Innovation agents

Vocational education and training skills and innovation in Australian industries and firms – Volume 1

Phillip Toner

Jane Marceau

Richard Hall

Gillian Considine

Need more information on vocational education and training?

Visit NCVER's website <http://www.ncver.edu.au>

- ✓ Access the latest research and statistics
- ✓ Download reports in full or in summary
- ✓ Purchase hard copy reports
- ✓ Search VOCED—a free international VET research database
- ✓ Catch the latest news on releases and events
- ✓ Access links to related sites

NCVER

Innovation agents

Vocational education and training skills and innovation in Australian industries and firms – Volume 1

Phillip Toner
Jane Marceau
Australian Expert Group in Industry Studies, University of Western Sydney

Richard Hall
Gillian Considine
ACIRRT, University of Sydney

Publisher's note

This report has been published in two volumes. Volume 1 is the main report. Volume 2 contains the appendices and is available only in pdf format which can be downloaded from the NCVER website <http://www.ncver.edu.au>.

ISBN 1 920895 43 4 print edition
ISBN 1 920895 44 2 web edition
TD/TNC 77.01

Published by NCVER
ABN 87 007 967 311
Level 11, 33 King William Street, Adelaide SA 5000
PO Box 8288 Station Arcade, Adelaide SA 5000, Australia
<http://www.ncver.edu.au>

Contents

Tables and figures

Tables

Figures

Executive summary

This study examined the role of vocational education and training (VET) and occupations in innovative industries and firms. Innovative industries are those that have implemented technologically new or significantly improved products or processes. Those categorised as intensive have contributed to the national expenditure on innovation after putting particular effort into research and development. The three over-arching aims were:

- to provide detailed information on the distribution of skilled (VET) occupations in innovation-intensive industries in Australia
- to provide information on employer, technical and further education (TAFE) and private provider inputs to training for these groups of personnel in innovative industries
- to highlight issues for policy-makers both in VET and within other portfolios relating to innovation at each major level of government in Australia.

Innovation-intensive products and services are increasingly playing a substantial role in world trade and thus, competitive success in innovation-based products and services is a significant and influential factor in long-term national prosperity. For this reason it is important that the linkages and communication between innovation-intensive firms and vocational education and training are well defined and efficient.

The methodology for the study involved a literature review, quantitative analysis and case studies.

The following summarises the key results using the framework of the specific research questions underpinning this study.

Which industries are most significant in undertaking innovation in Australia?

From the composite index of innovation a clear hierarchy emerges, with the industries clustered into three distinct groups. These groups are:

- *High-innovation industries:* mining; manufacturing; property and business services; and communication services
- *Medium-innovation industries:* electricity, gas and water; wholesale trade; finance and insurance; and transport and storage
- *Low-innovation industries:* personal services; retail trade; cultural and recreational services; health and community services; and construction.

It is interesting to note that the high-innovation group comprises two traditional goods producers as well as the most recently developed and fastest growing service industries. It reveals that the more popular notions of what constitutes technologically dynamic industries require change. In 2001 these four industries accounted for 33.5% of gross domestic product (GDP) and 26.3% of employment. The fact that the share of gross domestic product significantly exceeds the share of employment indicates the comparatively high productivity of these industries.

The broader literature on innovation and the case studies identified an interrelated set of factors which are strongly associated with high-innovation intensity. The factors include:

- large firm size

- regular upgrading of capital equipment
- strong linkages between producers and suppliers of capital equipment and other inputs
- competition within the respective industries and product markets based on product differentiation, reducing cycle times for introducing new products to markets, customisation, reliability, quality, design and integrating products and services
- well-functioning linkages between external research and educational institutions and firms
- customers who require continuous product improvement from suppliers
- regulatory requirements which allow for novel solutions in meeting prescribed standards
- high expenditure on training.

The eight case study firms, individually and collectively, demonstrated most, or all of these characteristics.

What is the role and significance of VET provision in Australian innovation?

Surveys of innovation-intensive industries by the Australian Bureau of Statistics (ABS) found that firms identified persons in VET occupations as among the principal sources of ideas for technological innovation. Skilled production, trade and technician occupations are essential for the *generation*, *design*, *installation*, *adaptation* and *maintenance* of new technologies. The case studies demonstrated that innovation-intensive firms regard VET as a critical transmission mechanism in the diffusion of knowledge and development of practical skills for a very broad range of occupations. ABS data also show that innovation-intensive industries have higher expenditure on structured training as a share of gross wages and salaries, and provide notably higher hours of training per employee. The case study firms spent two to four times more on training as a share of gross wages and salaries than other firms.

A common element across all case studies was that training was seen as an essential element in the maintenance and growth of their business, and flowed automatically from their decisions regarding the pursuit of product and process improvements. This reflects the bases of competition within the industries and markets into which they sell their goods and services.

An important finding is that most of the factors which were identified in the literature review as strongly stimulating innovation were also identified in the case studies as strongly stimulating training. This is not a surprising result. The fundamental purpose of vocational training is, after all, the transmission of economically useful knowledge. Industries which experience comparatively rapid changes in the knowledge base of their processes and products require more intensive training to transmit this knowledge.

What is the occupational profile of innovative industries and which occupations within innovative industries rely on VET providers?

The high innovation-intensive industry group as a whole has a disproportionately large share of managers/professionals and trades and advanced clerical occupations. (There are a disproportionate number of managers/professionals and advanced clerical occupations in communication services and property and business services and a disproportionate number of trades in manufacturing, and mining.) All other occupational groups are under-represented in the group. However, within the four industries comprising the high innovation-intensive category—manufacturing, mining, communication services, and property and business services—there is very considerable diversity in their occupational structures. Indeed, the degree of variation in the occupational structure across these four innovation-intensive industries is as great as that across all industries.

In other words, taken collectively, there are significant differences in the occupational structure between the high-innovation intensity group and the other two innovation groups. However, taken as separate industries, these differences become much less distinct. The fact that the association between occupational structure and innovation intensity of industries depends on the level of analysis undertaken suggests that the association is not robust.

Another important and related finding is that the variation in educational attainment within the innovation-intensive industries is as great if not greater than that across all industries. This is primarily due to the large variation in occupational structures across the four innovation-intensive industries. These results suggest that the principal occupational groups play a different role, and are of differing significance in the innovation process within each of the high innovation-intensive industries. For example, in manufacturing industry, only 11% of employees have graduate or post-graduate degrees, compared with 33.6% for property and business services.

These results also suggest that, by itself, educational attainment—in particular, a high proportion of an industry's workforce with university qualifications—is not a strong predictor of innovation intensity. For example, of all industries, the health and community services industry has the highest share of persons with university qualifications at 40.4%, although it is classified to the low-innovation group.[1] This finding is consistent with the literature on innovation which finds that a very broad range of factors, both internal and external to a firm and industry, determine the intensity of its investments in innovation-related activities.

How do innovation-intensive industries recruit, maintain and update their skills? What problems, if any, do innovation-intensive industries have in recruiting, maintaining and updating skills provided by the VET sector?

The study found innovation-intensive firms use a wide range of training providers. These include TAFE institutes, private providers, equipment and other vendor suppliers, professional associations and in-house providers. Amongst higher-level VET occupations, such as technical officers or forensic investigators with diplomas and advanced diplomas, conferences, journals and professional associations, were an important means of keeping up to date with advances in their fields. Nevertheless, a key role was identified for TAFE in that six of the eight case study firms used TAFE to supply entry-level qualifications.

Across the cases studies there was a universal requirement for entry-level VET training to result in formal qualifications. This requirement was due to enterprise bargaining agreements providing for training to lead to the acquisition of recognised, transferable qualifications. It was also due to the widespread adoption of formal quality assurance methods which typically require that employees can document their competency to perform the range of work they undertake. In addition, larger firms operate formal human resource management policies in which formal qualifications are used as criteria in recruitment and promotion.

From the case studies, a typology was developed describing and explaining the differences in training sources, methods and curricula. Five different models were identified in terms of the methods and sources used to recruit, maintain and update vocational skills. The picture which emerges from this typology is a highly adaptive training system.

What are the strengths and weaknesses of VET provision within Australia's innovation-intensive industries?

The case studies revealed, overall, a high level of satisfaction with the public and private VET system. Staff interviewed for the case studies all commented very positively on training provided by TAFE, especially in relation to its emphasis on the acquisition of practical skills. The firms especially valued training with a practical and applied orientation. This form of training was valued because it reduced the amount of on-the-job training required for employees to become productive.

[1] Aggregation of health and community services obscures the relatively high-innovation intensity of the health industry.

Firms also commented positively on the linking of off-the-job training with on-the-job work experience, allowing students to apply their knowledge.

An obvious, although still key, finding was the importance of consultation. It is concluded that the satisfaction expressed by firms regarding TAFE training was due to the high level of consultation between the firms and TAFE.

It must be recognised, however, that a crucial basis for the generally high level of satisfaction and high level of consultation is the large size of the case study firms. The scale of training sought by the firms made it economically feasible for TAFE and other providers to customise course content, assessment and delivery. The scale of training also made it feasible for the VET providers to invest in the development of their own staff which enabled them to keep abreast of the latest technologies and pedagogies in their fields.

A considerable amount of post-entry-level training was provided, mostly in the form of short courses, typically with a duration not exceeding 2–3 days. The case studies and survey data indicate that a wide variety of training providers were used for this post-entry-level training. In approximate order of importance, they included equipment and other input suppliers, in-house training, private providers and TAFE. A high level of satisfaction was expressed by the case study interviewees regarding the quality, cost and flexibility of the training supplied by all of these providers. Firms sought flexibility in training arrangements for this post-entry-level training, especially the capacity for on-the-job delivery and customisation of training to conform to firm-specific operating procedures and equipment.

All of the case study firms emphasised the need for employees to develop behavioural skills such as effective team work and to develop problem-solving and communication skills, including improved literacy, numeracy and information technology skills. The demand for these behavioural and communication skills resulted from:

- the requirements of formal quality systems
- the automation of production, requiring operators to have a higher-level conceptual understanding of production processes
- work organisation change leading to flatter management structures and devolution of responsibility to supervisors and operators
- the expectation that employees contribute to product and process improvement through various consultative mechanisms.

There is unmet demand for training in these behavioural skills, especially related to team work and problem-solving.

Finally, while larger innovation-intensive firms have the financial capacity and willingness to invest in structured training, other sectors have significantly reduced their VET investments. This has contributed significantly to skill shortages in occupations which are critical, for example, to success in export markets and competing against imports in manufactured products. This is a concern given that, to be competitive, innovation-intensive sectors depend on efficient and technically flexible suppliers of components and services from all sectors. Without the presence of these clusters of high-quality and technically agile smaller suppliers, the survival of larger innovation-intensive firms is at risk. A variety of measures are suggested to address these skill shortages.

There is a volume 2, which contains the data tables for the construction of the composite index of innovations, the case study interview schedules and the case studies, and can be downloaded in pdf format from the NCVER website.

Chapter 1: Introduction

Background

The causes and effects of innovation have been the subject of intense international research and policy interest. This research has identified the central role of technological change in economic growth (OECD 1997; Cantwell 1999) and restructuring of regions, industries and occupations (OECD 1996; Department of Trade and Industry 1998; Department of Industry, Science and Resources 1999). 'Growth accounting' studies have shown that technical innovation and the consequent growth in productivity account for around 80% of total output growth, and that technical change (along with an increase in capital per worker) is almost solely responsible for the growth in output per worker, or increments in per capita income. In other words, the dominant contribution to the growth in total output is change in the quality of inputs to production and production processes, rather than simply the growth in the quantity of labour and capital and other inputs to production (OECD 1997; Cantwell 1999; Fagerberg 2001, p.5).

While it is agreed that certain industries are key sources of innovation, it is also acknowledged that all industries are affected to varying degrees by the new products, processes, and shifts in trade, consumption and investment patterns induced by innovation and the need to invest in skills upgrading. Across the Organisation for Economic Co-operation and Development (OECD) the key sources of innovation are certain manufacturing industries, notably pharmaceuticals, aircraft, electronics, chemicals and metal processing, and service industries such as information technology, education, health, communications, and property and business services. Within the latter, technical services, such as computer and engineering consultancy and private scientific research, are especially important. With the exception of some areas of manufacturing, these industries have experienced significant employment growth over the last two decades. It is also increasingly clear that, in innovative firms, there are increasing links between manufacturing and services (Australian Expert Group in Industry Services and Australian Business Foundation 2001). The last trend means that current training provision in innovative industries may need substantial adjustment.

The central role of innovation in economic growth and structural change offers regions and nations the choice of taking the 'high road' to the development of high-skill, high-wage employment or low-skill, low-wage jobs (Marceau, Manley & Sicklen 1997). A skilled workforce is a critical element in the capacity of a firm, region or nation to innovate and compete. Many studies show that skills from the VET system play a key role in improving productivity, product and process innovation and in the creation and diffusion of new knowledge throughout a national economy (Finegold & Soskice 1988; Prais 1995). In this sense, the vocational education and training (VET) sector itself is a crucial part of the knowledge economy and is subject to the rapid changes in technology, work arrangements and institutional re-structuring characteristic of the emerging knowledge-based economy.

Aims of the project

Many studies of innovation in Australian industry have been carried out, but as yet there has been little focus on the links between VET and innovation. The present project seeks to fill that gap. The aims of this project are threefold:

- to provide detailed information on the distribution of skilled (VET) occupations in innovation-intensive industries in Australia
- to provide information on employer, technical and further education (TAFE) and private provider inputs to training for these groups of personnel in innovative industries
- to highlight issues for policy-makers both in VET and within other portfolios relating to innovation at each major level of government in Australia.

Research questions and methodology

The specific research questions underpinning the project are:

- *Which industries are most significant in undertaking innovation in Australia?*

  Using standard international definitions of innovation and innovation-related expenditures, an extensive array of data were collected relating to the innovation intensity of industries and the relative contribution of these industries to total national expenditure on innovation in Australia. This is based largely on Australian Bureau of Statistics (ABS) innovation surveys and other ABS economic data. These data were used to construct a composite index of innovation, ranking each industry in terms of their innovation intensity and contribution to total national expenditure on innovation. The benchmark is used to differentiate innovation-intensive and non-innovation-intensive industries. The methodology also includes a review of the innovation concept and difficulties in its empirical measurement.

- *What is the role and significance of VET provision in Australian innovation?*

  A review was undertaken of national and international literature focusing on the role of VET-related workforce skills and VET skills formation systems in innovation.

- *What is the occupational profile of innovative industries and which occupations within innovative industries rely on VET providers?*

  Data were drawn from a broad range of labour market data, notably the ABS labour force, population census and education and training data, cross-tabulating detailed occupational and industry classifications. This permitted a comparative analysis of innovation-intensive industries and non-innovation-intensive industries in terms of their VET occupational structure, their role and significance in the VET labour market and the training investments made by employers.

- *How do innovation-intensive industries recruit, maintain and update their skills? What problems, if any, do innovation-intensive industries have in recruiting, maintaining and updating skills provided by the VET sector?*

  The eight case studies provided the principal data source for examining how innovation-intensive firms recruit, maintain and update their skills. The firms in these studies were selected as belonging to industries which were identified as the most innovation-intensive in the composite index. All of the firms in the case studies had a large proportion of their workforce in VET occupations.

- ✧ *What are the strengths and weaknesses of VET provision within Australia's innovation-intensive industries?*

  Conclusions regarding the performance of VET provision for innovation-intensive industries were drawn largely from the case studies and broader literature.

Overview of the report

Chapter 2 provides definitions of the key terms 'VET' and 'innovation', which form the analytical core of the present study. The report makes use of two approaches to the definition of innovation. The first is the standard OECD approach used for the quantification of certain innovation-related expenditures. The second is the 'product system' approach, which places the individual firm within the broader context of both inter-firm flows of products, personnel and knowledge, and an institutional framework for the generation and diffusion of knowledge. VET systems form a central part of this institutional framework. This chapter also summarises the key results of Australian innovation surveys and describes the method for identifying innovation-intensive industries. This methodology entails the construction of a composite index of innovation, using a variety of official data. A clear hierarchy of 'innovation intensity' across industries emerges from the analysis. The results of the composite index and the product-system approach are used to identify the eight case studies and to structure the analysis in these case studies.

Chapter 3 summarises the key international literature on the links between innovation and VET. A very broad range of literature and data are drawn upon, including 'matched plants' studies; the relation between trade patterns and training; studies of the diversity of international VET systems and important Australian data on the role of production and technical staff in innovation. This literature identifies a number of well-defined mechanisms linking innovation and VET. Depending on the nature of these linkages—self-reinforcing virtuous or vicious cycles of economic growth or decline—a 'low or high skill equilibrium' will be created.

Chapter 4 provides a detailed description and quantitative analysis of the differences in VET occupational structures and training activity across innovation and non-innovation-intensive industries.

Chapter 5 complements the literature review and quantitative analysis by providing the key results of the eight case studies of innovation-intensive firms. These case studies employed the product-system approach by analysing the firms' innovation and training activity within a broader context of inter-firm flows of products, personnel and knowledge and the institutional frameworks for the generation and diffusion of knowledge, including the VET system. The case studies demonstrate the complex linkages between innovation and training, and between firms and the VET system. While these linkages are complex and differentiated, a pattern of interaction between innovative firms and the VET system emerged. A typology was developed which provided a description of these linkages and the structural bases for the distinct patterns.

The final chapter summarises the results of the study in terms of the key research questions and draws out the policy implications for the provision of VET in innovation-intensive industries.

Chapter 2: Identifying innovation-intensive industries

Definition of vocational education

Given that VET occupations, VET qualifications and VET training systems are a focus of this study, the following definition of VET occupations and the VET systems is employed in this report. VET occupations are defined as Australian Standard Classification of Occupations (ASCO) major group 3, associate professionals, to major group 9, labourers and related workers. VET qualifications are defined as Australian Qualifications Framework (AQF) levels I–IV/V. The VET training system is defined as all providers, excluding universities, both public and private, who provide vocational training to the occupations defined above. These providers include non-conventional providers such as equipment manufactures and suppliers. The term 'VET skills' is used throughout the report and denotes the range of tasks and competencies acquired by VET occupations as a result of both formal training and on-the-job learning.

Two approaches to innovation

In this study two complementary approaches to the definition of innovation are used. The first of these approaches is the OECD (1997) definition of innovation, which is used for official data collections of expenditure on innovation activities. The second is the product-system approach.

The OECD approach

The OECD approach generates data used for quantifying expenditures on innovative activities such as research and development (R&D), and for comparing inter-industry and international differences in the level and intensity of such expenditures. This approach is used in this study to identify innovation-intensive and non-innovation-intensive industries. In turn, this is used to compare and contrast the occupational structure of innovation and non-innovation industries and to assist in the selection of firms and industries for the case studies.

For the purposes of official data collection within the OECD, including the ABS surveys, innovation is defined as:

> Implemented technologically new products and processes and significant technological improvements in products and processes. An innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). Innovations therefore involve a series of scientific, technological, organisational, financial and commercial activities. An innovating business is one that has implemented technologically new or significantly technologically improved products or processes during the period under review. (OECD 1997, p.47)

More specifically, product and process innovation is quantified by surveying expenditures and comprises the following activities:

- design
- research and development

- acquisition of technology internally within the business or externally through acquisitions patents, technology licenses and trademarks
- acquisition of new technology embodied in machinery and equipment
- tooling-up and industrial engineering
- manufacturing start-up and pre-production development
- workforce and management training
- marketing of new products.

Research and development is thus a sub-set of innovatory activity, although research and development is also the subject of separate official surveys across the OECD. Research and development is defined as:

> 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. (OECD 1994)

Official surveys of innovation and research and development have been conducted in Australia. These permit the broad identification of innovation-intensive industries. These surveys and other related indicators have identified a distinct hierarchy of industries in terms of:

- their relative contribution to total national expenditure on innovation
- differences across industries in the proportion of firms undertaking innovation
- inter-industry differences in the intensity of the innovation effort through measures such as research and development expenditures as a share of industry value-added.

This hierarchy is employed in the composite index used to identify innovation-intensive industries.

The product-system approach

There are, however, several limitations to the conventional OECD quantitative approach to the definition of innovation. To address these limitations, a second and complementary approach to the analysis of innovation is used in this report. This is the product-system approach.

