] Jensen and Webster (2004).
[5] Harhoff *et al.* (1999).
[6] For evidence that the number of forward citations is associated with patent value see Jaffe, Trajtenberg and Fogarty (2000).

Another approach to the problem of finding a suitable proxy for innovative activity is to compile a composite measure using multiple indicators (Hagedoorn and Cloodt 2003). Although an imperfect solution, this approach attenuates some of the biases associated with using a single indicator. For instance, an index can be constructed which includes different types of IP rights (patent, trade marks and designs) or which includes both R&D expenditure and IP rights. There is another way in which proxies for innovative activity can be improved. Given that investment in innovation is lumpy, the use of flows of IP applications introduces some problems. What is really of interest is the stock, rather than the flow, of IP rights. Unlike the citation and renewal-adjusted patent variables, this variable is not sensitive to year (i.e. more recent years are not biased downward as in the case of forward citations and renewals for applications) and the whole time series of patent stock data is valid. Accordingly, this is the approach to measuring company innovative activity that is adopted in this paper. Unlike Hall, Jaffe and Trajtenberg (2005), our stock measure is the actual number of patents in force in each year, and is not an estimate based on past applications.

2.2 The effects of innovation on company performance

Profitability – the return to a given level of invested funds – is the definitive measure of the success of an innovation to a company and therefore is the appropriate measure of company performance. Unfortunately, without data on the amount spent by the company on the whole innovation process, it is not possible to calculate a rate of return to the investment in innovation and thereby estimate whether it is above, below or at the normal rate.[7] The lack of accounting data on the costs of innovation is one of the main deficiencies in existing datasets which prevent us from making empirical judgments about whether firms under- or over- invest in innovation, or whether companies have earned at least a normal rate of profit from past investment strategies.

Given this data constraint, it is not possible to analyse the effects of innovative activity on profitability. As a consequence, most studies which examine the relationship between innovation and company performance using market value or profits as the dependent variable are only measuring the returns *from that time forward*. Griliches

[7] In addition, we need to have some knowledge of what the normal rate of profit – appropriately adjusted for uncertainty – is. Not a trivial issue.

(1981), who pioneered the market value approach, predominantly used it to establish the place of innovation activities in the missing accounting data. Since then, the basic format of his equations has been employed to test whether secondary interactive characteristics make patents or R&D activity more or less valuable, *ceteris paribus*.[8] These interactive characteristics have included market power (Connolly, Hirsch and Hirschey 1986, Blundell *et al.* 1999, Toivanen *et al.* 2002, Bosworth and Rogers 2001), a measure of the effectiveness of patents for preventing imitation (Cockburn and Griliches 1988), the debt-ratio (Toivanen *et al.* 2002), sales revenue (Hall 1993, Toivanen *et al.* 2002, Bosworth and Rogers 2001, Hall and Oriani 2003) union power (Connolly *et al.* 1986), and profits or cash-flows (Bosworth, Wharton and Greenhalgh 2000). Industry dummy variables are often included to capture more ill-defined factors such as import penetration which are believed to vary by industry but difficult to collect on a firm-by-firm basis.

Overall, these studies find that patents are more valuable – as judged by the stock market – in firms where patents are regarded by managers as being more effective, in firms with lower debt ratios, and when the growth in firm's sales revenue is strong (although this result is not particularly robust). There was no clear evidence that market power affected the market valuations. Many studies also find that either new patent applications,[9] or R&D expenditure, have a positive and significant effect on the firm's market value, but not both together (see Toivanen *et al.* 2002 for example).

A second approach is to analyse whether the existence of an invention or innovation, as embodied in a registered IP title, contributes, with a time lag, to profit levels. Although this approach is less commonly used than current market value as the measure of company performance, it has a number of advantages. The first is that using realised profits captures actual rather than expected outcomes and therefore does not rely upon the assumption of efficient stock markets. Moreover, if the paper is seeking to inform stock brokers and finance analysists, it is circular to use stock market data to identify existing information inadequacies.[10] One downside is that unlike market value equations, profit

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[8] A limited number of studies have also used other innovation measures such as 'innovation counts' which are derived from mentions of innovations in trade journals or external expert assessments of a company's innovations. These measures are not widely available and usually only exist for limited time periods.

