9. Innovation scoreboards: an Australian perspective

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1 INTRODUCTION

Innovation is generally recognized by economists as the ultimate engine of growth and prosperity. As Gans and Stern (2003, p. 7) state: 'World class competitiveness and prosperity depends on … the ability to develop and commercialise "new-to-the-world" technologies, products and business organizations.' This insight has spawned burgeoning interest in the analysis of innovation and its determinants at both the national level and the company level. While governments are typically interested in aggregate measures of innovation so that a nation's performance can be benchmarked against others, it is at the firm level where most of the innovative activity actually occurs: firms take the risks involved in commercializing the inventions which ultimately drive the growth of the domestic economy. As a consequence, measurement of companies' innovative performance has also received a lot of attention from academics, policy-makers and business analysts.

However, measurement of innovation at either the national or company level is difficult for a number of reasons. First, an innovation (by its very definition) is something that is 'new', which makes it difficult to construct a measure of innovation which is general enough to be used to compare to other innovative outputs. Second, the innovation process typically takes many years and involves managing numerous risks. As a result, the relationship between inputs (such as R&D expenditure) and outputs (such as patents) is potentially non-linear and it is unclear how these factors can be accounted for in a single measure of innovation. Finally, much of what is innovative within a firm – particularly, process innovations and development of intermediate goods – is invisible to the outsider. Thus, commonly used measures of innovative performance such as R&D expenditure or the number of patents may be imperfect proxies of innovative activity. However, much progress has been made on the empirical measurement of innovation, including the use of multiple indicators measures of innovation which capture more than just that which is easily observable (such as patent activity).

Bearing these issues in mind, the aim of this chapter is to construct an index which enables us to measure innovative activity at the company level. This innovation index reflects many of the recent developments in the academic literature aimed at deepening our understanding of what constitutes innovative activity within the firm and therefore provides an accurate picture of the current state of innovative activity. The index is then used to compile an 'innovation scoreboard', which is simply each firm's indexed 'score' in a given year, which forms the basis of our comparison of the innovative performance of Australian companies over the period 1998–2003.[1] Using the results of the innovation scoreboard enables the following questions to be addressed: which Australian companies are the most innovative? In what sectors do they operate? How does their innovative performance change over time?

2 DEFINING INNOVATION

Economists often argue that the search for new and improved goods and services – which is often referred to as 'innovation' – is one of the primary drivers of economic development in capitalist nations. But the term 'innovation' is often used in a very ambiguous and imprecise fashion, which causes much confusion. In particular, does innovation include only final goods and services or are improvements in production processes also important? Furthermore, should changes in work culture or management practice also be included in the definition? Are invention and innovation synonymous? For the purpose of this chapter, it is worth reflecting on issues relating to the definitions of innovation and invention.

The classic economic representation of innovation is contained in Schumpeter (1934), who articulated five aspects of innovation: product innovation, process innovation, organizational innovation, input innovation and market innovation. Although these aspects are not mutually exclusive, using this taxonomy enables us to get a clearer picture of what we are referring to when we talk of 'innovation'. Product innovation refers to the creation of new (or improved) goods or services that are launched on to the market. Process innovations, on the other hand, refer to changes in the way in which goods and services are produced. Organizational innovation refers to changes in the architecture of production and accounts for innovations in management structure, corporate governance, financial systems or changes in the way workers are paid. Market and input innovations refer to improved ways of sourcing supplies of raw inputs or intermediate goods and services as well as opening up new market opportunities (which could relate to either creating new domestic or export markets).

While this framework provides a means of categorizing the different kinds of innovation, it also implicitly outlines another important dimension of innovation: whether it constitutes something that is new to the world or something that is new to the firm. The former is a narrow definition of innovation that only includes inventions,[2] while the latter is a much broader definition that includes imitation and adaptation of existing products as well as invention. It is the second definition of innovation (i.e. new to the firm) that we use here. The extent of novelty included in the definition of innovation is a critical factor in understanding the effects of innovation since the risks and returns of the two definitions are fundamentally different.[3] Moreover, it is important to understand the distinction between invention and innovation when deciding how to measure the relevant phenomenon: using patents, for example, may be a good measure of invention but not innovation.