The limitations to the conventional OECD definition are several. First, research and development expenditures undertaken by an industry are implicitly assumed to relate to or benefit that industry. For example, an industry, such as construction, may be identified as being comparatively un-innovative because it has low expenditures on research and development. This could give a misleading view, as the bulk of construction-related research and development is undertaken within other industries, such as manufacturing and universities.[2] The construction industry spends only about 10% of the total private business expenditure on construction-related research and development. Around 75% of the private construction-related research and development investment is undertaken by manufacturing industry, specifically, building products and supplies (structural and fabricated metal products and non-metallic mineral products), with another 10% undertaken by manufacturers of tools, fasteners and machinery and equipment (Toner 1999a). A similar situation holds for agriculture, where the bulk of the research and development is undertaken by government (the Commonwealth Scientific and Industrial research Organisation [CSIRO] and state departments of agriculture), and to a lesser extent by manufacturing (pesticides

[2] For the purpose of ABS R&D surveys, the R&D undertaken by an industry does not necessarily have to be funded by that industry. In most cases the share funded by external industries is small, generally not exceeding 15% of expenditures. The exception is the sub-division, scientific research, which is part of property and business services, where up to 40% of its R&D is funded by other industries and organisations (ABS 2000, table 3).

and fertilisers etc.). The effect of this is to understate the level of innovation-related expenditures directed towards these industries.[3]

Secondly, the industrial classification often obscures the nature of the activities undertaken within an industry and its constituent firms.[4] In reality, many firms undertake a diversity of economic activities and produce a variety of products and services encompassing numerous 'industrial' activities. However, the classification system requires that these firms be allocated unambiguously to only one industry. A recent study by the Australian Expert Group in Industry Studies found that 75% of firms classified to manufacturing provide a variety of services related to the products they manufacture. These services include design, customisation, installation, maintenance, training, retailing and wholesaling, transport, finance, insurance, waste management and even disposal of equipment and goods sold to purchasers. Not surprisingly, some of these firms regarded themselves as primarily service companies (Australian Expert Group in Industry Studies and Australian Business Foundation 2001).

The third difficulty with the conventional classification is that it does not capture the dynamic aspects of the innovation process, especially in regard to inter-industry and inter-firm flows of knowledge. This is particularly the case for so-called 'dis-embodied' knowledge (not incorporated into equipment or products), such as innovation in engineering techniques. In addition, the narrow focus of the conventional approach to 'technological innovation' (defined as product and technical process innovation) does not capture changes to work organisation and management practices. In many instances these changes either facilitate technological innovation or induce the uptake or development of new technologies. For example, Kersley and Martin (1997) identified the positive effect on productivity of the introduction of formal feedback mechanisms, such as quality circles. These arrangements permitted improved communication between production workers and management. International and inter-firm differences in work organisation and training systems have, for example, been identified as a major element in explaining international and inter-firm differences in productivity and the level and rate of technological innovation. (This is the subject of chapter 4.)

Finally, the conventional approach does not capture the 'drivers' of innovation—what is stimulating the firm or industry to devote resources to innovation. For example, it has been found that a major driver, or stimulus, for innovation in the food processing and textile, clothing and footwear (TCF) industries is large retailers. The retailers' requirements in the case of food, for instance, for extended shelf life and ease of use by consumers, necessitated food processing firms within manufacturing to undertake extensive product and process innovation (Senker 1988; Australian Expert Group in Industry Studies 1999a, Australian Expert Group in Industry Studies & Australian Business Foundation 2001). More generally, this failure to capture the dynamic aspects of innovation arise from the inability of the industrial classification system to capture inter-firm and inter-industry relations, such as those demonstrated by the now extensive literature on 'clusters' and 'networks'.[5]

These limitations are addressed to a large degree by the 'product system' approach. This approach emphasises the dynamic aspects of innovation by locating individual firms and industries within a wider system, through mapping linkages in terms of flows of goods, services and knowledge

---

3 Offsetting this problem to some extent is that inter-industry flows of innovations 'embodied' in capital goods can be measured. Thus the flow of innovations from an industry developing an innovation to other 'user' industries can be captured in this instance. This is taken up in more detail in the discussion of the composite index used to identify innovation-intensive industries.

4 Within conventional industrial classifications, such as the Australian and New Zealand Standard Industrial Classification (ANZSIC) a firm is classified to one of 17 industries 'on the basis of its predominate activities' (ABS 1993, p.2). Where a firm undertakes a variety of activities, the 'predominate activity' could be a small proportion of its total sales or value-added.

5 A good summary of clustering is provided in the *Cambridge Journal of Economics*, vol.23, no.2, 1999.

between firms and industries, and identifying clusters of firms and industries formed by these linkages. It seeks to identify the drivers of innovation.

The level of analysis is that of a total chain of production and consumption, rather than the traditional notion of a 'firm' or 'industry'. The drivers of innovation include, for example:

- demands by users of the firms' output for changes to this output, such as the introduction of new products and services
- competitive strategies of other firms
- innovation by suppliers of capital and intermediate goods, permitting the users of these goods to introduce quality improvements and new products
- the regulatory framework, such as environmental and foreign trade laws
- available collective infrastructure, such as public and private training institutions which are a key to the diffusion of new technical knowledge and innovation.[6]

This product-system approach was crucial to the design of the eight case studies. This approach provides a broader perspective to position the individual case study firms within inter-industry and inter-firm linkages and clusters, and to identify the drivers of innovation within the firm. In turn, this enabled the researchers to position the analysis of the VET workforce, VET training system and training needs of the firms in a broader context.

Key results of Australian innovation surveys

This section provides a brief description and analysis of the key findings of surveys of innovation in Australian industries. These surveys are based on the conventional OECD definition of innovation, as outlined above. The purpose of this section is to provide background material on the components of expenditure on innovation, which, in turn, will be used to construct the composite index of innovation. Secondly, the section will identify a number of key characteristics of innovation-intensive firms. These 'stylised facts' will be used, along with the composite index, to identify innovation-intensive industries and firms for detailed analysis of VET occupations and to assist in the selection of firms for the eight case studies.

It should be noted from the beginning that there are significant limitations in terms of the currency, scope and industry coverage of official innovation surveys in Australia. The only economy-wide survey covering all industries was conducted in 1994. The survey only examined the proportion of firms in each industry undertaking innovation and did not separately identify or quantify expenditure on the components of innovation activity. The other surveys of innovation, conducted in 1996–97, are limited to manufacturing and mining industries. Nevertheless, the surveys, supplemented with other official data, provide sufficient information to describe the pattern of innovation expenditures across Australia and to assist in the construction of the composite index. Given the increased policy focus on innovation, the ABS intends to conduct another innovation survey over the period 2003–2004 and subsequently, every two years. The scope of the survey will be selected 'market sector' industries.

Propensity and intensity of innovation

There are large inter-industry differences in the propensity to undertake innovation. (Propensity is the proportion of firms in an industry undertaking innovation.) The first official survey of innovation in Australia (ABS 1995) indicated that manufacturing industry has, by a large margin, the largest proportion of firms undertaking technological innovation activities. Manufacturing,

---

[6] The product-system approach has been used by AEGIS to examine innovation in the toolmaking, building and construction, TC&F and medical devices industries (Australian Expert Group in Industry Studies 1999a, 1999b).

according to that survey, has 2.8 times the proportion of firms investing in such activity compared with the average of all other industries. After manufacturing, the industries with significantly above-average shares of firms undertaking innovation include communication services (1.8) and wholesale trade (1.7). Industries such as construction (0.7) are significantly below average (ABS 1995, table 1, 1997a, table 1). Other data, however, indicate that the mining industry has an even higher proportion of firms undertaking innovation than does manufacturing (ABS 1997b).

These results and other data, such as research and development and capital equipment expenditure, to be detailed below, demonstrate the dominance of the manufacturing industry's contribution to innovation expenditures in Australia. The central role of manufacturing in innovation expenditures is an OECD-wide phenomenon (Department of Industry, Science and Technology 1996).

There are also significant intra-industry differences across manufacturing sub-divisions in innovation intensity (table 1). These sectors with significantly above-average shares of firms undertaking innovation include: petroleum, coal and chemicals; machinery and equipment; food, beverages and tobacco; and non-metallic mineral products. Two sub-divisions are significantly below average. These include textiles, clothing and footwear, and wood and paper products.

In addition to data on the propensity to undertake innovation, data are also available on the relative intensity of industries' innovation expenditures and the relative contribution of different industries to total innovation expenditures. (The intensity of innovation expenditures is the expenditure of an industry on innovation as a proportion of that industry's value-added). Table 2 shows the contribution of manufacturing sectors to total innovation expenditures and the relative innovation intensity of these industries. Just over two-thirds of total expenditure on innovation in manufacturing is accounted for by just three sectors, machinery and equipment (38%), petroleum, coal and chemicals (16.2) and food, beverages and tobacco (15%). Two of these sectors also have above-average innovation intensity as measured by the ratio of a sector's innovation expenditures to its value-added. For all manufacturing sectors this ratio is 5.9%. The innovation intensity of machinery and equipment is 12.4% and for petroleum it is 6.7%. Food, beverages and tobacco, while it is below the manufacturing industry average, has the fourth highest level of innovation intensity of any manufacturing sector. These three sectors therefore are notable both for their absolute contribution to the manufacturing industry's total innovation expenditure and the intensity of their innovation expenditures.

Table 1: Innovation in Australian manufacturing, ranked by proportion of firms

Manufacturing sub-division	Proportion of firms undertaking technological innovation (%)	Ratio of firms undertaking technological innovation to total
Petroleum, coal and chemicals	42.1	1.6
Food, beverages and tobacco	36.3	1.4
Non-metallic mineral products	35.5	1.4
Machinery and equipment	35.3	1.4
Printing, publishing and recorded media	25.6	1.0
Wood and paper products	15.7	0.6
Metal products	21.1	0.8
Other manufacturing	20.9	0.8
Textiles, clothing and footwear	15.4	0.6
Total manufacturing	**26.0**	**1.0**

Source: Derived from ABS (1997a)

Table 2: Contribution of sub-industries to innovation expenditures in Australian manufacturing, ranked by industry's share of total innovation expenditures, 1996–97

Manufacturing sub-division	Expenditure on innovation activity ($m)	Industry's expenditure as % of total	Expenditure on innovation activity as % of industry value-added
Machinery and equipment	1498.0	38.0	12.4
Petroleum, coal and chemicals	636.7	16.2	6.7
Food, beverages and tobacco	588.8	14.9	4.7
Metal products	400.0	10.1	3.4
Printing, publishing and recorded media	250.9	6.4	3.8
Wood and paper products	243.7	6.2	5.2
Non-metallic mineral products	143.9	3.7	3.2
Textiles, clothing and footwear	109.3	2.8	3.5
Other manufacturing	69.6	1.8	2.7
Total manufacturing	**3940.9**	**100.0**	**5.9**

Source: Derived from ABS (1997a, 1997c)

Components of innovation expenditure

In 1996–97, manufacturing industry spent $3.9 billion on technological innovation. Table 3 shows that expenditure on innovation is comprised largely of two components. Research and development is the largest component of innovation expenditures, accounting for 50% of the total, with investment in new equipment and associated engineering expenditures representing 29%. Training related to the introduction of innovation accounts for 3.5% of total expenditures. These three components comprise 83% of the total.[7]

These three components are of considerable importance as they are the only components of innovation expenditure for which current economy-wide data are available. Given that these three components comprise the bulk of innovation expenditures, and that economy-wide data are readily available for these components, they have been selected as the key data sources for the construction of the composite index of innovation.

Table 3: Components of innovation expenditures, manufacturing industry, Australia

Type of innovative activity	Per cent of total
Research and development	50.36
Tooling-up, industrial engineering and start-up	28.92
Marketing of new or improved products	10.68
Acquisition of technology developed by other (patents, trademarks etc.)	4.41
Training related to introduction of innovation	3.50
Other	2.13
Total	**100.00**

Source: Derived from ABS (1997a)

Empirical support for the use of these three components is also to be found in the analysis of the structure of innovation expenditures in other industries. The ABS undertook a survey of innovation in the mining industry covering the same time period as for manufacturing (July 1994 to June 1997). While it had the same conceptual framework as the manufacturing survey, there were differences in terms of the elements of innovation expenditure for which data were sought.

[7] While there is some variation across the sub-industries in terms of the share of the various components of expenditure on innovation, the combination of R&D and new equipment expenditures are the dominant activities for all manufacturing industries.

Specifically, the mining industry survey included expenditures on mine development and exploration. By excluding these expenditures, the elements of innovation expenditure for the manufacturing and mining industries can be compared. On this basis, expenditure by the mining industry on research and development, new plant and equipment and training comprised 81% of total mining industry innovation expenditure (ABS 1997b). This provides further confirmation for the use of these three components in the composite index of innovation.

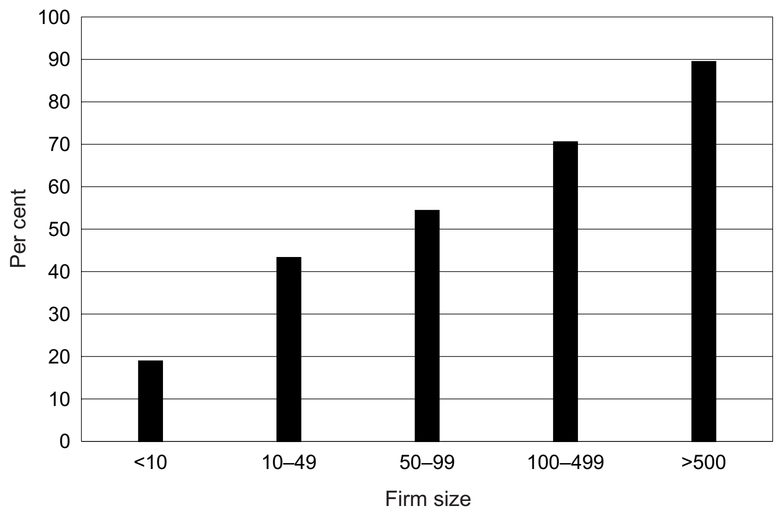
Manufacturing firms spent $138 million on training related to the introduction of innovation, but this accounted for just 3.5% of total innovation expenditures. While training is a small component of total innovation expenditures for manufacturing, these expenditures comprise a large share of total structured training expenditures within manufacturing industry.[8] Expenditure on training related to the introduction of innovation represented 21% of total training expenditures within manufacturing over the 1996–97 period. Mining spent $96 million on training related to the introduction of innovation in 1996–97 and this represented 37% of total structured training expenditures within the mining industry.

Innovation and firm size

Finally, an important empirical regularity regarding innovation is the strong positive association between increasing firm size and the propensity to undertake innovation and the disproportionate contribution of larger firms to total innovation expenditures. This stylised fact will be of considerable importance regarding the selection of the eight firms for the case studies.

Figure 1 demonstrates the almost linear relationship between increase in firm size (as measured by the number of employees) and increased propensity to undertake innovation. Just under one in five manufacturing firms with fewer than ten employees invested in innovation, compared to nearly all firms with more than 500 employees.

Figure 1: Firms undertaking innovative activity by size, percentages, 1996–97



Source: ABS (1997a, table 2)

8 The ABS surveyed training expenditures for all industries, including manufacturing, over July to September quarter 1996 (ABS 1996). Extrapolating the quarterly expenditure over the financial year 1996–97 results in total annual training expenditures by manufacturing of $646 m. The data relate to expenditure on structured training, defined as 'training activities which have a pre-determined format designed to develop employment related skill and competencies' (p.45). Training data collected for the innovation surveys did not specify whether the training was to be structured or informal on-the-job training. However, advice from the ABS section which undertook the mining and manufacturing surveys indicates that firms reporting training expenditures would have relied largely on business accounting data which only record the type of expenses associated with structured training. The principal expenses include external training consultants, hire of venues and labour costs of workers undergoing training.

Table 4 indicates that firms with 100 or more employees account for over two-thirds (66.3%) of total expenditure on innovation, while only 8% was undertaken by firms with fewer than 10 employees. This is despite the fact that manufacturing firms with more than 100 employees account for only 3.5% of all manufacturing firms (Industry Commission/Department of Industry, Science and Technology 1997, table 3.13). Other data also indicate that the intensity of innovation (as measured by the level of innovation expenditures per employee) is significantly higher for larger firms (ABS 1997a, table 12).

Table 4: Percentage of total expenditure on innovative activity in manufacturing industry by firm size

Firm employment size	<10	10–49	50–99	100–499	>500	Total
Percentage of total expenditure	7.9	16.4	9.4	21.2	45.1	100.0

Source: ABS (1997a, table 12)

The disproportionate share of technological innovation undertaken by large firms is explained by a number of factors. These include firstly, the level of risk associated with product and process innovation, which entails either the pursuit of new knowledge or the application to novel ends of an existing stock of knowledge. By their nature, the probability of success of such investments and the time period for their development, commercialisation and marketing cannot be calculated with any certainty (Solow 1956). Large firms, with large capital resources, operating in diverse product markets, are more readily able to accept and manage such risks. Secondly, there are considerable costs associated with the protection of innovations, through establishing patents and copyright and the potential defence of such intellectual property through the courts. Thirdly, compared with small single-product firms, larger multi-product firms have a wider scope for the application of product and process advances arising from innovation. Finally, there are considerable indivisibilities, or barriers to entry, to investment in innovation. Innovation in many fields of industry, such as aerospace, computers, electronics, telecommunications, biotechnology, pharmaceuticals and motor vehicles, requires large research staff and sophisticated laboratories, which are beyond the scale of smaller firms. Firms with large sales are more readily able to spread the high fixed costs associated with innovation.[9]

Identification of innovative industries

As noted earlier, there are data limitations in terms of the currency, scope and industry coverage of Australian innovation surveys. However, there are also regularly published data available on a disaggregated industry basis of the principal elements of innovation expenditure. These data are for expenditures on research and development, capital investment in new plant and equipment and structured training. Data on other components of innovation expenditure are not collected or are not available on a disaggregated industry basis. It has been demonstrated earlier that these three elements are the principal components of innovation expenditures, accounting for over 80% of total innovation expenditures. These data are used for the construction of the composite index of innovation.

This approach to the construction of the index and, in particular, to the use of these components of innovation has strong support in the literature on the measurement of innovation. For example, after reviewing the various empirical approaches to the measurement of innovation and 'knowledge', Smith argues that:

> There is a strong case for not focussing simply on research and development when we consider expenditure by firms and industries on innovation and knowledge creation … also a

[9] Indeed, there is considerable evidence that the costs of R&D are increasing in real terms at a rapid rate. This is one of the main drivers of the increase in inter-firm strategic alliances and mergers between large multinationals over the last two decades (Department of Industry, Science and Technology 1990).

> need to look into the significance of other sources of knowledge. It seems particularly important to look at capital investment, which represents a very significant component of innovation expenditure. It is also important to note that capital expenditure is a key mode of 'embodied' knowledge spillover from the capital goods sector to using industries.
>
> (Smith 2000, p.17)

New plant and equipment and intermediate goods are a key transmission mechanism for the innovation and new productive knowledge, as these improvements are 'embodied' in newer vintages of capital goods. Not only do capital and intermediate goods producers benefit from their own and others' research and development expenditures, they also embody incremental improvements in their goods as a result of experience in the production of these goods.

This 'learning by doing' is primarily the result of 'innumerable design improvements that result from the repeated application of particular engineering principles' (Kaldor 1972, p.1243). Work organisation and management practices are also important in either stimulating or retarding learning by doing.[10] There are also quality and productivity improvements in the capital goods sector arising from experience in the use of these goods in production. The purchasers of capital and intermediate goods provide regular feedback to the producers of these goods, communicating suggestions for design and other changes to improve the performance or reduce the cost of these goods. This is referred to as 'learning by using' or 'user-producer interaction' (Rosenberg 1982, pp.121–2; von Hippel 1988).[11]

It has also been found that there is an inverse relation between research and development expenditures and capital investment, such that 'firms that have relatively low R&D shares [as a proportion of their total innovation expenditures] have higher investment shares' (Smith 2000, p.14). The implication of this is that 'a low R&D industry may well be a major user of knowledge generated elsewhere' (Smith 2000, p.10).

Disembodied flows of knowledge and innovation are also crucial and entail 'knowledge translated through scientific and technical literature, consultancy, education systems, movements of personnel and so on' (Smith 2000, p.19). Training related to the introduction of innovations is clearly an important element in innovation as it is directed at diffusing new theoretical and practical knowledge to the workforce. In addition, the subsequent literature review of the link between training, innovation and firm performance will highlight a strong link between firm performance and the quality of vocational training and the broader institutional structure within which training is regulated, recognised and accredited.

Composite index of innovation

Data on research and development, capital investment in new plant and equipment and structured training have been used to construct a composite index of innovation (ABS 2000, 1996–2001, 2001c). These data are used to assist in identifying innovative industries, and in turn, firms within these industries for the case studies. A key feature of the index is the use of data which compare both the inter-industry level and intensity of innovation expenditures. The level of expenditures is

---

[10] The separation of 'conception' from 'execution', which is the basis for the Taylorist division of labour, has been argued to retard learning by doing as it explicitly separates production workers from involvement in product and process improvements. This pattern of work organisation is contrasted with that, for example, in large Japanese corporations (Cole 1992).

