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The Determinants of Research and Development and Intellectual Property Usage among Australian Companies, 1989 to 2002

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The Determinants of Research and Development and Intellectual Property Usage among Australian Companies, 1989 to 2002

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Abstract

This paper traces the innovation pathways of new creations from R & D activity through to intellectual property (IP) applications using enterprise panel data from 1989 to 2002. Our estimation method explicitly addresses the selection issues associated with missing R&D data which is a common problem among this type of data set. We find that R&D activity is a highly path dependent process that relies heavily on firm specific effects. These firm specific effects were subsequently found to be correlated with managerial style – more aggressive and intuitive managers have higher R&D *ceteris paribus* – and extensive use of incentive schemes for employees within the firm. In addition, we find that R&D is higher when the previous year's enterprise debt ratio is lower, the speed of technological change is faster, the firm's ability to absorb knowledge spillovers is greater and the product market is less contestable. Furthermore, these firms appear to be using the various methods of appropriation, IP and non-IP, as complementary packages to capture the quasi-rents from previous R&D expenditure rather than as substitutes.

1. Introduction

This paper estimates the major determinants of R&D activity among large Australian companies using a 14 year panel data set.[†] Two sets of equations are used to represent the sequence of new creations from R & D activity through to intellectual property (IP) registration. Relative to other studies in the area, there are three contrasting features of our analysis. First, our study specifically addresses the selection biases caused by missing R&D data. Secondly, it follows the decision about how much to invest in R&D activities through to the appropriability decision and thirdly, by merging qualitative data on companies obtained by directly surveying managers, it identifies some of the elements contained in the time-invariant firm-specific characteristics. We find evidence that debt levels, speed of technical change pertinent to the firm and the firm's ability to absorb knowledge spillovers all influence the decision to engage in R&D activity. However, there is clear evidence that R&D is a highly path-dependent process which relies on unobservable enterprise specific effects, such as the managerial style and the work culture. For those firms which undertook R&D, the different components of registered IP – patents, trade marks and designs – appear to be used as a package (rather than as solitary strategies), along with non-IP methods such as secrecy and lead time, to prevent imitation.

Knowing the determinants of variation in the amount of firm R&D is important insomuch as it indicates variation in the level of innovation. Innovation, broadly defined, is almost the only form of activity that leads to sustained improvements in productivity. Most production is simply an arrangement of physical matter and since the amount of matter in the world is fixed, how cleverly people can engineer this re-arrangement determines productivity. Innovation represents new ways to re-configure matter. For the purposes of this paper however, we limit innovation to the invention of new-to-the-world products.

This paper begins with a discussion of what can be gained from studying R&D and innovation models, and what cannot. It follows in section 3 with a simple deductive model of the innovation investment decision, and in section 4 with a review

[†] Prior to this study, no panel data econometric examination had been undertaken of Australian research and innovation pathways, due to the absence of a long and comprehensive longitudinal data base.

from the empirical literature of the main expected determinants of the innovation pathway. We then discuss the data and, in particular, estimation issues that arise from the use of accounting, administrative and survey enterprise data sets. Bearing these complications in mind, in section 5, we present estimates of the determinants of enterprise R&D and, in section 6, for those that undertook R&D, their use of the IP system. Section 7 concludes.

2. What do innovation models reveal?

As an economic study, innovation has attracted increasing academic attention over the previous century. The percentage of articles referring to technology, invention or innovation, somewhere in its text, in leading economic journals has progressively risen from about 5 per cent in 1900 to over 40 per cent in 1999 (see Figure 1). In somewhat of a contrast, technology's first cousin, 'productivity' became more common in articles published up to 1960[‡] but then waned until 1995 since when there has been a small resurgence. These trends stand in distinction to the number of articles referring to 'competition' which declined over the century and 'prices' which, while popular, exhibited no trend.

It is not entirely clear why technology, invention and innovation have risen in prominence since the proposition that economic progress is driven by technological development is arguably centuries old. It is plausible however to suppose that the study and analysis of technology, invention and innovation has grown because increasingly, it is being engineered and directed by company managers, public policy makers and management strategists. Alternatively, or perhaps as a consequence, the contribution of technological change towards rising standards of living may be growing relative to other sources of productivity growth such as enhanced worker skills, changes to public regulations, reformed institutional behaviour and changes to the quality of (price) competition.

[‡] This corresponds to the slow down in measured productivity in the US economy.

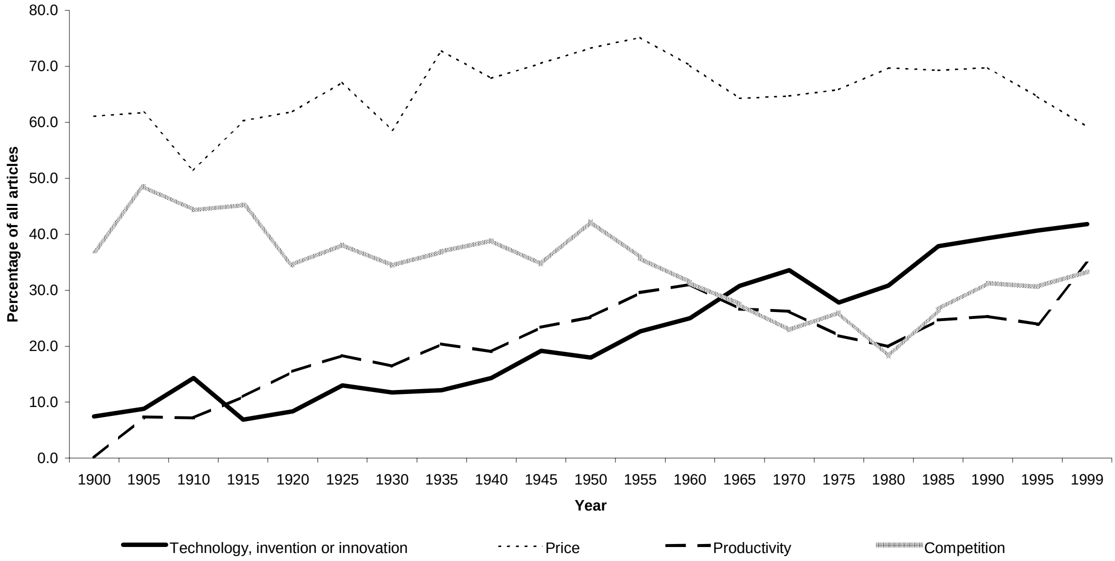

Figure 1: Percentage of articles from nine leading economics journals[§] with specific words in the text, 1900 to 1999

If we assume that either or both of these reasons are true, then it becomes more interesting to know and understand what characterises more innovative firms. Econometric models enable us to examine, in a general sense, whether interrelationships within industries and technology clusters are critical to firm outcomes. Ultimately however, the big question for economists is whether it is possible to empirically determine the most advantageous levels of innovation and/or public support for innovation. Regrettably, the findings from this paper, and other studies of this genre, do not offer a prescription for this question. Nonetheless, if governments believe that R&D and innovation should be further encouraged, then it behoves them to know what essentially distinguishes more innovative from less innovative firms and whether these factors are amenable through government or corporate policy. We may find for example that both contributions from science and knowledge spillovers are significant factors but while little can be done about increasing the contribution of basic science to firms' technological opportunities, the government can have a strategic role enhancing knowledge spillovers and workforce skills.

[§] This includes all journals published in JSTOR from 1900: American Economic Review, Econometrica, Economic Geography, Economic Journal, Economica, Oxford Economic Papers, Review of Economic Studies, Publications of the American Economic Association, and American Economic Association Quarterly.

As a step towards a clearer comprehension of the separate determinants of innovation, a large number of empirical studies have been conducted over the past three decades. Almost without exception, the level of sophistication of the estimation method is determined by the extensiveness of the database. Prior to the 1980s empirical analysis was largely undertaken using industry aggregated time series data (see Griliches 1995 for an overview). Enterprise level data bases, especially those requiring more than just accounting variables, are notoriously difficult to collect and early single equation models relied upon small samples of a single cross-section of data. Panel data studies did not emerge until 1981 (Griliches 1981), and, since then, there have been several such studies for the UK (Toivanen and Stoneman 1998, Blundell *et al.* 1999, Greenhalgh and Longland 2001, Greenhalgh *et al.* 2001, Bosworth *et al.* 2000, Toivanen *et al.* 2002, Bloom and Van Reenen 2002, Greenhalgh and Longland 2002), the USA (Ben-Zion 1984, Griliches 1986, Jaffe 1986, Hall *et al.* 1986, Griliches *et al.* 1991, Hall 1993, Hall and Hall 1993, Himmelberg and Petersen 1994, Chauvin and Hirschey 1997, Chiao 2002), Canada (Johnson and Pazderka 1993) and Spain (Martinez-Ros and Labeaga 2002).