3 MEASURING INNOVATION

One of the difficulties with measuring innovation is that it is a dynamic process which has no beginning and no end: it is a process in which products and processes are in a constant state of flux. The innovation process follows a complex pathway which involves feedback loops generated by on-the-job learning, trial-and-error and other discontinuities in production. Capturing the complexity of this process with a simple, static indicator is difficult since much of the innovative activity that occurs within a firm may not be easily observed. In attempting to make innovation measurement tractable, some assumptions about the beginning and end of the innovation pathway have to be made. The standard convention is that innovation begins with R&D. Following this, some outputs may become encoded into patents and/or trademarks, integrated into business secrets or embodied in tacit organizational knowledge. With good management and fortune, this may evolve into new products or production technologies.

Given this innovation pathway, there are a number of single indicator proxies for innovation that could be used. For example, company R&D expenditure data could be (and often are) used as a proxy for innovation. However, not all firms that collect R&D data report it in their annual reports even though this is required by many national accounting standards. Thus, there may be substantial holes in our understanding of innovation if we simply rely on R&D data. Furthermore, it is not clear whether we should be using what is essentially an input into the innovation process (R&D expenditure) or outputs of the process (such as patents or trademarks).

In this section, we consider issues related to the use of single indicator innovation proxies and then consider some of the benefits of adopting a multi-indicator approach to develop a composite measure of innovation.

3.1 Single Indicator Approach

As already mentioned, innovative activity could be measured using a number of single indicators such as R&D expenditure, patent counts or the number of new products introduced over any given period of time. However, each of these proxies suffers from a common problem: the units of measurement are heterogeneous. Since the act of measuring is concerned with quantifying commensurate elements of an activity, measurement can only be achieved if the units of input/output are homogeneous. What does it mean to say that a company has 100 patents if the effort that went into creating each patent is substantially different? Is a dollar spent in one company on R&D equivalent to that spent in another company and, if not, does comparing R&D expenditure tell us anything about either company's innovative activity?

Each of the single indicator innovation proxies also suffer from some specific problems. Patents, for example, are known to have considerable biases in terms of their ability to measure innovation since many innovations are not patentable (because they do not fulfil the patenting requirements of novelty and inventiveness). In addition, only firms who believe that the legal protection offered by patents is more valuable than it costs will attempt to apply for it. Accordingly, inventions in technical fields not well covered by patent laws, (for example, software programs) and inventions that can be protected by other methods (for example, secrecy, copyright or keeping ahead) are less likely to be captured using a simple single indicator of innovation. Similarly, inventions that are otherwise hard to imitate – usually because they are embedded in complex production systems –are expected, a priori, to have a lower correlation between patent rights and innovation (see Arundel and Kabla 1998). There is also some other empirical evidence to suggest that patents are biased towards firms in manufacturing industries (see Jensen and Webster 2004).

Another problem with single indicators of innovation is that it forces a decision to be made with regard to which end of the innovation pathway provides more valuable information regarding innovative activity. For example, a choice must be made as to whether to use R&D expenditure or new products (which lie at opposing ends of the innovation pathway). While there may be some persuasive reasons for using new products as a measure of innovation, the further we progress down the innovation pathway, the more we are using a measure of innovation based on the successful launch of a product, rather than innovation per se. Since innovation is a risky activity, many investments in research (and development) may not actually result in any new product being launched on the market. However, these problems are not insurmountable. They simply reflect the fact that innovation is an easy concept to understand but a difficult one to measure. One way in which we can overcome some of the shortcomings of single indicators is the use of multi-indicator measures of innovation.

3.2 Multi-indicator Approach

In order to illustrate the potential weakness of a single indicator approach for measuring innovation, consider the following example from Feeny and Rogers (2003). Let us say there are two firms of the same size and other characteristics which spend $1 million and $5 million on R&D, respectively. In addition, assume that the first firm produces two patents, whereas the second firm produces only one patent. If we measure innovative activity based on a single indicator such as R&D expenditure, then the first firm is least innovative. However, if we use the number of patents produced, the same firm becomes the most innovative.

