The Definition and Measurement of Innovation*

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Abstract

This paper discusses the definition and measurement of innovation at the firm-level. Innovation is the process of introducing new ideas to the firm which result in increased firm performance. Various measures of innovative activity are discussed and evaluated. All the individual measures discussed can only act as partial indicators of the extent of innovation. This is because innovation covers an extremely broad range of activities which varies between firms. To create better measures of innovation it is necessary to aggregate the various individual measures. Methods to achieve this are discussed. The paper also provides a short review of previous Australia firm-level studies on innovation.

Key words: innovation, R&D, patents, intellectual property, investment, firm performance

Current working papers from the ’Performance of Australian Enterprises’ project

Title	**Number**	**Author(s)**
The Theory and Measurement of Profitability	7/98	Gow/Kells
The Definition and Measurement of Productivity	9/98	Rogers
The Definition and Measurement of Innovation	10/98	Rogers

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1 Introduction

This paper is concerned with the definition and measurement of innovation. The paper is prepared at the start of a research project on firm performance and is, therefore, principally interested in firm-level innovation. Innovation can be defined as the application of new ideas to the products, processes or any other aspect of a firm's activities. Innovation is concerned with the process of commercialising or extracting value from ideas; this is in contrast with 'invention' which need not be directly associated with commercialisation. While this definition of innovation may appear straightforward, a more precise definition involves consideration of a number of issues. These issues are outlined in section 2 which compares the definition of innovation used by the OECD, Australian government agencies and businesses. The conclusion of this section is that, while the basic definition of innovation is relatively simple, a precise definition, appropriate to all types of firms, is not so straightforward.

Section 3 of the paper considers the various methods that are available to measure the extent of innovation by firms. Such methods include the use of information from survey data, company accounts and intellectual property statistics. These methods yield a large number of potential innovation measures or indicators which can be used for subsequent analysis. These innovation indicators can be classified into the outputs of innovation and the inputs to the innovation process. Both output and input measures are useful for the difficult process of quantifying the overall extent of innovation. In fact, given the broad nature of innovative activities it is essential to consider a broad range of innovation indicators.

All of the innovation indicators discusses in section 3 have various drawbacks. In some cases it is possible to use econometric techniques to refine the measures of innovation. Ultimately the importance of innovation is due to its impact of the performance of the firm. Hence, it seems appropriate to try and link the various indicators of the extent of innovation to firm performance. If this can be done it allows a more complete measure of the value of innovative activities. Section 4 discusses some econometric methods that have been used for this purpose. A number of studies have considered how research and development (R&D) and patent activity has impacted on firm performance. However, there is no reason why this approach cannot be extended to include other innovation inputs.

Section 5 considers how the various innovation measures have been used in Australia firm-level studies. The section provides a summary of such studies; future papers that use similar techniques will discuss relevant studies in more detail. The final section concludes.

This paper's focus is on firm-level innovation. Specific issues concerning industry- or economy-level innovation, which involve different problems and techniques, are not focused on.[1] Case studies on specific firms and industries can also provide useful information about innovation, but again such studies are not covered here.[2]

2 The definition of innovation

There are various definitions of "innovation" that appear in the literature. The purpose of this section is to compare some of the major definitions. Joseph Schumpter is often thought of as the first economist to draw attention to the importance of innovation. He defined, in the 1930s, five types of innovation (see OECD, 1997, p.28):

- introduction of a new product or a qualitative change in an existing product
- process innovation new to an industry
- the opening of a new market
- development of new sources of supply for raw materials or other inputs
- changes in industrial organisation.

[1] For example, a recent area of research has been in the concept of 'national systems of innovation' (see Freeman, 1995). This looks at the entire innovation system comprising of education, government and business, and the institutional links between them. Lattimore (1991) and Gregory (1993) provide industry- and economy-level discussions on 'innovation' in Australia, mainly in regard to R&D. See Dept. of Industry Science and Tourism (1996) for industry- and economy-level data on R&D, patents and trade for Australia.

