Firm Performance and Investment in R&D and Intellectual Property*

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Abstract

This paper analyses the relationship between innovation - proxied by Research and Development (R&D), patent and trade mark activity – and profitability in a panel of Australian firms (1995 to 1998). Special attention is given to assessing the nature of competitive conditions faced by different firms, as the nature of competition is likely to affect the returns to innovation. The hypothesis is that lower levels of competition will imply higher returns to innovation. To allow for a time lag time before any return to innovation, the market value of the firms is used as a proxy for expected future profits. The results give some support for the main hypothesis: the market's valuation of R&D activity is higher in industries where competition is lower. However, the paper highlights the difficulty in assessing competitive conditions and finds a number of results that challenge the simple hypothesis.

1. Introduction

This paper analyses how innovative activity affects firm profitability in a sample of Australian firms. Innovation can be viewed as an investment made in the anticipation of profits. In general, the decision makers in a firm will make the investment if its expected internal rate of return (IRR) is greater than the market rate of interest. However, if the firm operates in a highly competitive environment the process of competition should drive the IRR to the market rate. The only reasons for long run rates of return to differ from this market rate would be due to (undiversifiable) risk, or that the supply of certain resources necessary for the investment are inelastic. The latter may well apply to innovation as key resources include tacit knowledge and specific forms of human capital. For these reasons, interest in the relationship between innovation and profitability has links to competition policy and issues concerning human capital and knowledge provision, in addition to being of interest to managers and investors.

Theoretical models of the relationship between innovation, profitability and competition have been insightful, but have not, so far, provided a single framework for empirical analysis. The results of formal modeling suggest that varying the intensity of competition may increase or decrease the returns to innovation depending on the characteristics of the firms and markets. [1] Other authors, who adopt a more institutional framework, have also noted the complex relationship between competition and innovation, pointing out that firms need some degree of 'control' over their environment, and freedom to collaborate with others, as well as incentives, to foster innovation (Dore, 2000, Kitson and Michie, 2000). This paper approaches the issue from an applied perspective. The paper's main contribution is in linking two empirical methodologies. One of these is concerned directly with innovation and profitability. In particular, since the impact of innovation on profits is subject to lags, the analysis uses the market value of the firms as a dependent variable (the market value should

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[1] For example, Kamien and Schwartz (1976) find that as rivalry increases, R&D per firm may initially increase but will, eventually, decrease. Loury (1979), in a model of endogenous R&D choices for firms that compete in a patent race, finds that an increase in the number of competitors reduces R&D per firm. These models consider identical firms, which suggests that there are no differences in (expected) profitability across firms. Boone (2001) models firms as bidding for a process innovation, finding that the effect of changing the level of competition on technical progress is ambiguous (it depends on the cost history of the industry and the initial level of competitiveness).

reflect the future stream of profits). The other methodology is concerned with the competitive conditions a firm faces. To assess competitive conditions the data are used to test whether firms have a common long run level of profitability. Evidence of the absence of such a common level of profitability implies that the competitive process is not perfect. In addition, there is an established methodology that analyses the persistence of profit shocks, with greater persistence being taken as evidence of weaker levels of competition from rivals.

The structure of this paper is as follows. Section 2 discusses previous approaches to modeling profitability. Section 3 introduces the data available. In summary, four years of innovation data (R&D expenditure, patent and trade mark applications) are available (1994 to 1998). Section 4 contains an analysis of competitive conditions by industry. The aim is to divide industries into groups that reflect the characteristics of competition. Section 5 assesses the relationship between market value and innovative activity. The hypothesis given greatest attention is that the market's valuation will vary according to competitive conditions in the industry. Section 5 summarises the results and critically evaluates the contribution of the paper.

2. Empirical approaches to analysing profitability

Early empirical studies on industry and firm profitability followed the so-called structure-conduct-performance (SCP) paradigm (see Martin, 1993, or Scherer and Ross, 1990, for a review). This held that the structure of the industry (concentration, barriers to entry) affects the conduct of firms (the extent of collusion), which in turn led to pricing decisions and thereby profitability. These studies show that there are differences in profitability across industries, and that the level of concentration and extent of barriers to entry are often important in explaining these differences. However, subsequent analysis undermined these results by noting that many of the explanatory variables were endogenous and that the focus on the industry as the unit of observation missed important firm-level differences. The endogeneity issue – for example can the level of advertising be used as an exogenous variable, or is it the outcome of strategic decisions by firms – led to a focus on game theoretic models. These, in turn, led to empirical analysis of single industries, with the implication that results could not be generalized. Sutton (1991, 1998) has tried to revive cross industry analysis with an approach that uses a mixture of 'watered-down' game theory and empirical data. However, Sutton's bounds approach requires extensive knowledge and analysis of individual industries.

The SCP paradigm has tended to view investment in innovation (especially R&D) as a barrier to entry that can raise profits by preventing entry. In contrast, others have regarded R&D as a method of gaining competition advantage through new-to-the-market innovation. Lev and Sougiannis (1996) use data on US firms (75-90) and show that past R&D expenditures have a significant positive effect on earnings, importantly their data suggest R&D carried out up to nine years ago can still have an impact. They find that the annual internal rate of return on R&D investment is between 15 and 28% (depending on the industry), which is above normal rates of return, although they note that this is prior to accounting for depreciation and taxes. Grabowski and Mueller (1978), using a sample of 86 US firms, also find that R&D has above average rates of return. Using market value as the dependent variable Bosworth and Rogers (2001) find some evidence of above average returns to R&D for Australian firms, something that has been found in market value studies in the US and the UK. The existence of above average rates of return suggests either a large risk premium or that R&D activity is not fully competitive. The latter seems likely as limited entry into R&D may occur due to capital market imperfections, shortages of human capital or knowledge, and the presence of scale effects in R&D.

The possible existence of above average rates of return on R&D, and potentially other types of innovative activity, suggests that the competitive process does not drive returns to market levels. The central issue highlighted in this paper is that it is unlikely that all industries face the same competitive conditions. Hence empirical analysis of the value of R&D should incorporate this aspect.