The potential problem with the single-indicator approach can be illustrated using a Venn diagram as in Figure 9.1 (Hagedoorn and Cloodt 2003). In the diagram, the space defined by the square box represents the true innovative performance and the space defined by each overlapping circle as the part of innovative performance measured by any single indicator. Notice that the circles may overlap with each other, indicating that two or more indicators may provide the same information regarding innovative performance. The greater the overlap between the circles, the more likely it is that one single indicator will be an adequate proxy for innovative activity. However, a complete overlap is highly unlikely since not all inventions that

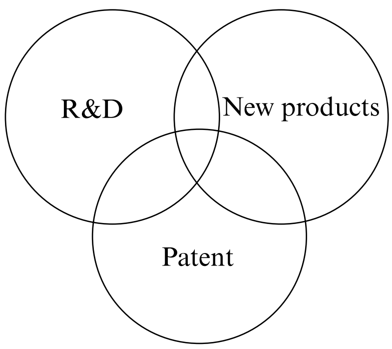

Figure 9.1 The relationship between innovation proxies

resulted from R&D investment can or will be patented, for various reasons explained before. In addition, not all patents will be incorporated into new products and not all new products result from R&D investment.

4 THE INNOVATION SCOREBOARD[4]

The aim of the construction of the Australian innovation scoreboard is to measure the innovativeness of Australian companies. As such, the scoreboard serves as a benchmarking and competitor analysis tool for Australian companies in terms of innovative performance. Investors and policy-makers, for example, can use the scoreboard to compare the extent and outcomes of innovative activities across companies and industries. Thus, the scoreboard is a particularly useful tool when the number of companies to be compared is large enough to render a thorough and in-depth comparison among them impractical. In this section, we discuss the construction of the index which is used to build the innovation scoreboard and demonstrate some useful ways in which the index can be used.

4.1 Construction of the Innovation Index

Given the problems with the single indicator approach, we use a multi-indicator innovation index which combines measures of innovative activities. The innovation index is based on the following formula:

$$I = \lambda_1\left(\frac{R}{A}\right) + \lambda_2\left(\frac{P}{A}\right) + \lambda_3\left(\frac{T}{A}\right) + \lambda_4\left(\frac{D}{A}\right) \quad (9.1)$$

where λ_j denotes the intensity of the j-th measure of innovative activities – R&D expenditure (R), patent applications (P), trademark applications (T) and design applications (D) – with respect to A, which is the replacement value of tangible assets. Each of these single indicators provides us with information about the extent of innovative activity within a firm at different stages of the innovation pathway. R&D expenditure, for example, captures both the initial investment made in conducting research about a potential innovation and the subsequent expenditure made in conducting the trials necessary to ensure that the innovation actually works. Trademarks, on the hand, reflect the outputs of innovative activity: they are typically observed after the R&D process has been completed and new products (or modifications of existing products) are launched on the market. The effect of combining these single indicators into an innovation index is to provide us with a much more comprehensive picture of the breadth and depth of innovative activity across all stages of the innovation pathway.

To compute the innovation index, we need to know the importance of each individual component. That is, we need to know the values of the weighting factors (the λ_js). In order to estimate these values, we analyse the relationship between innovative activities and the market value of the company.

Following Griliches[5] (1981), we express the market value (V_{it}) of company i at period t as:

$$V_{it} = V(A_{it}, K_{it}) \tag{9.2}$$

where A_{it} is the replacement value of tangible assets and K_{it} is the replacement value of intangible assets. The regression function to obtain estimates of λ_j is then derived by assuming a specific functional form for equation (9.2) as shown below:

$$V_{it} = b(A_{it} + \lambda K_{it})^{\sigma} \tag{9.3}$$

where b denotes the 'current market valuation coefficient' of the company assets, σ is the degree of returns-to-scale, and λ expresses the relative shadow value of intangible assets to tangible assets. Taking the logarithmic values of both sides of equation (9.3), subtracting $\log A_{it}$ from each side, utilizing the approximation $\log(1 + c) \approx c$, using the book value of intangible assets (B_{it}), R&D expenditure, patent, trademark and design applications as proxies for K_{it}, and assuming $\sigma = 1$, we get:

$$\log\left(\frac{V_{it}}{A_{it}}\right) = \log b + \hat{\lambda}_1\left(\frac{R_{it}}{A_{it}}\right) + \hat{\lambda}_2\left(\frac{P_{it}}{A_{it}}\right) + \hat{\lambda}_3\left(\frac{T_{it}}{A_{it}}\right) + \hat{\lambda}_4\left(\frac{D_{it}}{A_{it}}\right) + \gamma\left(\frac{B_{it}}{A_{it}}\right) + \beta X_{it} + u_{it} \tag{9.4}$$