[11] A related example is the absence of learning by doing and learning by using, which can result from the contracting-out of maintenance activities. When maintenance activities are conducted in house, there is more likely to be the flow of information from maintenance crews to the firm's production manager on issues related to both preventative maintenance and adapting or modifying the equipment to reduce breakdowns and increase efficiency of the plant. Depending on the contractual arrangements between a firm and its maintenance contractors, sometimes a perverse incentive can be constructed limiting the flow of information from maintenance personnel to firm managers (Denniss & Toner 1999).

an industry's share of total expenditure on each of the three innovation expenditures. This quantifies inter-industry differences in the contribution to total national innovation expenditures. The intensity of innovation is defined as the ratio of an industry's expenditure on innovation to the industry's value-added or gross wages and salaries over the same period. The intensity of research and development and capital expenditure is defined as the ratio of these respective expenditures to the industry's value-added. The intensity of training expenditures is the ratio of an industry's training expenditures to the industry's wages and salaries. Given the year-to-year volatility in some innovation-related expenditures, notably research and development and capital investment, a three-year average of these data have been used.

The scope of the index is restricted to selected private sector industries, since limitations with the availability of data resulted in the exclusion of industries in the area of government administration and defence; education; accommodation, cafes and restaurants; and agriculture from the analysis. Data for these industries, where available, are included in the data tables and final composite index for comparative purposes, although not in figure 2 which only charts the industries for which full data are available.

The index cardinally ranks each industry for the level and intensity for each of the data items used to measure innovation expenditures. The industries with the highest contribution to national innovation expenditures and/or intensity for each of the data items are given the highest rank, with the other industries ranked in descending order. The sum of these rankings for each industry provides a single measure for inter-industry differences in the contribution to total national innovation expenditures and innovation intensity of industries. The lowest possible score that an industry could attain would be 7 (assuming the industry achieved the last rank on all components of the index). The results of the analysis have a high degree of 'face validity', as they accord with the broader literature on inter-industry differences in innovation.

It is interesting to note that, in general, an industry's ranking for their contribution to national innovation expenditures on an item is similar to its ranking for intensity of expenditure on the item.

The data used to construct the index are provided in tables 30–33 in appendix 1. The composite index is provided in table 5 and figure 2.

Key features of data

There are large inter-industry differences in the level of research and development expenditures or the contribution of industries to total research and development expenditure. These differences are a function of absolute size differences, as measured by industries' value-added, and variations in the inter-industry intensity of research and development expenditures. Manufacturing accounts for 51% of total expenditures; property and business services, 20%; mining, 10.5%; and wholesale trade, 8%. Within manufacturing, machinery and equipment manufacturing accounts for just over 25% of all research and development, with petroleum coal and chemicals and metal products accounting for 9% and 7%, respectively (table 30 in appendix 1).

The overall share of research and development to value-added in the economy is 0.85%. Industries which have a high level of research and development also have a high intensity of research and development. The intensity of research and development in manufacturing is 3%; mining, 1.5%; property and business services, 1.2%; and wholesale trade, 1%. Again within manufacturing, machinery and equipment manufacturing has a research and development intensity of just over 7%; petroleum coal and chemicals, 3.5%; and metal products, 2.6% (table 31 in appendix 1).

Manufacturing industry accounts for 16% of total new plant and equipment investment in the economy. In descending order, the other largest contributors are mining, 14%; communication services, 9%; property and business services, 8%; and electricity, gas water, 8% (table 32 in appendix 1).

For the economy as a whole, the investment rate—that is, new plant and equipment investment as a share of value-added—is 21%. Inter-industry differences in investment rates obviously reflect differences in the capital intensity of production processes. In general, the same industries which account for a disproportionate share of total investment also have the highest intensity of investment. The exceptions are manufacturing and property and business services which are below the economy-wide average, with an investment rate of 18% and 13%, respectively. In descending order, mining has an investment rate of 46%; electricity, gas and water, 40%; communication services, 38%; and cultural and recreational services, 35% (table 32 in appendix 1).

Manufacturing accounts for 14% of total expenditures on structured training expenditures. In descending order, the other largest contributors are property and business services, 9%; finance and insurance, 8%; retail, 6%; and mining, 5% (table 33 in appendix 1).

For all industries, expenditure on structured training as a percentage of total wages and salaries was 2.5%. The industries with the largest proportional expenditure on training as a share of their respective wages and salaries, in descending order, include: mining, 5.8%; electricity, gas and water, 4.5%; communication services, 3.2%; transport and storage, 2.6%; and property and business services, 2.5%. Manufacturing was marginally under the economy-wide average with 2.2%. However, within manufacturing, machinery and equipment, and petroleum, coal and chemicals were above the economy-wide average. The industries with the lowest training expenditures were construction, 1.3%; accommodation, cafes and restaurants, 1.3%; and retail trade, 1.9% (table 33 in appendix 1).

It is obvious from the above discussion of the data used to construct the index, and from table 5, that there is some variation in the relative ranking of an industry across the various data items. (The higher the index number, the higher the innovation ranking.) Nevertheless, a very clear hierarchy of innovation across industries has emerged. In addition to a clear hierarchy of industries, the industries are also clustered into three distinct groups. These groups are:

- *High-innovation industries:* mining; manufacturing; property and business services; and communication services
- *Medium-innovation industries:* electricity, gas and water; wholesale trade; finance and insurance; and transport and storage
- *Low-innovation industries:* personal services; retail trade; cultural and recreational services; health and community services and construction. (The ABS does not publish research and development data for the accommodation, cafes and restaurants industry because of the very low levels of such expenditure. The low ranking of the health and community services industry is problematic. In particular, a large section of the health industry is notable for innovation in terms of research and development, investment and training. However, this is obscured by its aggregation with the low-innovation community services industry).

Table 5: Composite Index of innovation—rankings of industries by measures of innovation

	Industry share of total R&D expenditure	R&D as % of industry value-added	Industry share of total CAPEX[1]	Investment rate[2]	Training as % of gross wages and salaries	% of total training expenditure	Total rank
Agriculture[3]			8	14			22
Mining	13	13	14	15	16	6	77
Manufacturing	15	15	15	8	7	16	76
EGW	7	7	10	13	15	3	55
Construction	9	9	2	3	1	4	28
Wholesale trade	12	12	7	4	6	9	50
Retail trade	5	5	6	2	3	10	31
Accommodation, cafes and restaurants[3]			3	9	2	2	16
Transport and storage	8	8	9	10	9	7	51
Communication	11	11	13	12	13	5	65
Finance and insurance	10	10	11	1	10	12	54
Property and business services	14	14	12	6	8	14	68
Government and defence[4]	2	2			12	11	27
Education[4]	1	1			11	15	28
Health and community services[2]	4	4	4	5	4	13	34
Cultural and recreational services	6	6	5	11	5	1	34
Personal services	3	3	1	7	14	8	36

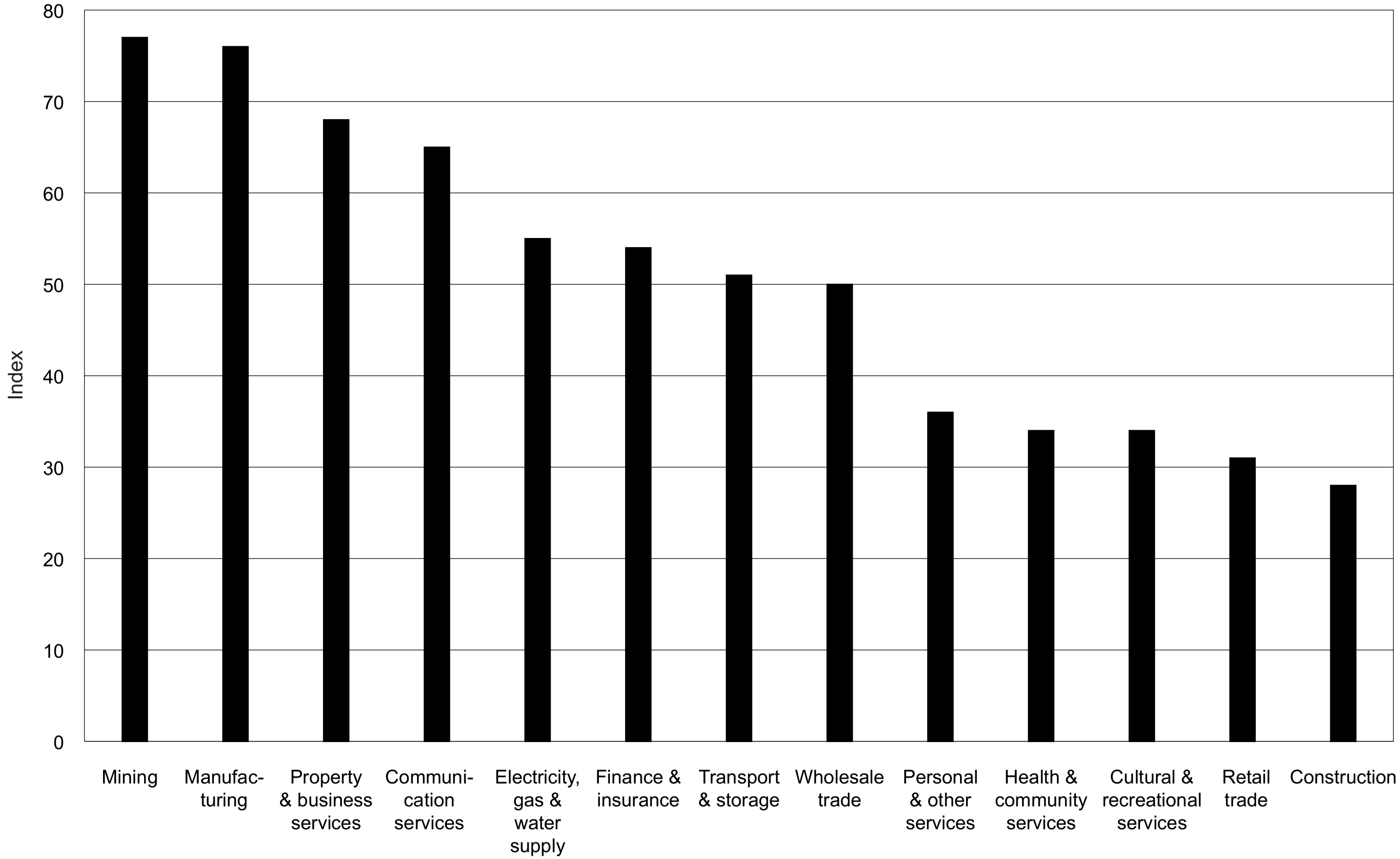
Notes: 1 CAPEX = capital expenditure

2 Investment rate is investment in plant and structures as a percentage of industry value-added.

3 No research and development data are collected for the industries, agriculture or accommodation, cafes and restaurants.

4 The data source used for CAPEX and investment rate did not include government administration and defence or education. This is in part due to the difficulty of deriving chain value or real price measures of output. In turn this reflects the difficulty of constructing independent measures of the quantity of both inputs and outputs for these industries.

Figure 2: Composite index of innovation, by industry



Note: The most innovative industry has the highest index score, with the least innovative industry having the largest index score. The lowest possible score that an industry could attain would be 7 (the industry achieving the lowest rank on all components of the index).

Conclusion—some 'stylised facts' about innovation in Australian industry

As indicated earlier, the purpose of constructing the index of industry innovation was to develop a robust methodology for differentiating innovation-intensive industries from non-innovation-intensive industries. These results are a primary means for identifying the industries and firms to be subject to detailed occupational analysis and case study within this project. (This method will be complemented by the product-system approach to innovation to enable a more comprehensive study of the causes and effects of innovation on vocational training, and the occupational structure of the selected industries and firms.) On the basis of the above analysis, a number of key characteristics or 'stylised facts' regarding innovation in Australia emerge.[12]

Key characteristics

- A clear hierarchy in terms of the innovation intensity of different industries is discernible, with mining, manufacturing, property and business services and communication services identified as the most innovation-intensive industries, by a large margin. The fact that this group comprises the most traditional goods-producing industries, as well as two service industries is of great interest. It reveals that the more popular notions of what constitutes technologically dynamic and knowledge-based industries require considerable adjustment. Within manufacturing, machinery and equipment, metal products and petroleum, coal and chemicals are the most innovation-intensive sectors.
- Given the data used to construct the composite index and the results of the index itself, there is a very large margin between innovation-intensive and non-innovation-intensive industries in terms of their respective contributions to total innovation-related expenditures and the intensity of these expenditures.
- There are other features, aside from the 'industry' variable, which are significant in identifying innovation-intensive industries and firms. These are firstly, the strong positive association between increasing firm size and the propensity to undertake innovation; secondly, the disproportionate contribution of larger firms to total innovation expenditures; and, finally, the greater intensity of such expenditures by larger firms. As explained earlier, there are sound economic reasons for this strong association between increasing firm size and increased innovation propensity and between contribution to total innovation expenditures and intensity of such expenditures. These relate to the risk of innovation investments, the costs of protecting intellectual property rights and indivisibilities in undertaking innovation. Accordingly, the firm size variable, in addition to the industry variable, should be an important consideration in the selection of firms for subsequent case studies.

[12] The notion of 'stylised facts' is derived from Kaldor's analysis of the essential difference between social reality and the natural world. In the former case, 'it is impossible to distinguish facts that are precise and at the same time suggestive and intriguing in their implications, and that admit of no exception' (Kaldor 1985, pp.8–9). Research should proceed inductively, to identify 'empirical regularities' which are, however, historically contingent, changing over time with transformations in the economic system. It is not necessarily the goal of economics to develop a grand unified theory accounting for all empirical regularities; 'separate theories may be required for each stylized fact' (Kaldor 1985, p.8).

Chapter 3: Links between VET and innovation

The interaction between work organisation and technology, encompassing issues such as authority and hierarchy within workplaces and the allocation of skills and tasks across occupations, has a long history in political economy. Adam Smith placed the cumulative relation between growth in the size of the market and increase in both the division of labour and capital intensive production methods at the analytical centre of his *Wealth of nations* (1776). Similarly, in *Capital* (1867) Marx charted the rise of the capitalist mode of production, with its evolving forms of work organisation and technology. Braverman's *Labour and monopoly capital* (1974) re-ignited interest in this field of research and spawned a vast literature on the 'labour process'. Importantly, however, Braverman's major thesis regarding the general tendency towards 'de-skilling' of blue-and-white-collar production operations has not been supported. Taken as a whole, the labour process literature suggests that:

> De-skilling is certainly not a universal phenomenon and … in so far as it has been implemented, it has been counter-productive in that in the longer term it may have reduced the flexibility of labour and weakened the effectiveness of firms. (Gospel 1991, p.3)

Notwithstanding this tradition of debate as to trends in skilling and de-skilling, it is the case that VET and links between VET and innovation have not received the scholarly attention they deserve. Gospel (1991) lamented that this was due to deficiencies across a number of social science disciplines.

> Economists have long been interested in technological change … However, they have tended to view the innovation process in a rather mechanistic fashion … [regarding the process of technical change within the firm as a] black box … Economic historians have long pointed to weaknesses in education and training in Britain and how they may have retarded economic growth. However … [they] have often neglected the study of training systems … business historians have usually only touched on training in their chapters on management and technical staff … Labour historians have usually only dealt with apprenticeship systems and how these have underpinned the activities of craft unions. The study of training has often been left to historians of education who have been primarily interested in schooling and formal education rather than industrial training. (Gospel 1992, pp.2–3)

Over the succeeding decade the lack of scholarly attention remains. Nevertheless, the international literature on the relationship between VET and innovation does reveal that VET skills play a key role in improving productivity, product and process innovation and in the creation and diffusion of new knowledge throughout a national economy. Skilled production, trade and technician occupations are essential for the generation, design, installation, adaptation and maintenance of new technologies.

The literature demonstrates the key role of production, trade and technician-level occupations in the generation of new ideas and in the all-important incremental improvement in the efficiency of production processes and product improvement (Koike 1988). In almost all fields of production of goods and services, the repetition of production tasks leads to a gradual improvement in the efficiency of production processes and product design and performance. The importance of such 'learning by doing' processes has long been recognised, as has the central place of direct production workers in innovation as sources of work-based learning (Landes 1972). These occupations and skills are also critical in what is known as learning by using or, more broadly, user-producer interaction. This form of learning entails the flow of information from the users of products or services to the producers of these products and services (Rosenberg 1982, pp.121–2).[13] The key role of production, trade, technician and lower management occupations in innovation applies not only to goods-producing industries, such as manufacturing, but also to construction, mining and electricity, gas and water, and to services such as wholesale, banking, and health provision.

In the following, the links between VET and innovation are analysed by drawing on a broad literature encompassing:

- 'matched plants' studies. These are international studies of similar firms to determine the effect of vocational training on firm performance. Criticisms of these matched plants studies are also detailed and assessed
- studies of the links between countries' international trade performance and differences in the respective countries' vocational training systems
- a brief summary of the factors leading to diversity in national vocational skill systems. This literature emphasises the integration of VET systems in national historical, cultural and economic differences, and the lack of transferability of such VET systems across countries
- a brief summary of Australian data on VET and innovation. This also includes a brief account of the adverse effect on the VET system of certain interrelated public policy initiatives, changes to the structure of the labour market (such as increased part-time and casual employment) and corporate strategies (such as increased contracting-out). It is claimed that these changes reduce the capacity of the VET system to maintain domestic supply of key VET skills.

High- and low-skill equilibrium

In an influential article a decade and a half ago, Finegold and Soskice (1988) produced two key arguments on the relationship between VET skills, innovation and economic development. The first was that, for a number of reasons, higher-level skills are becoming increasingly important in explaining differences in countries' capacity for innovation and economic performance. The importance of higher-level skills derives from the increased share of countries' production that is exported, the large scale shift of lower-skilled mass production commodities to developing countries and the shift towards more skill-intensive products in world trade, in which quality, reliability, timeliness of supply, and customisation are increasingly important.[14] These are products which 'require a well-qualified workforce capable of rapid adjustment in the work process and continual product innovation' (Finegold & Soskice 1988, p.21). Secondly, they raised the prospect of a set of self-reinforcing economic and institutional forces within countries, leading them into either a vicious circle of economic decline, 'trapped in a low-skills equilibrium', or a virtuous circle of 'high skill' growth and innovation.

Taking the example of Britain, they argued that:

> … there is a two way relationship between ET [Employment and Training policy] and the economy … Britain's failure to educate and train its workforce to the same levels as its international competitors has been both a product and a cause of the nation's poor relative

[13] Learning by doing and using are the result of the accumulation of knowledge generated in the production process. As noted earlier, the success of this accumulation depends critically on the type of work organisation employed in production, especially the capacity of management to actively promote information feedback from production workers and networks with which the firm has linkages. It also depends on the willingness of management to act on this information.

[14] Over the period 1970 to 1995 the share of agricultural and raw materials in world merchandise trade declined from 36.5% to 22.2%. The share of manufactures increased from 64.5% to 77.8%. This increase in manufactures was accounted for by 'science-based' manufactures, which increased from 9.5% to 21.5% (Guerrieri 1999, p.141). Science-based manufactures include, for example, computers, telecommunications equipment, motor vehicle engines, aircraft, electric power machinery, and pharmaceuticals (Guerrieri 1999, p.156).

> economic performance; a product, because the ET system evolved to meet the needs of [a] … large, mass-production manufacturing sector [which] required only a small number of skilled workers … and a cause, because the absence of a well educated and trained workforce has made it difficult for industry to respond to new economic conditions.
> (Finegold & Soskice 1988, p.22)

As a result of this vicious circle, Britain is:

> … trapped in a low-skills equilibrium, in which the majority of enterprises are staffed by poorly trained managers and workers [who] produce low-quality goods and services. The term 'equilibrium' is used to connote a self-reinforcing network of societal and state institutions which interact to stifle demand for improvements in skill levels. This set of political-economic institutions … includes: the organisation of industry, firms and the work process, the industrial relations system, financial markets, the state and political structure, as well as the operation of the ET system'. (Finegold & Soskice 1988, p.22)

One of the key implications of this analysis of the low-skills equilibrium is that skills are identified as a necessary, but not sufficient, condition for innovation and high economic performance.

Since the publication of this article, subsequent literature on VET, innovation and firm and national economic performance generally supports these key arguments.[15] This literature is the subject of this chapter.

Matched plants studies

Matched plants studies seek to account for differences in firm performance across countries by treating such differences as a dependent variable, and differences in training systems and skill levels as an independent variable. The object of the studies is to attempt to control for, or make comparable, a range of variables such as the type and quality of firms' output, production methods and equipment, so that the independent variable is limited to factors such as skills, training and internal work organisation. Over the 1980s and early 1990s a comprehensive program of matched plants studies was undertaken by the National Institute of Economic and Social Research (NIESR) in the United Kingdom. The matched plants were in Britain and several European nations. These studies are summarised in Prais (1995) and Mason, Van Ark and Wagner (1996).