Various empirical studies have assessed competitive conditions by analysing the persistence of profitability (Mueller and Cubbin, 1990, Waring, 1996, Goddard and Wilson, 1999, Glen et al, 2001). These studies on are based on an equation such as

$$\pi_{i,t} = \alpha_i + \beta\pi_{i,t-1} + X_{it}\chi + \varepsilon_{it} \qquad [1]$$

where π_{it} is firm *i*'s profits in year *t*, α_i is a firm fixed effect, β represents the persistence to a profit shock, *X* is a matrix of other explanatory variables (with coefficient vector χ) and ε_{it} is the standard error term. This type of equation can be used to assess the persistence of profitability within an industry. For example, in some studies the fixed effects are excluded and all firms are assumed to share a common long term profitability level (which is given by $\pi^* = \alpha/(1-\beta)$). In these studies a β coefficient close to zero implies little persistence and, therefore, a competitive environment (i.e. any positive profit shock due, say, to an innovation, is rapidly competed away by rivals). In contrast, when $\beta>0$, profit shocks persist and the implication is that the competitive process is less strong. Using equation [1], however, means that we cannot solely rely on the value of β to assess competitive conditions, since unless α_i is equal to a common value within industries we would generally consider competitive conditions to be weak. This said, the existence of firm-specific accounting procedures or risk profiles would imply that α_i may vary even though competition may be high.

Equation [1] will form the basis for the preliminary empirical analysis in this paper. Specifically, the results from estimating equation [1] by industry will be used as a method of classifying industries into four different groups. The groups are defined by whether the data suggest that a) we can accept a common profitability across firms in an industry over the four year period, and b) whether profit persistence is present. In theory, industries where common profitability is rejected are less competitive and, *ceteris paribus*, should provide greater incentives to innovate. Equally, in industries where there is higher profit persistence should, *ceteris paribus*, provide greater incentives to innovate.

As noted above, an important issue is the lag time between the innovative activity and any impact on profitability. Analysis can be conducted using profitability as the dependent variable. However, *a priori* this is expected to have little validity due to the presence of lag effects. An alternative method of allowing for lag times is to use the market value of the firm as the dependent variable. This methodology is often called a Tobin q's specification. In theory the market value of a firm should reflect the present discounted value of future profits. There are a large number of empirical studies that use market value data as the dependent variable in analyses of innovation and other firm level characteristics (see Bosworth and Rogers, 2001). Of course, this methodology assumes that any valuation errors made by financial markets are orthogonal to the variables of interest, specifically innovation activity.

The basic framework followed is derived from Griliches (1981). This assumes that the market value (V) of the firm is given by

$$V = q(A + \gamma K)^{\sigma} \quad , \qquad [2]$$

where A is the stock of tangible assets of the firm, K is the stock of intangible assets, q is the 'current market valuation coefficient' of the firm's assets, σ allows for the possibility of non constant returns to scale, and γ is the ratio of shadow values of intangible assets and tangible assets (i.e. $\frac{\partial V}{\partial K} \Big/ \frac{\partial V}{\partial A}$).

Using the approximation log(1+ε)≈ε) we can rearrange [2] to yield

$$\log V_i = \log q_i + \sigma \log A_i + \sigma\gamma \frac{K_i}{A_i} + u_i \qquad [3]$$

which forms the basis of the empirical analysis of innovative activities and future profitability (proxied by market value).

3. Data

The data for the analysis come from the IBIS large firm data base for Australian firms. The data base is derived from a variety of sources including published accounts, the Australian Stock Exchange and surveys (see Feeny and Rogers, 1999, for a detailed discussion). The measure of profitability is the ratio of profit before tax to sales (PM). The innovation proxies – R&D, patents and trade marks – come from the Innovation Scoreboard. The Innovation Scoreboard data base is compiled from matching intellectual property (IP) applications data to the company structure data from the IBIS data base. Data on IP are restricted to the 1994 to 1998 period, hence this forms the time period for the analysis. R&D data are taken directly from the IBIS data base which is, in turn, derived from company accounts, ASX information, and surveys of firms. Definitions of the variables are shown in Table 1.

Table 1 Definitions of key variables

Variable	Description
Profit margin (PM)	Net Profit before Tax/Total revenue
Market value	Sum of the share market valuation and book value of debt.
Market share	Ratio of firm revenue to industry (two digit ANZSIC)
Capital intensity	Total assets / revenue defined at parent level
R&D intensity	Research and development / total revenue
Patent intensity	Applications for patents / total revenue
Trade mark intensity	Applications for trade marks / total revenue
Gearing	Ratio of non-current liabilities to shareholders' funds.

The sample of firms is restricted to those firms with profit margins between –10% and 50%.[2] The few firms with profit margins outside this range appear to reflect unusual circumstances (e.g. mergers, extraordinary losses, or that their accounts refer to a financial holding company rather than the core business). In addition, firms with total revenues less than $10 million are

[2] A similar condition is made by Warring (1996).

excluded to focus the analysis on large firms. These conditions produce a balanced panel of 721 firms from the IBIS data base for the period 1995 to 1998.[3]

In the analysis below many regressions are conducted at the industry level, where an industry is defined at the 2-digit ANZSIC level. This level of aggregation is not ideal; but 3- and 4-digit classification of firms in the IBIS data is patchy. There is also the fact that ANZSIC definitions are based on similarities in production methods, rather than any market similarities which the economist would prefer. This is a familiar problem faced by many studies.[4]

4. Analysis of competitive conditions by industry

In this section the data are used to assess the competitive characteristics of each industry. The ultimate aim is to classify industries into groups for subsequent analysis, although the results of this section are of interest in their own right. Equation [1] was used as the regression equation for each of the 26 industries that had at least 32 observations (that is, 8 firms) for the four-year period. The dependent variable is net profit before tax to total revenue. There are some econometric issues in using specification [1]. Estimation of [1] requires either a within or first difference estimator, which removes the time invariant, firm specific effects (α_i). This means coefficients on any explanatory variables will be based on deviations from firm specific means or changes. For example, if a company maintains a constant level of R&D intensity over time, the explanatory variable will exhibit no variation and it will not be possible to estimate a coefficient. Put another way, the firm specific effect will capture any time invariant aspect of the firm's performance. In addition, since equation [1] is a dynamic panel model, the fixed effects estimator will produce a biased coefficient for β. Nickell (1981) discusses these problems and provides a method of adjusting for the bias, a procedure we adopt here.