In order to capture variation in market valuation of companies across industries and aggregate movement across time, the regressions also include year and two-digit industry dummy variables as part of X_{it}. Equation (9.4) is then estimated with ordinary least squares using firm level data on patent, trademark and design applications (from IP Australia), market value data (from SIRCA) and accounting data (from IBISWorld). Since not all companies are listed in Australian Stock Exchange or appear in the SIRCA database and not all companies report any R&D expenditure,[6] we only include those with observed market values and/or R&D expenditures in the relevant analyses.

To assess the importance of non-R&D reporting companies, we compared the relative distribution of those companies with and without R&D expenditure across sectors in our sample data in 2003 with the relative distribution of sectoral R&D expenditures in the 2002/03 Business Expenditures on Research and Development (BERD) (ABS 2004). Overall, even though there are less than one third of 875 companies included in the 2003 sample with reported R&D expenditures, those companies account for more than 60 per cent of the total BERD in the same period.

The coefficient estimates ($\hat{\lambda}_1 \ldots \hat{\lambda}_4$) are substituted for ($\lambda_1 \ldots \lambda_4$) in equation (9.1), respectively, to compute the innovation index. Feeny and Rogers (2003) estimated equation (9.4) using the 1996–98 data for 300 companies.[7] Using their estimation results, we compute innovation scores for each company in each year using the following:

$$I_{it} = 2.409\left(\frac{R_{it}}{A_{it}}\right) + 6.822\left(\frac{P_{it}}{A_{it}}\right) + 1.132\left(\frac{T_{it}}{A_{it}}\right) + 0.385\left(\frac{D_{it}}{A_{it}}\right) \qquad (9.5)$$

4.2 Innovative Performance in 2003

Using this approach, we can construct the innovation index for 2003. In this section, we report results from the innovation scoreboard in order to analyse which industry sectors are the most innovative and which companies are the most innovative.[8] Table 9.1 shows the average innovation scores of companies in the top six industry sectors along with the corresponding intensity levels of innovative activities in these sectors.[9] The most innovative sector in the sample, photographic and scientific equipment, consists of four companies. Altogether, these four companies had an average score on the innovation index of 46.5, spent approximately 9.3 per cent of their total revenues on R&D and filed an average of six patent and three trademark applications. In contrast, companies in the property and business services industry sector had an average score on the innovation index of 11, spent 3.8 per cent of revenues on R&D and applied for three trademarks.

In addition to analysing inter-industry variation in innovative activity, the innovation scoreboard can also be used for company benchmarking and/or competitor analysis purposes. Table 9.2 lists the ten most innovative Australian companies in 2003.[10] Note that the innovation scores shown in the second column of Table 9.2 are normalized values with respect to the highest score in that period. Thus, the most innovative company – Cochlear – received a score of 100 while the second company on the list – Varian Holdings – scored 77. Given the construction of the index, this can be

Table 9.1 Top six innovative industry sectors in 2003

Industry sector	No. of companies	Innovation score[a]	R&D/ revenue[a]	Patent applications[a]	Trademark applications[a]	Design applications[a]
Photographic and scientific equipment manufacturing	4	46.5	9.3%	6	3	0
Scientific research	1	29.0	9.1%	15	6	0
Electronics and electrical equipment and appliance manufacturing	13	14.6	4.9%	2	5	1
Printing, publishing and recorded media manufacturing	1	14.0				
Industrial machinery and equipment manufacturing	15	11.4				
Property and business services	17	11.0	3.8%	0	3	0
All	51		2.6%	2	4	1

Note: [a] Average per company.

interpreted as meaning that their innovative performance of the second-ranked company is 23 per cent lower *relative* to Cochlear.