Within the high-income OECD nations there are very large differences in skill formation systems and in the proportions of the working population with different levels of vocational and general educational qualifications. 'It has now become entirely clear that inter-country differences in the proportions of the workforce trained to various levels of vocational competence are very substantial indeed' (Prais 1995, p.15).

Table 6 shows the proportion and type of formal workforce qualifications across several OECD countries included in the matched plants studies. Data for Australia are also included for comparative purposes. The key differences are that close to two-thirds of the British workforce have no vocational qualifications. The Netherlands, Germany and Switzerland have a much smaller share of unqualified persons in their workforce. Only 25% of the British workforce have vocational

[15] Some 11 years after the Finegold and Soskice article, one of the authors of the report maintained the validity of the original analysis, although questioning the 'idea of stability implied by the idea of "equilibrium"'. In the low-skill case 'the onset of intensified competition from low-cost producers in the NICs [newly industrialised countries] would render … this equilibrium highly vulnerable to challenge'. There are also 'grounds for doubting the stability of even high skill equilibria'. This is due to the rise of neo-liberalism and the weakening of institutions which seek to provide collective goods, such as the multi-employer coordination required for the maintenance of an apprenticeship system. There are also challenges to continued high-level investment in VET skills associated with the rapid rise of a 'contingent workforce'; increased self-employment and reduction in firm size associated with corporate down-sizing (Crouch, Finegold & Sako 1999, p.22). These issues are discussed in more detail later in the chapter.

qualifications. Most of the other European countries have more than double this proportion with vocational qualifications in their respective workforces. These differences in the distribution of qualifications, especially the proportion having vocational qualifications and/or no qualifications, are argued to be influential in determining international differences in firm performance, including the capacity for product and process innovation.

Table 6: Qualifications of the workforce—selected countries, percentages

Level of qualification	UK	Netherlands	Germany	France	Switzerland	Australia
University degree	11	8	11	7	11	15
Vocational	25	57	63	40	66	34
Technician/diploma	7	19	7	7	9	9*
Craft/lower technical diploma	18	38	56	33	57	25
No vocational	64	35	26	53	23	46
Total	**100**	**100**	**100**	**100**	**100**	**100**

Note: * Includes non-technical qualifications
Source: Prais (1995, p.41) and ABS (2001a)

The National Institute's matched plants consisted of samples from metalworking, woodworking, clothing and food manufacture, and also included a service industry, hotels. A total of 160 workplaces were visited: 70 in Britain, 60 in Germany and 30 in other European countries, mostly France and Holland. The selection of workplaces and products was based on a 'choice of plants producing similar and characteristic products in each country. [This] was necessary to facilitate cross-country comparability; relatively simple products were chosen so that process, skills and throughput could more readily be compared' (Prais 1995, p.44).

Firm size was controlled by excluding the largest and smallest firm size quartiles from the sample. This was to control for the variety of scale economies arising from increases in the volume of production (Toner 1999b, pp.9–14). The typical plant in the sample had 50–300 employees (Prais 1995, p.50). Differences in firm performance were assessed by defining the workplace output as physical output over a given time period and the labour input was defined as the number of worker hours directly and indirectly employed in the sequence of operations required for the output.

The results of the comparison are given in table 7. These results are consistent with productivity differences based on manufacturing census data across the countries. It is clear that there are very substantial productivity differences between Britain and other European nations in the production of relatively simple products and services.

Table 7: Summary of the National Institute of Economic and Social Research matched plants results

Products used in firm comparisons	Productivity differential between Britain and Germany (%)	Productivity differential between Britain and Holland (%)
Engineering (drills, springs, motor vehicle components)	63	36
Woodworking (fitted kitchens)	60	
Clothing (women's skirts, jackets, suits)	100	
Food manufacturing (biscuits)	45	35
Hotels (middle range large city hotels)	51	

Source: Derived from Prais (1995, ch.3)

In addition to productivity differences, the study also found large quality differences in the commodities produced. For example, German clothing and kitchen cabinet products were of much higher quality in terms of the complexity of the individual operations required in their manufacture and the degree of customisation of the products. In turn, this reflects the use of 'flexible specialisation' production methods in Germany and the adoption of mass production techniques among the British plants surveyed. By definition, mass production demands both the standardisation of the product and simplification of individual production operations through the division of labour. The machinery used for mass production is typically dedicated and specialised, in that it is designed to efficiently perform a limited range of operations over a large volume of output. Work in progress passes along a production line in which each stage of the processing or transforming of the product is undertaken by a dedicated machine with its attendant specialised workers. For example, in clothing manufacture, the British plants had a typical production run of 15 000 for a particular garment, whereas the typical production run for the German plants was 150–300. Similarly, the British kitchen cabinet plants produced a standardised product in a ready to assemble 'flatpack' for the do-it-yourself market. By contrast, the German kitchen cabinet makers produced cabinets made to the specifications of each customer.

> 'Flexible specialisation' is a production technique based on the use of programmable machinery, commonly referred to as computer numerically controlled (CNC). The 'objective' of flexible specialisation 'is to produce a greater range of specialised variants to meet the needs of individual customers … and to do so with modern machinery on which small batches of variants do not incur heavy surcharges. (Prais 1995, p.73)

Surcharges arise from the set-up costs entailed in changing the configuration of inflexible specialised machinery, such as that designed for mass production techniques.

These differences in production techniques and quality of output were attributed primarily to differences in workforce skills. In Germany:

> … the more highly skilled labour force not only enables companies to produce small batch sizes of customised products but also to switch easily to new processes thereby *promoting product and process innovation and economic growth* … In Britain, complexity in the average production process tends to be avoided and preference is given to mass-produced products for which a mainly semi-skilled workforce is sufficient … products are mainly sold in competition with those from low-wage countries. (Wagner 1991, p.146, emphasis added)

Reasons for productivity/innovation differences

The study identified a number of skill and training-related contributors to the large differentials in productivity and scope for product and process innovation across the case study plants.

Defect rates

A significantly higher defect and re-work rate in British plants across all product types led to lower physical output, and hence lower productivity. The lower defect rate was the result of building quality assurance into German production processes. This contrasts with the quality control methods based on the rectification of faults in products at the end of the production line in the British plants. In turn, these differences arise from the employment of more highly skilled and trained production and maintenance persons in German plants and the operation of machinery allowing for more automated control of production processes and closer tolerances of work.

Ratio of direct to indirect labour

The second factor behind higher productivity in Germany and other European countries was a much lower ratio of indirect to direct labour. The higher ratio of indirect labour, such as foremen, supervisors and clerical support, was partly a function of the higher defect rate necessitating more quality checkers. The employment of more semi-skilled persons in British plants operating within a Taylorist work organisation, in which individual production employees acted with little autonomy, necessitated layers of supervisors and management to monitor production and directly manage the introduction of new products and processes. To take an example from the clothing industry:

> When putting a new style into production, an average 2–3 days 'running in' to reach full operating speed was required by German machinists, whereas the average British machinist required several weeks to reach full production speed. In that 'running in' period German machinists were able to work directly from technical sketches, with only occasional need for advice from their supervisor … while in British plants very few machinists could work directly from technical sketches, and required supervisors to physically demonstrate new operations. British plants understandably opted for the production of longer runs—with fewer changeovers—and for less elaborately stitched products: even so, two and a half times as many checkers ('passers') and supervisors were required per machinist in British than in continental clothing plants. (Prais 1995, p.69)

Utilisation rate of machinery

The British firms had a far lower rate of plant capacity utilisation as a result of machinery breakdown, compared with all of the European plants visited. This was despite the fact that the average age of equipment in the plants visited was younger in Britain (Prais 1995, p.64). The down-time due to machinery breakdown was in excess of 100% greater in Britain than in the European plants visited. The much higher plant breakdown accounts for a large share of the productivity differences between British and European plants in the sample.

The higher rate of plant breakdown was attributed to inadequate plant maintenance in the British plants, and more specifically, to inadequate preventative maintenance programmes (Prais 1995, pp.61, 71). The much higher rate of plant breakdown and inadequacy of preventative maintenance are, in turn, 'attributable to … differences in the skill levels of maintenance teams—though inadequate technical skills at intermediate management level must bear a share of the blame' (Prais 1995, p.71). For example, in Britain most maintenance personnel had completed 'a time-served apprenticeship' without taking external examinations (Prais 1995, p.69). In Europe formal examinations and qualifications to craft level are usually the minimum for members of maintenance teams, with almost all maintenance foreman having technician or *Meister* level qualifications.[16] Among higher-level technical support staff concerned with production planning, quality control and research and development, 80% of such persons in Dutch plants had technician or higher-level qualifications compared with 45% in the British case studies (Prais 1995, p.70).

Flexible specialisation and skills

It was noted earlier how the German plants had, in general, adopted innovative flexible specialisation techniques, which allowed for both the customisation of products and the more rapid introduction of new products. The latter is also commonly referred to as reduced 'cycle times' for the introduction of product innovations; that is, products incorporating new designs, features and components.

The use of flexible specialisation is argued to be critically dependent on the availability of high-level production and maintenance staff. In turn, this dependence is due to two key features of flexible specialisation. Firstly, there is use of programmable production equipment, generically referred to as computer numerically controlled machines. It was found that, among the case study plants, German firms had 50% more computer numerically controlled machines than their equivalent British plants (Prais 1995, p.64). Secondly, it entails the automation of production processes through, for example, automatic loading and transfer devices, where the product is passed via machines from one stage of processing to another. In the case of British mass production methods there was an absence of such automation, with the use of semi-skilled employees to feed work into

[16] The closest equivalent in Australia to the German *Meister* is the post-trade certificate, associate diploma or diploma. For example, toolmakers and certain classes of electrician obtain these post-trade certificates. Whereas post-trade certificates are technically oriented, *Meister* qualifications include training in management and supervision. The management function of the *Meisters*, performing middle management functions in the German plants accounts, in part, for the lower indirect labour ratio in these plants.

stand-alone machines and manually transfer components to different stages of production. The automation of production, however, also increases the complexity of machine operation and maintenance, as 'the probabilities of failure cumulate if machines are linked'. British plants adopted a less risky production technique of mass production with stand-alone machines (Prais 1995, p.62). The much lower penetration of computer numerically controlled machines and automation of loading and work-in-progress transfer devices are attributed to a lower level of both production and maintenance skills in Britain.

Role of workforce skills and training

The importance of the National Institute of Economic and Social Research matched plants study for the issue of vocational skills and innovation is that it demonstrated the circular and cumulative interaction between the development of higher-level production, maintenance and technician skills; the use of more complex and productive equipment; and the growth of productivity, quality and scope for product and process innovation. This interaction is summarised as follows:

> Decisions as to the variety and types of products to be made thus affect the type of machinery installed and the ancillary feeding and automating mechanisms; that *joint complex of decisions*—that is, affecting both products and equipment—is related to supplies of skills.
>
> (Prais 1995, p.65, emphasis added)

Subsequent studies employing the match plants methods support the findings of the National Institute of Economic and Social Research, although the conclusions are somewhat more nuanced (Crouch, Finegold & Sako 1999, pp.79–84).

Criticisms of matched plants studies

Cutler (1992) criticised these studies relating differences in firm performance in Britain and Europe to differences in the level and distribution of vocational skills and skill formation systems. In a wide-ranging critique he argued that there are problems in the comparability of national systems of education and training, especially in establishing the technical equivalence of the different national qualifications. Secondly, he argued the studies gave insufficient attention to inadequacies in higher management in British plants and international differences in work organisation methods.[17] Thirdly, differences in the type and quality of machinery were inadequately controlled for as an explanation of productivity and quality difference. Finally, the National Institute for Economic and Social Research gave insufficient attention to the broader economic policy context within which individual firms operate. Cutler did not elaborate on this point. Presumably what he had in mind are the large differences in national industrial policies across the matched plants sample. These are state policies directed at influencing the national industrial structure in terms of the type and proportion of industries in the overall economy and the competitiveness of individual firms and clusters of firms. National industry policies directed at fostering more competitive and innovative products and production processes directly affect the level of, and demand for, vocational skills. It has been argued that, in Britain, there was long-standing government policy indifference to manufacturing industry, compared to the strong national, state and local government support for manufacturing in Germany and other European nations. This has been argued by Keep and Mayhew (1999) to be a crucial factor in the relative performance of British and European

[17] There is a considerable literature on the problems of British higher management, as it developed over the nineteenth and early twentieth centuries. These problems include the overwhelming predominance of liberal education graduates and absence of technical and business graduates (with the exception of accounting). This led to the rise of 'generalist' managers and poor integration of technology strategies within the firm's overall business strategy. There were, of course, exceptions to this generalisation, with companies such as Shell, ICI and Vickers, establishing large-scale internal management training and integrating engineering and scientific personnel within their higher level management structure (Gospel & Okayama 1991).

manufacturing firms. Eatwell (1982) provides an excellent background to the development of British industry policy.

There is a substantial literature on the impact of work organisation patterns on productivity and quality. Studies such as Black and Lynch (1997) and Kerlsey and Martin (1997) highlight the role of work organisation which fosters the ready flow of ideas on product and process improvement from production and technical staff to management, as important to improved firm performance. Summarising this literature Maglen and Hopkins conclude that:

> Workers need to be comfortable with initiating ideas and contributions, and the environment needed to be one that encouraged rather than demanded active participation. The studies complement and support the National Institute findings by emphasising that setting affects skills expression, interpersonal and technological. (Maglen & Hopkins 1998, p.27)

There is undoubtedly merit in Cutler's critique. For example, the National Institute for Economic and Social Research's own evidence shows there were marked differences in the type of machinery and ancillary devices across the matched plants. These differences include a much lower penetration of computer numerically controlled equipment and automated loading and transfer devices in British plants. This clearly violates the researchers' assumption that differences in production machinery had, in some way, been controlled for in comparing the matched plants.

Nevertheless, the National Institute for Economic and Social Research studies remain crucially important in explaining, at least in part, the very large differences in productivity, quality and scope for product and process innovation across the case study plants. For instance, the National Institute for Economic and Social Research is surely correct in arguing that key contributors to the differences in machinery, production techniques (flexible specialisation in German plants as against mass production in British plants) and scope for product and process innovation, are comparatively lower-level production and maintenance skills in British plants. This is not to say that other factors, such as the skills and corporate strategy of higher management, work organisation and broader industry policies are unimportant; rather, it is to argue that VET skills are an essential element in the joint complex of decisions affecting the innovation performance of firms.

Trade patterns and training

A related approach to examining the relation between innovation and vocational skills has been to examine cross-country differences in trade performance and national differences in the composition of workforce skills. Comparative studies have found that a major 'factor in national systems of innovation is the skill profile of the workforce' (Pavitt & Patel 1999, p.103). Of particular interest are international differences in the level and distribution of production, trade and technician skills and qualifications. The demonstrated differences in 'education attainment' give rise to 'marked differences in productivity and product quality' (Pavitt & Patel 1999, p.103). For example, the higher proportion of 'skilled production workers and technicians' in Germany and Japan, in part, explains the respective countries' importance in world trade in higher value-added manufactures with particular 'strengths in automobiles, machinery and production engineering' (Pavitt & Patel 1999, p.104). These are products for which the basis of international competition is quality, reliability, innovation in product design and features, reduced cycle times for innovation, and through-life support for the product.

A recent major study confirmed the existence of a strong relationship between international differences across high-income OECD countries in the composition of skills and the patterns of trade. The study compared the long-run rate of growth, from 1976 to 1994, in exports of three types of manufacture (low-, intermediate- and high-skill products) across a number of high-income OECD countries and for the world as a whole. It was found that both Germany and Japan had a significantly higher growth rate of exports of intermediate-skill products (defined as engines, machine tools, metal machine tools and non-electric machines, and power-generating equipment) than for the world as a whole, and over 60% faster than for Britain and the United States. The situation was reversed, however, for high-skill products (defined as organic and inorganic chemicals, pharmaceuticals, office equipment—including computers, dyes/paints and petroleum/gas products). In this case Germany was below the average growth in world trade, with the United States substantially above the world average. The United Kingdom was only marginally above the world average growth. Finally, for low-skill products (defined as meat, rubber, rubber products, leather and textiles), most of the high-income countries were substantially below the average growth in world trade. This is due largely to intense competition from developing countries in these products. The United States, however, was only marginally below the world average growth rate in low-skill products (Crouch, Finegold & Sako 1999, pp.103–5). The study also noted that both the United Kingdom and the United States export a much smaller proportion of their manufacturing output than other advanced countries and that both countries run consistent trade deficits in manufactures (Crouch, Finegold & Sako 1999, p.107).

These trade patterns were argued to reflect differences in the national composition of skills and skill formation systems. Both Germany and Japan have particular strengths in production, trade and technician-level training. Both countries 'provide broad-ranging, company-based training for particularly high proportions of their workforce' (Crouch, Finegold & Sako 1999, p.106). By contrast, the United States and the United Kingdom have comparatively poor intermediate or vocational training systems, although world-class tertiary educational systems, notably in science and technology fields. This is reflected in both countries' above-average performance in high-skill intensive exports. This has led both countries to 'strong performance in some highly skilled sectors', but their overall, trade and industrial structure is 'bifurcated between high and low-skill activities' (Crouch, Finegold & Sako 1999, p.215). The export volume of these high-skill products from the United States and the United Kingdom is small by comparison with their imports of intermediate-level products. Consequently, both countries run substantial merchandise trade deficits.

Another study focused solely on the long-run trade performance of Germany and the United Kingdom. Using data on the skill structure of the United Kingdom and Germany in export industries, the study found that:

> The skill level of UK workers in manufacturing were found to be substantially lower than those of German workers. At the higher intermediate and lower intermediate levels, Germany has proportionally twice as many qualified people as the UK. The UK has twice the level of workers with no qualifications … Evidence was found that the skills gap does influence export performance [specifically] the UK's skill deficiencies influence the volume of her exports.
> (Oulton 1996, pp.224–5)

The volume of German exports is around four times that of United Kingdom-manufactured exports (Oulton 1996, p.211). The rate of growth of German exports also greatly exceeded that of the United Kingdom. The link between skills and export performance was made by examining the level and distribution of qualifications for the respective workforces which were producing the exported commodities. It was found that:

> The larger the proportion with no qualifications in the UK relative to … Germany, then the poorer is the UK's export performance … the UK's export performance is better in industries where the gap in lower intermediate skills is least. Furthermore, these effects of skill gaps are not only statistically significant, but also economically significant, in the sense that closing the gaps would lead (other things being equal) to a substantial rise in UK relative to German exports. (Oulton 1996, pp.225–6)

Another major factor driving these differences in trade patterns is investment decisions of multinational corporations. Differences in vocational skill levels affect the location of investments by multinational corporations. Thus:

> Britain has gained a disproportionate share of Japanese plants manufacturing electronic goods requiring primarily semi-skilled workers; Germany has attracted Japanese operations in a

> more dispersed range of industries, including rubber and plastics, chemicals, and machinery. Britain's advantages seem to be in relatively low-cost, semi-skilled labour, and Germany's in those sectors where skilled and more expensive labour was required. The sources of cost-advantage are therefore different. (Crouch, Finegold & Sako 1999, p.82)

This analysis is relevant to Australia in that the country has a VET skills structure of its workforce which is approximately mid-way between that of European nations which have a highly developed VET skills formation system and that of the United Kingdom (table 6). Compared with Britain, Australia has a higher share of its workforce with either a vocational or craft qualification and a lower share with no qualifications. Compared with the European nations, Australia has been a relatively low investor in technical skills (Marceau, Manley & Sicklen 1997, pp.8.1–8.21). The linkages between skills and export success in higher value-added manufactures would also appear to hold for Australia, in that Australia also runs growing trade deficits in skill and innovation-intensive manufactures. The deficit in what are termed 'elaborately transformed manufactures', such as motor vehicles and machinery, is equivalent to over 10% of Australia's gross domestic product (Toner 2000).

Diversity in national VET systems

The literature on comparative international VET systems has a number of important findings relevant to the study of the links between VET and innovation. First, there is a diversity of national vocational training systems, which largely reflects the integration of these training systems within the specific historical and political–economic characteristics of individual nations. This integration means that national vocational training systems are not readily transferable across nations.

Second, different national training systems, such as those in Japan and Germany, are equally compatible with strong economic performance and innovation. Given the integration of national training systems and the fact that no one model of skill formation has been identified as the single optimal approach for facilitating innovation and growth, there are limits on the extent to which countries should attempt to emulate different training systems (Campbell 1991, p.165). For example, both the German and Japanese systems have been argued to be models which other countries should emulate, in part or in whole.