Finding or devising a theoretical framework for the decision to invest in innovative activities is not straight forward and is almost universally neglected. The literature on the determinants of the investment decision is bifurcated between deductive reduced form modelling, which usually casts the decision in terms of the optimal capital stock, and the inductively driven case study findings. In the former, the determinants of investment are usually reduced to the tangible capital stock, rates of interest, dividends and the debt position of the unit of analysis (for examples see Jorgenson 1971, Kalecki 1968, Gordon 1993, Williams 1993). The application of these models is usually intended for inclusion into macroeconomic modelling and, or, time series estimation. However these models offer little insight into the motives for investment and why some units (firms) pursue more innovative strategies than others. By contrast, the inductive literature goes straight to the heart of the motivations for investing in innovation but offers little in the way of a guide for the specification of an equation for estimation.

In an attempt to bridge this gap, we have devised a model in the following section to identify in the decision making process the costs and benefits of investing in innovative activities.

3. Modelling the innovation decision

We begin with the postulate that some level of monopoly power is required by firms to cover their fixed costs[**] and reduce the capriciousness and variability of their product demand that, with time, will expose a firm to near certain bankruptcy. Firms accordingly invest in intangible capital, of which innovation is a subset, in order to gain cost or demand side advantages, aka monopoly power. As such, the determinant of investment in innovation can be modelled as a component of an *ex ante* profit-maximising set of decisions. We assume therefore that firms are seeking to maximise the present value of expected future profits – denoted as *V*. Because we are dealing with expectations, we assume that firms conceive of future revenues and costs as steady-state streams, not because they believe random fluctuations will not occur, but because, in general, they cannot predict one-off changes or exogenous events that cause these streams to rise or fall over time.[††]

The expected revenue stream assumes that the quantity of products sold is a positive, but declining function of the level of investment into market expansion activities, denoted *I*. Investment in innovation is restricted here to production innovation, but in a more general model it will include advertising and other marketing, organisational and distributional activities related more to the process of production. Let us model expected average quantity sold, *q*, as:

$$q = \alpha \ln(I) + \beta \tag{1}$$

where α is a parameter representing the firm's expected ability to convert market enhancing investments into actual sales, given the expected level of aggregate demand and habitual consumer buying patterns, β. Thus α represents the effectiveness of investments in product innovations (due to cost advantages arising from basic science, knowledge spillovers and the firm's capabilities) and the firm's ability to appropriate revenues from these innovations. Subsequently, the present value *R* of an infinite future revenue stream is:

$$R = p\frac{\alpha \ln(I) + \beta}{(x + r)} \tag{2}$$

** Assuming rising marginal costs are the exception rather than the rule.

†† '[W]e assume that the present is a …serviceable guide to the future...In other words we largely ignore the prospect of future changes about the actual character of which we know nothing.' (Keynes 1937, p214.)

where p is the price of the product, x is the premium the firm requires to compensate for the uncertainty associated with the investment activity I and r is the default-free rate of interest common across the whole economy. We assume that the market is not static; rival producers are also investing and so our designated firm has to continually invest in these activities in order to sustain a particular market position. Equation (2) depicts a fixed-price, variable quantity model. We could have similarly created a variable price model but this does not have a substantive effect on the final result and we retain the simple version.[‡‡]

Assuming costs for each separate investment project are one-off, the present value of a continuous stream of investments of value I is:

$$C = \frac{I}{(x+r)}$$

Expected profits are maximised subject to the limited availability of investment funds. Following Kalecki's (1939 pp285-93) principle of increasing risk, the level of investment funds, either through new equity or debt, is limited by the prior level of owners' equity, S. This constraint may be modelled as:

$$I \leq S \tag{3}$$

The respective investment demand equations can be derived from maximising $V=R-C$ subject to (3). The resulting product investment equation is:

$$I = \frac{p\alpha}{(1+\lambda(x+r))} \tag{4}$$

where λ is the Lagrangian multiplier, which in our model is the shadow price of investment funds. Accordingly, the higher the product price p and expected success rate of investments into market expansion α, and the lower the uncertainty surrounding this activity x, the higher is the proposed investment activity. While this model suggests the likely determinants of firms' decisions to invest in innovation, much is contained in the parameters, the effectiveness rate α, the shadow price of funds λ and the premia for uncertainty, x.

[‡‡] We assume here that the risk premia are equal across all investments, although this assumption is not strictly true in reality.

The following section itemises more closely the specific determinants of the effectiveness rate and the shadow price of funds using findings from the inductive literature. We are not able to include the uncertainty premia in the full model, but as will be revealed later when we analyse the fixed effects, managerial attitudes to risk are a significant determinant of the level of R&D spending *ceteris paribus*. Rather than present the innovation investment decision as a single equation, we model the process as two sets of equations: actual R&D expenditure and the registration of IP.

4. The determinants of the innovation stages

4.1 Research and development

Investment in innovation is a process that begins with research and follows through to development, commercialisation and the utilisation of appropriation strategies. The factors that affect the decision to begin this process may be divided into cost or supply-side factors and revenue or demand-side factors.[§§]

The main cost considerations include: the opportunities afforded by the scientific sector, the flow of positive knowledge externalities emanating from related organisations, the ability of the firm to reap any economies of scale that may exist in R&D, the availability and cost of imitating the existing state of the art, the calibre of the firm's internal capabilities and the cost of investment funds. We elaborate briefly on these issues below.

With respect to the first factor, it has been argued that in general, the greater are the opportunities arising from science in the firm's technology area the lower are the expected costs of innovation (Jaffe 1986, Cohen and Levinthal 1989). During the last few decades for example, basic and applied science has thrown up more possibilities in biotechnology and electronics than mechanics and textiles and accordingly we expect firms operating in these areas will engage in more R&D, *ceteris paribus*.

[§§] While many of these factors can be related to firm size, increasingly the empirical literature has found that it is not size *per se* that confers the advantage but the underlying conditions of opportunity and appropriability (Cohen *et al.* 1987). However, this may not be true if size, and the underlying financial resources it implies, enhances the scope of an enterprise's opportunity and appropriability sets. In addition, the literature has become increasingly wary of the role of market structure as a truly independent determinant of the intensity of competition and subsequent innovation decisions. Phillips (1966) and Sutton (1991) for example, have argued that the more intense the process of competition, the more concentrated the market may become. This theoretical scepticism has been complemented by empirical findings which suggest when other technological and economic features of the market are controlled for, market structure – usually denoted as concentration – loses significance (Levin *et al.* 1985, Scherer 1967, Bosworth and Rogers 1998).

In addition, more positive externalities in the technology area rising from other companies undertaking similar R&D through knowledge flows and skilled labour exchange will reduce those costs of firm's own innovation (Jaffe 1986, Griliches 1995). Firms vary according to how able they are to network, gather information, and subsequently opportunistically analyse this information. Cohen and Levinthal (1989) have argued that a firm's learning or absorptive capacity is enhanced by its own R&D activity[***] and this may be enhanced by the presence of universities and other supportive scientific infrastructure.

Thirdly, if there is a high minimum efficient scale (MES) in R&D production, for example because the minimum size of a viable laboratory is high, then we expect that large companies, with their greater access to investment funds will be advantaged.[†††] It is plausible however, that MES relates more to reported R&D rather than actual R&D activity since informal and task-specific R&D is often carried out on-the-spot using existing tools.[‡‡‡]

Fourthly, the fewer and more expensive are the alternative sources of innovation via licensing or foreign affiliates the lower the cost of imitation and less incentive for the firms to engage in its own R&D. It is plausible to assume that subsidiaries of foreign firms may come to rely upon its parent for inventions and innovative ideas. Related to this is the tendency for R&D branches of firms to be located close to head office (Leahy *et al.* 2004).

Fifthly, the better developed the track record of managers and their workforce with respect to successful R&D and innovative activities, the lower the expected costs of subsequent innovation. The importance of these factors have been documented in the managerial science literature largely through case study analysis, although there are also several studies involving qualitative company surveys (see Lee 2002, Rothwell *et al.* 1974, Cohen 1995).[§§§] Because knowledge creation and learning are

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[***] Although these advantages may be eroded if the company's products are in direct competition with each other.

[†††] See also Levin *et al.* (1987a), Acs and Audretsch (1993), Kleinknecht *et al.* (1993), Cohen (1995). The survey by Levin and Reiss (1984) suggests that the inconclusive results may arise because the MES is low for many technologies.