[9] See the summary in Bosworth and Rogers (2001), Table A1 and Hall (2000), Table 1.

[10] However, since some level of sale and purchase activity in the stock market is primarily concerned with the sale and purchase expectations of other traders, some degree of circular reasoning may be desirable.

equations require considerable (and unknown) time lags between the explanatory and dependent variable, or measures of the vintage of the capital stock. Nonetheless, it will be revealing to compare the stock market's valuation of IP rights with a valuation based on actual profits, which we do in the penultimate section of the paper.

One well-known paper that examines the relationship between innovation and profits is the paper by Geroski, Machin and Van Reenen (1993) which estimates the effects of firm level innovation counts on its profit margin (profits before interest and tax as a ratio of revenue). The authors found a small but positive relationship between the number of commercially successful innovations in any one year and profit margins. This outcome is not surprising since it follows, almost tautologically, that a commercially successful innovation will be associated with higher revenues, and thus higher profit margins, *ceteris paribus*. Even if a count of all innovations (i.e. successes and failures), had been used, such a finding would not signify profitability since it does not include any measure of the innovation costs, which were sunk at the time the innovation was documented. The appendix illustrates the difference between profit margins and profitability. [11]

Despite this shortcoming, this paper has been cited as evidence of profitability of innovation both in the paper itself and in subsequent work (see Roberts and Amit 2003, Bleaney and Wakelin 2002, Lockett and Thompson 2001, Haynes and Thompson 2000, Colombo and Delmastro 2001, Brouwer and Kleinknecht 1999, Daniels 1999, Roberts 1999, Aiginger and Weiss 1998, Geroski, Van Reenen and Walters 1997, Van Reenen 1997). To the extent the costs of the innovation are largely sunk at the time of launching it on to the market, the profit margin will rise simply because revenues have risen. A rise in current revenues is clearly not the same as a rise in either long-term profits or profitability, which both depend on an enumeration of costs.[12] Despite these important conceptual differences, profit margins have been implicitly treated as a credible measure of firm performance in the literature (see for example Hanel and St-Pierre 2002, Thompson 2001, Klette and Griliches 2000, Blonigen and Taylor 2000).

[11] As such profit and market value measures only reflect the revenues minus costs of the innovation from that time forward. All sunk costs should have already been factored into to share prices or reported profits (since the R&D costs are customarily expensed).

[12] There are further flaws in the use of profit margins as a correlate with profitability. Because profit margins include profits before interest is deducted, more capital- or investment-intensive firms will tend to have higher profits.

3. Modelling profits

Given the problems with using market value in innovation studies, the approach adopted in this study is to use profits as a measure of firm performance. We model profits in the following manner. The annual rate of profitability of shareholders' investments is defined as the level of profits net of returns to debtors (interest) and depreciation in a given year, divided by the present value of all investments made by shareholders in the company since its inception. Investments include all injections of equity through new share issues and retained earnings, the latter being in effect a simultaneous withdrawal and re-investment by shareholders. In accounting parlance, shareholders' funds (equity), at the start of the year, should represent the present value of investment at that time if all asset values are re-valued for unanticipated market changes and inflation and if all investment expenditures in both tangible and intangible goods are classified as investments (and subsequently added to assets).

One pervasive problem with studies on the relationship between innovation and performance is that only a very narrow range of intangible investments, such as patent attorney fees, and externally bought IP (i.e. not created by the firm) are included as investment expenditure and are accordingly included in shareholder funds. The most common practice in Australia and elsewhere is to immediately expense most intangible investments, such as workforce training and the wages of R&D staff.[13] To correct for this mis-assignment in intangible investments, economists try to create measures which mimic the true value of company intangible assets. Flows of IP applications are commonly used (for example Hall 2000 and studies listed above in previous section) presumably because data on renewals is not available. However, a more appropriate measure is an asset or stock variable.

Company profits (plus expensed investment expenditures) are determined by:

- Shareholders' funds adjusted for missing intangible assets, V; and
- The company's rate of return on shareholder funds, z, which can be disaggregated into, the default-free rate of interest (set by the central bank), r; the additional normal rate of profit for undertaking business, n; returns to

[13] AASB 1011, *Accounting for Research and Development Costs,* requires businesses to expense R&D costs except when they are expected beyond reasonable doubt to be recoverable.

monopoly power, including (in)efficient management and workers, *m;* compensation for abnormal risk, *x*; and good or bad fortune, ε .