The Oslo Manual, produced by the OECD (1997, 2nd Edition), aims to set a benchmark for innovation surveys and research for its members. The Oslo Manual decides to concentrate on the first two Schumpter categories, which it claims are relatively easier to define and measure. The Manual clarifies the definition of the two categories as follows. A *technological product innovation* can involve either a new or improved product whose characteristics differ significantly from previous products.[3] The characteristics may differ due to use of new technologies, knowledge or materials. A *technological process innovation* is the adoption of "new or significantly improved production methods, including methods of product delivery" (p.49). In each case the words "new" or "improved" apply to a firm (e.g. even if a firm introduces a technique that is being used by others this still represents an innovation for that firm). Therefore, innovation can involve both the creation of entirely new knowledge, as well as the diffusion of existing knowledge. By way of shorthand, the OECD use the term *TPP innovation* to refer to both these types of innovation. The use of the word 'technological' in the Oslo Manual is meant to distinguish TPP innovation from organisational innovation. The latter refers to the introduction of new or improved organisational structures, management techniques or strategies.

The Oslo manual's definitions draw a distinction between 'new and improved' and 'insignificant or minor' (the latter are not considered to be part of 'innovation'). They also suggest that improvements that are purely creative or aesthetic should not be considered as innovation. As they acknowledge, such distinctions are subjective and the final judgement will rest "with respondents and/or persons selecting TPP innovations to include in databases" (OECD, 1997, p.55). The exclusion of aesthetic improvements is a very strong assumption, as economists normally try to consider real income (i.e. utility), hence aesthetic improvements should, in principle, be included. Moreover, the exclusion of minor innovations is in contrast with possibility that a significant proportion of growth in an economy may be due to incremental improvements.

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[2] See Part II of Dodgson and Rothwell (1994) for a selection of papers on innovation in specific industries.

[3] Note that 'product' refers to both goods and services.

The basic lesson from the extensive work in the Oslo Manual is that 'innovation' is problematic to define precisely. In practice, survey research must choose a relatively short definition for innovation and accept the fact that respondents will use varying interpretations. Any subsequent analysis of survey data should be aware of this fact. For example, the ABS, in Australia's most comprehensive innovation survey, used the following definition prior to questions on innovation:

> [A]n innovation [..] is any new or substantially improved good or service which has been commercialised, or any new or substantially improved process used for the commercial production of goods and services. 'New' means new to your business. (ABS Innovation Survey questionnaire, Section B).

The ABS Innovation Survey also asked a single question on organisational and managerial change, which were defined to include office automation, enterprise bargaining, staff training programs and management techniques.

Phillips (1997), in a paper discussing the results of the ABS innovation survey, distinguishes between technological innovation and non-technological innovation (which includes novel marketing strategies and changes to management techniques or organisational structures). In Phillips' analysis a firm is defined as technologically innovative if it introduced at least one new or substantially improved product or process in a three year period. Similarly, a non-technologically innovative firm was defined as having introduced one of the changes mentioned above.

The Department of Industry Science and Tourism (DIST) use a relatively broad definition of innovation, namely:

> [I]nnovation, at the level of an individual firm, might be defined as the application of ideas that are new to the firm, whether the new ideas are embodied in products, processes, services, or in work organisation, management or marketing systems (DIST, 1996, p.2, and credited to Gibbons et al, 1994).

Lastly, the Business Council of Australia have used the following definition:

> In business, innovation is something that is new or significantly improved, done by an enterprise to create added value either directly for the enterprise or indirectly for it customers (Business Council of Australia 1993, p.3)

Note that this defines innovation as something that 'adds value'. In general, innovation is only regarded to have occurred if it has been implemented or commercialised in some way. The creation of abstract knowledge, or the invention of new products or processes, is not normally considered innovation until it has been productively incorporated into the enterprise's activities. This means that innovative activity is not something that can occur separate from the firm's core activities, rather it must involve the coordination of various inventive, learning and implementation skills.

This last point highlights that innovative activity requires substantial effort form all elements of a firm. Moreover, innovative firms are likely to have the characteristics that allow innovation to occur consistently through time. DIST (1996, p.2) express this as follows "effectively innovating firms are those with strategies, values, organisational forms and practices which are conducive to consistent innovation and continuous improvement".

