Firms' Decisions to Innovate and Innovation Routines *

Elizabeth Webster
Melbourne Institute of Applied Economic and Social Research
Intellectual Property Research Institute of Australia
The University of Melbourne

Melbourne Institute Working Paper No. 5/03

ISSN 1328-4991 (Print)

ISSN 1447-5863 (Online)

1. ISBN 0 7340 3117 3

November 2004

*This paper is the result of work being undertaken as part of a collaborative research program entitled *The Impact of Enterprise and Workplace Focused Industrial Relations on Employee Attitudes and Enterprise Performance*. The project is supported by the Australian Research Council, the Business Council of Australia, the Committee for the Economic Development of Australia and IBISWorld. The views expressed in this paper represent those of the author and not necessarily the views of the collaborative partners. The author would particularly like to thank other members of the survey team, Mark Wooden, Danny Samson, Peter Dawkins, Joanne Loundes, Tim Fry and Pat Foley for the design of the survey and Anita Aherne for her excellent efforts in ensuring the surveys were completed. In addition, I would like to thank Maria Tarrant, Jongsay Yong and Tim Fry for comments on this paper.

Melbourne Institute of Applied Economic and Social Research
The University of Melbourne
Victoria 3010 Australia
***Telephone* (03) 8344 3701**
***Fax* (03) 8344 5630**
***Email* melb-inst@unimelb.edu.au**
***WWW Address* http://www.melbourneinstitute.com**

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Abstract

This paper investigates the forces that lead some firms to engage in more innovative activities than others using a survey of 360 large Australian firms. Many earlier studies on the determinants of innovation followed the Schumpeterian tradition, and focused on size and market structure as possible causes of innovativeness, however with the event of new qualitative measures of industry knowledge and managerial styles, these factors have been found to be less important. The results of the present study show that external factors and generic routines common to all industries, such as the extent of learning, knowledge spillovers, appropriability and managerial approach are more important than industry specific forces. Foreign owned companies were also found to be more innovative, other things considered.

Introduction

There are several (non-exclusive) motivations for firms to engage in innovation. Innovations can reduce production cost, increase the quality of products, capture or create new product markets and reduce the firm's reliance upon unreliable or capricious factors of production. In general, any innovation that gives the firm a sustained cost or demand-side advantage over its rivals should enhance its profitability.

This paper investigates the forces that lead some firms to decide to engage in more innovative activities than others and examines the types of routines associated with this decision. There have been few attempts to address this question, perhaps because of the unusual demands on the data (recent examples include Beneito 2003 and Galende and de la Fuente 2003; see Cohen 1995 for a discussion). The present paper does not consider final profitability outcomes nor does it assume a positive monotonic relationship between innovation and performance. Innovation is an inherently risky business and more innovative activities, or certain forms of innovation, may be debilitating in differing circumstances. Lack of innovation may accordingly be a well chosen decision by a firm and may be entirely appropriate given its operating environment and internal capabilities. Notwithstanding this, *successful* innovation, compared with no innovation at all, can be the key to a strong market position and high profits. Doing nothing may not be an option.

It is argued that the conditions under which innovation is desirable for firms will vary according to external pressures and constraints (the nature of its input and output markets, its production processes, knowledge spillovers), and, its inherited internal capabilities (principally via the skills and accumulated experience of its workforce). Once management has identified the desired balance between innovative and prosaic activities, it may seek to realise it through routines associated with certain styles of management, the nature of the work culture in relation to learning and appropriation.

Innovation, which is '…to introduce changes and new ideas'[1] can refer to changes and ideas which are new to the world (an invention) or new to a firm (inventions, imitations and adaptations). This paper uses the second, broader meaning. Both inventions and imitations and adaptations affect firm performance, and it is likely that the latter are complementary activities to the former. In this paper, therefore, a more innovative firm is either more creative and original or quicker to keep abreast of competitors and to modernise their operations.

The subsequent sections of this paper discuss first, the general approaches to theories of firm behaviour, and secondly a specific model characterising the innovation choice. Subsequently, the model is estimated using data from a survey that was undertaken, in three stages, between October 2001 and December 2002.

Models of firm behaviour

The decision by the firm to innovate should be regarded in the light of what firms aim to do. Profit orientated firms aim to improve their operational efficiency to reduce costs, and through broadening their market reach, expand their revenues. Both goals are achieved through decisions over the mix and level of their physical and human technologies (including organisational forms), and both goals must be cognisant of gains from both static production efficiency and dynamic innovation.

Neoclassical theories of firm behaviour have little to say about the determinants of these innovative improvements. The standard 'theory of the firm' is essentially concerned with the pricing and factor use decisions and makes no direct comment about investment intentions. Jorgenson's (1971) prototype neoclassical investment model only represents decisions which have been motivated by the need to extend productive capacity. This is a peripheral motive for innovation investments which are more concerned with the need to compete and contain business uncertainty or actuarial risk. Game theory explicitly models the innovation decision but it assumes a large amount of certainty in relation to the innovation and invention process

such as the outcomes of invention, rival responses and invention costs. For many people, this assumes away critical features of invention and innovation.