An initial decision is which explanatory variables to include. It seems appropriate to include year dummies (to capture any macroeconomic trends). Also, other explanatory variables

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3 The use of a balanced panel is required to test the hypothesis of common profitability across the four-year period.

4 The existence of diversified firms makes industry classification problematic, although the data available are not sufficient to tackle this issue The IBIS data base does have 'segment' level accounts for profit, revenue and assets classified by industry, but there is no method of allocating innovative activity to these segments.

included are market share, the square of market share, and capital intensity.[5] The results from the industry regressions are shown in Table 2.

Table 2 Results from industry regressions

Industry	Obs	Prob H_o: $\alpha_i = \alpha$	Prob. Joint sig.	Adjusted β	Mean Profit
Metal Ore Mining (13)	72	0.08	0.03	0.64	0.15
Food, Beverage and Tobacco (21)	228	0.00	0.03	0.56	0.05
Textile, Clothing, Foot., Leather (22)	44	0.74	0.83	0.73	0.03
Wood and Paper Product (23)	32	0.00	0.01	ns	0.09
Printing, Pub.and Recorded Media (24)	44	0.00	0.90	ns	0.12
Petroleum, Coal, Chemical Manu. (25)	240	0.00	0.46	ns	0.07
Non-Metallic Mineral Product (26)	52	0.05	0.29	0.83	0.09
Metal Product (27)	124	0.00	0.23	ns	0.08
Machinery and Equipment (28)	216	0.02	0.05	0.45	0.06
General Construction (41)	52	0.00	0.24	-0.07	0.02
Basic Material Wholesaling (45)	200	0.00	0.00	ns	0.02
Machinery and Motor Wholesaling (46)	272	0.02	0.42	0.53	0.03
Personal and H'hold Good Whole. (47)	188	0.01	0.07	ns	0.02
Personal and H'hold Good Retail (52)	84	0.00	0.37	ns	0.06
Motor Vehicle Retail & Services (53)	64	0.01	0.27	0.87	0.02
Road Transport (61)	32	0.07	0.93	ns	0.06
Services to Transport (66)	88	0.00	0.11	0.48	0.05
Finance (73)	308	0.01	0.14	0.53	0.11
Insurance (74)	120	0.01	0.44	ns	0.05
Services to Finance and Insurance (75)	40	0.10	0.34	ns	0.13
Property Services (77)	72	0.07	0.01	ns	0.12
Business Services (78)	108	0.01	0.00	ns	0.05
Health Services (86)	52	0.00	0.40	ns	0.02
Motion Picture, Radio and TV (91)	56	0.00	0.07	ns	0.12
Sport and Recreation (93)	56	0.00	0.75	-0.23	0.11
Other Services (96)	40	0.00	0.84	-0.22	0.06

Notes: Column 2 shows the total number of observations in each industry (firms x years). Column 3 shows the probability from a F-test of equality of firm specific profitability. Column 4 shows the probability from a F-test that the explanatory variables (market share and capital intensity) are jointly zero. Column 5 shows the adjusted coefficient on the lagged profit margin (ns = not significant). The last column shows the mean profit margin for the industry.

Our initial interest is in testing whether $\alpha_i = \alpha$ (i.e. that the long run level of profitability[6] is equal across all firms in an industry). Using an F-test, we cannot accept the null hypothesis of

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[5] These are motivated by SCP studies. Theoretically, market share is linked to price cost margin and is also a proxy for market (pricing) power. Capital intensity is a proxy for barriers to entry. The relationship between market share and profitability for Australian firms has been shown to be non-monotonic (Feeny and Rogers, 1999, Feeny and Rogers, 2000).

equal, long run profitability in 20 out of the 26 industries at the 5% level (and 24 out of 26 at the 10% significance level). The probability associated with the F-value is shown in column 3 of Table 2. The results suggest that in 20 industries the internal forces of competition are too weak to drive profitability to a common level, although an alternative explanation which we cannot discount entirely is that firm specific, and permanent, differences in accounting methods or risk are driving the results. As an additional check, the above regressions are run excluding the market share and capita intensity variables. The results, in terms of significance of β's are identical. For the test of $\alpha_i=\alpha$, all industries returned the same qualitative results except industry 61 (probability 0.01) and industry 75 (probability 0.05).

The fourth column in Table 2, entitled 'Adjusted β' shows the value of the coefficient on lagged profitability (if the t-statistic on the unadjusted β had a magnitude greater than 1.67). The adjusted value, based on Nickell (1981, equation [17]), is due to the fact that the coefficient on a lagged dependent variable will be biased towards zero in a dynamic panel model. The most striking part of these results is how often the adjusted β is not significantly different from zero (i.e. an 'ns' is entered in the column). A β value of zero suggests that long run expected profits are α_i and that deviations from this are random.

The results from Table 2 concerning whether $\alpha_i=\alpha$, and whether $\beta>0$, allow four types of industries to be identified as shown in the Table 3. As discussed above, theoretically there should be no industries where $\alpha_i=\alpha$ and $\beta>0$, since the former implies a competitive industry and the latter does not, or where $\alpha_i\neq\alpha$ and $\beta=0$. In terms of Table 3 all the industries *should* be in quadrants 2 or 3 (the 'top right' and 'bottom left'). Clearly this is not the case. Table 3 also shows the mean profit levels of firms in each group. These show that the industries where $\alpha_i=\alpha$ is accepted have the higher mean profit margins. Although differences in risk and accounting conventions may be part of the explanation, it is difficult to refute the idea that accepting $\alpha_i=\alpha$ is indicative of within-industry rivalry and not a broader concept of competition (which would reduce profit margins to market rates).

Given this, it appears more acceptable to focus attention on the β values as an indicator of competitive conditions. This is the interpretation favoured by the existing literature where a β value close to zero implies higher levels of rivalry. However, from the point of view of

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[6] 'Long run' is used for expositional reasons only since, in reality, the firm specific effects are based on four years of profit data.

investment in innovation, a β value of zero would not necessarily indicate returns are low since firms that innovate may create a permanent profitability difference. Hence, the incentives facing industries in the bottom right quadrant are uncertain. The analysis has shown that it is difficult to fully assess competitive conditions when using the established methodology. This prompts us to consider other industry characteristics.