[‡‡‡] Studies using data on innovations counts (as published in journals for example) suggest more ambiguity about the correlation between firm size and innovation intensity (see Kleinknecht *et al.* 1993 for example).

[§§§] It has been suggested that large companies are less efficient in garnering the innovative potential of its employees due to bureaucratic frustrations and less directed pecuniary incentives (see the review by Cohen 1995).

both inputs and outputs of the inventive and innovation process, internal capabilities are generally considered path dependent, and thus subject to cumulative causation.

Finally, regardless of the companies' incentives to undertake R&D, they will not be able to execute their decisions without access to high risk investment finance. Prudent financiers (of either equity or debt) will not lend without some form of collateral, and the greater is the risk, the higher is the required collateral and loan premium for risk. The highest risk forms of investment, especially those that produce no tangible collateral, are consequently more likely to be sourced from retained earnings and we expect that firms with higher pre-existing profits and lower debt ratios will have fewer funding limitations imposed on them. Empirical studies have found, on balance, evidence that the firm's financial state affects their investments in R&D (see Cohen 1995 for a review).

From the demand side, we expect that *ex ante* returns to innovation will be greater: the stronger the *ex ante* growth in customer demand for the product and the more practical forms of appropriability, including registered IP, available to the firm. Both of these determinants are intuitive. Anticipated profits from innovation should be greater the higher is the expected growth in *ex ante* demand for the broad product market area and thus the greater the commercial use for both process and product innovations that lie within the scope of the area (Schmookler 1966). In addition, some technical features of product or process innovations are easier to codify and define and are thus more amenable to IP registration and protection. For example, drugs are technically easier to protect through patents; some processes are easier to protect through secrecy (Hunter 2002). Appropriability can also vary according to the economic conditions of the firm. Large companies, for example, may find it easier to both enforce their registered IP and produce and sell on a large scale. Foreign companies may expect higher rates of appropriation because they have an established channel for exploiting their new inventions in green field markets through intra-firm technology transfer (Dunning 1988, Caves 1982).

4.2 Registered intellectual property

While the availability of cheap and efficient modes of appropriation will affect the decision to invest in R&D, not all firms will seek to protect their invention through registered IP. It has been well documented in the US that while a high proportion of potentially significant inventions are patented in pharmaceutical and chemicals, the rates are considerably less for other fields (see Mansfield 1986, Levin *et al.* 1987b). The coverage rates for trade marks and designs are less well documented, but research by Jensen and Webster (2004) finds that IP counts are not well correlated with process innovations. Three forms of registered IP are used in our model: patents, trade marks and designs. While patents are used to claim monopoly ownership over a potential future new product or process, trade marks can be complementary to the launch of a new product (Loundes and Rogers 2003), and designs are used to claim monopoly over the appearance of a new product.

We expect that the higher is the level of R&D expenditure the greater is the chance of producing one or more of these innovations in any year and that there will be systematic differences in the rate at which firms seek legal protection for a potentially significant innovation. Certain technologies are more clearly defined and protected by legal means and certain firms may anticipate that they can more effectively utilise legal means of protection than others.

Accordingly, the registration of a potentially significant innovation will depend on first, the features of the invention such as the ease of imitation, codifiability and the definition of clear invention boundaries (Griliches *et al.* 1987). Technologies that are more amenable to both patent documentation and imitation by competitors stand to gain most from patent and design protection. In the case of trademarking activity, the scope of apparent market opportunities for particular products or the number of competitors, rather than the actual technology of the underlying product, may determine the trademarking rate.

Secondly, the IP registration rate will be lower the greater the expected economic loss through disclosure. Because new products are disclosed when sold, there is less expected disclosure loss than for process innovations which need never be publicly disclosed to be used.

Thirdly, because using the legal system is costly, the firm would need to have the resources to finance the fixed costs of the complete IP application and be prepared to defend the title if necessary.

Finally, we expect that the more serviceable are alternative forms of appropriability available to the firm, the less likely they will be to register for IP protection.

5. The R&D equation

5.1 The econometric model

Since innovative activities are a sequence of events which are linked over time and do not occur simultaneously, we have modelled the equations as separate equations rather than a system of equations. The following sections consider the estimations of first, the R&D expenditure decision and then the decision to protect innovation through registered IP.

The major modelling issue for estimating the R&D expenditure decision is how to treat missing R&D data. In our data set which is described in Appendix 1, R&D expenditure is collected from company annual reports, supplemented with telephone survey information. However, there still remain a very large proportion of missing data (85.3 per cent) and it is not possible to discern whether these represent true zeros, R&D spending below a threshold limit or the non-reporting of values above this threshold.[****] Most likely, missing values are a combination of all three. According to Table 1, about 1.5 per cent of the R&D data refer to missing annual values for enterprises which have also reported significant values in other years, and a further 12.3 per cent refer to enterprises that never report R&D expenditure but had made patent applications during the same period. Both these cases most likely represent non-reported positive R&D values.

Table 1: Firm characteristics of R&D observations, 1989- 2002

Type of R&D records	Freq.	Percent
No. observations where firm reports R&D at some time in its history		
- complete set of R&D observations	2,733	16.8
- gaps in set of R&D observations	248	1.5
No. observations where firm never reports R&D in its history		
- has a history of patent applications	2,009	12.3

[****] However, despite it being a requirement of accounting standards, in practice, only subsets of this R&D are formally recorded (often to obtain special tax treatment), or reported in published accounting statements. Stoneman and Toivanen (2001) for example, found that among listed UK firms, that large companies were most likely to report R&D. We find that manufacturing, public and foreign owned companies are more likely to report R&D than other companies.

- has no history of patent applications	11,315	69.4
Total	**16,305**	**100.0**

Most existing studies of the determinants of R&D do not discuss or explicitly treat missing R&D data points. However, missing R&D data are endemic in accounting based data sets and these omissions can be important if there are selection issues. It seems reasonable to assume that missing values for R&D expenditure for firms which are also patenting, do not constitute true zeros. A cross-sectional multinomial logit model relating each of the categories of R&D reporting to industry type, company type and type of ownership suggests that firms reporting R&D, compared with those that neither report or apply for patents, are most likely to be in manufacturing, electricity, gas and water, communications and agriculture, and least likely to be in education, accommodation, cafes and restaurants. They are also more likely to be medium size, foreign owned or public companies, *ceteris paribus*.

If the panel nature of the data is accommodated by estimating a fixed-effects model with fixed effects for the firms, then the fixed effects term will capture any sample selection bias caused by the omission of observations from firms who never report R&D. This fact can be demonstrated by considering a two-equation sample selection model (see, for example Verbeek 2000, p.206). In the context of our model, we have the R&D equation

$$RD_{it} = \alpha_i + \delta RD_{i,t-1} + \mathbf{X}_{i,t-1}\boldsymbol{\beta} + \varepsilon_{it} \qquad (5)$$

where the subscripts i and t refer to the i-th firm in the t-th time period and the vector $\mathbf{X}$ represents the independent determinants of the decision.

In addition, there is a participation, or selection, equation

$$w*_i = \mathbf{z}_i\boldsymbol{\gamma} + u_i \qquad (6)$$

where a firm reports R&D when the latent variable w_i^* is positive and does not report R&D for $w_i^* \leq 0$. The vector $\mathbf{z}_i$ contains time-invariant firm characteristics including variables such as industry type, type of corporation and type of ownership. It is assumed that the error terms (ε_{it}, u_i) have a bivariate normal distribution with zero mean, $\text{var}(\varepsilon_{it}) = \sigma^2$, $\text{var}(u_i) = 1$ and correlation ρ. Then, given that firms that do not report R&D are discarded, the relevant expectation for estimating the R&D equation is

$$E(RD_{it} \mid RD_{i,t-1}, w_i^* > 0) = \alpha_i + \delta RD_{i,t-1} + \mathbf{X}_{it}\boldsymbol{\beta} + E(\varepsilon_{it} \mid w_i^* > 0) \qquad (7)$$

where

$$E(\varepsilon_{it} \mid w_i^* > 0) = E(\varepsilon_{it} \mid u_i > -\mathbf{z}_i\boldsymbol{\gamma}) = \rho\sigma E(u_i \mid u_i > -\mathbf{z}_i\boldsymbol{\gamma}) = \rho\sigma\, \phi(\mathbf{z}_i\boldsymbol{\gamma}) / \Phi(\mathbf{z}_i\boldsymbol{\gamma}) \quad (8)$$

and $\phi(.)$ and $\Phi(.)$ are the standard normal density and distribution functions, respectively. Since the term $\rho\sigma\, \phi(\mathbf{z}_i\boldsymbol{\gamma}) / \Phi(\mathbf{z}_i\boldsymbol{\gamma})$ is time invariant, it can be incorporated into the fixed effect α_i. Relaxing the assumption of normality (as would be necessary if, for example, non-reporting was explained by a logit model) changes the exact expression for $E(\varepsilon_{it} \mid w_i^* > 0)$, but does not alter the fact that it is time invariant. As discussed above, most of the 'decision' to report R&D depends on time invariant characteristics such as the industry and ownership of the firm. We ignored the very small number of observations (accounting for 1.5 per cent of all observations) where non-reporting of R&D was time varying.