Evolutionary models, which owe many foundations to Nelson and Winter (1982), are perhaps more apposite. These argue that industries, or groups of rival firms, evolve through a process involving the creation of variety (through industrial invention), inheritance (through the persistent of each firm's routines and behavioural norms) and selection (through competition and market exit). The evolution of industries requires continual cycles of invention, inheritance and selection.[2]

Firms embrace routines and make decisions based on rules of thumb in response to behavioural or fundamental uncertainty[3] in both external markets and the firm's internal processes. According to Hodgson, (1999; p 260)

> 'In the context of an uncertain world the analysis of human behaviour has to be centred on the development of capabilities to deal with complexity and change, and on the modes of generation and transmission of knowledge about the socio-economic environment'.

These procedures for profit making arise from the firm's acquired skills and accumulated experience, intangible assets, history of innovation, and modus operandi. External pressures are influential, but not absolute as in the neoclassical model. What appears the best strategy *ex ante* will not necessarily work out the best *ex post*, because of bounded rationality and the fundamental uncertainty of the business world (Hall 1994). This process of path dependency and managerial latitude leads to diversity between firms not present in the neoclassical models.

While the evolutionary approach emphasises the more germane aspects the innovation process, its reliance upon path dependent activities and outcomes makes it more difficult to model and estimate. Nonetheless, the following sections devise and test a model to capture certain features associated with the routines used by firms which pursue more innovative strategies.

A model of the decision to innovate

In determining their profit seeking strategy firms will implicitly, if not explicitly, make a decision about the relative emphasis they give to improving static operational efficiency against improving their dynamic efficiency. The greater emphasis laid on the latter, the more innovative the firm. While non-systematic individual factors are relevant in this decision, systemic extra-firm factors associated with the prevailing technology, and technological opportunities in their product area, and given external market circumstances are also expected to have some bearing (see both the theoretical (Nelson 1959, Schmookler 1966, and Dosi 1988) and applied studies (Arvanitis and Hollenstein 1996, Crepon *et al.* 1996, Geroski and Walters 1995). These decisions will involve choice over the physical and human technologies employed by the firm. By the latter, we mean the skill mix of the workforce, the structure of information and decision making and the extent of cooperative work within the production line.

Under the evolutionary model of firm behaviour, the decision over how actively innovative activities will be pursued, will be accompanied by a series of routines and practices that support and nurture these activities. These routines are generally stable over time, only breaking in response to a large stimulus. It is this inertia in routines that ensures that the 'selected' efficient companies, continue to operate efficiently (Hodgson 1999).

1.1.1 Routines complementary to innovative activities

While it is not possible to generalise about specific routines and rules of thumbs used for decision making in firms, it may be possible to speak of generic styles associated with those routines. These may include managerial attitudes, the modes of communication within the organisation, the level of encouragement given to staff to learn about new products and processes, and the deployment of means to appropriate profits that may accrue from new products and processes. The use and effectiveness of these complementary practices is a

discretionary managerial decision, but is also subject to constraints external to the firm. For example, how effective patents are for protecting new products depends both on how patentable the product is and how many resources the company devotes to establishing and defending its patent.

The use of effective means of appropriating returns is perhaps the strongest and most cited force associated with the inventive or innovation decisions in the literature, whether this is through extensive use of patents and secrecy – forces discretionary to the firm – or, through less directly malleable forces such as company size, market concentration is still under debate (see Felder *et al.* 1996, Kleinknecht 1996 for example).

In this paper, we test a model of both the external factors affecting the innovative decision and the internal routines that accompany this decision using firm level data. While there have been several formalised theoretical models to describe the evolution of firms and industries based on rules regarding rates of invention and imitation (i.e. Iwai 1984, Winter 1984, Winter *et al.* 2003), the types of routine employed by firms, being more fuzzy concepts, appear less amenable to such precise modelling. Accordingly, a very generic model will be used, and estimated using non-linear least squares.

The data: The Melbourne Institute Business Survey

Data was derived from a business survey of large Australian firms during the period from October 2001 to December 2002. The largest 1000 enterprises (by total revenue) were chosen from the IBISWorld enterprise database in each of the two years, and subsequent to initial calls, 1466 surveys were mailed out, with 436 useable surveys returned from unique organisations. This is a response rate of 21.8 per cent (or 29.7 per cent of the mailed out surveys), which is consistent with surveys of this type (see for example, Huselid 1995, Covin *et al.* 2001). Descriptive statistics for the organisations are given in Table 1, which presents the major industry categories, location and employment size of the organisations in our

survey. More than a quarter of organisations were located in manufacturing, with the next highest proportion represented by finance and insurance, wholesale trade, and property and businesses services. Importantly however, the distribution of responses across characteristics does not differ markedly from the initial selected population, implying that the responses should not be biased towards a particular group.[4] This is confirmed by the regression analysis which found no support for the hypothesis that there has been a selection bias in the responding firms based on industry and company type.