Net profits (after interest and depreciation) π for enterprise *i* in year *t* can be expressed as the returns to capital services contributed by the owners' assets, and are defined as:

$$\pi_{it} \equiv z_{it} V_{it} \tag{1}$$

$$\pi_{it} \equiv (x_i + m_i) V_{it} + (r + n) V_{it} + \varepsilon_{it} V_{it} \tag{2}$$

where *x* and *m* are time invariant but enterprise specific, and *r* and *n* are common across the whole economy and are also time invariant. *V* is by definition the sum of tangible and intangible assets less the total value of liabilities. Let

$$V_{it} \equiv \left(IK_{it}^{*} + IK_{it}^{\times}\right) + TK_{it} - L_{it} = IK_{it}^{*} + S_{it} \tag{3}$$

where IK^* is the value of intangible assets missing from the accounts, $IK^{\times}$ is the value of intangible assets as formally recorded in company accounts, *TK* is the value of tangible assets, *L* are company liabilities and *S* is shareholders' equity. Thus, net profits can be expressed as:

$$\pi_{it} \equiv (x_i + m_i)(S_{it} + IK^*_{it}) + (r + n)(S_{it} + IK^*_{it}) + \varepsilon_{it}(S_{it} + IK^*_{it}) \tag{4}$$

The first part of this equation $(x_i + m_i)(S_{it} + IK^*_{it})$ depends on the rate of return to monopoly power and the abnormal uncertainty facing the firm ($x_i + m_i$), both of which we assume to be time invariant. If we write S_{it} and IK^*_{it} in terms of deviations from their firm means, say $S_{it} = \overline{S}_i + \nu_{it}$ and $IK^*_{it} = \overline{IK}^*_i + e_{it}$, then equation (4) can be rewritten as

$$\pi_{it} = \alpha_i + (r + n)\left(S_{it} + IK^*_{it}\right) + u_{it} \tag{5}$$

where

$$\alpha_i = (x_i + m_i)\left(\overline{S}_i + \overline{IK}^*_i\right) \tag{6}$$

$$u_{it} = \varepsilon_{it}\left(S_{it} + IK^*_{it}\right) + (x_i + m_i)(\nu_{it} + e_{it}) \tag{7}$$

In the estimations discussed below, the α_i are treated as firm fixed effects while u_{it} was treated as a random error. Assuming that the unobservable intangible assets *IK** are correlated with a company's innovative activity as represented by its stock of registered IP, we can approximate *IK** with indices of intangible investment. We assume that this index is constructed as:

$$\begin{aligned} IK*_{it} &= a_1 P_{it} + a_2 LifeP_{it} + a_3 AppP_{it} * time + a_4 CoAge_{it} * P_{it} + a_5 S_{it} * P_{it} + a_6 Pend_{it} \\ &+ b_1 T_{it} + b_2 LifeT_{it} + b_3 AppT_{it} * time + b_4 CoAge_{it} * T_{it} + b_5 S_{it} * T_{it} \\ &+ c_1 D_{it} + c_2 LifeD_{it} + c_3 AppD_{it} * time + c_4 CoAge_{it} * D_{it} + c_5 S_{it} * D_{it} \\ &+ d_1 CoAge_{it} + d_2 S_{it} * CoAge_{it} \end{aligned} \qquad (8)$$

where *P*, *T* and *D* represent stocks of the firm's patents, trade marks and designs, *LifeP*, *LifeT* and *LifeD* represent the average life, in days, of each IP title, *AppP*, *AppT* and *AppD* represent new applications of each IP type, and *CoAge* is the number of years since the company was first registered with the corporate regulator. The stocks of patents include those granted *P* and those whose applications are pending *Pend*. The average age of the granted patent (*LifeP*), trade mark (*LifeT*) or design (*LifeD*) has been used as an indicator of the quality of the stock. The IP application variables *AppP*, *AppT* and *AppD* are interacted with time to capture any trends in the values of applications. We include *CoAge* as a rough approximation of the accumulation of other intangible assets such as the acquired knowledge and capabilities of the workforce, marketing, distribution and organisational capital. We have also interacted the IP stock variables with company age *CoAge* and shareholder funds *S* to test whether profits per title are affected by the age or the size of the firm. The trade mark variables should also represent the firm's marketing capital. The parameters, *a, b*, *c* and *d,* represent the average costs associated with the creation of each title.