The vector $\mathbf{X}_{it}$ includes company size (i.e. sales revenue), demand conditions (change in industry sales), the ability of the firm to finance new risky investments (lagged company profits, lagged debt ratio), local knowledge spillovers (R&D by firms in same technology area – as defined by those that patent in each technical area, interaction of the latter with own R&D), scientific opportunity (US patenting activity over previous five years in related technology area[††††]), technical and economic conditions of appropriability (profit mark-up, expected sales). Each of these variables was lagged one period to allow for a delayed impact on R&D expenditure.

The firm specific fixed factor, α_i, will capture time invariant aspects of R&D behaviour including managerial attitudes, internal firm capabilities, access to investment funds and technology, firm-specific conditions of appropriability as well as the selection term. According to Cohen (1995), both technical opportunity and appropriability conditions, while variable, are relatively inert and a considerable portion of their impact will be reflected in the firm specific fixed effects.

[††††] This may also correlate with inherent ease of appropriability associated with specific technology areas.

Including the lagged dependent variable $RD_{i,t-1}$ allows for path dependency; expenditure on R&D by a firm is likely to depend on the past history of that firm's R&D expenditure. However, inclusion of $RD_{i,t-1}$ also complicates the estimation procedure. For large *N* (the number of firms) and small *T* (the number of time series observations), which are characteristics of our data, the ordinary least squares (OLS) fixed effects estimator is inconsistent. As an alternative estimation procedure, Arellano and Bond (1991) suggest a generalized method of moments procedure that uses as instruments lagged values of the dependent variable, and the exogenous variables differenced, and applies them to a differenced version of the original equation.

In addition to the results from the Arellano-Bond estimator, we report estimates from the OLS-estimated fixed effects model and an OLS-estimated model with dummy variables for industry type, company type and foreign ownership, and no fixed effects for firms. Since instrumental variable estimators typically obtain consistency at the expense of increased variance, it is also useful to consider results from the OLS fixed effects estimator that, despite its small-*T* bias, is likely to have a lower variance. The model with industry, company and foreign ownership dummies but no fixed effects for firms is considered for two reasons. First, it permits across-firm variation in R&D within each industry and company type (in addition to within-firm variation over time) to be explained by corresponding variation in the explanatory variables; and, second, it seems reasonable to hypothesize (as we do in what follows) that the magnitudes of the fixed effects for each firm can be related to industry type, company type and foreign ownership.

5.2 Estimations results

The results are presented in Table 2. The use of a differenced equation and lagged instruments means the data demands of the Arellano-Bond estimator are greater and so fewer companies and less observations are used to compute values for this estimator.

Two access-to-finance variables, lagged net profits before tax and the lagged debt ratio, were tested to see if they had the expected effect on R&D expenditure. As can be seen from the first column of estimates, only the debt ratio was correctly signed and it was only weakly significant in the Arellano-Bond estimation but significant in the both the industry/company-dummy and fixed effects OLS estimations. Nonetheless, it suggests that firms with a higher level of relative debt are less likely to subsequently invest in R&D, presumably due to the risk associated with this form of investment. This outcome is consistent with the findings in Himmelberg and Petersen (1994) which show that among a sample of high-tech firms, cash flow (retained earnings) had a substantial effect on the level of R&D expenditure and with Geroski *et al.* (2002) who used panel data with a system of recursive equations to show that cash flow had a significant but only very small effect on R&D and patents.

A variable to proxy for knowledge spillovers was constructed as the sum of all R&D expenditure conducted in the previous year by other firms patenting in the same technology areas as the subject firm, interacted with the lagged R&D expenditure by the subject firm. The interaction term has been included to represent the subject firm's ability to absorb and apply this knowledge. This variable was weakly significant in the Arellano-Bond estimation but highly significant in the OLS estimations.

Measuring opportunities from science for the purposes of estimation is difficult and not wholly successful (see Cohen 1995 for a discussion). Nonetheless, we attempted to capture two aspects of the technological area the enterprise appeared to be working in. To ensure that these variables were exogenous from the Australian research environment, we used technology specific data from the USA (the average of the previous 5 years).[‡‡‡‡] The first indicator, the technology cycle time, represents how fast the technology is turning over, defined as the median age in years of the US patent references cited on the front page of the company's patents. In fast moving technologies, companies may gain the advantage by innovating more quickly.[§§§§] The second measure is the number of forward patents cites in each technology area (the number of citations a patent receives from subsequent patents) which indicates how often the technology becomes prior art in future technological advances. Harhoff *et al.* (1999), among others, have shown that highly cited patents represent economically and technically important inventions. However, firms that did not patent, and hence could not be classified to a technology area (using their IPC), were assigned the residual class data. Accordingly, we should be somewhat cautious about the findings.

[‡‡‡‡] Data was from CHI research. See http://www.chiresearch.com/about/data/tech/indicator.php3#growth.

[§§§§] According to CHI Research, cycle times are short (3-4 years) in semiconductors, but long (more than 10 years) in shipbuilding. The average is 8 years.

Bearing this in mind, only the coefficients on the technology cycle were significant and correctly signed: enterprises apparently working in fast moving technological areas tended to undertake more R&D, *ceteris paribus*. This finding is consistent with the Geroski *et al.* (2002) results which support the view that conditions of technical opportunity are more important than capital market limitations.

To capture the effects of exogenous demand conditions, we have included a variable to indicate the recent growth in production in the main industry of the enterprise. This, and other proxies for demand, such as the lagged change in the enterprise sales, were only significant in the cross-sectional equation but were not significant in the panel estimations.

Finally, the large value of rho (0.633), the proportion of the residual variance in R & D explained by firm specific effects, calculable only for the OLS equation, suggests that the combined time invariant aspects of R&D behaviour, managerial attitudes, internal firm capabilities and technology, access to investment funds, firm-specific conditions of appropriability and selection issues are very important. To separate the effects of these different elements, we regressed the fixed effects against qualitative management data we have obtained on many of these companies from a separate survey conducted over the period 2001 to 2003 (see the appendix for details of this survey).

Table 2: Determinants of R&D expenditure (A$000) among large companies, Australia, 1991 to 2002.

Dep var: R&D expenditure ('000)[(a)]	*Coef.*	*z*	*Coef.*	*z*	*Coef.*	*z*	*Coef.*	*z*
Path dependent effects								
Lagged R&D expenditure	0.519**	48.33	0.25**	18.24	0.547**	16.44	0.550**	18.58
Firm size								
Employees[(b)]	0.391**	11.31	0.77**	9.57	0.740**	7.69	0.734**	7.73
Access to Finance								
Lagged net profits before tax	0.001*	2.31	-0.0039**	-3.95	-0.0001	-0.08		
Lagged debt ratio	-1500*	-2.16	-2239*	-2.27	-2093	-1.55	-2109	-1.57
Access to knowledge spillovers								
Lagged absorption	0.706**	8.39	0.57**	7.23	0.169	1.4	0.166	1.38
Scientific opportunity[(c)]								
Lagged length of technology cycle	-419.5**	-3.29	-397.3**	-2.42	-538.0*	-2.16	-533.8*	-2.14
Lagged patent citations			12.12	0.01	-583.7	-0.36		
Demand conditions								
Change in value added in industry	1064**	2.39	235.26	0.61	7.28	0.13		
No. companies	402		402		286		286	
No. observations	1673		1673		1267		1267	
R^2 – within	0.76		0.345					
Test for significance of dummies	F=5.36**							
Rho[(d)]			0.673					
corr(u_i, Xb)			0.354					
Estimation method	OLS & Dummies		Fixed effects		Arellano-Bond		Arellano-Bond	

Notes: (a) All financial variables have been deflated by the CPI (1989-90=100). (b) Missing values for employees have been imputed from lagged employees and current sales revenue. (c) Missing values for the scientific opportunity variables have been imputed as the residual technology category '30' in the CHI data base.
Significance: ** 1%, *5%, †10%.