Respondents were asked to answer 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 level of innovation within the firm, or 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. [5] Because the variables are averages of up to 16 items, they are very like continuous variables bounded between 1 and 7.

1.1.2 Developing variable measures from the data

Following the discussion above, item questions from the survey questionnaire and the IBISWorld data base have be used to devise measures of:

1. The innovativeness of the chosen human technology.

2. The external conditions that influence the emphasis firms place on innovation compared with static efficiency: physical technology, corporate structure and size, external product market conditions, external labour market conditions and the extent of knowledge spillovers from competitor firms. No measures were available for the pre-existing capabilities of the firm.[6]

3. The routines that complement this choice: management style and communication techniques, the effectiveness of avenues for learning and the effectiveness of means of appropriability.

Table 2 presents a summary of the selected measures. The *innovation mode*, is defined by the priority given by the organisation to innovation and the state-of-the-art developments. This included managers' rating on the 1 to 7 scale of: resources devoted to organisational change and other firms' technologies over the past three years; how often new or modified products have been introduced over the past three years; the extent to which firm produces a continuous stream of state-or-art products; the extent to which firm was first to the market with new products; and the extent to which the firm responded to early market signals concerning new opportunities.[7] While this measure of innovation includes information on R&D expenditures, it does not rely upon R&D expenditure explicitly because of frequent under-reporting in accounting data, especially for medium size companies, and concerns about consistency of definition between firms. Empirical studies which rely solely upon accounting R&D data have been found to get unreliable results (Kleinknecht 1996).

The external conditions variables were comprised of a combination of objective industry and company data. Only a rather limited measure of the extent of expenditure on *physical technology* was available.[8] This comprised two measures of the firm's expenditure on plant and equipment and on external technologies. To some extent, the industry variables will capture other dimensions of the dominant physical technology and thus the technological opportunities available to the firm. *Corporate size and structure* variables included data on the total revenue, foreign versus local ownership, whether the firm was a single integrated business, a multiple related business or another type, whether is was public, private or government, and whether it was listed on the stock exchange. The *external product market* variables were reflected in 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 the ease of entry into the industry. Except for the industry coding (which is done by IBISWorld), these measures were drawn from survey responses. Knowledge spillovers from competitors were measured as the inverse of the average effectiveness of all firms in the firm's industry at appropriating the advantages of their new and improved products and processes. The argument is that the greater the ability of other firms in their industry at keeping their knowledge and competitive advantages to themselves, the fewer the spillovers that will naturally flow to their colleague firms.

Finally, a series of variables were constructed to reflect routine types. Four different types of *managerial approach* 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 final

management style variable was a measure of how, and to what extent, the firm made an effort to communicate with its employees. This variable, *communication techniques*, 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.

In addition, routines relating to leaning and appropriability were also considered. The *extent of learning* about new products and processes was derived from a series of questions about how much companies learnt from licensing new technologies, patent disclosures, publications or technical meeting, informal and formal networks with other organisations, hiring skilled employees from other companies, reverse engineering, R&D, lead customers, suppliers and consultants. The effectiveness of the *means of appropriating* the profits from innovation was collected from a series of questions about the effectiveness of the following methods for both new products and processes: patents, secrecy, lead time, moving quickly down the learning curve, control over distribution, brand name and marketing, organisational know-how and capabilities and product and production complexity (adapted from Levin *et al.* 1987).

1.1.3 Descriptive analysis

Given that most of the measures devised for the model have been ordinally enumerated, it makes little sense to present absolute descriptive data as only the distributions convey information. The following three figures present histograms (of the average summated scores) for three key variables: the innovation intensity, the extent of learning within each firm from the specified sources and the extent to which the firm appropriates returns from its process advantages. A normal distribution has been overlaid on the figure for comparative purposes. These figures show each variable has an approximately bell shaped distribution.

Figures 1, 2 and 3 about here

Estimated effects

1.1.4 Specifying the model

The preceding discussion implies that the intensity of innovativeness is determined by the external conditions (contained in the vector **z**) and fashioned by the complementary routines (in vector **x**). Since by construction, the measure *I* is bound between 1 and 7, it has been modelled as a logistic function. Assuming υ_i represents an i.i.d. error term, this gives:

$$I_i = \left[\frac{6}{1 + \exp(-\mathbf{z}_i^{'}\beta - \mathbf{x}_i'\alpha)} \right] + 1 + \upsilon_i \qquad (1)$$

(1) where *I* is the measure of *innovativeness* and *i* represents the individual organisation.

Equation (1) produces a function, whereby *I* is must lie between one and seven for all values of the exogenous variables constrained in **z** and **x.** It is unlikely that υ_t is normally distributed, given that *I* is a bounded variable and it is assumed that $\ln(I_i) = \ln\{f(.)\} + v_i$ such that $v_i \sim N(0, \tau^2)$, where $f(.) = \ln\left[\frac{6}{1 + \exp(-\mathbf{z}_i^{'}\beta - \mathbf{x}_i'\alpha)} + 1 \right]$.