Equations (5) and (8) form the basis of an equation for estimation. The variables in the estimating equation are S_{it} and those used to define the index for IK^*_{it}. The coefficients on the *S* and IP variables will be estimates of $(r+n)$, $(r+n)a_1,\ldots,(r+n)a_5$, $(r+n)b_1,\ldots,(r+n)b_4$, $(r+n)c_1,\ldots,(r+n)c_4$, $(r+n)d_1$ and $(r+n)d_2$, respectively. In one of our estimations S^2 was included in addition to *S* to capture possible nonlinear impacts of firm size. Doing so changes the meanings of the effected coefficients accordingly.

4. Data and model estimation

Annual 'parent' enterprise level accounting data from the IBISWorld database have been matched across to applications for patents, trade marks and designs by Australian firms, collected from IP Australia. A match was made if the applicant name was identical to either the name of the parent or one of its subsidiaries.[14] IP stock variables were then constructed from application and renewal data, also collected from IP Australia.[15] The two types of patent stocks were constructed: a stock of patents granted (and still valid) and a stock of patents pending. The latter are more recent applications but can sometimes be up to 6 years old.

All Australian-located parent firms and the highest accounting unit of foreign firms with an annual turnover over $50m were included in the data set.[16] Only public and private companies, trusts, associations, cooperatives and partnerships were included in our estimations, but as shown in Table 1, our sample was predominantly public and private companies from 1989 to 2002. In 2002, there were 1922 such entities, but 3950 over the whole 14 year period. Just under three quarters of all entities reported a profit figure, and these were disproportionately public companies and cooperatives. Because we are interested in the stock of accumulated investment funds at the start of the profit period, we defined S_{it} as shareholder funds from the previous year. In the results below it is reported as lagged shareholder funds.

Table 1: Companies by type, 2002

Company type	Number	Percentage	Percentage reporting profits
Association	14	0.73	78.57
Cooperative	17	0.88	100.00
Public company	972	50.57	58.64
Private company	919	47.81	86.18
Total	1,922	100	72.32

Source: Companies selected from the IBISWorld dataset.

[14] A company is defined as a subsidiary of a parent if the latter owns at least 50 per cent of the former.

[15] It is possible that the intellectual property for an innovation made by a local enterprise is owned in the name of its foreign parent company. A small survey by the authors of 91 patenting companies in 2002 and 2003 revealed that, in general, 80 per cent of patents were taken out in the name of the local entity and only 14 per cent in the name of a foreign parent or subsidiary (the remainder being the inventor and 'other').

[16] It includes Australian owned companies and the highest accounting unit of Australian-located foreign owned multi-national companies.

Table 2 presents selected descriptive statistics of our sample. On average, companies were 25 years old with an average reported annual profit figure of $31.36m and shareholder funds of $230.7m (both 1989-90 prices). The average stock of patents and patents pending was 1.098 and 0.085, with the average stock of trade marks and designs being 21.47 and 2.151. For firms that have a granted patent, the average tenure of the patent was 2173 days (about 6 years), for firms that have a trade mark, the average tenure of the trade mark was 4120 days (11 years) and for firms that had a design, the average tenure of the design was 2602 days (7 years).

Table 2: Descriptive statistics, company means, Australia, 1989-2002.

Enterprise type	Company age (years)	Net profit before tax (A$000)[a]	Lagged shareholder funds (A$000)[a]	Stock of granted patents[b]	Stock of patents pending[b]
Association	*5.4*	*$5,959*	*$92,855*	*0.10*	*0.03*
Co-operative	20.1	$6,424	$63,572	0.23	0.03
Proprietary company	23.8	$6,336	$50,085	0.54	0.04
Public company	27.3	$49,794	$367,586	1.68	0.14
Total	25.4	$31,364	$230,717	1.10	0.09
	Average life of patents (days)(c)	**Stock of granted trade marks(b)**	**Average life of trade marks (days)(c)**	**Stock of granted designs(b)**	**Average life of designs (days)(c)**
Association	*748*	*3.6*	*2315*	*0.25*	*2265*
Co-operative	2017	17.7	4632	0.61	2127
Proprietary company	2165	17.8	4518	1.31	2700
Public company	2188	25.4	3773	3.04	2543
Total	2173	21.5	4120	2.15	2602

Notes: (a) All financial variables have been deflated by the CPI (1989-90=100). (b) Enterprise means for patent and trade mark counts include zeros. (c) Mean for enterprises with positive granted patents, trade marks or designs only.