Table 3 Typology of competitive conditions

	Profit persistence $\beta > 0$	No profit persistence $\beta = 0$
Accept $\alpha_i=\alpha$	Equal profits in 'long run', persistent profit shocks (13, 22, 26) mean profit margin = 10.2%	Equal profits in 'long run', no persistent profit shocks (61, 75, 77) mean profit margin = 10.1%
Reject $\alpha_i=\alpha$	'Long run' profit differences, persistent profit shocks (21, 28, 46, 53, 66, 73) mean profit margin = 7.2%	'Long run' profit differences, no persistent profit shocks (23, 24, 25, 27, 41, 45, 47, 52, 74, 78, 86, 91, 93) mean profit margin = 7.1%

Note: In the table it is assumed that negative values for β – as occur in industries 41, 93 and 96 – are treated as β=0. Mean profit margins are calculated for those firms in the regression sample for Table 5 below.

An area of interest is whether there are differences in the nature of innovation activity between the four groups show in Table 3. The extent and nature of innovative activity is obviously one of the factors that affects competitive conditions. Table 4 shows summary statistics for R&D activity for each of the four groups of industries. These statistics relate only to the sample of firms used in the regression analysis below. The R&D data in Table 4, and the histograms in Appendix, suggest some interesting differences. The top left quadrant of industries ($\alpha_i=\alpha$, $\beta>0$) have the highest participation in R&D, but low mean intensities and a tight distribution. The 'competitive' industries (top right) have virtually no R&D at all. This, of course, also reflects the fact that there are no manufacturing industries in this group. Both the bottom two quadrants have between a third and a half of firms doing R&D with a skewed distribution of R&D intensities. Similar statistics for patent and trade mark activity are shown in the Appendix 1. Some of the patterns from the R&D activity are present in the patent data, but trade mark activity is more consistent across the groups and, from this perspective, appears much less linked to competitive conditions.

The conclusion of this section is that econometric analysis can be used to assess competitive conditions by using tests of common profit levels and the degree of profit persistence.

However, use of both criteria results in some uncertainty since the two tests can give conflicting signals. Looking at R&D activity in each of the four groups reveals that ‘competitive’ industries have virtually no R&D. Also, industries where common profits levels cannot be rejected, but profit persistence is present, have the highest proportion of firms doing R&D, but low R&D intensities.

Table 4 Competitive conditions and R&D activity

	Profit persistence $\beta > 0$	No profit persistence $\beta = 0$	Row total
Accept α_i=α			
Number of firms	18	12	30
Proportion doing R&D	0.67	0.08	0.36
Total expenditure	$1,087,381	$2,484	$1,089,865
Mean of R&D/revenue (rdi)	0.0034	0.0001	0.0021
Standard deviation of rdi	0.0047	0.0009	0.0040
Maximum rdi	0.0250	0.0063	
Reject α_i=α			
Number of firms	43	78	121
Proportion	0.33	0.47	0.32
Total expenditure	$985,426	$3,915,088	$4,900,514
Mean of R&D/revenue (rdi)	0.0051	0.0035	0.0041
Standard deviation of rdi	0.0204	0.0129	0.0160
Maximum rdi	0.1729	0.1150	

Note: Number of firms and proportion are calculated for 1996 and refer only to firms in the regression sample in Table 5.

5. Innovative activity and market value

In this section the association between market value and innovative activity is assessed. To use equation [3] in empirical analysis, proxies are required for the q_i and *K/A* terms, as well as market value data. Market value data are available for 151 of our previous 721 firms, as most firms are not quoted on the Australia stock market. In the regression analysis the data are pooled over the four-year period to produce 665 observations.[7] To proxy q_i a range of

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[7] The panel becomes unbalanced since a few companies do not have profit or revenue data for 1993 (which are required to calculate the growth of profits and revenue variables used as explanatory variables). An alternative specification would be to retain the time series dimension and use fixed effect models, or use a between estimator. The latter produces too few observations in some of the sub-samples. A concern with the former approach is that the measurement error presence in the innovation proxies tends to attenuate coefficients (i.e.

variables are included: past revenue growth, past profit growth, market share, and gearing. The proxies for K_i are R&D, patents and trade mark activity. Importantly, this means that flow variables are used to proxy what should be a stock variable.

Table 5 presents results from a series of regressions using equation [3]. The first column shows the results from the full sample and the next four columns show the results from a regression on each of the sub-samples ("quadrants") identified in Table 3. These regressions contain a number of interesting results, including:

- Theory, and previous empirical results, suggests that the coefficient on logA should be close to 1. This is true for the full sample regression and groups 3 and 4. However, groups 1 and 2 – which accept common profit levels – are substantially below 1, indicating that firms with higher assets do not have the proportional increase in market value.
- The coefficients on the R&D/A variable vary across sub-samples in both significance and magnitude (this is discussed in detail below).
- The coefficient on the patent/A variable is never significant. The trade mark based variable shows no significant partial correlation in the full sample, but is significant and negative in regression (3), and significant and positive in (4) (see below).
- The coefficient on intangibles/A is negative and significant in the full sample and sub-samples (1) and (4).
- The coefficients on the market share variables generally imply a concave relationship with market value, although this is not the case in sub sample (2) and (3).
- The level of gearing often shows a negative association with market value (as expected, higher gearing implies higher risk and lower valuation).
- The growth of revenue coefficient is insignificant in the full sample. In group (2) the coefficient on growth of revenue is negative and significant, yet the coefficient is positive and significant in (3). In contrast, the coefficient on past profit growth is positive and significant in groups (1) and (4).

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bias them to zero). In addition, pooling the data is the method used in Bosworth and Rogers (2001), which allows a direct comparison.