1.1.5 Regression results

Results from the non-linear estimation of (1) using the full specification of the model is presented in the first two columns of data in Table 3. The last two columns present the significant variables only. Table 4 presents a written summary of these significant results.

One of the major shortcomings from using measure based on Likert scales it that it is not possible to interpret the size of the estimated coefficients other than by comparison with other variables measured in the same way. However, these scales do enable researchers to assess whether a variable has a statistically significant relationship, once other factors are controlled for, and whether that association is direct or inverse. A further consideration to bear in mind

when interpreting these results is the possible endogeneity of some variables which our model treats as partly exogenous to the innovation decision. Market volatility and firm size are possible contenders here. Innovativeness may cause, not result from market volatility and ditto for firm growth. The lack of time series and historic variables in the data set are an unfortunate limitation of this study.

Nonetheless, given the shortcomings imposed by the cross-sectional nature of the data, the findings are suggestive and not counter-intuitive. Table 3 reveals that investment in new physical capital is likely to be a complement to, or determinant of, the companies' innovation stance. More innovative companies also spend more on new physical capital goods. Few of the variables that described the corporate structure were shown to influence innovation. Foreign owned companies were found to be more innovative, *ceteris paribus*. The smaller of the companies in our large company population (medium companies) were associated with higher levels of innovation, although this effect was only apparent when many of the insignificant variables were dropped (this effect is also found in Martinez-Ros and Labeaga 2002).[9] This is not similar to the empirical findings of Brouwer and Kleinknecht (1996), and Felder *et al.* (1996), who report that the largest companies compared with medium-size companies are not only more likely to invent, but also spend more on inventive activities. Foreign companies, were more likely, all other things considered, to be innovative, perhaps reflecting the greater ease of technology transfer from the overseas branches of the company.

In the final estimation, wholesale trade was significantly more innovative than the average industry and accommodation, cafes and restaurants; health and community services and construction were significantly less innovative. If the dependent variable is regressed on the industry dummies only, many were found to be significant but once account is taken of the other variables – being systematic features common to all the industries – they lose significance. Several of the qualitative measures of the nature of the industry were however

significant. Firms operating in more volatile product markets adopted a significantly more innovative mode of production than other firms. More contestability in the firm's markets (in terms of ease of entry and concentration) was associated with less innovation. Overseas empirical work for the importance of non-price competition is mixed (Arvanitis and Hollenstein 1996) and there is mixed evidence that market structure, such as concentration and contestability, matter (Arvanitis and Hollenstein 1996, Crepon *et al.* 1996, Geroski and Walters 1995, Felder *et al.* 1996, Arvanitis and Hollenstein 2001, Martinez-Ros and Labeaga 2002, Arvanitis and Hollenstein 2002, Bosworth and Loundes 2002, Beneito 2003). According to Cohen 1995, the findings from studies of the relationship between market structure and innovation depend on what else is held constant. A higher degree of knowledge spillovers about product and process advantages emanating from other companies in the same industry sector were significantly and positively associated with the firms adopted innovation stance.

Most of the hypothesised complementary internal routines were found to have a significant association with the firm's innovation mode. More flexible styles of management and more aggressive managerial approaches were significantly associated with more innovative modes of production. Additionally, and not surprisingly, the more innovative firms claimed that they were more likely to have learned about new product and processes from networks, meetings, hiring skilled workers and licenses, and so on. Studies from Europe have found consistent support for a positive relationship between the differing measures of the extent of learning and innovation (Hollenstein 2002, Arvanitis and Hollenstein 2001). Finally, effective use of different ways to protect product and process innovations was related to the firm's innovative stance. Measures of firms' abilities to appropriate the returns from their inventions have shown in previous studies to have a positive, reliable and robust effect on the intensity of innovation (Cohen 1995, Arvanitis and Hollenstein 1996, Arvanitis and Hollenstein 2002).

Conclusion

Many earlier studies on the determinants of innovation followed the Schumpeterian tradition, and focused on size and market structure as possible causes of innovativeness, however with the event of new qualitative measures of industry knowledge and managerial styles, these factors have been found either to be less important. Furthermore, our results, and those emanating from overseas over the last few years, are also showing that factors common to all industries, such as the extent of learning, knowledge spillovers, appropriability and managerial style, are arguably more important than industry specific forces. Among all the independent variables that were measured on the Likert scales – and thus can in some sense be compared – knowledge spillovers and managerial aggression had much higher coefficients (by a multiple of more than 4) meaning that these two attributes are the most important complementary routines.

Our results suggest that company policy makers who believe that industry levels of innovation, in the sense of invention, imitation and adoption, is too low, should consider enhancing the effectiveness of avenues for learning, drawing upon industry knowledge spillovers and developing the private means by which firms protect the advantages arsing from their innovations. Becoming a more innovative firm does not mean spending more money on innovative activities. It also requires a set of complementary managerial and work practices within the organisation.