Data from this survey allowed us to construct a series of variables on external product market conditions, internal management techniques and human resource management methods. The external product market conditions were represented by a series of 16 industry dummies to reflect the 17 major industry groups, a measure of product market volatility (based on the uncertainty scales of Miller and Droge 1986), and a measure of the ease of entry for competitors into the industry. Three different types of management style were distinguishable from the data (rather than *a priori*). The first style, ‘inflexible’, reflected the inflexibility and unresponsiveness of the organisation’s functional areas. The second, ‘systematic’, indicated managerial reliance upon formal and extensive quantitative analysis rather than intuitive information for making decisions. The third factor, ‘aggressive’, reflected how aggressive managers were in the face of uncertainty and how willing they were to initiate competitive clashes with rival companies. The last management technique variable was a measure of how, and to what extent, the firm made an effort to communicate with its employees. This variable, ‘communication’, gives weight to organisations that have clear strategic missions that are understood throughout the enterprise, use several procedures to communicate with staff, involve employees directly in decisions and act on suggestions of employees.

Finally, four aspects of the firm’s human resource management methods were measured in the survey. First, the variable ‘selection methods’ measures the firm’s use of explicit selection criteria and its provision of career paths and training programs for employees. Secondly, ‘team work’ measures the firm’s use of team and its willingness to act on the decisions and suggestions of employees. Thirdly, ‘pay rewards’ measures the firm’s use of pecuniary incentives to reward employees and finally, ‘other’ includes firm offers pastoral support, flexible working times and internally consistent human resource management practices.

We were able to match the survey information for 122 of the 390 firms which reported R&D and for which information on industry, company type and foreign ownership status was available. Accordingly, we estimated three regressions with the fixed effects from Table 2, as the dependent variable and with the qualitative survey information, industry type, company type and ownership status as explanatory variables. In the first regression, all variables were included and only 122 observations were used. In the second all 390 observations were included, but the qualitative survey variables were excluded. The third regression was a compromise between the first two. It included all 390 observations and the survey variables; to accommodate the missing data on the survey variables a dummy variable ‘Missing management variables’ was set to 1 if there were no survey variables, and the values of these survey variables were set to zero. This equation is likely to provide a reasonable approximation if the survey variables are uncorrelated with industry, company type and ownership status. The results from these regressions, which are presented below in Table 3, reveal that whether or not the firm was covered by the survey was not related to the magnitude of the fixed effect and consequently we assume that the coefficients for the survey variables are representative of all firms. With respect to these other variables, we found that firms with a specific propensity to undertake more R&D expenditure were also more likely to have a foreign parent, less likely to sell into contestable product markets, were more likely to use intuitive decision making methods (as opposed to using formal, systematic tools), were more aggressive and bold in their managerial posture and were more likely to make extensive use of pecuniary incentives to reward high performing employees. The other factors were not significant at the five per cent level.

Table 3: Determinant of firm specific effects (R&D equation)

	Regression 1		*Regression 2*		*Regression 3*		*Regression 3 (ex-insignif. variables)*	
Explanatory variables	***Coef***	***t-stat***	***Coef***	***t-stat***	***Coef***	***t-stat***	***Coef***	***t-stat***
× 1 Public company	-424.4	-0.24	634.8	0.7	560.44	0.61		
× 1 Foreign parent	1622.7	0.9	1621.6†	1.85	1727.37†	1.94	1415.1†	1.89
× 1 Missing management variables					189.73	0.04		
External product market (Likert scales)								
Volatile	224.1	0.29			-295.77	-0.41		
Contestability	-1063.1†	-1.82			-702.63	-1.26	-716.6	-1.48
Management variables (Likert scales)								
Inflexible	605.0	0.72			465.54	0.58		
Systematic	-1968.0*	-2.13			-2052.5*	-2.29	-1951.2*	-2.41
Aggressive	1183.1	1.22			1402.10	1.53	1352.3†	1.76
Communication	1354.5	0.95			1041.98	0.78		
Human resource management (Likert scales)								
Selection methods	-1698.8	-1.08			-1044.74	-0.76		
Team work	25.4	0.02			319.07	0.29		
Pay rewards	953.7	0.67			1010.24	0.80	1330.6*	2.11
Other	89.0	0.1			-47.15	-0.06		
Industry variables (Dummy variables)								
× 1 Mining	13412.0	1.58	1204.2	0.48	1163.59	0.46		
× 1 Manufacturing	7747.7	0.97	659.1	0.31	629.95	0.30		
× 1 Electricity, Gas & Water Supply	3405.0	0.39	-2931.2	-0.99	-2932.59	-0.95	-3471.8	-1.61
× 1 Construction	na	na	-2208.1	-0.57	-1886.52	-0.49		
× 1 Wholesale Trade	8953.1	1.1	143.9	0.06	180.06	0.08		
× 1 Retail Trade	4533.4	0.49	-2182.4	-0.59	-1731.93	-0.47		
× 1 Transport & Storage	6870.8	0.74	-3639.6	-1.04	-3696.53	-1.03	-4147.4	-1.49
× 1 Communication Services	-19567†	-1.75	-8856.0*	-2.43	-8721.8*	-2.39	-9029**	-3.03

× 1 Finance & Insurance	6393.0	0.71	196.5	0.07	200.24	0.07		
× 1 Property & Business Services	6926.0	0.82	588.0	0.24	645.09	0.26		
× 1 Health & Community Services	1769.6	0.16	-2100.1	-0.49	-2283.19	-0.54		
× 1 Cultural & Recreational Services	10393.3	1.16	838.7	0.23	1740.40	0.46		
Sample	122		390		390		390	
Adj-R^2	0.08		0.02		0.02		0.05	
Test for significance of industry dummies	F=1.12				F=1.12			
Estimation method	OLS		OLS		OLS		OLS	

Notes: Missing industry is Education.

6. The registered IP equations

6.1 The econometric model

The second set of equations describes what influences the firm's decision to use registered IP forms of appropriability, given they are conducting R&D. As discussed in the previous section, the influencing factors include the ease of imitation, the ability to codify and define clear boundaries around the invention, the use of complementary or substitutable appropriation methods, anticipated economic loss through disclosure and the ability of a firm to pay for fixed costs of IP registration and possible enforcement.

Equations were estimated to explain the three measures of registered intellectual property, patents (*PT*), trade marks (*TM*) and designs (*DS*). Using some general notation, these equations can be expressed as

$$PT_{it} = \phi_i + \mathbf{W_{it}}\varpi + \varepsilon_{it} \qquad (9)$$

$$TM_{it} = \varphi_i + \mathbf{Y_{it}}\boldsymbol{\theta} + \eta_{it} \qquad (10)$$

$$DS_{it} = \gamma_i + \mathbf{Z_{it}}\vartheta + \xi_{it} \qquad (11)$$

The coefficients ϕ_i, φ_i and γ_i denote firm fixed effects while *W*, *Y* and *Z* denote the relevant explanatory variables included in each of the equations. There are two modelling/data issues that complicate estimation. First, to the extent that patents, designs and trade marks are used to reinforce the appropriability strategies of the firm, there is likely to be correlation within companies between the three types of registrations. Two possible ways to accommodate this correlation are (i) to allow for correlation between the error terms ε_{it}, η_{it} and ξ_{it} or (ii) to use a simultaneous equation framework where *W*, *Y* and *Z* each include the two IP registrations from the other equations. The second estimation complication is the count nature of the IP registrations. It suggests that a count data regression model such as the Poisson or negative binomial model might be appropriate. However, the large number of zeros corresponding to firms that never register any form of IP is likely to make a simple count data model inadequate.[*****]

Together, these two complications imply some kind of multivariate or simultaneous equation count data model, with fixed effects, is likely to be suitable. Estimation techniques

[*****] Of those firms undertaking R&D in the previous year, the percentage recording no IP applications were 80.8, 49.9 and 89.7 for patents, trade marks and designs respectively.

for such models are not well developed (see Cameron and Trivedi 1998 for an idea of the difficulties that arise). As a compromise, we accommodated the correlation between the three IP registrations by including in each equation the other two IP registrations, but we did not employ a simultaneous equation estimation technique. Given the choice between ignoring the complementarities between the three facets of IP and incurring some bias in the estimators, we opted for the latter. We estimated OLS fixed effect models as well as Poisson and negative binomial fixed effects models but found that the OLS estimates appeared as least as good, if not superior, to those from the other models and accordingly, only the OLS estimates are reported in what follows.