3 Measuring innovation

As should be clear from the discussion in section 2, the measurement of innovation is likely to be difficult due to the broad nature of the scope of innovative activities.[4] One method of trying to assess innovation is to make the distinction between the *outputs* of innovative activity and the *inputs* to innovative activity. It is under these categories that we organise our discussion.

[4] Indeed, the Oslo Manual excludes organisational innovation partly due to "its measurement appears to be very difficult both conceptually and in practice" (OECD, 1997, p.43)

3.1 Output measures of innovation

Ultimately, the key output measure of innovative activity is the success of the firm. Firm success can be proxied by profits, revenue growth, share performance, market capitalisation or productivity, amongst other indicators. All of these indicators have drawbacks (see Gow and Kells, 1998, for a discussion of profitability measures, and Rogers, 1998, for productivity measures) and, importantly, can be caused by factors other than the level of innovativeness. However, the extent of firm success can be used as a measure of innovativeness if certain econometric techniques are used (we return to these issues in section 4). A strength of using such techniques is that the extent of a firm's innovativeness can be quantified and directly compared to other firms.

An alternative measure of innovative output is to create variables for the number of new or improved products introduced, or the number of new or improved products introduced. The SPRU data base (University of Sussex, UK) on major innovations uses such an idea. It used a panel of industry experts to assess the most important innovations by UK firms over the period 1945 to 1983. The data set has subsequently been used for a variety of empirical research.[5] The ABS Innovation Survey and the Business Longitudinal Survey ask firms directly whether they have introduced any new/improved products or processes. The yes/no answers to such questions are a basic way of categorising firms into innovative or non-innovative categories. The answers to such questions, however, are subjective and give no indication of the number of innovations made or the importance of each. In this sense, such output measures are only crude indicators of the level of innovation. The ABS innovation survey refined this type of question by asking firms to estimate the percentage of their sales accounted for by a) new products, b) improved products and c) unchanged products, where the former two categories refer to products introduced over the last three years. Highly innovative firms would be expected to have a higher percentage of sales from

[5] The experts produced a total of about 4300 major innovations. Geroski (1995) provides an example of the use of these data in an analysis of innovation and corporate performance.

new and improved products.[6] The survey also asked firms to estimate the percentage of product sales accounted for by new or improved processes. These measures rely on the ability of firms to correctly and consistently report such percentages but are, in principle, a better assessment of (past) innovative activities.[7]

Another potential set of output measures are intellectual property (IP) statistics, such as patents, trade marks and designs (Appendix A gives definitions for each of these). The procedure for obtaining IP rights is to file an application which is then checked for novelty and legality. If the application is successful, a full property right will be granted for a period of years. An application for such an intellectual property right implies that the firm considers it has created some new knowledge that can be protected. In addition, the fact that a firm has incurred the cost of applying for protection implies that the knowledge has some perceived value. This is one reason for using applications as a proxy for innovative output, since an innovation is defined as something that is new to the firm. In other words, even if the application is subsequently rejected on the basis on lack of novelty (i.e. some other firms are using, or have already registered, the property rights) the application still indicates innovative behaviour by the firm. In broad terms, the grant of an intellectual property right indicates that the application represented a 'new' advance on existing knowledge. In the case of patents, therefore, a grant indicates an invention (which is one aspect of innovation). A criticism of using patent data as an output measure is that patents do not necessarily represent a commercially exploited innovation. Instead, some researchers have considered patent and other IP data as indicators of inputs to the innovation process rather than outputs.[8] Thus we discuss IP measures again in section 3.2 below.

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[6] DeBresson et al (1996, p.42) note that a high percentage of sales from new products may not be a good indicator of a firm's future performance, since even new products may be sold into static or declining markets.

[7] DeBresson (1996) discusses that fact that many innovation surveys appear to have very high response rates to questions concerning past innovation levels.

[8] Griliches (1990) states that Jacob Schmookler – who was the first economist to intensively study patent data – started his research considering patents as an output measure, but by the end of his research decided that "patents became an index of inventive "activity", primarily an input rather than an output index" (Griliches, 1990, p.1670).