References

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.

Arvanitis, S. and Hollenstein, H. (1996), Industrial innovation in Switzerland: A model-based analysis with survey data, In *Determinants of Innovation. The Message from New Indicators*(Ed, Kleinknecht, A.) Macmillan, Hampshire and London, pp. 13-62.

Arvanitis, S. and Hollenstein, H. (2001), The Determinants of the Adoption of Advanced Manufacturing Technology, *Economics of Innovation and New Technology,* **10,** 377-414.

Arvanitis, S. and Hollenstein, H. (2002), The impact of spillovers and knowledge heterogeneity on firms performance: Evidence from Swiss Manufacturing, In *Innovation and Firm Performance. Econometric Explorations of Survey Data*(Eds, Kleinknecht, A. and Mohen, P.) Palgrave, Houndmills, Basingstoke and New York, pp. 225-52.

Athreye, S. (2001), Competition, Rivalry and Innovative Behaviour, *Economics of Innovation and New Technology*, **10,** 1-23.

Beneito, P. (2003), choosing among alternative technological strategies: an empirical analysis of formal sources of innovation, *Research Policy,* **32,** 693-713.

Bosworth, D. and Loundes, J. (2002) The Dynamic Performance of Australia Enterpises, In *Melbourne Institute Working Paper*, Vol. Melbourne Institute of Applied Economic and Social Research University of Melbourne, 3/2002.

Brouwer, E. and Kleinknecht, A. (1996), Determinants of innovation: A microeconometric analysis of three alternative innovation output indicators, In *Determinants of Innovation. The Message from New Indicators*(Ed, Kleinknecht, A.) Macmillan, Hampshire and London, pp. 99-124.

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.

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.

Crepon, B., Duguet, E. and Kabala, I. (1996), Schumpeterian conjectures: A moderate support from various innovation measures, In *Determinants of Innovation. The Message from New Indicators*(Ed, Kleinknecht, A.) Macmillan, Hampshire and London, pp. 63-98.

Dosi, G. (1988), Sources procedures and microeconomic effects of innovation, *Journal of Economic Literature,* **26**.

Dosi, G., Marengo, L., Bassanini, A. and Valente, M. (1999), Norms as emergenet properties of adaptive learning: The case of economic routines, *Journal of Evolutionary Economics,* **9,** 5-26.

Fagerberg, J. (2003), Schumpeter and the revival of evolutionary economics: an appraisal of the literature, *Journal of Evolutionary Economics,* **13,** 125-159.

Felder, J., Licht, G., Nerlinger, E. and Stahl, H. (1996), Factors determining R&D and innovation expenditure in German manufacturing industries, In *Determinants of*

Innovation. The Message from New Indicators(Ed, Kleinknecht, A.) Macmillan, Hampshire and London, pp. 125-154.

Galende, J. and de la Fuente, J. M. (2003), Internal factors determining a firm's innovative behaviour, *Research Policy,* **32,** 715-736.

Geroski, P. and Walters, C. (1995), Innovative activity over the business cycle, *Economic Journal,* **105,** 916-28.

Hall, P. (1994) *Innovation, Economics and Evolution,* Simon & Schuster International Group, Hemel Hempstead.

Hodgson, G. M. (1999) *Evolution and Institutions. On evolutionary economics and the evolution of economics,* Edward Elgar, Cheltenham, UK, Northhampton, MA, USA.

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.

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.

Iwai, K. (1984), An evolutionary model of innovation and imitation, *Journal of Economic Behavior and Organization,* **5,** 159-190.

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

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

Kleinknecht, A. (1996), New indicators and determinants of innovation: An introduction, In *Determinants of Innovation. The Message from New Indicators*(Ed, Kleinknecht, A.) Macmillan, Hampshire and London, pp. 1-12.

Knight, F. H. (1921) *Risk, Uncertainty and Profit,* Houghton Mifflin company, The Riverside Press Cambridge, 1946, Boston, New York.

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

Martinez-Ros, E. and Labeaga, J. (2002), The relationship between firm size and innovative activity: A double decision approach and an application to Spanish manufacturing firms, *Economics of Innovation and New Technology,* **11,** 35-50.

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

Nelson, R. R. (1959), The simple economics of basic scientific research, *Journal of Political Economy*, **67,** 297-306.

Nelson, R. R. and Winter, S. G. (1982) *An Evolutionary Theory of Economic Change,* Belnap Press of Harvard University Press., Cambridge Mass. and London.

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

Shackle, G. L. S. (1961-62), The description of uncertainty, In *The Nature of Economic Thought,* Cambridge University Press, [1966], Cambridge, pp. pp. 85-99.

Webster, E. M. (1999) *The Economics of Intangible Investment,* Edward Elgar, Cheltenham.

Winter, S. G. (1984), Schumpeterian competition in alternative technological regimes, *Journal of Economic Behavior and Organization,* **5,** 287-320.