6.2 Estimations results

Results from Table 4 indicate that the amount of prior R&D was a marginally important influence on the probability of applying for a patent, but not for trade marks and designs. Given the level of last years R&D, the number of patent applications was higher for medium size firms (cf larger) but the number of trademarking and design applications was higher for large firms. Prior profits tend to induce patent and design application, but not trademarking which might suggest that financial resources are less important for the trademarking decision. Finally, we note that patents appear complementary to trade marks and designs, but trade marks are not complementary to designs. This suggests that IP is being used by firms as a package of methods to appropriate profits rather than as substitutes.

Similar to the R&D equations, firm specific effects are important and ‘explained’ about half of the variation in patent and trade mark applications and nearly ninety per cent of design applications once the other listed factors are accounted for; a finding consistent with Hall *et al.* (1986). Recall from the previous section that these effects should reflect the time invariant characteristics of the invention such as the ease of imitation, codifiability and the economic loss through disclosure. In addition, it will also include the time-invariant availability of complementary or substitutable appropriation methods. Similar to the fixed effects for the R&D equation, we regressed the fixed effects estimated from the three separate IP equations against, firm type and ownership, industry and the extent of use of non-IP methods for capturing rents from innovations from the survey. These results which are presented in Table 5 to Table 7 reveal that having a foreign parent, being in an industry other than property and business services and cultural and recreational services was associated with a higher patenting rate per dollar of R&D expenditure. Additionally, more extensive use of the non-IP forms of appropriation such as secrecy, lead time and moving down the learning curve, were associated with a greater rate of patenting, not less, as expected *a priori*.

Trade mark firm specific effects were significantly greater, per dollar of R&D expenditure, for domestic companies, for firms in manufacturing, communication services and cultural and recreational services and significantly less for mining, transport and storage and retail trade. For designs, the only significant, and positive, variables were being a public company and having a foreign parent.

Table 4: Determinants of IP use among large companies, Australia, 1991 to 2002 (includes only those which undertook R&D in previous year)

Explanatory variables	*Patent count*		*Trade mark count*		*Design count*	
	Coef.	*t*	*Coef.*	*t*	*Coef.*	*t*
Level of lagged R&D expenditure	10.43	1.37	-27.57	-0.8	7.638	0.75
Time (years)	-0.010	-0.51	0.010	0.12	-0.040	-1.55
Firm size						
Lagged employees	-66.3**	-2.49	776.28**	6.55	62.77†	1.76
Complementary IP						
Patent applications			0.708**	5.63	0.158**	4.22
Trade mark applications	0.034**	5.63			-0.002	-0.28
Design applications	0.088**	4.22	-0.027	-0.28		
Access to Finance						
Lagged net profits before tax	37.0	1.60	-1018.6	-10.1	59.869†	1.93
Lagged debt ratio	0.219	0.71	-0.818	-0.59	-0.260	-0.63
No. companies	396		396		396	
No. observations	1657		1657		1657	
Rho[(c)]	0.489		0.497		0.880	
Estimation method[(d)]	Fixed effects OLS		Fixed effects OLS		Fixed effects OLS	
corr(u_i, Xb)	0.313		0.264		0.014	

Notes: (a) All financial variables have been deflated by the CPI (1989-90=100). (b) Missing values for employees have been imputed from lagged employees and current sales revenue. (c) Percentage of remaining variation in dependent variable, after controlling for the independent variables, that is explained by fixed effects, (d) Results for negative binomial and Poisson not dissimilar and accordingly have been omitted.

Table 5: Determinant of firm specific effects (Patents equation)

	Regression 1		*Regression 2*		*Regression 3*		*Regression 3 (ex-insignif. variables)*	
Explanatory variables	***Coef.***	***t-stat***	***Coef.***	***t-stat***	***Coef.***	***t-stat***	***Coef.***	***t-stat***
× 1 Public company	0.945†	1.76	0.513*	2.1	0.460†	1.910		
× 1 Foreign parent	-0.784	-1.51	-0.229	-0.96	-0.259	-1.090	0.566**	2.770
× 1 Missing management variables					0.757	0.830		
Appropriation (Likert scales)								
Use of non-IP forms of appropriability	0.392†	1.7			0.302	1.590	0.150**	3.380
Industry variables (Dummy variables)								
× 1 Mining	1.452	0.61	0.284	0.41	0.262	0.380		
× 1 Manufacturing	0.383	0.18	0.337	0.6	0.197	0.350		
× 1 Electricity, Gas & Water Supply	0.109	0.05	0.669	0.84	0.324	0.410		
× 1 Construction			-0.117	-0.14	-0.027	-0.030		
× 1 Wholesale Trade	1.001	0.45	0.282	0.46	0.217	0.360		
× 1 Retail Trade	-0.716	-0.28	0.793	0.91	0.728	0.840		
× 1 Transport & Storage	-1.154	-0.43	-0.045	-0.04	-0.198	-0.200		
× 1 Communication Services	5.294†	1.72	0.807	0.85	0.813	0.870		
× 1 Finance & Insurance	-0.855	-0.36	-0.385	-0.52	-0.534	-0.730	-0.705	-1.450
× 1 Property & Business Services	-0.134	-0.06	0.060	0.09	0.083	0.130		
× 1 Health & Community Services	-0.430	-0.14	-0.305	-0.25	-0.462	-0.380		
× 1 Cultural & Recreational Services	-0.981	-0.4	-0.580	-0.67	-0.808	-0.930	-0.908	-1.380
Constant	-2.297	-0.9	-0.770	-1.31	-1.573	-1.450	-0.826**	-4.830
Sample	109		355		355		355	
Adj-R^2	0.03		0.0		0.02		0.05	
Test for significance of industry dummies	F=1.44				F=0.98			
Estimation method	OLS		OLS		OLS		OLS	

Notes: Missing industry is Education.

Table 6: Determinant of firm specific effects (Trade marks equation)

	Regression 1		***Regression 2***		***Regression 3***		***Regression 3 (ex-insignif. variables)***	
Explanatory variables	***Coef.***	***t-stat***	***Coef.***	***t-stat***	***Coef.***	***t-stat***	***Coef.***	***t-stat***
× 1 Public company	0.91	0.33	0.86	0.73	0.515	0.440		
× 1 Foreign parent	-0.69	-0.26	-1.60	-1.38	-1.488	-1.300	-1.639	-1.650
× 1 Missing management variables					-8.746**	-1.980	-3.635**	-3.510
Appropriation (Likert scales)								
Use of non-IP forms of appropriability	-1.25	-1.07	-2.39	-0.84	-1.099	-1.190		
Industry variables (Dummy variables)								
× 1 Mining	-7.47	-0.61	-3.01	-0.9	-3.772	-1.150	-2.783	-1.350
× 1 Manufacturing	2.15	0.19	2.33	0.86	1.405	0.520	2.017†	1.920
× 1 Electricity, Gas & Water Supply	-1.06	-0.09	0.92	0.24	-1.466	-0.380		
× 1 Construction			-1.98	-0.47	-1.701	-0.410		
× 1 Wholesale Trade	-3.03	-0.26	0.85	0.29	0.232	0.080		
× 1 Retail Trade	-7.48	-0.57	-10.74**	-2.54	-12.08**	-2.890	-11.07**	-3.380
× 1 Transport & Storage	-5.53	-0.41	-5.45	-1.11	-6.477	-1.340	-5.6	-1.390
× 1 Communication Services	71.81**	4.58	15.80**	3.45	15.409**	3.420	16.175**	4.330
× 1 Finance & Insurance	-3.99	-0.33	-0.63	-0.18	-1.779	-0.500		
× 1 Property & Business Services	-4.24	-0.34	-0.98	-0.31	-1.395	-0.450		
× 1 Health & Community Services	4.82	0.31	0.23	0.04	-0.386	-0.070		
× 1 Cultural & Recreational Services	6.14	0.49	9.48**	2.24	7.993†	1.910	8.69**	2.650
Constant	6.04	0.47			6.250	1.190	0.865	0.740
Sample	109		355		355		355	
Adj-R^2	0.27		0.08		0.12		0.13	
Test for significance of industry dummies	F=3.58**				F=3.34**			
Estimation method	OLS		OLS		OLS		OLS	

Notes: Missing industry is Education.