Equation (5) was initially estimated as a fixed effects panel model using ordinary least squares (OLS). The results of this estimation (model 1) are presented in Table 3. The results from this estimation do not appear to be particularly promising; the coefficients were large and sensitive to a small number of large observations.

Furthermore, as is suggested by the definition of the equation error u_{it} that appears in equation (7), there is heteroskedasticity in the error terms. In order to correct for the non-normal errors, we tried using a generalized least squares (GLS) approach, which allows for a heteroskedastic variance specification with the error variance related to variables and subsets of variables appearing in the mean function. However, the GLS estimations also turned out to be sensitive to variable selection and heavily influenced by a relatively small number of observations. Therefore, they are not reported here.

To overcome the sensitivity of the results to outliers, along with inevitable data inaccuracies and misreporting, we turned to some robust estimation techniques of the type described by Judge et *al*. (1988, Ch.22). The first of these is a firm fixed-effects model (model 2), which was estimated using a least absolute deviations estimator (LAE). All observations are expressed in terms of deviations from their firm means, as is customary when computing OLS estimates of the fixed-effects model. The results of the LAE estimation are presented in the second column of Table 3. As a result of the fact that the very large observations are given less weight in an LAE estimation relative to standard OLS (which squares the differences), the coefficients (and the standard errors) in this model look more robust. One caveat to note is that the LAE model does not directly account for the heteroskedasticity problem noted earlier.

In the second robust estimation (model 3), we chose an alternative robust estimation procedure known as trimmed least squares (see, for example, Judge et *al*. 1988, p.905). This discards the very large observations which appear to have an undue influence on the coefficients.

5. Results and analysis

The results from estimating the three models appear in Table 3. As noted before, the results from model 1 do not appear to be robust: some of the coefficients are far too large and a number of them are insignificant. An analysis of the data revealed that a number of observations were affecting the size and significance of the OLS estimates considerably. Many of these problems were addressed by using the LAE approach to model estimation (model 2). The results from model 2 show that higher profits are associated with both the measures of innovative capital and those which are intended to embrace intangible capital more broadly. With respect to the former, more numerous and older stocks of registered patents, are linked to higher profits. The latter implies that renewed patents are associated with higher average profits. Moreover, the average value of patents has been rising over time. By contrast, estimation of the one per cent trimmed model finds no trend in the value of applications. In two of the three estimations, the average number of patents pending appeared to have a larger effects on profits than registered patents in force, but the estimates were only significant in the LAE estimation.

The findings for trade marks is fairly consistent between models. Stocks of trade marks in force are strongly associated with higher annual profits, but the maturity of the mark does not appear to have any effect. On the other hand there is a strong positive trend in the contribution of the average trade mark to profits over the 14 year estimation period. By contrast, the results for designs are fairly erratic hard to interpret. The main consistent finding was a rise in the value of designs over time.

Focussing on the broader intangible capital measures – essentially the company age related variables – all three models find that IP stocks have a lower impact on profits, the older the company. However, being an old company per se, has a positive effect on annual profits, we suggest because of the accumulated intangible capital in the form of organisational, marketing and goodwill capital.

If we interpret the values of the coefficients in model 2 literally then an additional registered patent will conservatively increase the annual profits by A$235,460 (in 1989-90 prices). Note that the figure is much larger if we were to use the results from either models 1 or 3. However, the specification of the estimated equation does not allow us to separately identify the value of the invention encoded in the patent application from complementary, or merely associated, enterprise innovations and investment, other than those correlated with the age of the company. These may include workforce training, minor unpatented innovations and technology transfers, organisational change, *inter alia*. In addition, the equation says nothing about the rate of return from investing in patented inventions and trademarked products. Data on the investment costs are required for a calculation of the rate of return. Not only are these costs excluded in our data set, but they are by convention not separately identified in company accounts around the world.[17]

Table 3: Determinants of profits (thousands of dollars), Australian companies, 1989 to 2002.