Winter, S. G., Kanjorski, Y. M. and Dosi, G. (2003), A baseline model of industry evolution, *Journal of Evolutionary Economics*, **13,** 355-383.

Table 1: Organisation characteristics, Australia 2001

	Respondent percentage	Top 1000 percentage
Major industry group		
Agriculture, Forestry & Fishing	0.8	0.8
Mining	3.7	4.5
Manufacturing	28.1	25.2
Electricity, Gas & Water Supply	4.3	4.8
Construction	3.2	2.9
Wholesale Trade	12.2	15.6
Retail Trade	5.6	6.4
Accommodation, Cafes & Restaurants	0.5	0.2
Transport & Storage	4.5	3.8
Communication Services	0.3	1.3
Finance & Insurance	12.7	15
Property & Business Services	9.7	8.1
Government Administration & Defence	1.4	0.4
Education	4.6	2.6
Health & Community Services	3.5	4.0
Cultural & Recreational Services	2.9	3.1
Personal & Other Services	1.9	1.3
Total	*100.0*	*100.0*
Employment size		
Under 200	7.3	16.4
200 to under 500	13.6	17.6
500 to under 1000	13.9	19.6
1000 to under 5000	25.3	34.7
Over 5000	40.0	11.7
Total	*100.0*	*100.0*

Source: Melbourne Institute Business Surveys 2001, 2002, 2003

Table 2: Variable definitions and descriptive statistics[a]

Variable	Description	Mean	Standard deviation
Extent to innovative activity			
Innovation	A 8-item, 7 point scale measuring the emphasis on creativity and innovation (α=0.79)	4.44	0.96
External conditions			
Physical technologies	A 2-item, 7 point scale measuring investment in new physical equipment and technologies (α=0.39)	4.27	1.19
Corporate structure & size			
Foreign owned	A dummy variable (1=yes, 0=no)	0.35	0.49
Single integrated business	A dummy variable (1=yes, 0=no)	0.41	0.50
Multiple related business	A dummy variable (1=yes, 0=no)	0.47	0.42
State Government authority	A dummy variable (1=yes, 0=no)	0.19	0.40
Public listed company (industrial)	A dummy variable (1=yes, 0=no)	0.02	0.15
Public listed company (mining)	A dummy variable (1=yes, 0=no)	0.19	0.40
Public not-listed company	A dummy variable (1=yes, 0=no)	0.35	0.48
Log of total revenue	Dollars	13.10	0.90
External product market			
17 major industry groups	A dummy variable (1=yes, 0=no) for each industry		
Volatile product market	A 5-item, 7 point scale measuring variability in demand, competitors, technologies (α=0.68)	3.83	0.98
Contestability	A 2-item, 7 point scale measuring ease of entry to product market (α=0.19)	3.67	1.31
Knowledge spillovers from industry	A 16 item 7 point scales for each industry measuring how effective companies are in protecting their product and process advantages.	4.26	0.42
Routine styles			
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 (α=0.83)	3.34	0.85
Systematic style	A 6-item, 7 point scale measuring whether managers use systematic analysis rather than intuitive methods for making decisions (α=0.52)	4.53	0.74
Aggressive style	A 5-item, 7 point scale measuring how bold and aggressive managers are (α=0.67)	4.22	0.84
Communication techniques	A 4-item, 7 point scale measuring the extent to which management seek to communicate with workers (α=0.79)	4.33	1.02
Extent of learning	An 11 item, 7 point scale measuring the extent to which the firm learns about new processes and products (α=0.78)	4.04	0.90
Extent of appropriability	A 16 item, 7 point scale measuring the effectiveness of protecting advantages from product and process innovations (α=0.90)	4.27	1.04

Notes: a. Only items with factor loadings with absolute values greater than 0.25 are included in the variable measure.
b. Median.
Source: Melbourne Institute Business Survey 2001, 2003 and 2003

Table 3: Regressions results: Dependent variable = Extent of innovation†

Independent variables	Coefficient	t		Coefficient	t	
Exogenous conditions						
Physical technologies	0.215	7.580	**	0.215	9.080	**
Corporate structure & size						
Log of total revenue	0.017	0.540		-0.049	-2.620	**
Domestic ownership	-0.021	-0.320		-0.119	-2.250	**
Single integrated business	0.066	0.730				
Multiple related business	-0.047	-0.530				
Federal Government Authority	0.141	0.590				
State Government Authority	0.176	0.570				
Public listed company - industrial	0.009	0.150				
External product market						
Industry dummies	yes			yes		
Volatile product market	0.144	4.280	**	0.126	4.640	**
Contestability	-0.026	-1.210		-0.045	-2.500	**
Few knowledge spillovers	-0.683	-6.400	**	-0.407	-6.640	**
Routine styles						
Management style			**			
Inflexibility of management	-0.077	-2.270		-0.094	-3.290	**
Systematic style	0.018	0.470	**			
Aggressive style	0.280	7.560		0.280	9.110	**
Communication techniques	0.117	3.040	**			
Extent of learning	0.042	1.230		0.106	3.310	**
Extent of appropriability	0.215	7.580	**	0.053	1.840	
Adjusted R^2	0.489			0.611		
Root mean squared error	0.731			0.617		
N	362			362		

Method: non-linear estimation

Notes: † The dependent variable is an averaged summated scale of 1 to 7 Likert responses to 8 questions on how innovative the firm has been over the past 3 years. It does not ask about how successful these innovations have been.