However, these countries have very different skill formation systems and supporting institutional systems, with the German system reliant on a highly regulated apprenticeship system, in which state and national laws govern the content and duration of training and the testing and accreditation of apprentices. It is also a system involving a high level of employer and employee coordination and cooperation in the training. The state also plays a major role in the provision of off-the-job vocational training through a variety of technical institutes and colleges. The accreditation of training in Germany applies to a set of discrete skills or widely recognised occupations, which are embodied in the industrial relations system and the pattern of work organisation. A combination a number of features in Germany—a key role for off-the-job training in VET institutions, an external accreditation system, and the existence of discrete VET occupations—has given rise to what is referred to as an 'occupational' labour market for key elements of the German VET workforce. Within this labour market structure there is a moderate degree of labour mobility of skilled staff between firms. The existence of widely recognised 'occupations' comprising a discrete set of skills accredited to a known standard facilitates labour mobility, since prospective employers can have some confidence in the 'quality' of the labour power they are purchasing.[18]

Interestingly, Australia is also argued to have an occupational labour market, especially in regard to its craft-based jobs (Curtain 1987; Gospel 1994a). Over the last decade or two there have been a number of changes, such as declining union density in many 'blue collar' industries, the

---

[18] Estevez-Abe, Iversen and Soskice (2001) provide a comprehensive analysis of the different institutional foundations of different skill formation systems in the United States/United Kingdom, Germany and Japan.

decentralisation of the industrial relations system, the growth of multi-skilling and traineeships, which have reduced the strength of this occupational labour market. Nevertheless, it is arguable that 'traditional' trades remain an 'occupational' labour market. There are a number of continuing institutional supports for this labour market. These include the mandating in some states, such as New South Wales, that entry-level training for trade-based occupations occur within an apprenticeship system and the state licensing system governs entry into certain trade occupations such as electrician, plumbing and some classes of welding.

In contrast to the 'occupational' labour market, the Japanese system, especially within the larger firms, is argued to have an 'internal' labour market (Dore 1973). Within the 'internal' labour market of large corporations, training is much more firm-specific and multiskilled than in the German system. These differences reflect the much lower level of labour turnover within large Japanese corporations, creating an incentive for Japanese firms to invest heavily in their employees, and an acceptance on the part of workers in large Japanese firms of training that is more biased towards firm-specific skills. Multiskilling and a high level of functional flexibility (or comparatively low level of occupational demarcations) are encouraged by the linking of pay to experience and time served with the firm rather than current production tasks undertaken. In addition, the premium placed by larger Japanese corporations on job security has been argued to significantly reduce resistance to the introduction of potentially job-reducing new technologies (Cole 1992, pp.196–200). Another essential feature of the Japanese VET skill formation system is the high degree of cooperation, especially in technology transfer, including skills training, between larger firms and their sub-contractors and across sub-contractors (Sako 1996).[19]

It must be understood, however, that under certain particular circumstances, innovation and high productivity have been achieved without the development of large-scale, high-quality vocational training for production and craft-level occupations. For example, in the United States in the nineteenth century, the combination of rapid economic growth and skilled labour shortages stimulated the development of capital-intensive mass production methods. 'US firms led the way in substituting machinery for craftsmen and in dividing traditional craft jobs into simpler constituent tasks that could be reassigned to less skilled workers' (Elbaum 1991, p.208).

In turn, this reinforced the comparatively poor development of the apprenticeship system, craft skills and production workers:

> Starting with relatively unskilled labour in the early part of this century, Taylorist or Fordist production strategies placed an emphasis on the achievement of very high levels of productivity based on the application of capital equipment, work organisation, and skilful managerial control, rather than front-line worker skills.
>
> (Crouch, Finegold & Sako 1999, p.206)

The failure of the apprenticeship system to thrive in the United States is also attributed to certain cultural mores, such as a strong predilection for *laissez-faire* amongst firms in this country and consequently, a resistance to collective employer action or cooperation. 'Within the US context, firms were unable to establish collective, market-wide standards regulating employment and training in the skilled trades. Without such standards, apprenticeship withered' (Elbaum 1991, p.208).

The weakness of trade unions in the United States was also a key factor in the retardation of the apprenticeship system. Craft-based unions strongly supported the apprenticeship system 'because it helped maintain skill and wage standards of the trade by preserving a role within the division of

[19] Over the latter 1990s there have, of course, been changes to supporting features of the Japanese internal labour market, such as the decline of lifetime employment and time-served based pay scales. There have also been significant moves away from informal on-the-job training towards increased use of external private training providers and formal testing and accreditation of workers receiving this training. These moves were due to the introduction of more sophisticated production technology and the need to develop both practical and theoretical production-related skills (Curtain 1994).

labour for the fully trained craftsman' (Elbaum 1991, p.209). In only a few industries, such as construction, was this support effective.

Two more recent features 'of the US business environment' have been identified, which are argued to produce 'a relative neglect of investment in human capital' (Crouch, Finegold & Sako 1999, p.208). These include 'a peculiarly high rate of labour turnover [which] discourages the retention necessary to give firms the incentive to regard employees as long-term investments, and therefore to invest in the creation of transferable skills'. The comparatively high turnover rates in the United States are attributed to a management strategy designed to reduce the size of a firm's core workforce and increase the firm's reliance on a contingent or contract workforce (Crouch, Finegold & Sako 1999, p.209). The consequence of this business strategy of focusing on core activities and contracting out 'non-core' functions is a huge increase in part-time, often low paid and casual employment. Not only do low-paid contingent workers receive little, if any, training from their employers, they also find it difficult to invest in their own training. (This aspect of corporate strategy in the United States is examined in detail in Harrison 1997.)

Secondly, United States capital markets are argued to shorten the investment timeframe for companies and discourage long-term investment in the skills of their workforce (Crouch, Finegold & Sako 1999, p.210). This line of analysis is supported by Michael Porter (1992). [20]

Australian data on VET and innovation

The following summarises the key results from a number of Australian surveys and studies on the linkages between innovation, VET and training. This includes both important data from the ABS on the significance of VET occupations as sources of innovation within firms, and econometric studies on the relation between training and innovation within firms.

In the introduction to this chapter it was noted that the literature on VET and innovation has traditionally identified a key role for production, trade and technical occupations in the development and diffusion of technical innovations. The links between VET and innovation can be both direct and indirect. These findings are confirmed by the data in tables 8 and 9.

Table 8: Sources of technological innovation within firms undertaking innovation—manufacturing, Australia, 1996–97

Sources	Initial idea %	Throughout the project %	Technical information %
Management	79.4	66.7	34.1
Production staff	23.4	44.4	19.3
Technical staff	17.8	31.4	22.1
R&D staff	12.1	16.2	11.0
Marketing staff	26.7	22.6	10.9

Source ABS (1997a, table 6)

[20] The skills formation system of the US results in 'strong performance in a number of particularly high-skilled sectors; a far less impressive average performance; and an extremely wide distribution, with a substantial group of the population with low skill levels'. On the other hand, the US 'has less need to be concerned over the failure of a system … to produce a skill-maximising strategy for the whole nation than smaller countries' (Crouch, Finegold & Sako 1999, p.211). This is due to the much lower share of US output that is exported (with industries subject therefore to less competitive pressures); its dominant super-power status which means it can effectively run 'permanent trade deficits' and 'a highly individualistic culture that does not seem to require the same kind of social cohesion of many European societies, or in some respects, Japan (Crouch, Finegold & Sako 1999, p.212).

Table 9: Sources of technological innovation within firms undertaking innovation—mining, Australia, 1996–97

Sources	Initial idea	Throughout the project	Technical information
Management	57.6	65.2	33.3
Production staff	21.0	68.8	23.6
Technical staff	27.8	57.4	40.3
R&D staff	15.5	19.6	20.2
Marketing staff	12.1	10.9	10.3

Source: ABS (1997b, table 3)

For manufacturing, 23% of firms identified production staff as a source of initial ideas on technical innovation. This is higher than for both research and development and technical staff. Once introduction of the innovation had commenced, the importance of production staff as sources of innovation increased dramatically. More generally, over 19% of firms identified production staff as sources of technical information and advice. A similar picture for the key role of production staff holds for the mining industry (table 9).

There have been several Australian studies of the links between training, innovation and workplace performance. Laplagne and Bensted (1999), for example, used data from the 1990 and 1995 Australian Workplace Industrial Relations Surveys (AWIRS) to study the linkages between these variables. Like many other studies which try to quantify the effect of training on workplace innovation and productivity and rely on discrete rather than continuous data, the study suffers from 'simultaneity bias'. This is because all three variables (training, innovation and workplace performance) are likely to interact through a type of 'feedback loop', so that it is almost impossible to separate dependent and independent variables (Laplagne & Bensted 1999, p.34). Controlling for a broad range of variables, such as industry and firm size, it was found that 'training and innovation are likely to occur in workplaces experiencing strong labour productivity growth'. Secondly:

> Labour productivity growth appears to be enhanced by the joint introduction of training and innovation. This is due to the fact that training requires the support of innovation to benefit labour productivity growth. Conversely, introducing innovation in isolation is sufficient to promote labour productivity growth, although its returns are increased by the addition of training. (Laplagne & Bensted 1999, p.46)

Rogers (2000) used data from the ABS to investigate the association between a range of explanatory variables, such as firm size, foreign ownership, market concentration and 'training intensity'. (Training intensity is defined as expenditures on formal training per equivalent full-time employee.) The probit regression results indicated that for both manufacturing and non-manufacturing firms, training intensity was not significantly associated with the propensity of firms to undertake innovation (Rogers 2000, pp.19, 21). The failure to find a statistical association between innovation and training intensity was attributed to the discrete nature of the data collected (all data related to only a single time period). 'Obviously, a single observation of training intensity is likely to be a poor proxy for the stock of human capital' (Rogers 2000, p.22). It was also surmised that:

> High training expenses could be caused by high labour turnover, or rapid employment growth, or the introduction of new equipment or systems that require training. In these cases high training intensity reflects the particular circumstances of the firm and is not an indicator of the quality of human capital. (Rogers 2000, p.22)

The failure by Rogers to find any statistical association also reflects the limitations of econometrics as a method of inquiry, in that the 'models' used by Rogers are 'possibly too simplistic and fail to do justice to the complex nature of innovation' (Rogers 2000, p.23).

Reduction in domestic VET training rates

Given that the international literature has found positive links between VET and innovation, it is important to note the trend in Australia of sustained reduction in both the absolute number of persons commencing training in many traditional VET occupations and the reduced training rate for these trade occupations. (The training rate is the ratio of the flow of persons in training for a particular occupation to the stock of persons employed in that occupation.) On the other hand, there has been a rapid and sustained increase in traineeships, although the rate of increase is much slower in trade-based occupations (Toner 2003). In particular, considerable concern has been expressed over the last decade about the decline in apprenticeship commencements in occupations such as metals and engineering, motor vehicles, electrical and construction, which traditionally represent core trade-level skills (Marshman and Associates 1996; Australian Industry Group 1999). The issue of declining apprenticeship approvals is not isolated to Australia, but has been a feature of many countries having apprenticeship systems including Great Britain and, to a lesser extent, the United States. It has also been the subject of considerable international research (Ball 1988; Rainbird 1991; Gospel 1994a, 1994b; Gann & Senker 1998).

Over the period 1987–1992 to 1993–2001 the training rate for metal apprentices declined by 19% and that for electrical and electronic trades and hairdressing declined by 23% and 25%, respectively.

It is important to note that the decline in training rates and absolute level of apprentices does not reflect a proportionate reduction in demand in the economy for trade skills. It would be expected that a trend decline in the *stock* of employed tradespersons would be accompanied by a similar proportional decline in the *flow* of new entrants into the trade. This is not the case. The average total level of trades employment between 1987–92 and 1993–2001 fell by less than 1%, while the total number of apprentices in training fell by 15%. The percentage fall in the level of metal and vehicle apprentices in training was nearly three times the percentage decline in the number of metal and vehicle tradespersons employed. The number of electrical apprentices in training declined by nearly one-quarter but employment of electrical trades increased by nearly 1%. The average number of building trades declined by 9.3% over the period but employment of building tradespersons increased by 6%.

Reasons for decline

Corporatisation and privatisation of activities by all levels of government

Toner (1998) found that, as a result of corporatisation and privatisation of government enterprises over the 1990s, there has been a large-scale withdrawal of all levels of government from apprentice training. This withdrawal has resulted in declines of over 80% in annual government intake. In some fields, such as construction and electrical, government intake accounted for over 10% and 20% respectively, of total annual intake in these trades. This reduction in public sector training has not been compensated by a lift in private sector training. More recent studies of public and private intake in Victoria have confirmed the magnitude and causes of this decline (Australian Centre for Industrial Relations Research and Training 2002).

Growth of labour-hire companies

Many of the industries which were traditionally large employers of apprentices, such as manufacturing, construction, and electricity, gas and water are also disproportionately outsourcing production, maintenance and other services (ANTA 1998; Hall & Bretherton 2000; Construction Training Australia 1999). The significance of this outsourcing of trade-based work to labour-hire companies is that 'labour hire firms primarily rely upon the pool of skilled people in the labour market, and are not large providers of formalised training of the type involved in the traditional apprenticeship' (ANTA 1998, p.1). The growth of labour hire, in turn, reflects increased competition and the need to reduce costs. This increased competition is both a cause and effect of the 'lean production' corporate strategy. This strategy entails the 'downsizing' of firms with a smaller 'core' full-time workforce and the growth of a 'peripheral' workforce comprising labour-hire employees and other part-time or casual employees (Harrison 1997). The growth of the labour-hire industry, contracting-out and downsizing in the private and public sectors are, at least in the medium term, mutually self-reinforcing, in that reducing a firm's full-time core employment increases its demand for contract staff, and on the supply side, 'downsizing and outsourcing means there has been an increase in the number of skilled workers available to labour hire firms' (ANTA 1998, p.46). Growth of the contingent workforce is an international phenomenon. In the United States for example, the labour-hire company, Manpower, 'is now the largest single [private] employer, with over 500 000 people on its books' (Crouch, Finegold & Sako 1999, p.16).

Reduction in firm size

The reduction in average firm size due to downsizing and the outsourcing of work to smaller specialist firms is also directly linked to a reduction in investment in apprentice training. The significance in the growth of small firms and the reduction in the average size of firms in the economy is that both the propensity to train and the intensity of that training increases with firm size. 'It is well known that large firms are more likely to provide formal training, and this extends to apprenticeship training. There is also a positive correlation between firm size and the absolute number of apprentices employed' (Dockery, Koshy & Stromback 1996, p.14).

In a series of detailed studies of the construction industry Toner found marked reductions in average firm size over the last two decades and evidence that this was a major cause of sustained reductions in apprentice intake (2000b, 2000c, 2000d).

Growth of casual and part-time employment

Significant growth of 'non-standard' working conditions, such as rapid growth of part-time work, casualisation and multiple job holding, have also restrained employer investment in training (VandenHeuvel & Wooden 1999). In 1982, 13.3% of the workforce were casual employees; this increased to 26.4% in 1999 (Campbell 2000). The growth of casual and part-time employment is the outcome of industrial re-structuring which has seen the growth of service industries, such as accommodation, cafes and restaurants, and recreational services, which employ a low proportion of full-time staff. Secondly, it is the product of downsizing and outsourcing by large firms, who are adopting 'lean production' techniques and are increasingly reliant on a casual, part-time and contingent workforce (Harrison 1997; Australian Centre for Industrial Relations Research and Training 2002). The significance of these changes in employment status for training is that, even when one controls for a very wide range of personal, educational, demographic, occupational and industrial variables, casual employees are much less likely to have undertaken employer-provided training compared with full-time employees (VandenHeuvel & Wooden 1999, pp.27, 43–5). One consequence of these long-term changes in labour market status of employees is that 'the growth of non-standard work implies that there may be a serious training deficit emerging with respect to comprehensive trade and vocational training and more generalist training' (Hall & Bretherton 1999, p.1).

Conclusion

This review of quite diverse literature and data sources has demonstrated a number of key conclusions on the relationship between VET skills and innovation.

Firstly, the level of VET qualifications and the proportion of the workforce with these qualifications 'matter' in that they enhance the capacity of individual firms and the national economy as a whole to introduce product and process innovations and improve productivity and competitiveness. Skilled production, trade and technician occupations are not only essential in the direct production of most goods and services, they are also crucial in the *generation, design, installation*, *adaptation* and *maintenance* of new technologies.

The mechanisms whereby VET-related skills enhance the prospects for innovation within the firm are both manifold and well defined. They include the well-documented role of VET skills in learning by 'doing' and 'using', or the generation of incremental product and process improvements through direct involvement in production processes. The particular forms of work organisation within firms and the linkages across firms and clusters of firms are very important in either facilitating or retarding these cumulative learning processes.

Another crucial mechanism by which VET skills influence innovation is what Prais termed the 'joint complex of decisions' involved in firms' choices of skills, equipment, and products. Higher-level production, trade and technician skills permit a cumulative increase in the sophistication of capital equipment, the quality of output, and reduced 'cycle times' for the introduction of changes to products and related production processes. For example, higher-level production and maintenance skills are essential for the efficient operation of 'flexible specialisation' techniques and the associated electronic machinery and scope for product customisation. This circular and cumulative interaction between skills, equipment, and product and process innovation gives rise to the possibility of a 'high-skills equilibrium'. On the other hand, a 'low-skill equilibrium' can arise '[w]hen successful innovation requires highly trained workers [and] economies can get stuck in a vicious cycle in which firms do not innovate because the workforce is insufficiently skilled and workers do not train sufficiently because there is insufficient demand for them from the innovating firms' (Snower & Booth 1996, p.341).

Such equilibria are unlikely to be stable in the longer term. Continual adaptation of skills, work organisation and corporate strategy in the face of a changing competitive environment are required for the maintenance of a high-skill equilibrium. It is evident, for example, in the case of the newly industrialising economies of North Asia, that countries do have the opportunity to change direction, provided they have an appropriate institutional structure.

The second key conclusion is that improved skills are a necessary, but not sufficient condition, for product and process innovation. Wider facilitative industrial and innovation policies greatly influence firm productivity, quality of output and the industrial structure, and consequently, the derived demand for occupations and skills.

Thirdly, there are a number of important conclusions flowing from the diversity in national VET skill formation systems. This diversity relates for example, to the balance between on-the-job and off-the-job training; the role of the state in training provision and accreditation; and the extent of collective employer and employee action in supporting and managing the VET systems. These differences reflect the integration of training systems within other aspects of national cultures and political economies. The key conclusions from this diversity are that the social and economic embeddedness of VET systems leads to difficulties in transferring VET skill formation systems across countries. Researchers and policy-makers must therefore be mindful of facile recommendations for improving, say, the innovation performance of the Australian VET system, by merely emulating large elements of a foreign training system. In addition, even in countries like Japan in which firm-based, on-the-job training is such a central element in worker training, the literature demonstrates that it is essential to place the individual firm within the broader skill formation and innovation system. For example, in Japan there are highly developed inter-firm cooperative networks for the diffusion of new technologies through training. This broader perspective on skill formation within the firm is consistent with the product-system approach, which will be used to analyse the linkages between VET and innovation in the eight case studies for this report.

The fourth key finding is that different national training systems, such as those of Germany and Japan, are equally compatible with strong economic performance and innovation. Notwithstanding this diversity, these countries have particularly strong VET skill formation systems. It must also be acknowledged that a few countries which do not have well-developed intermediate or VET skills formation systems, such as the United States, are not disadvantaged in overall economic performance. For the United States this situation is the product of several unique features of its political economy. These include, for example, the superpower status of the United States permitting it to run large long-term current account deficits without currency devaluations, and the strength of the United States in higher-level, science-based products, which depend on the skills from its world-class scientific and technology institutes, as well as massive defence budgets (Crouch, Finegold & Sako 1999, p.212). It is fair to conclude that the international literature finds the United States 'the exception which proves the rule', in terms of the central role attributed to VET skills in innovation and national competitiveness.

Finally, there is a large Australian and overseas literature which argues that a broad range of changes to government policy and the structure of the economy and labour market are reducing the capacity of the Australian economy and the VET system to adequately reproduce the stock of trade-level skills. Given the overall conclusion that VET skills 'matter', this is an issue of some concern.

Chapter 4: Occupational structure and training in high and lower innovation-intensive industries

Introduction

The previous chapter introduced some of the key Australian data on the links between VET and innovation. From that analysis it is apparent that VET skills and VET occupations can make a critical contribution to process and product innovation. In order to further investigate the potential contribution of VET skills and VET occupations to innovation, it is necessary to identify the extent to which VET occupations, and thus VET skills, are represented in innovation-intensive industries (as defined in the analysis undertaken in chapter 2).

This chapter analyses the incidence of VET occupations in innovation-intensive industries and examines the training patterns characteristic of these industries as a means of clarifying the relationship between VET skills and innovation at the aggregate level. The first section analyses the incidence of VET occupations in innovation-intensive industries as at 1996—the time of the last Census of Population and Housing. The second section looks at developments since 1996, utilising unpublished ABS labour force data to consider whether there have been any changes in the distribution of VET occupations across industries since the last census. The third section briefly analyses the available data on patterns of training in innovation-intensive industries.