Table 5 Market value regressions

Explanatory variable	Full	$\alpha_i=\alpha$		$\alpha_i\neq\alpha$	
		Group 1 $\beta>0$	Group 2 $\beta=0$	Group 3 $\beta>0$	Group 4 $\beta=0$
Log (tangible assets)	0.972	0.384	0.671	1.103	0.961
	(35.91)	(4.10)	(4.48)	(21.93)	(24.28)
R&D / tangible assets	3.405	58.23		1.28	7.766
	(2.21)	(3.10)		(1.12)	(2.38)
Patents / tangible assets	1.953	30.07	151.751	-6.017	-4.025
	(0.47)	(1.39)	(0.33)	(-1.31)	(-0.60)
Trade mark/ tangible assets	0.264	-2.08	2.102	-2.207	0.813
	(0.70)	(-0.93)	(0.88)	(-3.45)	(2.07)
Intangible / tangible assets	-0.202	-1.167	-1.65	-0.129	-0.294
	(-2.60)	(-1.73)	(-0.99)	(-0.55)	(-3.75)
Market share	3.326	14.643	9.064	-1.495	5.207
	(3.75)	(4.06)	(1.46)	(-0.27)	(4.17)
Square of market share	-3.799	-26.748	-10.494	-7.1	-6.175
	(-3.52)	(-3.15)	(-0.62)	(-0.20)	(-4.14)
Gearing	-0.138	-0.832	0.172	-0.148	-0.264
	(-16.10)	(-3.33)	(0.76)	(-14.98)	(-3.76)
Growth of revenue	-0.021	-0.315	-0.117	0.24	-0.051
	(-0.63)	(-0.82)	(-1.76)	(1.78)	(-1.20)
Growth of profitability	0.015	0.008	0.063	0.001	0.026
	(2.32)	(2.00)	(1.08)	(0.04)	(1.99)
Industry dummies (significant)	Yes (Yes)	Yes (Yes)	Yes (Yes)	Yes (No)	Yes (Yes)
Year dummies (significant)	Yes (Yes)	Yes (No)	Yes (Yes)	Yes (No)	Yes (Yes)
Normality	0.01	0.04	0.34	0.00	0.28
RESET (Fail/accept)	0.00	0.14	0.00	0.00	0.00
Observations	595	70	48	169	308
R-squared	0.915	0.932	0.944	0.951	0.907

Notes: t-statistics in brackets are based on robust standard errors. Full sample refers to all data available. Industry dummies refers to two digit ANZSIC classification, year dummies entered for 1996, 1997 and 1998 (significance judged by F-test at 5% level). The ‘normality’ row shows the probability from a test of normality of residuals (null hypothesis normal residuals). The ‘RESET’ row shows the probability from an F-test of the joint significant of adding the powers of the explanatory variable as additional explanators.

5.1. R&D activity

The R&D/assets coefficients in Table 5 require detailed comment. The R&D variable has a coefficient of 3.4 in the full sample, a magnitude similar to that found in Bosworth and Rogers (2001) for Australian firms over 1993 to 1996. To interpret this coefficient we can recall that the coefficient is $\sigma\gamma$, hence γ has a value of 3.5, which is the ratio of shadow values (i.e $\frac{\partial V}{\partial K}\Big/\frac{\partial V}{\partial A}$). However, since R&D is current expenditure, not the stock of R&D, this cannot be taken as direct evidence of under investment in R&D. For example, suppose that R&D is (suddenly) obsolete after 3 years and that R&D is constant through time at level R, hence the stock value would be 3R. Thus, the coefficient estimate from using R as a proxy will be three times as high (in this case the 'true' ratio of shadow values would be 1.17). An alternative method of interpreting coefficient values is to use the standard deviation (s.d.) of the variable. For the full sample, the s.d. of R&D/A is 0.0134, hence a one standard deviation change is associated with a 4.6 % change in market value.

The R&D/A coefficient in regression (2) has a magnitude of 58, which implies a γ value of 151. This is a very high value implying either very high returns to R&D, or very little obsolescence in R&D. Both of these reasons seem difficult to accept. In this sub-sample the s.d. of R&D/assets is 0.004, which implies a one standard deviation increase in R&D is associated with a 23% increase in market value. Further investigation reveals that this result depends on industry 26 (non-metallic mineral products) being included in this sub-sample (omitting firms in industry 26 makes the coefficient insignificant). The results in Table 2 suggest the probability from the F-test of common profit levels for industry 26 is 5.16%, which implies failure to accept the hypothesis, and classification into group (1). This highlights a drawback of the analysis: the classification of industries into competitive groups is sensitive to the significance levels chosen (in this case the possibility of a type II error).

There is no R&D/A coefficient reported in regression (3) since no firms do R&D in this sub-sample.[8] For regression (3), the coefficient on R&D/A is not significant, suggesting R&D activity has no impact on market value. Since around a third of firms in these industries undertake R&D this result is surprising. Inspection of the data show that R&D activity in this sector is skewed with a few firms with high R&D intensities. Excluding firms with R&D/A above 0.025 (the maximum of the sub-sample (2)), still results in an insignificant coefficient. Regression (4) shows a coefficient for R&D/A of 7.8, implying a higher shadow value of R&D that the full sample result. The coefficient implies a one standard deviation increase in R&D/assets (0.013 in this sub-sample), implies a 10% increase in market value.

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[8] In fact, there is one firm that reports R&D in a single year. This firm is classified in industry 77 (property services), although it also carries out construction (which would be industry 41). Including their R&D in the sample yields a coefficient 92.6 with a t-statistic of 3.8.

5.2. Patent and trade mark activity

The regressions indicate that patenting activity is never significantly associated with market value. The implication is that either patent applications are a poor proxy for innovative activity, or that the stock market fails to recognise such value. An issue in interpreting the results is that the patent to assets variable is correlated with the R&D variable (correlation coefficient 0.28), and this may cause multicollinearity. Excluding the R&D/A variable, and re-estimating the regressions, reveals that the coefficient in group 1 becomes significant. This suggests that patenting activity may raise profits in these industries.

For trade mark activity, the negative coefficient in group 3 suggests a one standard deviation increase in trade mark intensity *reduces* market value by 4.4%. Why this should be the case is unclear, especially as in group 4 a one standard deviation increase is associated with a 4% *rise* in market value. Since trade mark applications are likely to have a closer association with marketing and advertising expenditures, rather than brand names[9], the implication is that some firms can over invest in the judgement of the market. Note, however, that these results do not hold for the sub-samples made up of non-manufacturing firms only (see below).