If we compare the ten most innovative firms listed in Table 9.2 with the rest of the firms in the industry, we can see that they spent a lot more on R&D expenditure, both in absolute and relative terms, than an average firm in the industry. In fact, the ten most innovative firms spend an average of 11.2 per cent of their revenue on R&D, while the average firm in the industry only spent an average of 1.6 per cent of their revenue on R&D. Similarly, there is a significant difference between the top ten most innovative firms and the average firm with regard to patenting activity. The most highly innovative firms in 2003 had an average of 7.7 patent applications, whereas the average firm had only 1.1 patent applications. Thus, patenting and R&D appear to be important determinants of scoring highly on the innovation index.

Similar conclusions can be drawn when we compare the average innovation score of the ten most innovative companies with the average score of the top 50 companies. Specifically, the top ten companies score more highly on both R&D and patenting activity. The average firm in the top 50 most innovative firms, however, receives higher scores in both trademarks (4.2 applications) and designs (2.4 applications) than the average firm in the top ten (with 2.6 and 0.1 trademark and design applications, respectively).

To better understand what possibly differentiates the most innovative firms from the rest of the industry, we match our sample with the results of a recent series of business surveys conducted by the Melbourne Institute in collaboration with the Business Council of Australia and the Committee for Economic Development of Australia. This survey has been conducted annually from 2001 and, for our purposes, contains three groups of relevant questions.[11] The first one asks a senior manager from each company how he/she rates the extent to which various methods of information gathering are used by the company in order to assess its business environment. The second group asks about the flexibility of the company in changing its strategic plan whenever faced with various contingencies. Finally, the managers are asked to what extent their competitive strategy focuses on a given list of potential competitive strategies.

Figure 9.2 compares the average score of some of the principal factors identified using factor analysis based on these three groups of questions for the top ten, top 50 (excluding those in the top ten) and the rest of the companies. In one of his widely read business/management books, Drucker (1986) lists various sources of innovative opportunities such as the development of new knowledge, the emergence of unexpected outcomes, or demographic shifts, and points out that only those entrepreneurs who can systematically identify and adapt to these changes are the ones who become successful innovators.

Table 9.2 Top ten innovative companies in 2003

Company name	Innovation score	2002–03 R&D expenditure ($000); % revenue; % assets			IP applications in 2003 Patents; trademarks; designs			Sector
Cochlear	100	37030	12.8	16.1	30	0	1	Electronics
Varian Holdings (Australia)	77	12192	9.5	19.1	5	0	0	Photographic and scientific equipment
ResMed Holdings	63	24593	8.7	9.4	21	9	0	Photographic and scientific equipment
Stargames	58	5127	8.3	11.3	2	7	0	Machinery and equipment wholesaling
Alcatel Australia	58	66119	17.4	30.4	0	2	0	Electrical and electronics equipment wholesaling
Schefenacker Vision Systems	40	9652	6.4	9.9	4	0	0	Glass manufacturing
Robert Bosch (Australia)	39	42528	4.9	11.2	13	2	0	Motor vehicle and parts manufacturing
Mincom	39	12632	7.5	17.2	1	0	0	Computer services
MYOB	38	14264	18.6	14.4	1	6	0	Computer services
Solution 6 Holdings	33	43160	17.9	16.1	0	0	0	Computer services
Top 10 average	55	26729	11.2	15.7	7.7	2.6	0.1	
Top 50 average	23	16908	5.2	6.5	3.2	4.2	2.4	
Industry average	6.1	6997	1.6	2.0	1.1	3.5	0.7	