Table 1 summarises the various output measures of innovation discussed above. The last column of the Table shows the main Australian data sources available for such measures.

Table 1 Output measures of innovation

Output measure	*Description / comment*	*Australian data source*
Introduction of new or improved product(s) or process (es)	Survey question. Normally, yes/no response that refers to a given time period.	BLS ABS Innovation Survey
Percentage of sales from new/improved product(s) or process(es)	Survey question. Relies on ability of respondent to assess percentage.	ABS Innovation Survey
Intellectual property statistics	Patent, trade mark and design applications and grants. Drawback is that these do not necessarily represent a commercialisation of ideas.	IP Australia have provided applicant details to the Melbourne Institute
Firm performance	Use econometric techniques to relate innovation indicators to firm performance (see section 4)	

3.2 Input measures of innovation

The level of research and development (R&D) expenditure has been the most extensively used proxy for the level of innovative effort. Its advantages are that it is a relatively well understood term and it provides a dollar figure for use in subsequent analysis. However, the precise definition of R&D is subject to some debate. The Frascati Manual, produced by the OECD (1993), defines R&D as:

> Research and experimental development (R&D) comprises of creative work undertaken on a systematic basis in order to increase the stock of knowledge,

> including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. (taken from DIST, 1998, Appendix C, p.14)

This is a very general definition which is expanded on in detail in the Frascati Manual. The ABS have used the following definition for R&D activity:

> systematic investigation or experimentation involving innovation or technical risk, the outcome of which is new knowledge, with or without a specific practical application of new or improved products, processes, materials, devices or services (ABS, 1996, 8104.0, p.24).

Note that this definition does not coincide with that of innovation since it requires no practical application. Nevertheless, it seems highly likely that, in commercial firms at least, R&D will be aimed at creating innovations for commercial exploitation. The ABS definition above is more general than the definition used by the Australian Department of Industry, Science and Tourism (DIST) for the purposes of the R&D tax concession. Appendix B states the full R&D definition used by DIST (which is currently under review). In short, the DIST definition excludes a number of areas that might normally be considered as innovative activities such as market research, cosmetic modifications to products, management studies, and tooling-up. This again means that R&D will not closely match the concept of innovation. For the purposes of this paper, the lesson to be learnt is that the definition of R&D is unlikely to match exactly with innovation. That said, its wide availability and the expected high correlation between R&D and innovation effort make it a valuable proxy for innovation activity.

As discussed above, intellectual property measures can also be considered as an input to the innovation process. The use of patent data, which has been by far the most studied component of intellectual property by economists, has been reviewed by Basberg (1987) and Griliches (1990). Griliches states a key problem with using patent data as an innovation measure as follows, "inventions that are patented differ greatly in their quality" (Griliches, 1990, p.1669) (i.e. an individual patent could be worth millions of dollars or nothing). Basberg considers two further questions concerning the use of patents at the firm level

- to what extent do patents reflect the commercial use of technology?
- how does the usage of the patent systems vary across firms and industries?

Regarding the first question, the existence of a patent does not signal commercial use of the idea. Moreover, not all commercially valuable ideas can or will be patented. This is in part because not all ideas are legally patentable, but also because the process of obtaining a patent involves the full disclosure of the knowledge, which may be of indirect use to competitors. Hence, firms may rationally choose not to patent commercially valuable knowledge and instead rely on secrecy.[9] The failure of patent or other intellectual property data to fully reflect innovative activities is of particular concern if the patent-innovation relationship varies across firms and over time (Basberg's second point). If this is the case some care must be taken in using such data for innovation analysis. There are methods of controlling for such issues, the most obvious being to restrict analysis to a sub-group of firms that use patents in a roughly consistent manner (e.g. large firms in manufacturing). Alternatively, section 4 reports on some methods that use citation and renewal data to try and infer a value for patents.