5.3. Other variables

The main conclusion concerning the other variables is that the magnitude and significance of the coefficients varying dramatically across sub-samples. The coefficients on the log of assets variable reveal that in the industries where common profitability is accepted are less that 1, something that suggests large firms could downsize and raise market valuations.[10] For the most competitive industries (group 2) note that the market share coefficients are insignificant: there is no apparent advantage to high market share in such industries. This is in line with intuition, although the same results holds in group 3 which might be expected to have market power effects. The instability of coefficients across sub-samples is also seen in the growth of revenue and profit variables.

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[9] Brand names are likely to be associated with the stock of trade marks held rather than the number of applications.

[10] Of course, all of the results are based on cross sectional differences between firms, hence there is no direct evidence that any specific large firm could 'downsize' and raise its market value.

5.4. Modifications

A concern with the regressions in Table 5 is that all the sub-samples contain both manufacturing and non-manufacturing firms. To the extent that manufacturing firms are more likely to conduct R&D and patent, it is possible that coefficients vary between manufacturing and non-manufacturing firms. Table 6 below shows the results from only using manufacturing firms (only coefficients on some of the variables are shown; the full specification is the same as in Table 5 and the coefficients on other variables are similar to Table 5). Overall, a similar pattern of results is shown, although coefficient magnitudes are different. The magnitude of the coefficient in group 1 now suggests that two firms with a one standard deviation difference in R&D/A have, ceteris paribus, a 65% difference in market value. This strong association suggests R&D is very important in these industries. Why firms do not increase R&D intensity if these high returns exist is unclear. One possibility is that there are firm-specific constraints in knowledge, opportunity or human capital.

Table 6 Market value regressions, manufacturing only

Explanatory variable	Full	$\alpha_i=\alpha$	$\alpha_i\neq\alpha$	
		Group 1	Group 3	Group 4
		$\beta>0$	$\beta>0$	$\beta=0$
Log (tangible assets)	1.157	0.769	1.249	0.978
	(29.38)	(2.57)	(16.48)	(16.59)
R&D / tangible assets	2.439	120.68	2.197	8.189
	(2.27)	(4.32)	(2.36)	(2.26)
Patents / tangible assets	11.757	54.558	1.913	-3.695
	(2.51)	(3.11)	(0.36)	(-0.63)
Trade mark/ tangible assets	-0.131	-3.18	-1.672	0.43
	(-0.34)	(-2.16)	(-2.44)	(2.28)
Observations	247	36	87	124
R-squared	0.935	0.983	0.952	0.949

Notes: t-statistics in brackets are based on robust standard errors.

In a similar way, Table 7 shows the coefficients on log of tangible assets and trade mark intensity for the non-manufacturing firms only. The R&D and patent variables are omitted from these regressions, but all other explanatory variables are included (again, their coefficients are similar and are not reported). The full sample of non-manufacturing firms shows a significant and positive coefficient on trade marks to assets. The magnitude of this coefficient suggests a one standard deviation change in trade marks to assets changes market value by 5%. Note that the coefficient on trade marks, as with R&D and patents in manufacturing, is much higher in group 1. However, the smaller standard deviation in this group implies a change of one standard deviation is associated with an 11% change in market value.

Table 7 Market value regressions, non-manufacturing firms only

Explanatory variable	Full	$\alpha_i=\alpha$		$\alpha_i\neq\alpha$	
		Group 1 $\beta>0$	Group 2 $\beta=0$	Group 3 $\beta>0$	Group 4 $\beta=0$
Log (tangible assets)	0.91 (24.63)	0.471 (3.32)	0.671 (4.82)	1.038 (20.52)	1.022 (17.19)
Trade marks / tangible assets	1.637 (2.16)	363.762 (2.85)	3.485 (1.52)	-1.577 (-0.56)	2.399 (2.76)
Observations	348	34	48	82	184
R-squared	348	34	48	82	184

Notes: t-statistics in brackets are based on robust standard errors.

6. Conclusions

This paper has analysed the relationship between innovative activity and market value of large Australian firms, with a specific focus on how this relationship may vary with competitive conditions. This is not something that the prior empirical literature on firm level innovation has focused on, although it is an issue studied by theoretical models. The methodology used is a two stage approach. Initially, a dynamic panel data model is run for each industry to assess whether there is a common level of profitability and whether profit shocks are persistent. For these regressions the net profit before tax to revenue is used as the dependent variable. This analysis is used to classify industries into four groups that have similar competitive conditions. This classification is then used in an analysis of innovative activity – proxied by R&D, patent and trade mark activity – and the market value of the firm. The market value of a firm should reflect the future expected flows of profits, hence it allows for lags in the time innovative activity takes to affect profits. The major drawback of this analysis is that it can only be undertaken for firms quoted on the Australian stock market and it relies on the market's valuation being informed and unbiased.

In using this new, two-stage procedure this paper has highlighted a number of empirical difficulties. First, the established methodology of assessing competitive conditions, which utilises a profit persistence type framework, does not provide an unambiguous classification of competitive conditions. Specifically, there are industries where the hypothesis of common profit levels is accepted (implying relatively high levels of competition) and yet profit persistence occurs (implying lower levels of competition). This paper suggests that additional information on mean profitability and innovative activity should be used to understand competitive conditions further. Second, the use of a two-stage analysis means that type I and II errors made in the first stage will affect outcomes in the second stage. Some testing of sensitivity is conducted, but the fact remains that the analysis has an inbuilt sensitivity. Third, the limited number of observations forced the analysis to be conducted at the two-digit ANZSIC level, a level of aggregation less than ideal.

Despite these difficulties the analysis produced some interesting results. The analysis of competitive conditions found that in 20 out of the 26 industries it is impossible to accept the null hypothesis of common profitability. This is an indication of lack of competitive pressure in the majority of industries, although differences in firm specific risk or accounting procedures may also be at work. Analysis of profit persistence revealed that 9 out of the 26 industries had positive profit persistence – an indication that internal rivalry is slow to compete away excess returns. The difficulty in interpreting results, however, is that some industries accept common profitability but also demonstrate persistence. It turns out that these industries have very high participation in R&D, with low R&D intensity, and also high mean profitability. A possible explanation is that these industries are ‘competitive’ in the sense that incumbent firms have few long run sustainable advantages, but that R&D is valued because it can create profitability differences in the short run and, possibly, acts as a barrier to entry. The absence of high R&D intensity firms in this sub-sample suggests firms do not see profitable opportunities from increasing intensity (despite the fact that the cross sectional evidence from the market value regressions suggests extremely high returns).