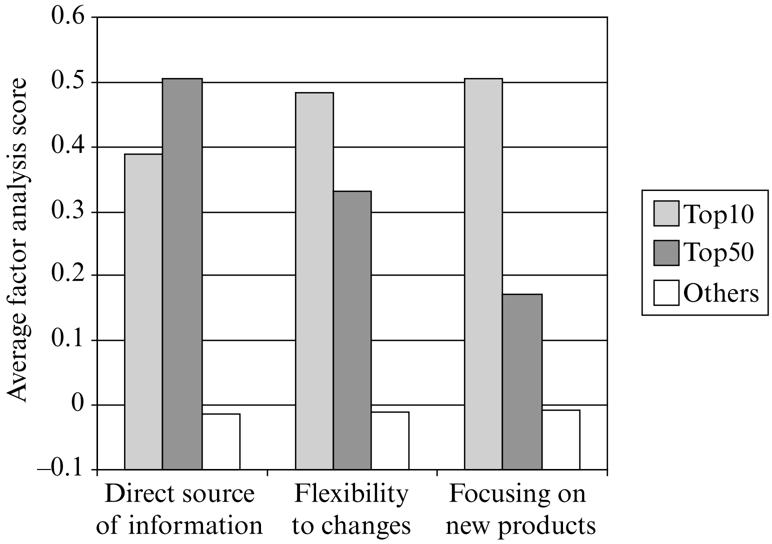

Figure 9.2 Sources of innovative opportunity

Indeed, from Figure 9.2, these are more or less how the most innovative companies seem to differ from the rest. For example, we can see that the most innovative companies are more likely to pursue information from primary sources such as their clients and conduct their information gathering more systematically. In addition, they are more ready to adapt their strategic plan in the face of external changes. Finally, they are more inclined to focus on developing new products or exploiting early signs of opportunity provided by the market.

4.3 Trends in Innovative Performance, 1998–2003

Over time, a company's innovative performance will probably change: some companies may gain in terms of their innovativeness, while others may be unable to sustain their past performance. By computing the innovation scores for each company using annual data from 1998 to 2003, we can track how the innovative performance of the companies has changed.[12] At the company level, the changes in innovative performance have been quite dramatic. For example, as shown in Figure 9.3, the innovative performance[13] of Cochlear resembles an inverted-U pattern; whereas, Varian's pattern of performance looks like a regular U-shape. Much of the U-shaped pattern of Varian's innovative performance is due to the reduction of R&D expenditures in the first half of the period and their revival at the later

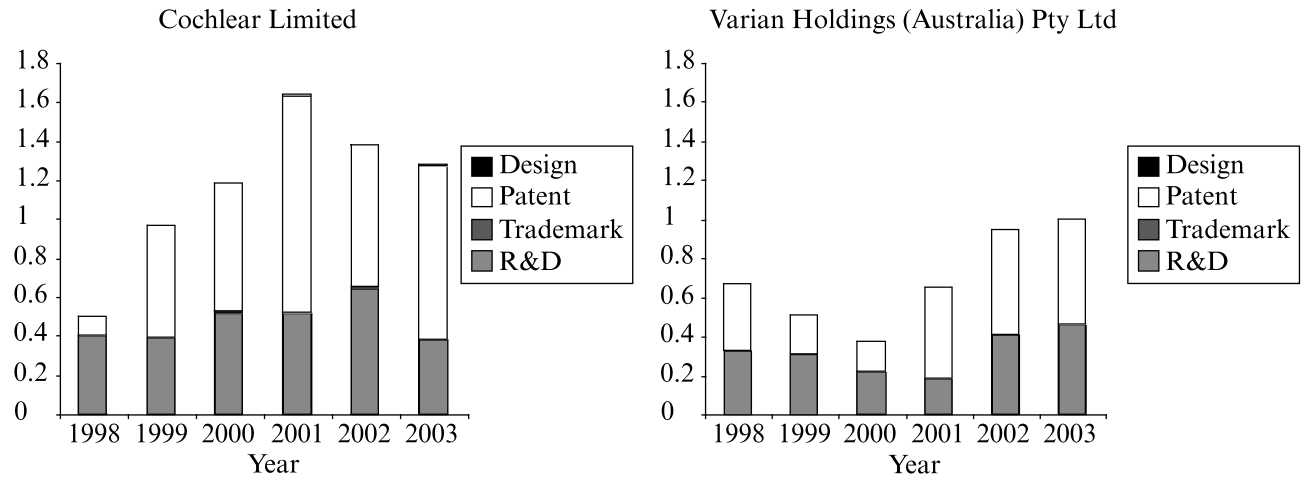

Figure 9.3 Patterns of innovative performance for two Australian companies, 1998–2003

half. A carefully designed and executed case study would help us uncover the underlying reasons for the fluctuation of R&D expenditures or other components of the innovation index. However, this is outside the scope of the present chapter.