The use of trade mark or designs data in analysis of innovation has been must less common than the use of patent data. Some surveys include questions that cover the purchase of trade marks (e.g. ABS Innovation Survey), but trade marks are usually grouped together will patents. In one of the few papers on trade marks, Wilkins (1992) states, "trade marks are – and have been since the late nineteenth and throughout the twentieth century – significant business assets … Yet they have not – nor have brand names, trade names, and company names [..] been systematically studied by economic or business historians." (Wilkins, 1992, p.66) The use of designs

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[9] The ABS Innovation Survey asks firms how they protect innovations, including the use of patents, designs and secrecy. Phillips (1997, p.30) tabulates the responses which show that patents are used by around 44% of firms, while secrecy is used by 74% of firms. Perhaps, more importantly, the use of patents varies dramatically by firm size, with 35% of small firms (<20 employees) using patents and 75% (>500) of large firms.

as innovation indicators also seems to have been neglected (see BIE, 1995, for a general discussion of the economics of designs). The larger project, of which this paper is a part, will use data on trade marks and designs to investigate of the use of these IP rights by Australian firms. Some firm-level data sets (e.g. the IBIS data set) also includes data on the value of intangibles assets. Intangibles assets, as reported in a set of accounts, are likely to be an overall valuation for goodwill, capitalised past R&D, as well as valuations of any holdings of patents, trademarks and licences. Thus, such a variable can be used as a measure of past innovation (or, possibly, the change in intangible assets between two periods may be a proxy for current innovation effort)

As stated in section 2, innovation is not the same as invention in that an innovative firm does not need to be the inventor of the new product/process. Buying in technology from other firms or institutions may be a key aspect of a firm's innovation strategy. With this is mind, data on the purchases of external technology has been used as an indicator of innovative activity. The ABS Innovation Survey asks firms to provide a figure for the "acquisition of technology (e.g. patents, trademarks and licences)". Technology may also be embodied in capital equipment. A firm that purchases the equipment or machinery which are improved versions of existing machines can legitimately be regarded as innovative. The ABS Innovation Survey considers this type of activity as "expenditure for tooling-up, industrial engineering and manufacturing start-up". The ABS asks respondents to this question to only include the expenditure that is associated with improvements in the firm's processes, or expenditure that is related to new products. Expenditure to replicate existing production methods should be excluded according to this definition. This, in turn, suggests a comparison between the "expenditure for tooling-up, industrial engineering and manufacturing start-up" and total investment expenditure. The difference between the two figures should be the investment solely used to replace existing machines and equipment with (approximately) identical ones. The BLS survey would, in principle, allow such an analysis since it contains expenditure data on both tooling-up, etc, as well as investment. The ratio of these expenditures may be a useful innovation indicator in its own right.

The expenditure on the marketing of new products is often considered to be part of innovation. Data on marketing expenditures are often requested in surveys, with both the BLS and ABS Innovation Survey containing the question "how much expenditure was associated with the launch of new or changed products (exclude expenditure on the building of distribution networks)".[10] Similarly, the expenditure on training that is related to the introduction of new and changed products and processes is also considered an innovative input.[11] The inclusion of both marketing and training expenditures follow from the fact that innovation involves the entire resources of a firm in developing and extracting value from new ideas; thus, the marketing of the ideas, and the ability of staff to efficiency implement the ideas, is crucial.

Lastly, innovation can also occur in the managerial methods and organisational structure of a firm. As with marketing and training, in theory it is possible to include questions about the expenditure on introducing such changes. However, many surveys only ask questions that require a yes-no response. This may be due to the fact that firms have traditionally not recorded such expenditures, or that the expenditures are regarded as confidential.

Table 2 summarises the various input measures of innovation that have been discussed above. The overall input into innovation can be regarded as the sum of all of these various inputs. However, as noted above, data on the expenditure on all the inputs is often not available. Therefore, the 'cost of innovation' is often considered to be a sub-set of these activities. For example, the ABS Innovation Survey defines the costs of innovation as equal to the sum of expenditures on R&D, acquisition of technology, training (related to new or changed products and processes), tooling-up (ditto) and marketing of new products.

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[10] Littler (1994) provides a summary of the marketing – innovation link and states, "the marketing function's concern is to ensure that industrial innovations are conceived and developed with a careful regard to the differential customer benefits they offer" (p.299).