The results from the regression analysis of market value show that the magnitude and significance of coefficients varies across the sub-samples formed on the basis of the analysis of competitive conditions. This is an important result that implies that the results from previous studies are averages of heterogeneous coefficients across different sub-samples. The results above suggested the highest returns to R&D are in industries that have profit persistence but common profitability. Moreover, the analysis showed that in these industries the market places a lower relative value on larger firms (as measured by tangible assets). Firms in these industries are also the only ones that have, in some regressions, a positive association with patenting. Similarly, if the analysis is conducted for non manufacturing firms and with trade marks as the only innovation proxy, we find high relative returns to trade mark activity in this group of industries. Although it is difficult to fully explain these results, they suggest the dynamics of competition and innovation in these industries are distinct.

Most of the firms are located in industries where we cannot accept the null hypothesis of equal profitability. This would suggest that firms may be able to use innovation to gain a sustainable competitive advantage. Moreover, within this sub-sample, those industries that exhibit profit persistence might be taken as implying even higher incentives to undertake innovation (since even a temporary boost to profits from an innovation would persist). This turns out not to be the case. In general we find that the sub-sample of industries where $\alpha_i \neq \alpha$ and $\beta=0$ have the higher returns to innovative activity. The implication of this is that some aspects of these industries permit higher returns. This implies further analysis of the complex nature of competition within industries, and the range of factors that can cause sustainable advantages and profit shocks.

Appendix 1: Innovation activity by competitive groups

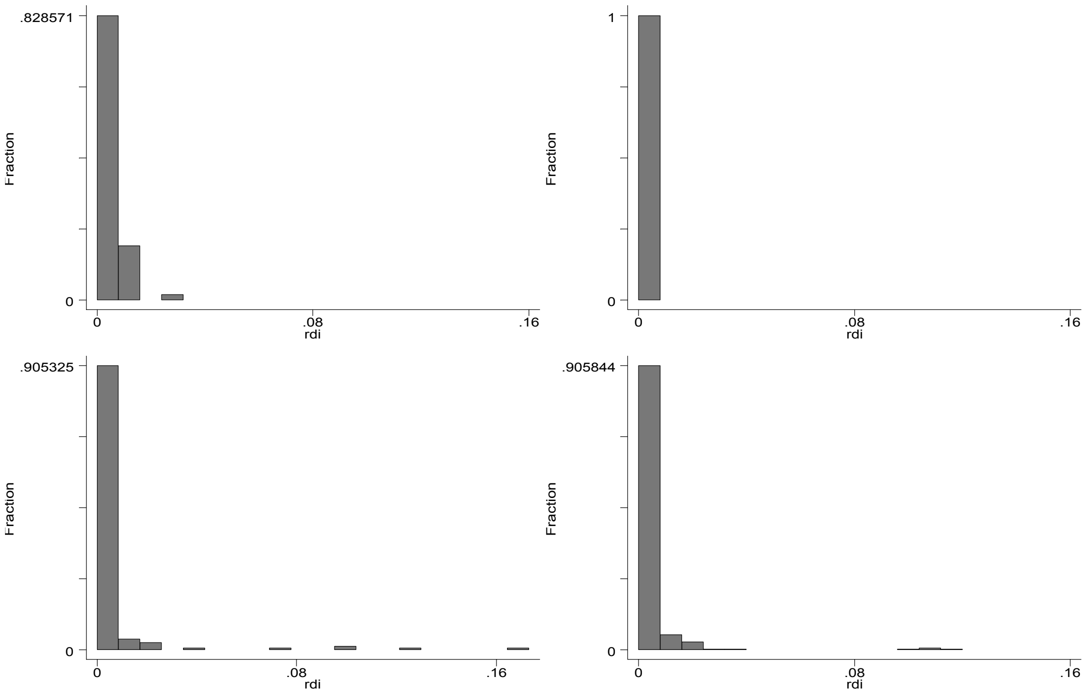
Competitive conditions and Patent activity

	Profit persistence $\beta > 0$	No profit persistence $\beta = 0$	Row total
Accept $\alpha_i=\alpha$			
Number of firms	18	12	30
Proportion	0.39	0.08	0.19
Total patent applications	408	8	416
Mean of patent/revenue (pi)	0.0020	0.0000	0.00145
Standard deviation of pi	0.0067	0.0001	0.0052
Maximum pi	0.0324	0.0007	
Reject $\alpha_i=\alpha$			
Number of firms	43	78	121
Proportion	0.15	0.16	0.16
Total patent applications	283	724	1007
Mean of patent/revenue (pi)	0.0014	0.0010	0.00134
Standard deviation of pi	0.0068	0.0034	0.0049
Maximum pi	0.0667	0.0234	