The following analysis explores this question through the use of classification frameworks for industry and occupations. The industry framework is based on the hierarchy of innovation-intensive industries defined in chapter 2 in terms of three clusters:

- *high-innovation industries:* mining; manufacturing; property and business services; and communication services
- *medium-innovation industries:* electricity, gas and water; wholesale trade; finance and insurance; and transport and storage
- *low-innovation industries:* personal services; retail trade; cultural and recreational services; health and community services; construction; and accommodation.

The occupational framework is based on the definition of VET occupations given in chapter 3. VET qualifications are defined as AQF levels I–IV/V. VET occupations are defined as Australian Standard Classification of Occupations (ASCO) major group 3, associate professionals, to major group 9, labourers and related workers. (VET occupations include all the classifications of occupations except professionals.) The occupational framework also uses a skill hierarchy as defined in the Australian Standard Classification of Occupations, which classifies the nine major group occupations into five skill levels. (Level I is the highest and level V is the lowest.) The skill levels are:

- managers and administrators and professionals
- associate professionals
- trades and advanced occupations
- intermediate occupations
- elementary occupations.

The data for this analysis comes from two sources. For the mid-1990s, the 1996 Census of Population and Housing provides the most reliable indication of employment levels and this is used in the next section, 'The situation in 1996', to present a detailed picture. Since they are based on a full enumeration, the census data are free from sampling errors, although non-sampling error is more common because the data collection is based on self-enumeration. This problem is evident in the use of the 'not further defined' (NFD) occupational category and the 'undefined' industry category which are common in the census data used for this report. These codes are employed by the ABS when insufficient detail is provided by the respondent to allow accurate coding to a more disaggregated level.

For the late 1990s through to 2001, ABS Labour Force Surveys for the month of August are used. While these surveys are less likely to suffer from non-sampling error because they are not based on self-completion, they are subject to sampling error. With the more disaggregated data, these errors can become quite large, so caution is required when tracking year-to-year changes. A reasonable approach is to avoid focusing on short-term changes and focus instead on patterns which appear to be consistent over time. The numerical difference between the two end points can also be assessed by reference to the tables of standard errors published by the ABS.

The situation in 1996

Overview

Nearly half of all employed persons work in low innovation intensity industries. Just under one-third work in high-innovation industries and the remainder, about one-fifth, work in medium innovation intensity industries (table 10). Within these industries there are some distinctive occupational clusters. The largest occupational grouping is found in the low-intensity industries and these tend to be at the lower end of the VET skills range. There are over 700 000 workers in the elementary VET category, followed by nearly 680 000 in the intermediate VET category. While managers and professionals also cluster in the low innovation intensity industries (about 570 000), they are also quite numerous in the high innovation intensity industries (over 510 000). The other significant occupational cluster is found amongst intermediate VET occupations in the medium innovation intensity industries (about 500 000 workers).

Looking more closely at the incidence of VET occupations within each industry group (table 11) we find that:

- While managers and professionals are the largest group within the high innovation intensity industries (nearly 27%), two VET occupational groupings are not far behind (trades and advanced workers at 22% and intermediate workers at 23%).
- Intermediate workers dominate the medium-intensity industries, accounting for nearly 45% of all workers; managers and professionals are a long way behind (19%) followed by trades and advanced workers (15%).
- There is a considerable spread of occupational groupings in the low innovation intensity industries, with the two lowest VET occupations each accounting for about 23% of workers, and two other groupings (managers and professionals; and trades and advanced) each accounting for about 19% of workers.

There is also an interesting pattern to the distribution of these occupations across each of the industry groupings (table 12). Managers and professionals are almost evenly split between the low innovation intensity industries and the high innovation intensity industries (44% and 40%, respectively). Associate professionals are overwhelmingly to be found in the low innovation intensity industries (58%). While trades and advanced workers are predominantly found in the low innovation intensity industries (50%), a significant proportion are in the high innovation intensity industries (36%). Intermediate workers are also more inclined to be found in low innovation intensity industries (42%), with the remainder roughly split between high and medium innovation intensity industries (27% and 31%, respectively). Finally, elementary workers are overwhelmingly clustered in low innovation intensity industries (61%), with another large cluster in the high innovation intensity industries (29%).

In summary, managers and professionals are somewhat over-represented in high innovation intensity industries. Intermediate workers are significantly over-represented in medium innovation intensity industries. Elementary workers are somewhat over-represented in low innovation intensity industries. The other two occupational groupings show no strong patterns in terms of their representation along industry lines.

Table 10: Occupation and industry totals, Australia 1996, population counts

VET occupations	Innovation intensity of industries			
	High	Medium	Low	Total
Managers and professionals	513 977	214 452	571 171	1 299 600
Associate professionals	193 010	129 522	438 412	760 944
Trades and advanced	428 102	169 420	597 973	1 195 495
Intermediate	441 966	497 120	677 122	1 616 208
Elementary	343 276	107 751	716 780	1 167 807
Total	**1 920 331**	**1 118 265**	**3 001 458**	**6 040 054**

Note: Table total is not equal to labour force total because the innovation intensity definition excludes agriculture, government administration and defence, and education.

Source: Unpublished data from 1996 Census of Population and Housing

Table 11: Distribution of VET occupations by industry intensity, Australia 1996

VET occupations	Innovation intensity of industries			
	High	Medium	Low	Total
Managers and professionals	26.8	19.2	19.0	21.5
Associate professionals	10.1	11.6	14.6	12.6
Trades and advanced	22.3	15.2	19.9	19.8
Intermediate	23.0	44.5	22.6	26.8
Elementary	17.9	9.6	23.9	19.3
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Unpublished data from 1996 Census of Population and Housing

Table 12: Distribution of industry intensity by VET occupation group, Australia 1996

VET occupations	Innovation intensity of industries			
	High	Medium	Low	Total
Managers and professionals	39.5	16.5	44.0	100.0
Associate professionals	25.4	17.0	57.6	100.0
Trades and advanced	35.8	14.2	50.0	100.0
Intermediate	27.4	30.8	41.9	100.0
Elementary	29.4	9.2	61.4	100.0
Total occupations	**31.8**	**18.5**	**49.7**	**100.0**

Source: Unpublished data from 1996 Census of Population and Housing

Innovation-intensive industries—a closer look at occupations

The VET occupational groupings are useful indicators of skill, and are thus a good pointer to how skills are distributed across the industry groupings. However, they are quite broad groupings and it is useful to move to a more disaggregated level of occupations (Australian Standard Classification of Occupations, sub-major groups, that I, 2-digit) in each of the industry groupings. Tables 13, 14 and 15 show the top 15 occupations in each of these industry groupings.

Turning first to high innovation intensity industries, the two largest groups are white-collar occupations: business and information professionals and intermediate clerical workers. Together they account for over 320 000 workers, or 17% of that industry grouping. These are followed by two large groupings of blue-collar workers: mechanical and fabrication engineering tradespersons and factory labourers. These two occupations account for over 220 000 workers, or about 12% of that industry grouping. The remaining occupations are a mixture of skills, ranging from specialist managers through to cleaners. It is worth noting that despite the label 'high innovation', the top occupations in this industry contain a considerable number of low-skilled workers, somewhere in the order of 330 000 workers.

Medium innovation-intensive industries are dominated by two large occupations: white-collar workers in the intermediate clerical category, and blue-collar workers in the road and rail transport occupation. The former account for nearly 20% of that industry grouping, and number over 215 000, while the latter account for nearly 12%, and number over 130 000. The next cluster of occupations tends to be business-related professionals and associate professionals. The remaining occupations contain a diverse mixture: specialist managers, various tradespersons, and sales workers in both the elementary and advanced categories.

Finally, in low innovation intensity industries we find the numerically largest group of workers, namely, elementary sales workers. These elementary sales workers number over 400 000 and constitute nearly 14% of this industry grouping. They are followed by three other large occupational groups: intermediate service workers (about 300 000 workers, or 10%) and managing supervisors and health professionals, who both number around 250 000 workers (or 8% of this industry grouping). The remaining occupations are mostly tradespersons and some other blue-collar occupations, such as cleaners and production and transport workers.

Table 13: High innovation industries—top 15 occupations

ASCO 2-digit occupation	Number	Per cent
Business and information professionals	170 440	8.9
Intermediate clerical workers	156 306	8.1
Mechanical and fabrication engineering tradespersons	114 929	6.0
Factory labourers	113 058	5.9
Specialist managers	106 165	5.5
Intermediate machine operators	93 130	4.8
Business and administration associate professionals	92 215	4.8
Other tradespersons and related workers	86 283	4.5
Secretaries and personal assistants	79 709	4.2
Science, building and engineering professionals	77 381	4.0
Social, arts and miscellaneous professionals	75 110	3.9
Cleaners	71 696	3.7
Science, engineering and related associate professionals	61 127	3.2
Other intermediate production and transport workers	52 294	2.7
Intermediate plant operators	50 448	2.6

Source: Unpublished data from 1996 Census of Population and Housing

Table 14: Medium innovation industries—top 15 occupations

ASCO 2-digit occupation	Number	Per cent
Intermediate clerical workers	215 606	19.3
Road and rail transport drivers	131 787	11.8
Business and administration associate professionals	78 501	7.0
Business and information professionals	70 622	6.3
Specialist managers	67 565	6.0
Intermediate sales and related workers	55 202	4.9
Other advanced clerical and service workers	51 266	4.6
Elementary sales workers	45 092	4.0
Other intermediate production and transport workers	37 384	3.3
Managing supervisors (sales and service)	35 654	3.2
Secretaries and personal assistants	35 473	3.2
Generalist managers	25 385	2.3
Mechanical and fabrication engineering	25 037	2.2
Intermediate plant operators	24 347	2.2
Electrical and electronics tradesperson	23 164	2.1

Source: Unpublished data from 1996 Census of Population and Housing

Table 15: Low innovation industries—top 15 occupations

ASCO 2-digit occupation	Number	Per cent
Elementary sales workers	408 003	13.6
Intermediate service workers	299 956	10.0
Managing supervisors (sales and service)	251 972	8.4
Health professionals	251 951	8.4
Intermediate clerical workers	177 636	5.9
Construction tradespersons	171 403	5.7
Other labourers and related workers	159 160	5.3
Automotive tradespersons	89 234	3.0
Social, arts and miscellaneous professionals	89 002	3.0
Other tradespersons and related workers	77 126	2.6
Cleaners	72 567	2.4
Other intermediate production and transport workers	70 693	2.4
Specialist managers	62 527	2.1
Electrical and electronics tradesperson	58 903	2.0
Food tradespersons	57 366	1.9

Source: Unpublished data from 1996 Census of Population and Housing

VET occupational groupings—the industry patterns

Occupational over-representation within industries

In this section we look at the industry dimension to the VET occupational groupings, which, as mentioned earlier, attempt to map a spectrum of occupational skill levels. Table 16 shows the occupational distribution for each of the Australian and New Zealand Standard Industry Classification (ANZSIC) subdivision industries (that is, 2-digit). The focus of this analysis is to pinpoint the industries in which the various VET occupational groups are over-represented.

The most highly skilled VET group, managers and professionals, are substantially over-represented in agriculture, although this is explained by the large number of farmer/owner–managers to be found here. More realistically, the two industries where this occupational category is significantly over-represented are motion picture, radio and television services and libraries, museums and arts. Whereas only 27% of workers in all industries are to be found in the manager/professional grouping, in these two industries, the relevant figure is close to 50%. Not far behind is business services: 44% of employees in business services are managers and professionals. In three other industries there is also considerable occupational over-representation: water transport (36%); oil and gas extraction (35%); and services to mining (32%).

At the next skills level down—associate professionals—the industry pattern is quite distinctive, with just three industries standing out as noteworthy. Whereas only 11% of all workers are in the associate professional category, in property services this proportion reaches 42%. Similarly, there is considerable occupational over-representation in other services (34%) and in accommodation, cafes and restaurants (25%).

The VET category of trades has quite a predictable profile. Manufacturing subdivisions, in particular, are where these occupations are strongly over-represented. Whereas only 18% of all workers are found in this occupational category, in several of the manufacturing subdivisions, the proportion is in the 30% to 50% range. However, where this occupational category reaches its highest level of over-representation is construction trade services, where nearly 68% of these workers are to be found. Another industry with considerable occupational over-representation is motor vehicle retailing and services, where 49% of the workers are in the trades and advanced category.

The intermediate occupational category covers machinery and transport equipment operators and intermediate clerical and sales workers. Consequently, it is no surprise to find that machinery and transport equipment occupations are over-represented in the extractive industries and in the transport industries. For example, the intermediate occupational category makes up about 25% of all workers, but in forestry, logging and in coal mining. In road transport, this occupational group is massively dominant (76%), and storage has a similarly high figure (61%). Intermediate clerical and sales are over-represented in finance and community services.

Finally, within the VET elementary occupations, there are three industry subdivisions where considerable over-representation is evident. Whereas elementary workers make up about 18% across all industries, within food retailing and personal and household good retailing, they make up around half of all workers (55% and 48% respectively). A slightly smaller proportion of these workers is found in food, beverage and tobacco manufacturing (41%). There is also slight over-representation in several other subdivisions (rail transport, 28%; and communication services, 28%).

Table 16: VET occupational distribution across industries

Industry subdivision (ANZSIC 2-digit)	Managers/ profess-ionals	Assoc. profess-ionals	Trades and advanced	Inter-mediate	Element-ary	Total
Agriculture	67.6	1.1	5.6	4.9	20.8	100.0
Services to agriculture; hunting and trapping	17.0	6.0	25.4	26.4	25.2	100.0
Forestry and logging	19.4	5.1	9.4	52.3	13.9	100.0
Commercial fishing	31.1	2.8	10.3	45.7	10.1	100.0
Coal mining	11.3	8.2	27.7	50.7	2.1	100.0
Oil and gas extraction	34.9	11.8	34.0	15.3	4.0	100.0
Metal ore mining	22.6	10.4	24.1	35.4	7.5	100.0
Other mining	16.6	5.2	17.1	54.3	6.7	100.0
Services to mining	32.0	10.3	27.2	21.6	9.0	100.0
Food, beverage and tobacco manufacturing	12.6	5.0	18.8	22.2	41.3	100.0
Textile, clothing, footwear and leather manufacturing	17.2	3.1	16.4	50.7	12.6	100.0
Wood and paper product manufacturing	13.5	3.6	32.1	31.7	19.1	100.0
Printing, publishing and recorded media	28.3	6.5	31.3	25.3	8.6	100.0
Petroleum, coal, chemical and associated product manufacturing	26.4	7.3	15.8	35.4	15.1	100.0
Non-metallic mineral product manufacturing	23.8	4.3	18.9	36.2	16.8	100.0
Metal product manufacturing	16.2	4.7	37.0	28.6	13.4	100.0
Machinery and equipment manufacturing	20.0	7.3	34.9	22.1	15.8	100.0
Other manufacturing	16.5	4.0	48.6	17.7	13.3	100.0
Electricity and gas supply	21.3	14.3	36.9	19.6	7.9	100.0
Water supply, sewerage and drainage services	24.0	14.7	14.1	33.2	14.1	100.0
General construction	26.1	11.4	33.8	14.7	14.1	100.0
Construction trade services	5.4	3.5	67.5	13.4	10.2	100.0
Basic material wholesaling	20.2	10.9	12.2	39.9	16.8	100.0
Machinery and motor vehicle wholesaling	24.8	9.9	24.3	31.8	9.2	100.0
Personal and household good wholesaling	21.5	6.7	9.8	44.9	17.2	100.0
Food retailing	2.7	17.0	8.0	17.2	55.2	100.0
Personal and household good retailing	10.2	17.3	9.8	14.8	47.9	100.0
Motor vehicle retailing and services	5.3	9.5	48.7	20.3	16.3	100.0
Accommodation, cafes and restaurants	4.7	24.8	10.1	36.4	24.0	100.0
Road transport	5.3	7.3	7.3	75.8	4.3	100.0
Rail transport	7.8	6.4	15.7	42.3	27.8	100.0
Water transport	36.4	6.3	11.7	38.4	7.3	100.0
Air and space transport	25.2	4.3	29.5	23.0	18.1	100.0
Other transport	17.7	8.8	18.0	47.6	7.8	100.0
Services to transport	20.6	8.9	8.6	51.0	10.9	100.0
Storage	12.5	7.0	8.3	61.0	11.4	100.0
Communication services	15.8	15.9	16.0	24.7	27.5	100.0
Finance	16.8	16.8	12.2	52.3	2.0	100.0
Insurance	23.6	15.6	24.3	33.3	3.2	100.0
Services to finance and insurance	26.7	34.1	18.8	18.0	2.5	100.0
Property services	15.4	42.2	14.0	19.4	9.1	100.0
Business services	43.6	10.5	15.1	13.8	17.1	100.0
Government administration	31.4	12.3	7.6	35.3	13.5	100.0
Defence	28.4	19.6	29.1	20.2	2.8	100.0
Education	70.1	5.1	5.1	14.4	5.2	100.0

Industry subdivision (ANZSIC 2-digit)	Managers/ profess-ionals	Assoc. profess-ionals	Trades and advanced	Inter-mediate	Element-ary	Total
Health services	51.2	11.1	4.7	25.0	8.0	100.0
Community services	26.2	9.0	5.0	48.2	11.6	100.0
Motion picture, radio and television services	49.0	7.1	18.4	13.2	12.2	100.0
Libraries, museums and the arts	51.0	10.3	9.9	18.8	10.0	100.0
Sport and recreation	13.4	25.0	11.9	30.1	19.7	100.0
Personal services	6.9	8.8	38.7	19.3	26.3	100.0
Other services	26.7	34.4	12.7	19.8	6.5	100.0
Private households employing staff	33.9	0.7	32.8	14.2	18.4	100.0
All industries	**27.4**	**11.6**	**17.8**	**25.3**	**17.9**	**100.0**

Source: Unpublished data from 1996 Census of Population and Housing

Industry distribution of VET occupations

Of course, over-representation of some VET occupational groupings within certain industries may not be significant if the absolute number of those occupations within that industry is very small. To explore this question further, table 17 shows the industry distribution within each of the VET occupational groupings.

Table 17: Industry distribution within VET occupational groupings

Industry subdivision (ANZSIC 2-digit)	Managers/ profess-ionals	Assoc. profess-ionals	Trades and advanced	Inter-mediate	Element-ary	All occup-ations
Agriculture	9.6	0.4	1.2	0.8	4.5	3.9
Services to agriculture; hunting and trapping	0.2	0.1	0.4	0.3	0.3	0.3
Forestry and logging	0.1	0.1	0.1	0.3	0.1	0.1
Commercial fishing	0.2	0.0	0.1	0.3	0.1	0.1
Coal mining	0.1	0.2	0.5	0.7	0.0	0.3
Oil and gas extraction	0.1	0.1	0.1	0.0	0.0	0.1
Metal ore mining	0.3	0.3	0.5	0.5	0.1	0.4
Other mining	0.1	0.1	0.1	0.3	0.1	0.1
Services to mining	0.2	0.2	0.3	0.2	0.1	0.2
Food, beverage and tobacco manufacturing	1.1	1.0	2.5	2.0	5.3	2.3
Textile, clothing, footwear & leather manufac.	0.7	0.3	1.1	2.3	0.8	1.1
Wood and paper product manufacturing	0.4	0.3	1.5	1.0	0.9	0.8
Printing, publishing and recorded media	1.5	0.8	2.5	1.4	0.7	1.4
Petroleum, coal, chemical and associated product manufacturing	1.1	0.7	1.1	1.6	1.0	1.2
Non-metallic mineral product manufacturing	0.5	0.2	0.6	0.8	0.5	0.5
Metal product manufacturing	1.1	0.8	4.0	2.2	1.4	1.9
Machinery and equipment manufacturing	1.9	1.7	5.3	2.3	2.3	2.7
Other manufacturing	0.5	0.3	2.3	0.6	0.6	0.8
Electricity and gas supply	0.4	0.7	1.1	0.4	0.2	0.6
Water supply, sewerage and drainage services	0.2	0.3	0.2	0.3	0.2	0.3
General construction	1.9	2.0	3.9	1.2	1.6	2.0
Construction trade services	0.8	1.3	16.1	2.2	2.4	4.2
Basic material wholesaling	1.1	1.4	1.1	2.4	1.4	1.5
Machinery and motor vehicle wholesaling	2.0	1.9	3.1	2.8	1.1	2.2
Personal and household good wholesaling	1.7	1.2	1.2	3.8	2.0	2.1

Industry subdivision (ANZSIC 2-digit)	Managers/ profess- ionals	Assoc. profess- ionals	Trades and advanced	Inter- mediate	Element- ary	All occup- ations
Food retailing	0.5	7.5	2.3	3.5	15.9	5.2
Personal and household good retailing	2.2	8.8	3.3	3.5	15.7	5.9
Motor vehicle retailing and services	0.6	2.4	8.0	2.3	2.6	2.9
Accommodation, cafes and restaurants	0.8	10.5	2.8	7.1	6.6	4.9
Road transport	0.4	1.2	0.8	5.8	0.5	1.9
Rail transport	0.1	0.3	0.4	0.8	0.7	0.5
Water transport	0.2	0.1	0.1	0.2	0.1	0.1
Air and space transport	0.5	0.2	0.9	0.5	0.5	0.5
Other transport	0.0	0.0	0.0	0.0	0.0	0.0
Services to transport	0.7	0.8	0.5	2.0	0.6	1.0
Storage	0.1	0.2	0.1	0.7	0.2	0.3
Communication services	1.2	2.8	1.9	2.0	3.2	2.1
Finance	1.6	3.6	1.8	5.2	0.3	2.5
Insurance	0.7	1.1	1.1	1.1	0.1	0.8
Services to finance and insurance	0.7	2.2	0.8	0.5	0.1	0.8
Property services	0.8	5.3	1.1	1.1	0.7	1.5
Business services	14.2	8.0	7.6	4.9	8.4	8.9
Government administration	4.6	4.3	1.8	5.6	3.0	4.0
Defence	1.0	1.7	1.7	0.8	0.2	1.0
Education	19.3	3.3	2.2	4.3	2.2	7.5
Health services	14.2	7.2	2.0	7.5	3.4	7.6
Community services	2.3	1.8	0.7	4.5	1.5	2.4
Motion picture, radio and television services	0.9	0.3	0.5	0.3	0.3	0.5
Libraries, museums and the arts	1.3	0.6	0.4	0.5	0.4	0.7
Sport and recreation	0.6	2.6	0.8	1.5	1.4	1.2
Personal services	0.5	1.4	4.1	1.4	2.7	1.9
Other services	1.9	5.7	1.4	1.5	0.7	1.9
Private households employing staff	0.1	0.0	0.1	0.0	0.0	0.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Unpublished data from 1996 Census of Population and Housing

The three most important industries for managers and professionals are education (19%), business services (14%) and health services (14%). Agriculture is also significant (10%), but as we observed earlier, this is area is something of an anomaly. Of the industries identified in table 16 as areas of over-representation, we see that only the business services subdivision is a major employer of professionals and managers. The other industry subdivisions identified earlier, such as motion picture, radio and television services and libraries, museums and arts are not large areas for employment at all.