[11] See Warner (1994) for a discussion of training and innovation.

Table 2 Input measures of innovation

Input measure	*Description / comment*	*Australian data source*
R&D	Widely available. Problems with precise definition. Does not match exactly with innovation.	IBIS data set BLS and other ABS surveys
Intellectual property statistics	Do not coincide closely with innovation. Virtually no research into trademarks or designs.	Melbourne Institute has created data set for firms on IBIS data set.
Acquisition of technology from others (e.g. patents, licenses)	Important element of innovation.	BLS and other ABS surveys
Expenditure on tooling-up, industrial engineering and manufacturing start-up associated with new products/processes	Relies on firm distinguishing between this type of investment and investment purely for replacement.	BLS and other ABS surveys
Intangible assets	Balance sheet figure will include goodwill and capitalised R&D. Change in intangible assets may be indicator of recent innovation.	IBIS data base
Marketing expenditures for new products		BLS and other ABS surveys
Training expenditures relating to new/changed products/processes		BLS and other ABS surveys
Managerial and organisational change	Normally, yes-no questions on surveys.	BLS, AWIRS and other ABS surveys.

4 Measures of innovation based on econometric analysis

The various output and input measures discussed above suffer from the fact that they are only partial measures of the overall extent of innovation by a firm. One method to rectify this is to add the various elements together. However, in many cases the units of measurement are not equal, or only categorical variables (e.g. yes-no responses) are available for some aspects. An alternative method is to relate the various innovation measures to the overall performance of the firm using econometric techniques. This allows inferences about the value of the different innovation activities, as well as an assessment of the overall value of innovation activities. This approach has been most commonly applied with R&D data. The variables used to quantify firm success have included market value (see Hall, 1993) and productivity (for two recent studies see Klette, 1996, or Adams and Jaffe, 1996)[12]. Various other studies have used patent data in place of R&D data (see Griliches, 1990) and, occasionally, both R&D and patent data (see Cockburn and Griliches, 1988). In principle, this type of approach can be expanded to include variables other than R&D and patents. The great advantage of these methods is that they link the innovation inputs to a quantifiable measure of innovative output.

An issue in the use of patent data is that a patent may never be commercially used and hence be of limited value (at least to the firm making the patent), hence patent statistics may be a poor proxy for innovation. If patent data is used in econometric analysis this is a particularly difficult problem if the proportion of 'commercial' patents varies across firms and industries, and also over time. There are a number of methods of assessing the value of patents in addition to the methods outlined in the paragraph above. These include direct surveys of patent holders, using data on patent renewals, and using citation data.[13] Griliches, (1990, p.1679-1682) gives a summary of some of these methods. Direct surveys to firms that hold patents can ask questions concerning patent use and value. Renewal data and citation data can be used to assess which are the more valuable patents (see Lanjouw et al, 1996, and Pakes and Simpson, 1989). This approach essentially relies on the fact that only valuable patents are renewed for the full potential life of the patent. Use of citations to infer a value for

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[12] Griliches (1984) contains a number of articles on these methods.

[13] Annual renewal fees are normally charged on patents and other IP rights. In Australia, annual charges are levied after the third year, these annual fees start at around $115 but rise to $790 by the 19th and final year of the patent. Each patent application is required to cite other relevant patents. These citation records can be used to give an indication of the 'value' of a patent to subsequent inventors.

a patent is based on the premise that more valuable patents will tend to be cited more extensively by subsequent patents.

5 Australian studies using innovation data

The purpose of this section if to provide a short summary of some Australia firm-level studies that use innovation data. The section is not intended as a complete review of existing work, instead it aims to highlight the basic methods and data used. More detailed discussion of previous work will be included in subsequent papers.