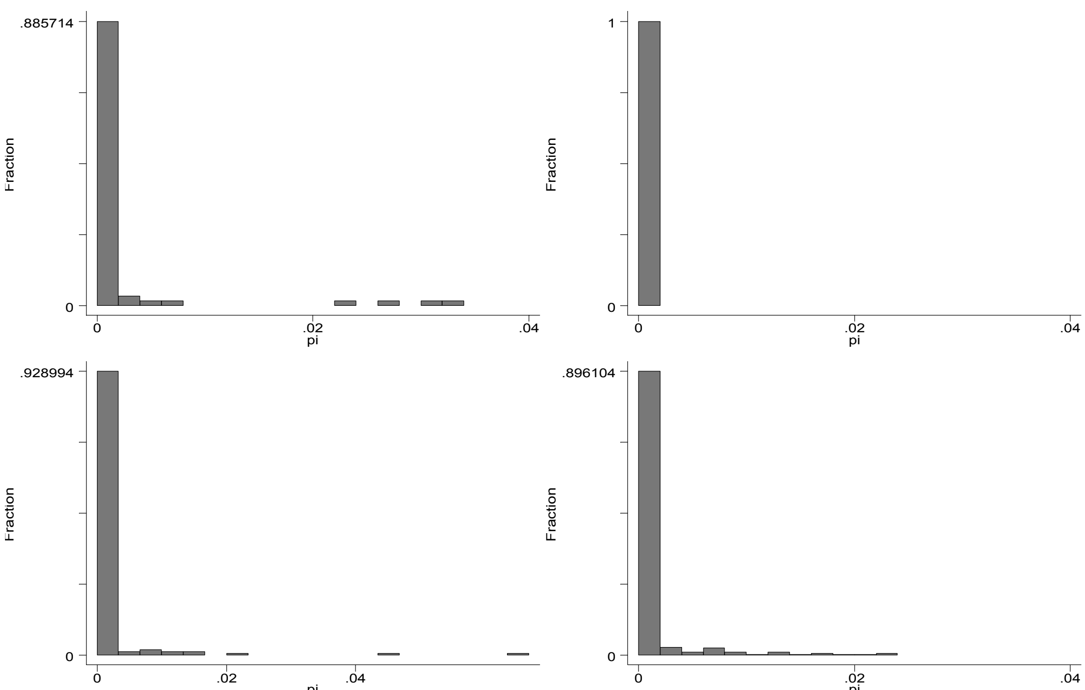
Competitive conditions and trade mark activity

	Profit persistence $\beta > 0$	No profit persistence $\beta = 0$	Row total
Accept $\alpha_i=\alpha$			
Number of firms	18	12	30
Proportion	0.61	0.75	0.45
Total trade mark applications	1516	424	1940
Mean of trade mark /revenue	0.0111	0.0168	0.01388
Standard deviation of ti	0.0256	0.0429	0.0337
Maximum ti	0.1533	0.1936	
Reject $\alpha_i=\alpha$			
Number of firms	43	78	121
Proportion	0.67	0.85	0.56
Total trade mark applications	4316	7487	11803
Mean of trade mark /revenue	0.0093	0.0153	0.02024
Standard deviation of ti	0.0210	0.0493	0.0417
Maximum ti	0.1799	0.7047	

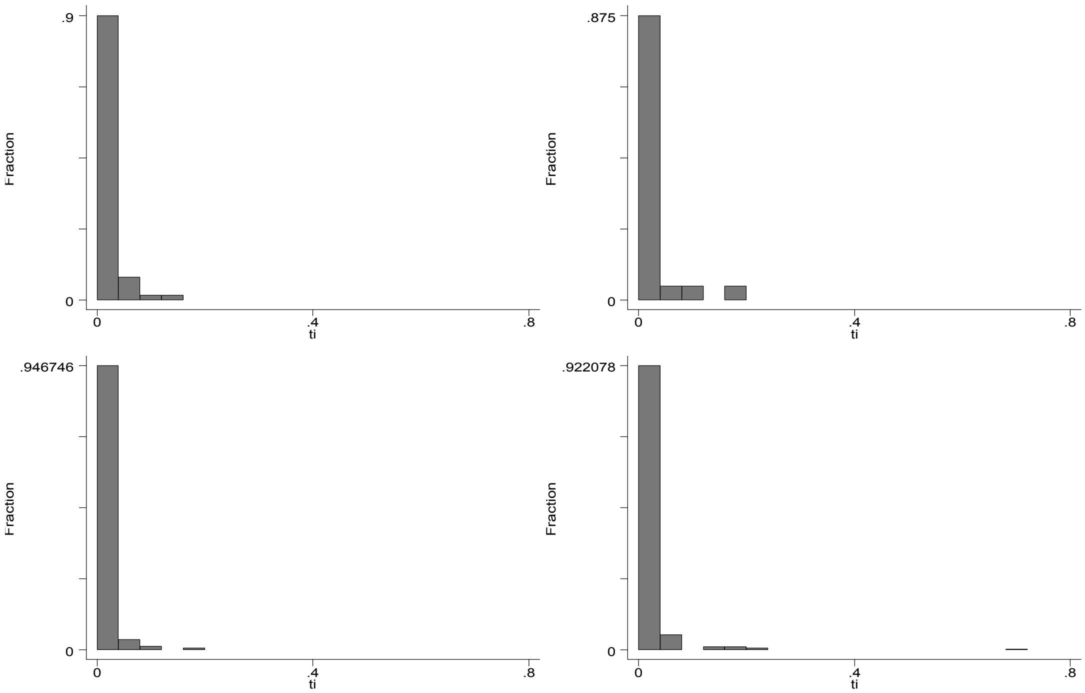
Histograms of R&D/total revenue by competitive groups



Histograms of patent applications/total revenue by competitive groups



Histograms of trade mark applications /total revenue by competitive groups



Data Appendix

The data come from the IBIS large firm data base, Australian Stock Exchange (ASX) (via the Securities Industry Research Centre of the Asia-Pacific, University of Sydney), and from the Innovation Scoreboard database created by the Melbourne Institute. R&D data are drawn from the IBIS Business Information Pty large firm data base which contains data on around 2,800 firms. The data are derived from a variety of sources including published accounts, the ASX and surveys. In general, Australian companies should abide by AASB 1011 which states that 'material' R&D should be reported in the accounts. This should ensure R&D data are present in the IBIS data base. However, in practice, it appears that some companies do not to report R&D even when significant R&D has been undertaken (Percy, 1997).

The data on intellectual property (patents, trade marks and designs) are for applications. These intellectual property data are compiled by matching the names of firms in the IBIS data base against IP Australia's *Annual Record of Proceedings*, which is the complete list of all applications made or designated in Australia. The parent company name, and the names of all majority owned subsidiaries, were checked against the *Proceedings*. Use of applications, not grants (i.e. successful applications) can be justified for two reasons. First, there can be lag of a few years before an application is granted, hence use of grants might provide an out of date assessment of a firm's current innovative activities. Second, since the use of the applications data is intended as a proxy for current innovative activities, and given that innovation is normally defined as ideas that are new to the firm, use of applications have some merit (i.e. even if the application is unsuccessful due to the idea existing somewhere else, there is still an implication that the firm is making efforts to innovate).

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