** significant at the 1% level

Table 4: Explanation of results: Factors are significantly associated with more innovative firms*

Associated factors
High rate of spending on physical plant and equipment
Corporate structure & size
Foreign owned
Medium size
External product market
In wholesale trade (rather than another industry)
Operating in a more volatile product market
Less easy to enter and more concentrated
Receives more knowledge spillovers from other firms in industry
Management style
More flexibility style of management
More aggressive style of management
Higher rate of learning about new products and processes from outside the company
More successful in using measures to appropriate returns from their investments in product and process advantages

Note: * all factors significant at the 6 per cent level.

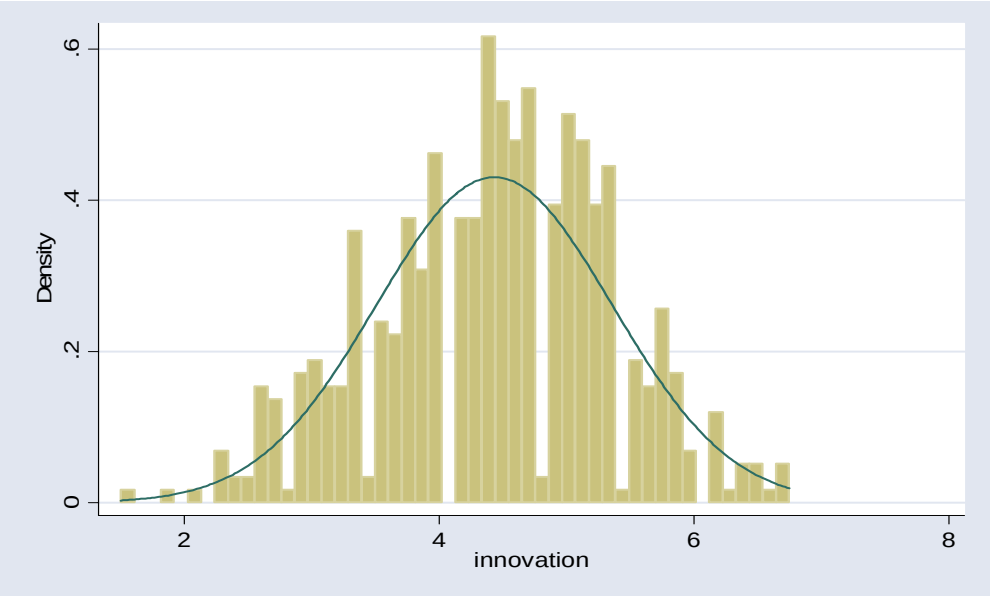

Figure 1: Frequency distribution the innovation intensity variable across organisations

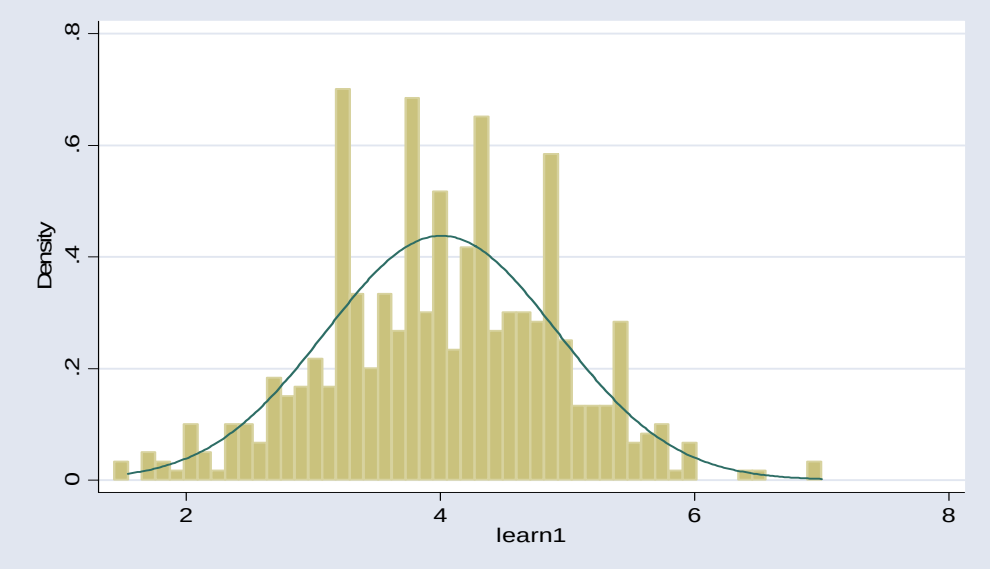

Figure 2: Frequency distribution the learning intensity variable across organisations