Table 7: Determinant of firm specific effects (Designs equation)

Explanatory variables	*Coefficient*	*t-stat*	*Coefficient*	*t-stat*
× 1 Public company	1.652†	1.850	1.417	1.660
× 1 Foreign parent	1.096	1.250	1.283	1.560
× 1 Missing management variables	0.033	0.010		
Appropriation (Likert scales)				
Use of non-IP forms of appropriability	-0.172	-0.240		
Industry variables (Dummy variables)				
× 1 Mining	-2.173	-0.860		
× 1 Manufacturing	-0.738	-0.360		
× 1 Electricity, Gas & Water Supply	-1.005	-0.340		
× 1 Construction	-1.739	-0.550		
× 1 Wholesale Trade	-1.237	-0.560		
× 1 Retail Trade	-2.462	-0.770		
× 1 Transport & Storage	-2.370	-0.640		
× 1 Communication Services	-3.256	-0.940		
× 1 Finance & Insurance	-1.642	-0.610		
× 1 Property & Business Services	-1.962	-0.820		
× 1 Health & Community Services	-1.702	-0.380		
× 1 Cultural & Recreational Services	-0.585	-0.180		
Constant	-0.025	-0.010	-1.331	-1.510
Sample	355		355	
Adj-R^2	-0.02		0.00	
Estimation method	OLS		OLS	

Notes: Missing industry is Education.

7. Conclusions

In contrast to other studies in this area, our analysis has first specifically addressed the selection biases caused by missing R&D data. Secondly, we have followed the decision about how much to invest in R&D activities through to the appropriability decision and thirdly, by merging in qualitative data on companies from directly surveying managers, we have identified some of the elements contained in the time-invariant firm-specific characteristics. One of the most consistent findings from our series of estimated equations has been that firm specific and / or path dependent effects are a very significant determinant of the innovation pathway taken by the company; a result also found by Scott (1984), Lee (2002) and Martinez-Ros and Labeaga (2002). Our exploratory analysis of these firm specific effects undertaken through linking the estimated coefficients to a separate management survey, suggests that the propensity to undertake R&D is related to both the managerial style of the firm – more aggressive and intuitive managers have higher R&D *ceteris paribus* – and the extensive use of incentive schemes for employees within the firm. In addition, our estimates support the hypothesis that R&D is higher when the speed of technological change is faster, the firm's ability to absorb knowledge spillovers is greater, the enterprise debt ratio is lower and the firm's product market is less contestable. When we examined the subsequent use of the IP system by firms undertaking R&D, we found evidence that firms are using the various methods of appropriation, IP and non-IP, as complementary packages to capture the quasi-rents from previous R&D expenditure rather than as substitutes.

These results have implications mainly for corporate policy. They suggest that being innovative is a long term strategy involving a certain managerial style, incentive schemes for employees and routines to absorb knowledge spillovers. Furthermore, they show that more innovative firms – as measured by R&D intensity – are using different appropriation methods as a complementary and reinforcing package, not alternatives.

Appendix 1. The accounting and IP data

Estimations of the determinants of R&D expenditure and IP registration have used annual 'parent' enterprise level data drawn from the IBISWorld database. These data have been matched across to applications for patents, trade marks and designs by Australian companies. IBISWorld enterprise data comprise mainly accounting data on all Australian located parent companies with an annual turnover over $50m.[†††††] We exclude government organisations, trusts and partnerships and limit our scope to public and private companies, associations and cooperatives. As shown in Table 8, our sample was predominantly public and private companies from 1989 to 2002. In 2002, there were 1971 such entities, but 3950 over the whole 14 year period. Just over half of all entities reported a profit figure.

Patent, trade mark and design applications were matched across to the parent company if the applicant name matched either the name of the parent or one of its subsidiaries.[‡‡‡‡‡] In 2002, about 5 per cent of enterprises had made at least one patent application, 33 per cent at least one trade mark application and 5 per cent at least one design application.

Table 8: Companies by type, 2002

Company type	*Number*	*Percentage*	*Percentage reporting profits*
Association	14	0.71	60.21
Cooperative	17	0.86	74.71
Public company	1,003	50.89	49.09
Private company	937	47.54	69.6
Total	**1,971**	**100**	**59.54**

Source: Companies selected from the IBISWorld dataset.

Appendix 2: The Melbourne Institute Business Survey

Data on the external product market conditions, managerial style, human resource practices and non-IP forms of appropriation were derived from a business survey of large Australian firms during the period from October 2001 to December 2003. The largest 1000 enterprises (by total revenue) were chosen from the IBISWorld enterprise database in each of the three years, and subsequent to initial calls, 3000 surveys were mailed out, with 652 useable surveys returned from 505 unique organisations. This is a response rate of 21.7 per cent, which is consistent with surveys of this type (see for example, Huselid 1995, Covin *et al.* 2001). The distribution of responses across major industry and size does not differ markedly

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

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

from the initial selected population, implying that the responses should not be biased towards a particular group. For our use, we have used the organisation as the unit of analysis and have averaged multiple responses from the same firms where they exist.

Respondents were asked to answer questions using a seven-point Likert scale with the anchors 1=strongly disagree and 7=strongly agree. Perceptual measures permit comparisons across very different organisations and industries and are easy to collect because they place fewer burdens on respondents than administrative or factual entries. However, they contain a subjective element and thus an undefined error and it would be unwise to over interpret the findings.

Similar to other studies of this type (see for example Arvanitis 2002, Hollenstein 2002), the majority of variables used in this paper are constructed using a data reduction method and do not rely upon a single variable. The use of a single variable is unlikely to adequately measure the underlying latent construct of interest, such as the management style adopted. However, we do not want to use a data reduction method that will exclude cases if there is a single missing response. Accordingly, we used factor analysis to select from a list of items (single questions) which we believed measured our concept. We only kept those items with factor loadings above 0.25. We then constructed variables as the average value of the selected items. Accordingly, while factor analysis has been used to accept or reject specific questions to be included as part of a variable, the actual variable is a simple average of the non-missing questions.[§§§§§] Because the variables are averages of up to 14 items, they are very like continuous variables bounded between 1 and 7. Table 9 gives a descriptive summary of the factors used in the regressions.

[§§§§§] Where appropriate, the 1 to 7 scales were reversed to order items in a consistent direction. All *a priori* innovation items were included in its summated scale.

Table 9: Variable definitions

Variable	Description
External product market	
Volatile product market	A 5-item, 7 point scale measuring variability in demand, competitors, technologies
Contestability	A 2-item, 7 point scale measuring ease of entry to product market
Management style	
Inflexibility of management	An 8-item, 7 point scale measuring how difficult it is for the firm to change in response to external conditions
Systematic style	A 6-item, 7 point scale measuring whether managers use systematic analysis rather than intuitive methods for making decisions
Aggressive style	A 5-item, 7 point scale measuring how bold and aggressive managers are
Communication techniques	A 4-item, 7 point scale measuring the extent to which management seek to communicate with workers
Human resource management	
Selection methods	An 8-item, 7 point scale measuring extent to which firm uses sophisticated selection and training practices
Team work	A 3-item, 7 point scale measuring the extent of disaggregated decision making within the firm
Pay rewards	A 7-item, 7 point scale measuring the extent firms use pecuniary incentives to reward employees
Other	A 3-item, 7 point scale measuring the extent to which the firm offers pastoral support, flexible working times and internally consistent HRM practices.
Appropriability	
Extent of appropriability	A 14 item, 7 point scale measuring the effectiveness of non-IP methods to protect advantages from product and process innovations

Source: Melbourne Institute Business Survey 2001, 2003 and 2003

References

Acs, Z. J. and Audretsch, D. B. (1993), Analysing innovation output counts: The US experience, In *New Concepts in Innovation Output Measurement* (Eds, Kleinknecht, A. and Bain, D.) St Martin's Press, Houndmills, Basingstoke and London, pp. 10-41.

Arellano, M. and Bond, S. (1991), Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations, *Review of Economic Studies*, **58,** 277-294.

Arvanitis, S. (2002) Explaining innovative activity in service industries: Micro data evidence for Switzerland, Vol. Swiss Institute for Business Cycle Research Swiss Federal Institute for Technology, 56.

Ben-Zion, U. (1984), The R&D and investment decision and its relationship to the firm's market value: Some preliminary results, In *R & D, Patents and Productivity* (Ed, Griliches, Z.) University of Chicago Press, Chicago and London, pp. 299-314.

Bloom, N. and Van Reenen, J. (2002), Patents, real options and firm performance, *Economic Journal,* **112,** C97-C116.

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. (1998) Research and development, Intangible Assets and the performance of Large Australian Companies, In *IBIS Collaborative Program in Enterprise Dynamics*, Vol. 2/98 University of Melbourne.

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.

Cameron, A.C. and P.K. Trivedi (1998) *Regression Analysis of Count Data*, Cambridge University Press, Cambridge.

Caves, R. E. (1982), Multinational enterprises and technology transfer, In *New Theories of the Multinational Enterprise* (Ed, M., R. A.) Croom Helm, London, Canberra, pp. 254-79.

Chauvin, K. W. and Hirschey, M. (1997), Market Structure and the Value of Growth, *Managerial and Decision Economics,* **18,** 247-254.