The second VET grouping, associate professionals, are spread across a range of industries, with six industry subdivisions dominant. Accommodation, cafes and restaurants is the largest area (11%), followed closely by two retailing areas (8%), business services (8%), health services (7%) and property services (5%). Again, there is some overlap with the picture presented in table 16. Two of these industry subdivisions—accommodation, cafes and restaurants and property services—featured in this table as industries with considerable over-representation.

For the VET category, trades and advanced, two of the industry subdivisions pinpointed earlier feature as important areas of employment. These are construction trade services, which provides about 16% of employment to trades and advanced workers and motor vehicle retailing and services, which provides 8% of employment. Many of the manufacturing subdivisions identified as important in table 16 remain prominent in table 17, but their contribution is quite modest (around 2 to 5%).

Within the VET category of intermediate workers there are no dominant industry subdivisions. About half a dozen industry subdivisions contribute between 5 and 7% of employment. Of these, only road transport featured strongly in table 16 as an industry with significant over-representation.

Elementary occupations are dominated by two industry subdivisions: food retailing and personal and household good retailing. Together they provide nearly one-third of all jobs in this occupational grouping. Considerably further behind are business services, providing 8% of employment; accommodation, cafes and restaurants (7%); food, beverage and tobacco manufacturing (5%); and agriculture (5%). Of these industry subdivisions, three featured prominently in table 16. The two retailing subdivisions were the same subdivisions with the highest over-representation by elementary workers, while food, beverage and tobacco manufacturing was also an industry subdivision with considerable over-representation.

Developments since 1996

The picture outlined in the previous section—the situation in 1996—draws on the ABS 1996 Census of Population and Housing, and is thus quite accurate at the more disaggregated levels presented there. In order to update this picture to take account of changes since 1996, we must move to a different data source, the ABS Labour Force Surveys. As mentioned earlier, these data are survey-based, and cannot be as reliably disaggregated as the census data. The standard errors for some of the smaller 2-digit occupations and industry subdivisions are quite large. Nevertheless, it is worth replicating the analysis from the earlier section in order to gauge whether the industry and occupational distribution of employment in industries with different levels of innovation intensity has changed.

Table 18 has the same format as table 10, but it is drawn from the 1996 Labour Force Survey (LFS). There is a large difference between the table totals, and this is mostly due to a much larger number of occupations in the low innovation intensity industries, particularly the elementary workers (which number over 200 000 more in the Labour Force Survey data compared with the census). Nevertheless, as table 19 shows, the row percentages are very close to those shown in the census table (table 12). By contrast, table 20 shows that the column percentages can vary by as much as 4 percentage points compared with the relevant census table (table 11). In other words, there is a very close correspondence between the census and the Labour Force Survey when it comes to the innovation intensity industry distribution within each VET occupational grouping. However, for the occupational distribution within each industry grouping, the correspondence is weaker. This suggests that a reliable strategy for working with the Labour Force Survey data is to work with the industry groupings, examining whether there has been any change in their relative importance during the period 1996 to 2001.

Nevertheless, there are a number of important and robust findings. Table 21 reveals that the high innovation industry employs close to 32% of the total labour force, although it also employs 41.1% of total managers and professionals in the economy. In the economy as a whole just under 20% of total employed persons were managers and professionals (table 10). It also has an over-representation of trades and advanced clerical occupations. The high innovation industries account for 35.4% of these occupations. These industries have an under-representation of Intermediate Sales and service and elementary occupations.

Table 18: Occupation and industry totals, Australia 1996, population estimates

VET occupations	Innovation intensity of industries			
	High	Medium	Low	Total
Managers and professionals	520 200	203 000	542 000	1 265 200
Associate professionals	191 100	135 800	466 500	793 400
Trades and advanced	510 300	191 700	740 500	1 442 500
Intermediate	548 600	598 100	784 300	1 931 000
Elementary	417 100	140 500	942 800	1 500 400
Total	**2 187 300**	**1 269 100**	**3 476 100**	**6 932 500**

Note: Table totals are not equal to labour force total because the innovation intensity definition excludes agriculture, government administration and defence, and education

Source: unpublished ABS Labour Force Survey, August 1996

Table 19: Occupation and industry totals, Australia 1996—distribution of VET occupations across industry groups

VET occupations	Innovation intensity of industries			
	High	Medium	Low	Total
Managers and professionals	41.1	16.0	42.8	100.0
Associate professionals	24.1	17.1	58.8	100.0
Trades and advanced	35.4	13.3	51.3	100.0
Intermediate	28.4	31.0	40.6	100.0
Elementary	27.8	9.4	62.8	100.0
Total	**31.6**	**18.3**	**50.1**	**100.0**

Source: unpublished ABS Labour Force Survey, August 1996

Table 20: Occupation and industry totals, Australia 1996—distribution of VET occupations within industry groups

VET occupations	Innovation intensity of industries			
	High	Medium	Low	Total
Managers and professionals	23.8	16.0	15.6	18.3
Associate professionals	8.7	10.7	13.4	11.4
Trades and advanced	23.3	15.1	21.3	20.8
Intermediate	25.1	47.1	22.6	27.9
Elementary	19.1	11.1	27.1	21.6
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: unpublished ABS Labour Force Survey, August 1996

Industry employment changes 1996 to 2001

There appears to have been little change in the relative importance of the different innovation intensity industries since 1996. Table 22 shows that high innovation intensity industries retained their share of employment at around 31% over these six years; medium innovation intensity industries showed a very small decline, from around 18% to 17%; and low innovation intensity industries showed a small increase, from around 50% to 52%.

Despite the stability at this overall innovation category level, within some of these categories there have been some notable compositional changes. For example, within the high innovation intensity industries, business services grew strongly over the period. In 1996 this subdivision accounted for 32% of high innovation industry employment and by 2001 this had grown to 39%. Within the medium innovation intensity industries, road transport remained at the top of the list of industry subdivisions, and increased its share of employment from 15% to 17%. At the same time, machinery and motor vehicle wholesaling saw its share slightly decline from nearly 15% to just under 12%. In the low innovation intensity industries, there was no noticeable compositional change during this period.

Table 21: Changes in employment levels 1996 to 2001 for innovation intensity of industries, population estimates

Year	Innovation intensity of industries			
	High	Medium	Low	Total
1996	2 187 300	1 269 100	3 476 100	6932 500
1997	2 263 000	1 241 800	3 465 800	6 970 600
1998	2 282 000	1 279 400	3 632 000	7 193 400
1999	2 264 300	1 326 200	3 734 200	7 324 700
2000	2 468 900	1 267 500	3 884 700	7 621 100
2001	2 390 900	1 267 100	3 976 700	7 634 700

Source: Unpublished ABS Labour Force Surveys, August 1996–2001
Note: Row totals are not equal to labour force totals because the innovation intensity definition excludes agriculture, government administration and defence, and education.

Table 22: Changes in employment shares 1996 to 2001 for innovation intensity of industries, percentages

Year	Innovation intensity of industries			
	High	Medium	Low	Total
1996	31.6	18.3	50.1	100.0
1997	32.5	17.8	49.7	100.0
1998	31.7	17.8	50.5	100.0
1999	30.9	18.1	51.0	100.0
2000	32.4	16.6	51.0	100.0
2001	31.3	16.6	52.1	100.0

Source: Unpublished ABS Labour Force Surveys, August 1996–2001

We saw earlier that each of the innovation categories had quite distinctive occupational profiles, and that examining the top 15 occupations within each category was informative. How have these profiles changed? Are the top 15 occupations relatively stable, or are some growing more strongly than others?

Turning to high innovation intensity industries first, the rankings of the most important occupations have not changed between 1996 and 2001, but the share held by the top occupation (business and information professionals) has increased, growing from 9% in 1996 to 13% in 2001. In the medium innovation intensity industries, there is very little change: the rankings have remained constant and the employment shares have not altered noticeably. The same is true for low innovation intensity industries: there are no noteworthy changes here either.

Conclusions

By its very nature, aggregate level data can only provide a very general overview of the incidence of VET occupations in innovation-intensive industries. Nevertheless, from this analysis it is apparent that a range of VET occupations and, hence VET skills, are important to a number of innovation-intensive industries. However, as might be anticipated, managers and professionals are significantly over-represented in innovation-intensive industries. Amongst the VET occupations, one category, trades and advanced, is also over-represented in the high innovation industries.

At a slightly more disaggregated level, it has been possible to identify the most common VET occupations in the high innovation industries. Eleven of the top 15 occupations in high innovation industries are VET occupations (see table 13). A more detailed examination of the high innovation industries reveals some interesting patterns of VET occupational incidence:

- *Mining:* two VET occupational categories (trades and advanced and intermediate workers) tend to be routinely over-represented. This is especially the case in coal mining where almost 80% of employees fall into these two VET categories.
- *Manufacturing:* these same two occupational categories (trades and advanced and intermediate workers) are also strongly over-represented. Trades and advanced workers are very strongly represented in metal product manufacturing (37% of employees), machinery and equipment manufacturing (35%) and other manufacturing (49%).
- *Communication services:* of the VET occupations, only elementary workers are strongly over-represented, making up almost 28% of all employees in the industry.
- *Property and business services:* all VET occupations are under-represented in business services, but associate professionals are strongly over-represented in property services.

The pattern of VET occupational incidence in various industries has been very stable since the mid-1990s.

Finally, looking at change in broad employment structure through the 'lens' of innovation does provide an interesting finding. Over the relatively short period 1996 to 2001, the share of the total workforce in high innovation-intensive industries remained steady, while that of medium innovation intensity declined by close to 2%, and low innovation-intensive industries increased their share from around 50% to 52% of the total workforce. While these are relatively small percentage changes, they involve a shift in the occupational structure of hundreds of thousands of Australians over the five years. Other studies have found that, across most advanced economies, there has been a 'hollowing-out' of middle-level employment, with employment growth occurring in both highly educated occupations of managers, professionals and paraprofessionals and lower skilled labourer and elementary sales and service. There has been a decline in the share of middle-level skills, especially trades and advanced clerical (Reich 1991; Gregory 1993; Wood 1994; Cully 1999). This is attributed to a range of factors, such as the relative decline of manufacturing, especially the loss of more labour-intensive manufactures due to import competition from low-labour-cost countries and the shift in consumption patterns towards services such as prepared foods, restaurants, cleaning, child care, and tourism. It also reflects the increased contracting-out by firms of services such as cleaning. This contracting out is associated with the growth of non-standard employment patterns. Many of these jobs lack a career path and have much lower levels of employer-provided training compared with that received by those in the primary labour market (Hall & Bretherton 1999).

Education and training

This section provides a closer look at the extent of differences in educational qualifications and investment in training within the high, medium and low innovation industry groups.

The data for this analysis come from a number of published and unpublished ABS sources. The ABS Survey of Training and Education provides comprehensive information on the training and education experiences of those in, or marginally attached to, the labour market. The Education and Work Survey provides the most recent information on education and training qualifications for all persons aged 15 to 64. The Employer Training Practices Survey provides information on the types of training which employers provide to their employees, and factors affecting the provision of training in the 12 months prior to the survey, while the Employer Training Expenditure Survey provides employer expenditure on the provision of structured training.

Education

There are some significant differences between high, medium and low innovation-intensive industries with regard to the level of educational qualifications attained by employees. Those in high-innovation industries are significantly more likely to have a degree or post-graduate degree than medium- and low-innovation industries. High-innovation industries have around 30% more persons with degrees or post-graduate degrees than the other two industries. This reflects the occupational differences between the three industries, with innovation-intensive industries having a much higher share of managers and professionals. For more than half of all employees across all three industries, the highest educational qualification is the completion of Year 12 high school or below. There is little difference in the extent to which employees in the three industry groupings are likely to have vocational qualifications. Around one-quarter of all those working have a diploma or certificate-level qualification, regardless of the extent of innovation within the industry group (see tables 23 and 24).

Table 23: Highest educational qualification

Educational qualification	Innovation intensity of industries			
	High	Medium	Low	Total
Degree or post-graduate degree	519 000	193 500	579 600	1 292 100
Diploma or Certificate	652 700	285 300	953 300	1 891 300
Up to and including Year 12	1 208 100	749 900	1 878 900	3 836 900
All qualifications	**2 409 400**	**1 242 200**	**3 460 800**	**7 112 400**

Source: ABS (2001b)

Table 24: Highest educational qualification, percentages

Educational qualification	Innovation intensity of industries			
	High	Medium	Low	Total
Degree or post-graduate degree	21.5	15.6	16.7	18.2
Diploma or certificate	27.1	23.0	27.5	26.6
Up to and including Year 12	50.1	60.4	54.3	53.9
All qualifications	**100.0**	**100.0**	**100.0**	**100.0**

Source: ABS (2001b)

There are considerable differences within the three categories of innovation intensity. Indeed, the variation within these industries is as great if not greater than that across the three industries. Table 25 lists the industries in each innovation-intensive grouping in descending order of highest qualification attained (degree or post-graduate degree). Within high innovation-intensive industries, property and business services have an over-representation of persons with degree or post-graduate degree qualifications. The average for high-innovation industries shows that 22% of all employees have a degree or post-graduate degree but within property and business services, 34% of all employees have a university education. However, in the low innovation-intensive industry group of health and community services, there is an even higher over-representation of degree and post-graduate qualified persons (40%). (The issue of the relationship between educational levels and innovation is dealt with below.)

The three industries with the greatest percentage of persons holding diploma or certificate-level qualifications are in the low, medium and high innovation-intensive industries respectively: construction (48%); electricity, gas and water supply (40%); and mining (36%) industries.

There is a slight tendency for specific industries in the medium and low innovation-intensive sectors to have an over-representation of persons with Year 12 qualifications or below. In particular, 74% of the retail industry, 67% of transport and storage and 63% of wholesale trade have relatively low levels of education (table 25).

The fact that variation in educational attainment within the industries is as great if not greater than that across the three industries suggests strongly that the major occupational groups play a different role in the innovation process within the industries. For example, in manufacturing industry, only 11% of employees have graduate or post-graduate degrees, compared with 33.6% for property and business services. In the composite index of innovation, manufacturing industry was slightly ahead of property and business services. However, there is also a significantly higher share of persons with diploma and certificate qualifications in manufacturing compared with property and business services. This is consistent with the evidence in earlier chapters that, in manufacturing industry, VET skills play an especially important role in the innovation process.

Table 25: Highest educational qualifications in descending order within industry group, percentage

Industry (ANZSIC 1-digit)	Education qualification			
	Degree/ postgraduate	Diploma/ certificate	Up to/including Year 12	Total
High				
Property and business services	33.6	21.0	43.9	100.0
Mining	21.2	35.5	42.5	100.0
Communication services	15.4	26.8	56.6	100.0
Manufacturing	11.2	32.3	55.4	100.0
Average high	*21.5*	*27.1*	*50.1*	*100.0*
Medium				
Finance and insurance	26.4	16.9	55.6	100.0
Electricity, gas and water supply	24.3	40.2	33.4	100.0
Wholesale trade	12.9	23.3	62.6	100.0
Transport and storage	7.8	24.8	66.7	100.0
Average medium	*15.6*	*23.0*	*60.4*	*100.0*
Low				
Health and community services	40.4	24.0	33.7	100.0
Cultural and recreational services	21.1	20.8	56.2	100.0
Personal and other services	14.8	32.0	51.2	100.0
Construction	6.2	47.7	44.9	100.0
Retail trade	5.7	19.9	73.5	100.0
Average low	*16.7*	*27.5*	*54.3*	*100.0*
All-industry average	**18.2**	**26.6**	**53.9**	**100.0**

Source: Derived from ABS (2001b)

These results also suggest that, by itself, educational attainment—that is, a high proportion of an industry's workforce with university qualifications—is not a strong predictor of innovation intensity. For example, of all industries, the health and community services industry has the highest share of persons with university qualifications at 40.4%, although it is classified to the low-innovation group. This finding is consistent with the literature on innovation which finds that a very broad range of factors, both internal and external to a firm and industry, determine the intensity of its investments in innovation-related activities. This issue is taken up in some detail in the case studies of innovation-intensive firms.

As with the highest education qualification, the pattern with regard to the most recent qualification attained is also quite similar across the high, medium and low innovation-intensive industry groups. However, the results show a strong preference across each of the three industry categories for employed persons to have a vocational qualification. Almost half of all persons who recently gained an educational qualification had completed a diploma or skilled vocational qualification (table 26).

Table 26: Most recent qualifications attained, percentages

Educational qualification	Innovation intensity of industries			
	High	Medium	Low	Total
Degree or post-graduate degree	28.4	23.1	25.7	26.3
Diploma or skilled vocation	45.5	43.4	48.0	46.3
Basic vocational skill	26.2	33.6	26.2	27.4
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: ABS, Survey of Training and Education, unpublished data, 1997

Training

At the aggregate level there seems little correlation between the innovation-intensive industries and the relative extent of training provided by employers in those industries (table 27). Across the three industry groupings, on average, almost two-thirds (between 59% and 65%) of employers provide some form of training. However, while there is little difference between the industry groups on the extent to which they provide *unstructured* training, there are differences in the extent to which *structured* training is provided. The medium innovation-intensive group is more likely than both the high and low innovation-intensive industry groups to provide structured training, with half of all employers in the medium innovation-intensive group providing structured training compared to only a third of all employers in the high and low innovation-intensive industry groups.

Table 27: Training provided by firms in the last 12 months in descending order within industry group, percentages

Industry	Training provided in last 12 months				
	Structured training	Unstructured training	Provided training	No training provided	Total of firms providing training/ no training
High					
Manufacturing	*35*	*60*	68	32	100.0
Property and business services	*36*	*53*	60	40	100.0
Mining	*37*	*39*	54	46	100.0
Communication services	*37*	*45*	54	46	100.0
Average high	*36.3*	*49.3*	*59.0*	*41.0*	*100.0*
Medium					
Electricity, gas and water supply	*83*	*77*	87	13	100.0
Finance and insurance	*47*	*53*	68	32	100.0
Wholesale trade	*40*	*53*	61	39	100.0
Transport and storage	*31*	*37*	43	57	100.0
Average medium	*50.3*	*55.0*	*64.8*	*35.3*	*100.0*
Low					
Personal and other services	*36*	*70*	78	22	100.0
Health and community services	*42*	*59*	68	32	100.0
Retail trade	29	55	60	40	100.0
Cultural and recreational services	*29*	*44*	50	50	100.0
Construction	*29*	*36*	47	53	100.0
Average low	*33.0*	*52.8*	*60.6*	*39.4*	*100.0*
All industry average	***35***	***53***	**61**	**39**	**100.0**

Note: Industry group averages have not been weighted by industry size and therefore provide an approximate measure only. Employers may provide both structured and unstructured training; therefore, these totals do not equal total training provided.