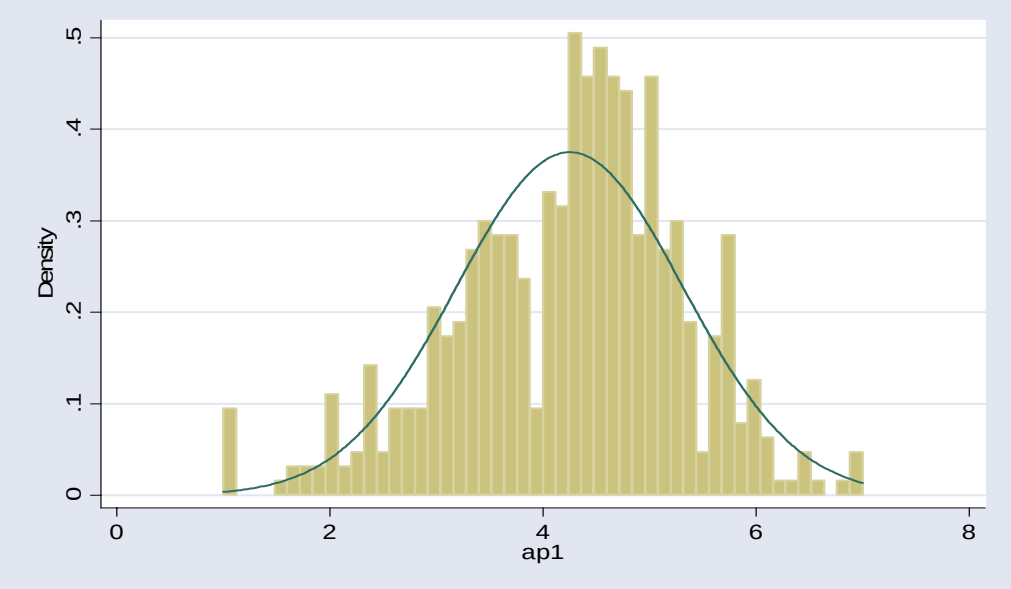

Figure 3: Frequency distribution the extent of appropriability variable across organisations

List of figures

*This paper is the result of work being undertaken as part of a collaborative research program entitled *The Impact of Enterprise and Workplace Focused Industrial Relations on Employee Attitudes and Enterprise Performance*. The project is supported by the Australian Research Council, the Business Council of Australia, the Committee for the Economic Development of Australia and IBISWorld. The views expressed in this paper represent those of the author and not necessarily the views of the collaborative partners. The author would particularly like to thank other members of the survey team, Mark Wooden, Danny Samson, Peter Dawkins, Joanne Loundes, Tim Fry and Pat Foley for the design of the survey and Glenys Harding, Catherine Fernando and Anita Aherne for their excellent efforts in ensuring the surveys were completed. In addition, I would like to thank Maria Tarrant, Jongsay Yong and Tim Fry for comments on this paper.

[1] Cambridge International Dictionary of English

[2] See also Hodgson (1999), Cantwell Fagerberg (2003), Dosi *et al.* (1999).

[3] Uncertainty is the '...plurality of those descriptions of the future which the decision-maker looks upon in some degree, as possible' (Shackle 1961-62: 86). Uncertainty excludes actuarial risks (Knight 1921, especially 321 and Keynes 1937). The outcome of a proposed action is considered risky if it arises from situations (or classes of situations) that occur with such frequency that one is able to derive a reliable contingent frequency table for possible outcomes. Fundamentally uncertain outcomes, however, arise from situations, which are so singular, or unlike past cases that no estimate, which is meaningful or reliable ex post, can be made.

[4] The main exceptions are: a slight over-representation of manufacturing, finance and insurance and education, with a corresponding under-representation of organisations from wholesale trade; and an over-representation of respondents from the larger firms, as measured by the number of employees.

[5] 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.

[6] A recent UK study by Athreye (2001) found supporting evidence for the influence of internal accumulated capabilities.

[7] The precise questions are "During the past 3 years, how many resources (time, money and labour) were devoted to: organisational change (e.g. restructuring, changes in work practices); and technology developed by others (e.g. patents, trademarks, licenses)." "How innovative has your organisation been in the past 3 year with respect to: new lines of products or services and minor changes in product or service?" "To what extent do these describe your organisation's competitive strategy? It produces a continuous stream of state-of-the-art products/services; it is 'first to market' with new products/services; and it responds to early market signals concerning areas of opportunity".

[8] Unfortunately, data limitations preclude the inclusion of more appropriate variables such as the nature of the production process..

[9] This was the only variable to change significant markedly as the most insignificant variables were dropped. This change was most likely due to the inclusion of an additional 66 cases.