An important recent study on innovation in the manufacturing sector is by Phillips (1997). This study uses firm-level data from the ABS Innovation Survey (conducted in 1994 and covering the period 1991 to 1994). The study contains summary statistics on the questions in the ABS survey, including the areas of: innovation intensity, R&D intensity, firm size and innovation, impediments to innovation, exporters and innovation, and sources of innovations. Regression analysis is also conducted on the determinants of innovativeness (which is proxied by the share of sales from new or changed products) and also the link between sales growth and innovativeness. The comprehensive data in the ABS survey allows the construction of a complete range of innovation measures and other variables for use in the regression analysis. Previous studies that have used survey data include the two Bureau of Industry Economics (BIE) publications which focus on small firms (BIE, 1987, 1993). Both of these reports contain substantial information on the nature of innovation and the various impediments to the innovation process.

Bosworth and Rogers (1998) uses data from the IBIS data set and data on market value from the Australian Stock Exchange to investigate the link between R&D and intangible assets and market value. This method was discussed in section 4. They find R&D and intangible assets have a positive relationship with the market value of the firm. Table 3 provides a brief summary of a number of other Australian studies.

Table 3 Australian firm-level innovation studies

Author, Year	*Title*	*Comment*
Stubbs, 1968	Innovation and research: a study in Australian industry	Statistics on a range of innovation measures. Survey of innovations of 45 manufacturing companies 1953-1964
McLean and Round, 1979	Research and product innovation in Australian manufacturing firms	Based on survey data of 980 firms. Finds positive correlation between % of sales from new products and R&D intensity
Bureau of Industry Economics, 1987	Small Business Review	Part of review concerns innovation in 119 small firms in high growth industries
Bureau of Industry Economics, 1993	A Report on Small Business Innovation	Uses ABS R&D data, R&D tax concession data and case studies of 43 small firms
Gallagher, 1991	Innovation, management skills and employee training in small business	Based on BIE survey of 1752 firms in 5 specific industries
Phillips, 1997	Innovation and firm performance in Australian manufacturing	Based on ABS Innovation Survey (4537 firms). (see main text for more description)
Harris and Kells, 1997	Victorian Innovation Survey	Survey and case study analysis of Victoria firms
Bosworth and Rogers, 1998	R&D, intangible assets and the performance of large Australia companies	Econometric analysis of R&D and intangible assets on market value.

6 Conclusion

This paper has discussed the various methods of defining and measuring innovation. Innovation is a word used to describe a vast number of changes to a firm's activities that lead to improved firm performance. As we have seen, these changes can relate to new or improved products or processes, investment in new machines, marketing expenditures, investment in training, the creation of intellectual property or the purchase of technology. The multifaceted nature of innovation makes a concise measure of innovation, which is appropriate to all firms, impossible. Different firms will use different methods of innovation, and even the same firm will adapt and improve its methods of innovating over time.

Innovation is widely agreed to be a fundamental determinant of firm performance. Understanding the nature and role of innovation requires analysis of the various types of innovative activity. In turn, this means that the extent and characteristics of innovation must be quantified with data, despite the difficulties involved in measurement. Section 3 of this paper discussed a large range of innovation indicators. Survey data can provide a number of innovation indicators such as whether new products or processes have been introduced, or the share of sales attributable to new products or processes, over a set time period. Depending on the nature of the survey, such measures can be developed to include the number of product innovations and/or the perceived value of such innovations. In addition to these measures, a number of quantitative measures of innovation are possible including: R&D, patents, trade marks, designs; as well as the expenditure on training, investment, marketing and new technology. The review of such measures leads to the conclusion that each of the measures has some validity, but none can act as a stand alone measure of innovation. This is the reason why such measures should perhaps be called "indicators". This, in turn, suggests the need to combine various indicators to form an overall measure of innovation. This is easily achieved if the indicators are in dollar terms, but many of the indicators are not (e.g. number of patents, percentage of sales due to new products). Section 4 discussed the econometric literature that tries to assess the value of innovation, by linking indicators such as R&D and patents to the performance of the firm. The expansion of these methods to include other indicators is one method of providing an overall measure of innovation.

Appendix A: Patents, trade marks and designs

The following descriptions of patents, designs and trade marks are based on information taken from IP Australia marketing publications.