Another way to assess the importance of variations in innovative performance across companies and over time is to look at changes in the distribution of the top performing companies. The more important within and between company heterogeneity is, the more significant the change in ranking of companies over time. Knowing the degree of such heterogeneity is an important step in understanding the underlying drivers of company innovative performance or to design any industrial policy to stimulate innovation.

Table 9.3 Top 20 innovative companies, 1998–2003

Company	Rank					
	2003	2002	2001	2000	1999	1998
Cochlear Ltd	1	1	1	2	2	10
Varian Holdings (Australia) Pty Ltd	2	7	5	11	5	8
ResMed Holdings Ltd	3	3	7	1	1	1
Stargames Ltd	4					
Alcatel Australia Ltd	5	20	17	16	14	7
Schefenacker Vision Systems Australia Pty Ltd	6	2	10	3	11	
Robert Bosch (Australia) Pty Ltd	7					
Mincom Ltd	8	14	12	8		5
MYOB Ltd	9					
Solution 6 Holdings Ltd	10	19			10	
Amrad Corporation Ltd	11	5	6	6	7	4
Marley Plastics Australia Holdings Ltd	12	48				
Thales Underwater Systems Pty Ltd	13					
NEC Business Solutions Ltd	14	15	3	7		
Ludowici Ltd	15		11	21		15
Aristocrat Leisure Ltd	16	17	2	4	16	3
MaxiTrans Industries Ltd	17					
Foxboro Australia Pty Ltd	18					
GUD Holdings Ltd	19	18	24	27	20	13
ANCA Pty Ltd	20					

Table 9.3 shows the ranking of the top 20 companies in 2003 over the period 1998–2003. From Table 9.3 we can see that approximately half of the companies have been among the top 20 throughout the period. This suggests that there has been some persistence in innovative performance over the years. Cochlear, for example, has been the top-ranked company since 2001, and was ranked second for two consecutive years before that. However, there has also been some considerable entry and exit in the list of top 20 innovative companies. For example, there are a number of companies – such as Stargames, Robert Bosch (Australia), and MYOB – which appeared in the top 20 for the first time in 2003. At the other extreme, there were companies ranked as high as second, sixth, and eighth in 1998 that were no longer among the top 20 in 2003. Further analysis would allow us to analyse why certain companies seem to be able improved their relative performance while others were unable even to maintain their position.

5 LIMITATIONS OF THE INNOVATION SCOREBOARD

Earlier in this chapter we argued that there are potential difficulties surrounding the use of single indicator measures of the innovative performance at either the company or national level. To address these issues, we constructed a multi-indicator measure of innovation, which takes into account both efforts and outcomes related to innovative activities within a company. While this index approach is better than a single indicator approach, there are still a number of problems with the innovation scoreboard which should be noted when using it for benchmarking or competitor analysis.

In this section, we discuss two discuss two potential biases in our measurement and analysis of Australian company innovation. The first is that the index does not address the possibility of heterogeneity in defining innovation and valuing innovative investment both across companies and across sectors. Instead, we assume that a dollar spent on R&D in biotechnology has the same value (in terms of its effect on a company's measured innovative activity) as a dollar spent on R&D in the motor vehicle industry. Moreover, we assume that the value of a patent granted to one firm has the same value as that granted to another firm. This assumption of homogeneity in both the inputs and outputs of the innovation process is clearly unrealistic, especially in light of emerging evidence that the distribution of patent value is highly skewed: that is, only a very small proportion of patents generate substantial economic rents (see Allison et al. 2004). Including patents which have little economic value in our measure of innovation seems to be counter-intuitive but it is very difficult to differentiate valuable patents from the rest: some have tried to use patent citations as a proxy for value but even this has its limitations (see Narin 1999).