Dep. Var.: Net profits before tax ('000)$^{(a)}$	**Model 1** *Panel estimation using firm fixed-effects (OLS)*		**Model 2** *Panel estimation using firm fixed-effects (LAE)*		**Model 3** *Panel estimation using firm fixed-effects (1% trimmed)*	
Tangible Assets	**Coef.**	**t**	**Coef.**	**t**	**Coef.**	**t**
Lagged shareholder funds ('00,000)	5.98	19.66	5.76	339.4	6.62	55.05
Patents						
Stock of registered patents	4875	6.81	235.46	5.90	743.8	2.65
Average tenure registered patent stocks (days)	6.40	3.72	0.27	2.85	2.29	3.35
Time × patent applications (trend)	169.07	1.49	23.164	3.67	-11.7	-0.26
Company age × stock registered patent	-125.57	-11.17	-11.21	-17.87	-22.92	-5.27
Stock of patents pending	2137	1.08	280.21	2.54	1142	1.45
Trade marks						
Stock of registered trade marks	1159	13.20	48.81	9.96	255.0	7.35
Average tenure registered trade mark stocks (days)	1.06	1.32	0.0	1.56	0.32	1.00
Time × trade mark applications (trend)	93.78	4.35	10.69	8.89	27.5	3.23
Company age × stock registered trade marks	-11.31	-7.60	-0.49	-5.88	-2.02	-3.43
Designs						
Stock of registered designs	568.65	1.01	-80.03	-2.54	109.2	0.84
Stock of registered designs squared	-2.48	-2.37	0.27	4.59		
Average tenure registered design stocks (days)	7.05	4.65	-0.12	-1.47	1.00	1.67
Time × design applications (trend)	364.76	4.80	7.92	1.87	68.7	2.43
Company age × stock registered designs	-10.57	-1.33	0.79	1.79	-7.07	-2.42
Other intangibles						
Company age	538.01	1.86	147.06	9.10	614.2	5.35
Constant	-33223	-4.06	13206	28.92	-8467	-2.615
No. observations	11929		11592		11675	
R-squared	0.11					

Notes: (a) All financial variables have been deflated by the CPI (1989-90=100).

6. Conclusions

Previous studies that have attempted to analyse the impact that innovation has on firm performance have used proxies for innovative activity such as R&D, patent flows or new product launches and proxied firm performance with market value (or, in some cases, a measure of profitability). These studies however do not model 'profitability' since they

[17] Systems for rectifying this deficiency are the subject of studies for new system of intellectual capital metrics.

do not include any figures on the cost of the invention. In addition, they do not attempt to account for other forms of intangible capital as indicated by the model. In this paper, we construct a new model of the relationship between realised firm profits and innovative activity which includes multiple indicators of innovation as well as variables to capture the broader dimensions of intangible capital.

Broadly speaking, our results confirm the standard finding that innovation has a positive effect on the performance of the firm, excluding prior sunk costs. Not surprisingly, the average effect of the stock of IP rights on realised profits is greatest for patents, followed by trade marks and (somewhat negatively) designs. The results from our estimations also show that older firms have a harder time extracting profit out of their patentable inventions; a result that could either be due to the fact that older firms are less effective in using patents to appropriate their returns or simply that their patents are less valuable; we cannot differentiate between these alternative conclusions here. Older firms also derived lower average profits from their trade marks than younger firms. These declining values may be due to a company lifecycle effect. On average, the value of patents, trade marks and designs has been rising over the period 1989 to 2002. In addition, the value of other intangibles, as represented by the age of the firm, rose over the same period – a finding consistent with macroeconomic measures of intangible capital (Webster 2000, Lev and Zarowin 1999).

Appendix

To illustrate the difference between profit margins and profitability, consider the hypothetical examples in Table 4. Both firms, A and B, have the same revenues and costs (expenses) but the first employs a labour intensive mode of production and limited shareholder funds are tied up in capital or fixed assets. In our example, the rate of profit is 1 and the profit margin 0.2. The capital intensive firm has the same profit margin of 0.2, but because of the large amount of funds tied up in the firm's fixed capital, returns a rate of profit of 0.1. Clearly the labour intensive mode of production is the most preferred from the perspective of 'total factor productivity', but profit margin measures of performance cannot distinguish between the two cases.