A **patent** is an intellectual property right which can be legally enforced and gives the holder exclusive rights to an invention in Australia. International protection can also be obtained. A patent is, in general, "any device, substance, method or process that is new, inventive and useful". Artistic creations, mathematical models, plans, business schemes usually cannot be patented. In Australia there are two classes of patents – petty and standard – the petty patent is a 'stream-lined way' to protect inventions and lasts for a maximum of six years. A standard patent has a life of up to 20 years. Patent holders can exploit the patent themselves or allow others to use the patent through a licence arrangement. Standard patents require an initial payment and, subject to the application satisfying certain requirements, are then issued for three years, after this period an annual renewal fee is required is legal protection is required. Petty patents are initially granted for 12 months and can then be renewed for the remaining five years.

A **trade mark** must be able to distinguish your goods or services from others by symbolising a certain image, quality and reputation. A trade mark can be a letter, word, phrase, sound, smell, shape, logo, picture, aspect of packaging or a combination of these. Trade marks are legally enforceable and last initially for 10 years. After this time they can be renewed (for a fee) for successive periods of 10 years. Trade marks must not be a sign that other traders may wish to use in the normal promotion of their goods and services.

A **registered design** can be used to protect the visual appearance of manufactured products. A design is the features of shape, configuration, pattern or ornamentation which when applied to an article gives an article a unique appearance. The design must be 'new' (to Australia) or 'original' (not having been applied to an existing product). A design must refer to an industrial good, purely artistic items are covered by copyright. Designs can be registered initially for a period of one year and can be extended for a maximum of 16 years.

Other forms of intellectual property rights are copyrights, circuit layout rights and plant breeders' rights. The former is free and automatically gives the creator legal protection (normally for 50 years) and no registration is required. The latter two refer to the specialised areas of circuit layouts and new varieties of plants. Given this, none of these IP rights appear suitable for inclusion in overall innovation measures.

Appendix B: Current Commonwealth definition of R&D

Extract from DIST (1998, Appendix B, available at http://www.ausindustry.gov.au/ rdpaper.doc**)**

Research and development activities means -

(a) systematic, investigative ***and*** experimental activities that involve innovation or ***high levels*** of technical risk and are carried on for the purposes of:

(i) acquiring new knowledge (whether or not that knowledge will have a specific practical application); or

(ii) creating new or improved materials, products, devices, processes or services; or

(b) other activities that carried on for a purpose directly related to the carrying on of activities of a kind referred to in paragraph (a);

Interpretations

For the purposes of the definition of research and development '*activities*':

(a) activities are not taken to involve innovation unless they involve an appreciable element of novelty; and

(b) activities are not taken to involve high levels of technical risk unless:

(i) the probability of obtaining the technical or scientific outcomes of the activities cannot be known or determined in advance on the basis of current knowledge or experience; and

(ii) the uncertainty of obtaining the outcome can be removed only through a program of systematic, investigative and experimental activities in which scientific method has been applied, in a systematic progression of work (based on principles of physical, biological, chemical, medical, engineering or computer sciences) from hypothesis to experiment, observation and evaluation, followed by logical conclusion.

Exclusions List

The following activities are taken not be to systematic, investigative and experimental activities:

a) market research, market testing or market development, or sales promotion (including consumer surveys);

b) quality control;

c) prospecting, exploring or drilling for minerals, petroleum or natural gas for the purpose of discovering deposits, determining more precisely the location of deposits or determining the size of quality of deposits;

d) the making of cosmetic modifications or stylistic changes to products, processes or production methods;

e) management studies or efficiency surveys;

f) research in social sciences, arts or humanities;

g) the making of donations;

h) pre-production activities such as demonstration of commercial viability, tooling-up and trial runs;

i) routine collection of information, except as part of the research and development process;

j) preparation for teaching;

k) commercial, legal and administrative aspects of patenting, licensing or other activities;

l) activities associated with complying with statutory requirements or standards, such as the maintenance of national standards, the calibration of secondary standards and routine testing and analysis of materials, components, products, processes, soils, atmospheres and other things;

m) specialised routine medical care;

n) any activity related to the reproduction of a commercial product or process by a physical examination of an existing system or from plans, blueprints, detailed specifications or publicly available information.

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