It is also apparent that patents (and trademarks) might not be the only way companies protect their inventions. In fact, companies such as Coca-Cola often rely on trade secrecy to protect inventions and there is evidence suggesting that trade secrecy is a more important source of protection than patents (see Cohen et al. 2000). Unfortunately, data on the use of trade secrecy is not readily available. As a result, we are not able to include such measures in the specification of the company market value function which may result in a classic 'omitted variable bias' in the estimation of the regression coefficients ($\hat{\lambda}_1 \ldots \hat{\lambda}_4$) on which the innovation index is based.[14] One common solution to this problem is to include a fixed-effect term in equation (9.4) and estimate it in a panel data analysis framework. The idea is that the fixed-effect term would capture any unobserved company heterogeneity that affects the company's market value and is not yet accounted for by other observed characteristics.[15]

The second problem with the innovation scoreboard is that it does not include any data on small and medium enterprises (SMEs) since accounting data on these firms are difficult to obtain. Data on the patent, trademark and design activity by SMEs is available but, without data on R&D expenditure, it is not possible to construct the innovation index for these firms. Unfortunately, the accounting data set used to construct the innovation scoreboard – IBISWorld – does not include data on SMEs. This may constitute a major problem since it is possible that there are SMEs that are highly innovative but will not be reported as so.

However, the extent of this problem is unclear since there is no conclusive empirical evidence supporting the notion that firm size is related in any systematic way to innovativeness. Schumpeter (1934) argued that large firms are more innovative since they have the retained earnings with which to reinvest in risky innovative activities. However, it has also been argued that SMEs may have some distinct advantages in innovation since they may have better information about the function that relates expected profitability of an innovation to development expenditure (see Arrow 1983) and that they may have less inertia than large firms and are therefore able to recognize (and take advantage of) market niches (see Rogers 2004).

6 CONCLUSION

This chapter has examined two interrelated issues in the study of the innovativeness of Australian enterprises: first, how to construct a multi-indicator innovation index and, second, how to interpret and analyse the index. Overall, in illustrating various ways to interpret the computed index, we found that a multiple indicator that takes into account both innovative inputs and inputs can be quite illuminating. For example, in a cross-section analysis, by combining with an enterprise survey data, we learned that our innovation index confirmed the popular notion that top innovators were those which were more active in pursuing direct information about their business environment and more willing to change whenever presented with opportunities. Adding the time-series dimension, interestingly, we also found the indicator's ability to capture the degree of persistence in innovative performance of top-ranked enterprises, as well as the wide variations of performance across companies, sectors and over time. For the future, a more detailed study of the underlying factors of these findings would help explain some of the determinants of innovative activity at the company level.

NOTES

1. The analysis draws on the innovation index reported in the annual series 'Research and Development and Intellectual Property (IP) Scoreboard' published jointly by the Intellectual Property Research Institute of Australia (IPRIA) and the Melbourne Institute of Applied Economic and Social Research in collaboration with IP Australia and IBISWorld.
2. Note that only inventions that are eligible for patenting since a requirement of patents is that they are novel (i.e. new to the world).
3. Innovation that is new to the world is a much riskier prospect than innovation that is new to the firm and therefore involves higher expected returns since a risk-averse inventor will charge a premium for bearing risk.
4. The discussion in this section draws on Feeny and Rogers (2003).
5. See also Hall (2000) and Hall and Oriani (2004).
6. It is not clear whether or not those companies which do not report any R&D expenditure are actually zero spenders in terms of R&D or whether this observation is just missing.
7. The sample period is chosen simply based on the availability of market value data at the time the analysis was conducted.
8. See IPRIA (2004) for a more detailed presentation of the results.
9. Due to the limited size of the sample within each sector, in particular scientific research and printing, publishing and recorded media, the ranking of the sectors should be taken as indicative only.
10. Note that there is an important caveat to this statement: because of data constraints, only medium and large companies are included in the innovation scoreboard. The implications of this are discussed in section 5 of this chapter.
11. See the second appendix of Griffiths and Webster (2004) for a more detailed description of this survey.
12. See IPRIA (2000), (2001), (2003) and (2004) for more detailed results.
13. The innovative performance score is the actual value of I_{it} for each company in each year rather than the normalized score described earlier.
14. Griffiths and Webster (2004) found strong evidence that unobservable characteristics that are correlated with variables such as work culture and managerial style influence the company's decision regarding which appropriability methods to use to protect their invention.
15. Note that this solution only fixes the estimates of the weights of the innovation index. It still has not fixed the bias against companies which rely more on trade secrecy rather than patents.

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