The case where there are two firms, B and C, one employing an intangible-intensive mode of production and the other employing a tangible-intensive mode of production has similar problems. Because expenditures on intangible investments, including innovation investments, are not capitalised in firms' accounts, they are not included in shareholders' funds and the timing of when they are expensed does not correlate to when they are used in production. As such intangible investment costs such as R&D are expensed and mistakenly appear as 'Costs' but, as shown in Table 4, the resulting capital item created does not appear in shareholders' funds. Even though the firm may be as capital intensive as a counterpart employing tangible capital and may – although we cannot tell from this example – have the same real rate of profit (were capital to be properly calculated), it appears to have a higher rate of profit but a lower profit margin.

Table 4: Hypothetical profit margins and profitability

Accounts for a given period	Firm A Labour intensive firm	Firm B Tangible capital intensive firm	Firm C Intangible capital intensive firm
R Revenues	500	500	500
C Costs (= expenses such as wages, inputs, depreciation, R&D)	400	400	450
π Net Profit before interest	100	100	50
K Shareholder funds at start of period	100	1000	100
r/π Rate of profits (= π/K)	1	0.1	0.5
PM Profit margin (=π/R)	0.2	0.2	0.1

References

Aiginger, K. and Weiss, C. R. (1998), Does it pay to be flexible? Empirical evidence on the relationship between labour demand flexibility and profit margins, *Review of Industrial Organization,* **13,** 543-556.

Bleaney, M. and Wakelin, K. (2002), Efficiency, innovation and exports, *Oxford Bulletin of Economics and Statistics,* **64,** 3-+.

Blonigen, B. A. and Taylor, C. T. (2000), R&D intensity and acquisitions in high-technology industries: Evidence from the US electronic and electrical equipment industries, *Journal of Industrial Economics,* **48,** 47-70.

Blundell, R., Griffith, R. and Van Reenen, J. (1999), Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms, *Review of Economic Studies,* **66,** 529-554.

Bosworth, D. and Rogers, M. (2001), Market Value, R&D and Intellectual Property: An Empirical Analysis of Large Australian Firms, *Economic Record,* **77,** 323-337.

Bosworth, D., Wharton, A. and Greenhalgh, C. (2000) Intangible assets and the market valuation of UK companies: Evidence from fixed effects models, In *Oxford Intellectual Property Research Centre*, Vol. 2/ April 2000 St Peter's College, Oxford.

Brouwer, E. and Kleinknecht, A. (1999), Keynes-plus? Effective demand and changes in firm-level R&D: an empirical note, *Cambridge Journal of Economics,* **23,** 385-391.

Cockburn, I. and Griliches, Z. (1988), Industry effects and appropriability measures in the stock market's valuation of R&D and patents, *American Economic Review,* **78,** 419-423.

Colombo, M. G. and Delmastro, M. (2001), Technology use and plant closure, *Research Policy,* **30,** 21-34.

Connolly, R. A., Hirsch, B. T. and Hirschey, M. (1986), Union Rent-Seeking, Intangible Capital, and Market Value of the Firm, *Review of Economics and Statistics,* **68,** 567-577.

Daniels, P. (1999), Economic gains from technology-intensive trade: an empirical assessment, *Cambridge Journal of Economics,* **23,** 427-447.

Geroski, P., Machin, S. and Van Reenen, J. (1993), The profitability of innovating firms, *Rand Journal of Economics,* **24,** 198-211.

Geroski, P. A., VanReenen, J. and Walters, C. F. (1997), How persistently do firms innovate?, *Research Policy,* **26,** 33-48.

Griliches, Z. (1981), Market Value, R&D and Patents, *Economics Letters,* **7,** 183-187.

Griliches, Z., Hall, B. H. and Pakes, A. (1991), R&D, Patents, and Market Value Revisited: Is There a second (Technological Opportunity) Factor?, *Economics of Innovation and New Technologies,* **1,** 183-201.