Chiao, C. (2002), Relationship between debt, R&D and physical investment, evidence from US firm-level data, *Applied Financial Economics,* **12,** 105-121.

Cohen, W. M. (1995), Empirical studies of innovative activity, In *Handbook of the Economics of Innovation and Technical Change* (Ed, Stoneman, P.) Blackwell, Oxford UK & Cambridge USA.

Cohen, W. M., Levin, R. C. and Mowery, D. C. (1987), Firm size and R&D Intensity: A Re-examination, *Journal of Industrial Economics,* **June,** 543-565.

Cohen, W. M. and Levinthal, D. A. (1989), Innovation and learning: The two faces of R&D, *Economic Journal,* **99,** 569-596.

Covin, J. G., Slevin, D. P. and Heeley, M. B. (2001), Strategic decision making in an intuitive vs. technocratic mode: structural and environmental considerations, *Journal of Business Research,* **52,** 51-67.

Dunning, J. H. (1988), International business, the recession and economic restructuring, In *Strategies in global Competition* (Ed, Hood, N. V., J. E.) Croom Helm, London, New York, Sydney, pp. 84-103.

Geroski, P., Van Reenen, J. and Walters, C. (2002), Innovations, Patents and Cash Flow, In *Innovation and Firm Performance. Econometric Explanations of Survey Data* (Eds, Kleinknecht, A. and Mohnen, P.) Palgrave, Houndmills, Basingstoke and New York.

Gordon, M. J. (1993), The Neo-classical and a Post Keynesian theory of Investment, In *Can the Free Market Pick Winners? What Determines Investment* (Ed, Davidson, P.) M. E. Sharpe, Armonk, New York and London, England, pp. 3-22.

Greenhalgh, C. and Longland, M. (2001), Intellectual property in UK firms: creating intangible assets and distribution the benefits via wages and jobs, *Oxford Bulletin of Economics and Statistics,* **63,** 671-696.

Greenhalgh, C. and Longland, M. (2002) Running to stand still? - Intellectual Property and Value Added in Innovating Firms, In *The Future of Manufacturing in the UK* mimeo, London School of Economics.

Greenhalgh, C., Longland, M. and Bosworth, D. (2001), Technological activity and employment in a panel of UK firms, *Scottish Journal of Political Economy,* **48,** 260-282.

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

Griliches, Z. (1986), Productivity, R and D, and Basic Research at the Firm Level in the 1970s, *American Economic Review,* **76,** 141-154.

Griliches, Z. (1995), R&D and Productivity: Econometric Results and Measurement Issues, In *Handbook of the Economics of Innovation and Technological Change* (Ed, Stoneman, P.) Blackwell, Oxford, UK and Cambridge, Mass., pp. 52-89.

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.

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

Hall, B. H., Griliches, Z. and Hausman, J. A. (1986), Patents and R and D: Is there a Lag?, *International Economic Review,* **27,** 265-283.

Hall, B. H. and Hall, R. E. (1993), The value and performance of U. S. corporations, *Brookings Papers on Economic Activity***,** 1-50.

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.

Himmelberg, C. P. and Petersen, B. C. (1994), R&D and internal finance: A Panel study of small firms in high-tech industries, *Review of Economics and Statistics,* **76,** 38-51.

Hollenstein, H. (2002) Determinants of the adoption of information and communication technologies (ICT), Vol. Swiss Institute for Business Cycle Research Swiss Federal Institute for Technology, 60.

Hunter, L. (2002) Intellectual Capital: Accumulation and Appropriation, In *Melbourne Institute working paper series*, Vol. Melbourne Institute of Applied Economic and Social Research University of Melbourne, 22/02.

Huselid, M. A. (1995), The Impact of Human Resource Management Practices on Turnover, Productivity, and Corporate Financial Performance, *Academy of Management Journal,* **38,** 635-672.

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.

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.

Johnson, L. D. and Pazderka, B. (1993), Firm Value and Investment in R&D, *Managerial and Decision Economics,* **14,** 15-24.

Jorgenson, D. W. (1971), Econometric studies of investment behaviour: A survey, *Journal of Economic Literature,* **9,** 1111-47.

Kalecki, M. (1939) *Essays in the Theory of Economic Fluctuation*, Clarendon Press, Oxford.

Kalecki, M. (1968), Trend and the Business Cycle, In *Selected Essays on the Dynamics of the Capitalist Economy* Cambridge University Press, Cambridge, pp. 165-183.

Keynes, J. M. (1937), The general theory of employment, *Quarterly Journal Of Economics*, **51,** 209-23.

Kleinknecht, A., Reijnen, J. O. N. and Smits, W. (1993), Collecting literature based innovation output indicators. The experience in the Netherlands, In *New Concepts in Innovation Output Measurement* (Eds, Kleinknecht, A. and Bain, D.) S t Martin's Press, Hampshire and London, pp. 42-84.

Leahy, A., Loundes, J. E., Webster, E. M. and Yong, J. (2004), Industrial Capabilities and Productivity in Victoria, *Economic and Labour Relations Review*.

Lee, C.-Y. (2002), Industry R&D intensity distributions: regularities and underlying determinants, *Journal of Evolutionary Economics*, **12,** 307-341.

Levin, R. C., Cohen, W. M. and Mowery, D. C. (1985), R&D Appropriability, Opportunity and Market Structure: New Evidence on some Schumpeterian Hypotheses, *American Economic Review*, **75,** 20-24.

Levin, R. C., Cohen, W. M. and Mowery, D. C. (1987a), Firm Size and R&D Intensity: A Re-examination, *Journal of Industrial Economics*, **35,** 543-565.

Levin, R. C., Klevorick, A. K., Nelson, R. R. and Winter, S. G. (1987b), Appropriating the Returns from Industrial Research and Development, *Brookings Papers on Economic Activity*, **3,** 783-820.

Levin, R. C. and Reiss, P. (1984), Tests of a Schumpeterian model of R&D and market structure, In *R & D, Patents and Productivity* (Ed, Griliches, Z.) University of Chicago Press, Chicago and London, pp. 175-208.

Loundes, J. and Rogers, M. (2003) The Rise of Trade Marking in Australia in the 1990s, In *Intellectual Property Research Institute of Australia Working Papers*, Vol. Faculty of Law University of Melbourne, 4/03.

Mansfield, E. (1986), Patents and innovation: An empirical study, In *Innovation, Technology and the Economy. The Selected Essays of Edwin Mansfield* (Ed, Mansfield, E.) Edward Elgar, [1995], Aldershot, UK. Brookfield, US, pp. 272-280.

Martinez-Ros, E. and Labeaga, J. (2002), Modelling innovation activities using discrete choice panel data models, In *Innovation and Firm Performance. Econometric Explorations of Survey Data* (Eds, Kleinknecht, A. and Mohen, P.) Palgrave, Houndmills, Basingstoke and New York, pp. 150-171.

Miller, D. and Droge, C. (1986), Psychological and Traditional Determinants of Structure, *Administrative Science Quarterly,* **31,** 539-560.

Phillips, A. (1966), Patents, potential competition, and technical progress, *American Economic Review,* **56,** 301-10.

Rothwell, R., Freeman, C., Horlsey, A., Jervis, V. T. P., Robertson, A. B. and Townsend, T. (1974), SAPPHO updated - project SAPPHO phase II, *Research Policy,* **3,** 258-291.

Scherer, F. M. (1967), Market Structure and the Employment of Scientists and Engineers, *American Economic Review,* **57,** 524-31.

Schmookler, J. (1966) *Invention and economic growth*, Harvard University Press, Cambridge, Mass.

Scott, J. T. (1984), Firm versus industry variability in R&D intensity, In *R&D Patents and Productivity* (Ed, Griliches, Z.) University of Chicago Press for the NBER, Chicago.

Stoneman, P. and Toivanen, O. (2001), The impact of Revised Recommended Accounting Practices on R&D Reporting by UK firms, *International Journal of the Economics of Business,* **8,** 123-136.

Sutton, J. (1991) *Sunk Costs and Market Structure,* MIT Press, Cambridge (Mass).

Toivanen, O. and Stoneman, P. (1998), Dynamics of R&D and investment: UK evidence, *Economics Letters,* **58,** 119-126.

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.

Verbeek, M. (2000) *A Guide to Modern Econometrics,* John Wiley and Sons, Chichester.

Williams, E. E. (1993), Investment, capital and finance: corporate and entrepreneurial theories of the firm, In *Can the Free Market Pick Winners? What Determines Investment* (Ed, Davidson, P.) M. E. Sharpe, Armonk, New York and London, England, pp. 83-130.

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