Griliches, Z., Pakes, A. and Hall, B. H. (1987), Patents as indicators of inventive activity, In *Economic policy and technological performance* (Eds, Dasgupta, P. and Stoneman, P.) Cambridge University Press, Cambridge, New York, New Rochelle, Melbourne, Sydney, pp. 97-121.

Hagedoorn, J. and Cloodt, M. (2003), Measuring Innovative Performance: Is There an Advantage in Using Multiple Indicators?, *Research Policy,* **32,** 1365-1379.

Hall, B. (1993), The Stock Market's Valuation of R&D Investment During the 1980s, *American Economic Review,* **83,** 259-264.

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

Hall, B. and Oriani, R. (2003) Does the market value R&D investment by European firms? Evidence from a panel of manufacturing firms in France, Germany and Italy, In *DRUID Conference and EEA-ESAM Conference* Elsinore and Stockholm.

Hall, B. H. (2000), Innovation and Market Value, In *Productivity, innovation and economic performance* (Eds, Barrell, R., Mason, G. and O'Mahony, M.) National Insititute of Economic and Social Research and Cambridge University Press, London and Cambridge.

Hall, B. H. and Kim, D. (2000) Valuing Intangible Assets: The Stock Market Value of R&D

Revised, In *University of California at Berkeley and Harvard University*.

Hanel, P. and St-Pierre, A. (2002), Effects of R&D spillovers on the profitability of firms, *Review of Industrial Organization,* **20,** 305-322.

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

Haynes, M. and Thompson, S. (2000), The productivity impact of IT deployment: An empirical evaluation of ATM introduction, *Oxford Bulletin of Economics and Statistics,* **62,** 607-+.

Hunter, L., Webster, E. and Wyatt, A. (2005), Measuring Intangible Investment, *Australian Accounting Review*.

Jaffe, A. B. (1986), Technological Opportunity and Spillovers of R & D: Evidence from Firms' Patents, Profits, and Market Value, *American Economic Review,* **76,** 984-1001.

Jaffe, A. B., Trajtenberg, M. and Fogarty, M. S. (2000), Knowledge Spillovers and Patent Citations: Evidence from a Survey of Inventors, *American Economic Review,* **90,** 215-218.

Jensen, P. and Webster, E. (2004) Examining Biases in Measures of Firm Innovation, In *Melbourne Institute working paper series*, Vol. 05/04 Melbourne Institute of Applied Economic and Social Research, University of Melbourne.

Klette, T. J. and Griliches, Z. (2000), Empirical patterns of firm growth and R&D investment: A quality ladder model interpretation, *Economic Journal,* **110,** 363-387.

Lanjouw, J. O., Pakes, A. and Putnam, J. (1998), How to count patents and value intellectual property: The uses of patent renewal and application data, *Journal of Industrial Economics,* **XLVI,** 405-432.

Lev, B. and Zarowin, P. (1999) The boundaries of financial reporting and how to extend them, In *Conference on Measuring Intangible Investment* OECD, Paris.

Lockett, A. and Thompson, S. (2001), The resource-based view and economics, *Journal of Management,* **27,** 723-754.

Pakes, A. (1985), On patents, R&D and the stock market rate of return, *Journal of Political Economy,* **93,** 390-409.

Roberts, P. W. (1999), Product innovation, product-market competition and persistent profitability in the US pharmaceutical industry, *Strategic Management Journal,* **20,** 655-670.

Roberts, P. W. and Amit, R. (2003), The dynamics of innovative activity and competitive advantage: The case of Australian retail banking, 1981 to 1995, *Organization Science,* **14,** 107-122.

Schankerman, M. and Pakes, A. (1986), Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period, *Economic Journal,* **96,** 1052-1076.

Thompson, P. (2001), The microeconomics of an R&D-Based model of endogenous growth, *Journal of Economic Growth,* **6,** 263-283.

Toivanen, O., Stoneman, P. and Bosworth, D. (2002), Innovation and the Market Value of UK Firms, 1989-1995, *Oxford Bulletin of Economics and Statistics,* **64,** 39-61.

Van Reenen, J. (1997), Employment and technological innovation: Evidence from UK Manufacturing firms, *Journal of Labor Economics,* **15,** 255-284.

Webster, E. M. (2000), The growth of intangible enterprise investment in Australia, *Information Economics and Policy,* **12,** 1-25.