Source: ABS (1997)

When considering the specific industries within the three innovation-intensive groups, there are more employers, on average, providing training from the medium industry group. On average across all industry groupings, 61% of employers provided some form of training. Three of the four industries in the medium innovation-intensive group had training levels at or above this level (ranging from 61% to 87%). In particular, however, the electricity, gas and water supply industry had unusually high levels of both structured (83%) and unstructured (77%) training. While the manufacturing industry in the high innovation-intensive group and the personal and other services and health and community services industry in the low innovation-intensive group performed above the total industry average, training in these industries was primarily focused on unstructured rather than structured training.

There is little difference at the aggregate level amongst the industry groups in terms of a preference for various training providers. External training providers are widely used, with between 86 and 93% of employers in each of the industry groups using external trainers who provide structured training on a fee-for-service basis (table 28).

Regardless of the intensity of innovation, there is a clear preference in each of the industry groups for either TAFE (46%) or private trainers (41%) and this varied little between the high and low innovation-intensive groups.

However, firms in the high innovation-intensive industry group are more likely to use university as a training provider than the medium and low innovation-intensive groups. In total, 15% of all employers in the high innovation-intensive group used university as a training provider compared with 8% and 5% of employers in the medium and low groups. Firms in the high innovation intensity industries are much more likely to use professional associations for training than low innovation intensity industries. Again, this probably reflects differences in occupational structure, with a much higher share of managers and professionals in high innovation-intensive industries. The other distinction is that employers in the medium innovation-intensive group are more likely to use equipment manufacturers, with 36% of all employers in this group using equipment manufacturers as training providers compared with 22% of employers in the high group and 17% of employers in the low innovation-intensive industry group.

Table 28: Use of external providers for structured training in the last 12 months, percentages

Training	Innovation intensity of industries			
	High	Medium	Low	All firms
Used external training providers	86.3	93.0	88.8	89.4
TAFE	43.8	45.3	48.6	45.9
University	15.3	7.5	4.8	9.2
Private trainer	39.3	47.0	36.0	40.8
Professional association	23.5	17.8	14.2	18.5
Industry association	19.8	21.0	17.2	19.3
Equipment manufacturer	21.5	35.8	17.4	24.9
Provided structured training	36.3	50.3	33.0	39.8

Note: Industry group averages have not been weighted for industry size and therefore provide an approximate measure only. Employers may use more than one kind of training provider so column percentages do not add to 100.

Source: ABS (1997d)

There is a clear correlation between innovation intensity and employer expenditure on training, as reflected by the percentage of the gross wages and salary bill and by total number of training hours per employee. The high innovation-intensive industry as a group has the highest expenditure as a percentage of gross wages and salaries (3.4%) followed by the medium innovation-intensive group (3.1%) and the low group (2.3%). Similarly, the number of training hours per employee was highest, on average, in the high industry group (8.3 hours), followed by the medium (6.5 hours) and the low (6.0 hours) innovation-intensive groups (table 29).

As discussed in relation to table 27, at the disaggregated industry level, there was considerable variation within and across the industry groups in terms of the propensity to train as measured by the percentage of employers who provide training. Table 29, however, shows a slightly different pattern in training expenditure than was evidenced by propensity to train. The mining industry has the highest expenditure in terms of both the percentage of gross wages and salary and the total number of training hours per employee. In the mining industry on average, 5.82% of the total gross wage and salary bill, and a total of 17.12 employee hours were spent on training in the three months prior to the survey. The second highest expenditure was in the electricity, gas and water supply industry in the medium innovation group, with on average, 4.5% of the gross wages and salary bill and 10.4 hours per employee spent on training. The third highest expenditure on training was from within the low innovation-intensive group, with expenditure in the personal and other services industry at 4% of gross wages and salary and 6.3 employee hours.

Table 29: Measures of training expenditure—by industry

Industry	Gross wages and salaries (%)	Training per employee (hours)
High		
Mining	5.8	17.1
Manufacturing	2.2	5.4
Food, beverages and tobacco	2.2	5.5
Textiles, clothing, footwear and leather	1.2	2.8
Wood and paper products	2.2	4.6
Printing, publishing and recorded media	1.3	2.7
Petroleum, coal, chemical and associated products	2.7	5.2
Non-metallic mineral products	2.7	6.6
Metal products	2.4	6.0
Machinery and equipment	2.9	7.9
Other manufacturing	0.8	3.9
Communication services	3.2	6.3
Property and business services	2.5	4.1
Average high	*3.4*	*8.3*
Medium		
Electricity, gas and water supply	4.5	10.4
Wholesale trade	2.1	3.5
Finance and insurance	3.0	6.2
Transport and storage	2.6	6.1
Average medium	*3.1*	*6.5*
Low		
Health and community services	2.1	4.1
Cultural and recreational services	2.1	2.8
Personal and other services	4.0	9.7
Construction	1.3	4.2
Retail trade	1.9	3.4
Average low	*2.5*	*4.9*

Note: Industry group averages have not been weighted by industry size and therefore provide an approximate measure only.
Source: ABS (1996)

Conclusions

Education and training plays an important, but complicated and highly differentiated role in the development of skills for innovation-intensive industries. This is evidenced by the fact that, for most of the variables examined, the variation within the three groupings of industries was as great as, if not greater than the variation across the three industries. However, focusing on the high-innovation industries, it is apparent that university qualifications are important—employees in these industries are much more likely to have a degree or postgraduate degree as their highest qualification than employees in other industries. Nevertheless, diploma and certificate qualifications are still important—27% of these employees have a diploma or certificate as their highest qualification. Perhaps more notable is the fact that a diploma or certificate is the most common, most recent qualification received for all workers including those in innovation-intensive industries—for 45% of employees in high-innovation industries, a diploma or certificate was the most recent qualification acquired.

The fact that the 'flow' of newly acquired qualifications differs substantially from the 'stock' of qualifications by being highly skewed towards vocational qualifications, is an interesting result. There are number of hypotheses which would explain this result. Firstly, persons with university education are undertaking vocational courses, say for specific skills development such as computing or accounting. Secondly, persons with vocational qualifications could be undertaking high-level vocational courses. Thirdly, it may reflect the rapid growth of traineeships in recent years. With the available data it is not possible to tests these hypotheses. It is a topic which deserves further research.

Training propensity does not appear to vary systematically on the basis of the innovation intensity of the industry. However, high innovation-intensive industries have significantly higher employer training intensity as measured by the level of expenditure and number of hours spent per person on training. High innovation intensity industries spend, on average, 3.4% of payroll compared to 3.1% for medium and 2.5% for low innovation-intensive industries. The vast majority of employers in all industry categories use some external training providers. TAFE is widely used across all industries—almost half of all employers use TAFE; however, the usage of TAFE is actually a little lower in high-innovation industries (44% of employers) than in medium (45%) or low intensity industries (49%). High innovation-intensive industries are much more likely to use university and professional associations as external sources of training.

Chapter 5: Case studies of skill formation in innovation-intensive firms

An essential part of this study was a series of eight case studies to examine how innovation-intensive firms recruit, maintain, and update their VET skills, to identify the role of these skills in the firms' innovation processes and to analyse the linkages between the firms and external training providers. The first section of the chapter describes the selection of the case studies. The second section summaries the key results of the case studies. In the final section a typology is developed to describe and explain the linkages between VET providers and the innovative firms.

Selection of case studies

To provide qualitative information on VET in innovation-intensive firms, eight case studies were undertaken. The case studies were:

- Forensic Services Group, New South Wales Police Service
- Pathology Unit, Gosford Hospital
- Beringer-Blass Winery, South Australia
- Infrastructure and Environmental Services Branch, New South Wales Department of Public Works and Services
- Optus Cadet Program, Technical Education Centre, Lidcombe, New South Wales
- plastics manufacturing company
- Visy Pulp and Paper Mill
- Getronics Australia

The case studies were based on semi-structured interviews. This allowed for the collection of common information to enable a comparison of key features across the eight case studies. It also allowed freedom to pursue issues particular to each case study. A broad range of information was collected in the case study. The case studies inquired into:

- the occupational structure of the firms' workforce
- the adequacy of current VET training for the firms
- how the skills of VET employees are upgraded when new products and/or production processes are introduced within the firms
- some of the key drivers of training and innovation within firms
- how training arrangements for VET-related occupations could be improved.

The eight case studies were selected largely on the basis of data from chapter 2, which identified innovation-intensive industries. For example, larger organisations were deliberately selected for interview, given that the previous data analysis clearly demonstrated the very strong association between firm size and propensity and intensity of both training and innovation. Almost all of the firms undertook research and development and had recent major capital equipment investments. All of the firms were substantially above average in their investments in training.

However, these criteria were modified by the necessity to select industries and firms with a reasonably large proportion of VET-level employees. For example, some firms may rate highly on the index of innovation intensity, but VET employees comprise only a small proportion of their total workforce. Secondly, the researchers wanted to avoid the limitations imposed by a purely 'data driven' selection of case studies. In particular, the data analysis was limited to private sector industries. This constraint was overcome by identifying selected public sector organisations which were both innovation-intensive and had a high proportion of VET employees in their workforce. This reasoning was used in the selection of the Police Forensic Services, a public hospital pathology laboratory and a large public sector engineering design service. In the case of the engineering design service, the organisation was managed under National Competition Policy principles. This required the organisation to operate in accordance with its private sector equivalents, as it was obliged to be both fully funded through the sale of its services and to pay a dividend to its owner, a state government. The public hospital pathology laboratory was also selected, in part, to offset the data limitations identified in chapter 3 arising from the aggregation of the health and community services industries. This aggregation obscures the relatively high innovation intensity of large parts of the health industry.

The researchers also found considerable resistance on the part of private sector pathology and engineering services firms to be involved in a study of their innovation and training activities. Given that innovation in products and processes and the associated training were essential aspects of their competitive strategies, several firms contacted expressed concerns regarding potential disclosure of their intellectual property and declined to be interviewed.

Key results of the case studies

The case studies demonstrate some of the key dynamics in the linkages between innovation and training within firms. The case studies also demonstrate the complex linkages between innovative firms and TAFE and the wider VET system. These results have important implications for the VET system. These results and implications are set out below.

All of the case studies had comparatively high levels of training expenditure in the range equivalent to 5–10% of their wage costs, although some firms exceeded this level of investment.

This compares with training expenditures of around 2.5% for all firms (ABS 1996, table 1.1). It is also considerably higher than the training expenditure per employee of 3.4% of wage costs of the high innovation-intensive industries identified in chapter 5.

For six of the eight case studies TAFE was the sole provider of the core VET qualifications required for entry into the VET occupations under study.

The term 'entry level' training covers both minimum VET qualifications for recruitment into the range of VET occupations as well as the upgrading of qualifications by existing employees who seek entry into higher-level positions within the firm. Of the two firms which do not use TAFE as a provider, one firm, Visy Pulp and Paper, is currently negotiating with TAFE to develop such a course. The other firm, the plastics manufacturing company, delivers its own training with a course developed in conjunction with TAFE, and in which TAFE plays an important role in workplace competency assessment. Across all of the case studies, the occupations requiring these entry-level qualifications ranged from production process and skilled plant operator (certificate AQF II or III) to technical officers with qualifications in engineering, computing, hydrology or biological sciences (diploma AQF IV or advanced diploma AQF V).

All of the case study firms required their VET employees to have formal qualifications on recruitment or to gain them after entry.

The reliance on formal qualifications is due to a range of factors. For some firms, such as Beringer-Blass, the enterprise bargaining agreement provides that training lead to the acquisition of recognised, transferable qualifications. The widespread adoption of formal quality assurance methods by the case study firms typically requires that employees can document their competency to perform the range of work they undertake. The attainment of formal qualifications is the most common method to demonstrate these competencies. Finally, large firms operate human resource 'systems' in which qualifications have an important role in the equity and transparency of recruitment and promotion decisions.

All of the case study participants commented very positively on training provided by TAFE, especially in relation to its emphasis on the acquisition of practical skills.

The Forensic Services Group, Pathology Unit, Gosford Hospital, Getronics and the Infrastructure and Environmental Services Branch explicitly contrasted the general and theoretical orientation of university education to the more pragmatic training provided by TAFE. Training with a practical and applied orientation was especially valued by these firms. This form of training was valued because it reduced the amount of on-the-job training required for employees to become productive. Both the Forensic Services Group and the Pathology Unit commented positively on the linking of off-the-job training with on-the-job work experience, enabling students to apply their knowledge.

It is difficult not to conclude that the satisfaction expressed by firms regarding TAFE training was due to the high level of consultation between the firms and TAFE.

The respondents indicated that such consultation is intended to ensure that the training meets the firms' needs. This consultation takes two forms. In the first instance, the firms were actively involved, either directly with TAFE or indirectly through industry training advisory boards (ITABs), in the design of national training packages. These packages are intended to provide industry-specific training linked to various levels of the Australian Qualifications Framework. This was the case with Beringer-Blass, Forensic Services Group and Optus. The second form of consultation involves direct contact between the firm and TAFE teachers who will deliver the training. In this case, industry training packages are modified to the particular needs of the firm, or indeed new curricula are developed. The majority of case study firms engage in this second form of consultation. Importantly, however, where these modifications occur, the new training packages are consistent with national standards, so that training based on these packages results in nationally recognised qualifications. This was the case, for example, with the plastics manufacturing company.

A considerable amount of post-entry-level training was provided, mostly in the form of short courses, typically with a duration not exceeding 2–3 days.

A wide variety of training providers was used for this post-entry-level training. In approximate order of importance, they included, equipment and other input suppliers, in-house training, private providers and TAFE. (These results are broadly consistent with the data provided in chapter 5.) A high level of satisfaction was expressed by the case study firms regarding the quality, cost and flexibility of the training supplied by all of these providers. For this post-entry-level training, flexibility in training arrangements, especially the capacity for on-the-job delivery and customisation of training to conform with firm-specific operating procedures and equipment, was sought by the firms, and on the basis of these case studies, this was provided to them.

It is important that VET training incorporate what are referred to as 'behavioural' skills.

All of the firms emphasised the need for employees to work effectively in teams, to develop problem-solving abilities and communication skills, including improved literacy, numeracy and information technology skills. In turn, these behavioural skills resulted from:

- the demands of formal quality systems
- the automation of production, requiring operators to have a higher-level conceptual understanding of production processes
- work organisation change leading to flatter management structures and devolution of responsibility to supervisors and operators

- the expectation that employees contribute to product and process improvement through various consultative mechanisms.

These are skills required of both new entrants and existing workers. For example, the Infrastructural and Environmental Services Group emphasised the need for its engineers and TAFE-trained technical officers to operate as project managers and to form effective teams in response to new contracts. In the view of the respondents, these are skills which are not adequately taught in the VET or university system. Across the case studies these behavioural skills were acquired mostly on the job. Other studies have identified the increasing importance of these behavioural skills in industry (Toner & Wixted 2002; Smith et al. 2002).

A common element across all firms was the extensive network of external sources of innovation each firm maintained.

This network included professional associations, conferences and journals. A very interesting finding was that firms which did not undertake in-house research and development, or only on a minor scale, funded third parties to undertake research and development. In the case of the Forensic Services Group, $5 m per annum is allocated to the National Forensic Institute. (Other state police forces also make contributions to the institute.) In the wine industry, both the wineries and grape growers contribute through a levy to Australian Wine Research Institute. The use of levies to fund research is a well-established practice across most primary industries. Even large wineries, such as Beringer-Blass, which undertake their own research and development, also contribute to the industry levy. By pooling resources, both the state police departments and the wineries create a critical mass of research resources and talent. Both the state police departments and the wineries are represented on the governing boards of their respective industry research institutes in order to influence the direction of research.

External networks also arise from cooperation between competitors. Inter-firm cooperation was also evident in the case of the wineries, allowing foreign winery employees to gain work experience in their firms. This was claimed to be representative of a cooperative culture across global wine-makers, described as ‘one big fellowship’.

The case studies revealed a common set of drivers which stimulated investment in both training and innovation.

In chapter 2 a number of variables were identified which were closely associated with high innovation intensity. Importantly, the drivers of innovation identified by the case study respondents closely matched that identified in chapter 2. This gives the results strong face validity.

As noted earlier, the case study firms had much higher intensity of training than average firms in the economy. There have been many studies of the causes of difference in the propensity and intensity of training across industries and firms (Wooden 1996a, 1996b; Toner 2000b; Ridoutt et al. 2002; Smith et al. 2002; NCVER 2002). These studies identified a range of factors which lead to higher propensity and intensity of training. These factors include large firm size; introduction of new technology and new capital investment; work organisation change (such as the introduction of quality assurance, teamwork or consultative mechanisms); and a high proportion of a firm’s workforce in technical and professional occupations and with comparatively higher levels of education. The drivers of training identified by the case study respondents are strongly consistent with the broad literature on training propensity and intensity. The following expands on the links between innovation and training.

A common element across all case studies was that training was seen as an essential element in the maintenance and growth of their business, and flowed automatically from their decisions regarding the pursuit of product and process improvements. This reflects the ‘bases of competition’ within the industries in which the firms operate. Within these industries the bases of competition are innovation in products and processes intended to reduce costs, improve quality and increase market share (Porter 1985, 1990). By contrast, in other industries such as primary production, residential construction and retail, price is a significantly more important basis of competition. A key role was also identified for VET skills in the development of innovation. A virtuous circle was evident in many of the case studies, where training was included as an essential element in the introduction of innovation, and through mechanisms such as employee/management consultative committees, suggestions for productivity, quality and innovation were promoted and implemented. In turn, these changes in equipment and operating procedures often resulted in additional training requirements.

A key driver of training identified by the case studies was maintenance of and improvements in the 'quality' of products and/or services produced by the firms. Some case studies, such as the hospital Pathology Unit, operated a formal International Standards Organisation (ISO) quality assurance system. The Pathology Unit had to maintain its certification to achieve accreditation with Medicare and receive rebates for its services. Most of the other case study firms operated formal quality assurance programs. A focus on quality of processes and products was also a consequence of the competitive operating environment in which the firms operated. For example, Beringer-Blass does not operate a certificated quality assurance program, but the firm identified quality improvement as a key driver of training and innovation.

In addition, for the Pathology Unit, a major driver was 'demanding customers'—doctors and patients—who demand the latest pathology techniques. These demands for the most advanced and current procedures led directly to additional training. For the Forensic Services Group, the quality of its services was judged by the acceptance of its evidence in the law courts and its contribution to successful prosecutions.

Another driver of training and innovation was in-house research and development. Research and development was undertaken to improve existing products, develop new products and improve the efficiency of production processes. All of these changes required employee training to be implemented. For example, Beringer-Blass, Visy and the plastics manufacturing company undertook considerable research and development, largely on the basis of commercial pressure from competition.

The upgrading of equipment by the firms invariably required training. This is because capital equipment and other inputs to production have long been recognised in the innovation literature as principal sources of 'embodied' technical change (Rosenberg 1982). The latest generations of capital equipment frequently embody technical advances over earlier generations of equipment and these advances typically demand training and re-training of staff. New equipment is used to introduce new products, improve the quality of existing products and to reduce costs. Four of the eight case study firms had undertaken very substantial capital investments within the previous three years. For some firms, such as Visy, the investments exceeded $500 million and the plants employ world-class technologies. Similarly, Optus had spent hundreds of millions in the continuing roll-out of its mobile and optical fibre network.

The case studies provided two very clear examples of how improvements to capital equipment prompted training. The plastics manufacturing firm recently upgraded its facilities, enabling the introduction of an important new product which had been under development for eight years. The company found that the new equipment was operated most efficiently and that higher quality was achieved if the plant operators were given a theoretical understanding of the plastics processing operations. This theoretical understanding is now an essential part of the formal training assessment. At the Visy Pulp and Paper Plant the production processes have been largely automated so that operators work in control rooms, monitoring and controlling each stage of the production process through computer screens and multiple numerical readouts. This contrasts with earlier production methods where a worker manually operated a few machines and directly monitored the process. The changes at the Visy plant require a much more sophisticated theoretical understanding of the production process, and much higher level literacy and numeracy skills.

Another driver of training and innovation is government regulation. This applied most obviously with occupational health and safety, where such training is a statutory requirement. Implementation of occupational health and safety in some instances induced a 'training multiplier effect'. For example, to achieve higher occupational health and safety standards, Beringer-Blass re-designed its grape crushing plant. The highly innovative design not only won awards for safety, but also required staff re-training in its operation. Environmental regulations also affect training. The Visy Pulp and Paper Plant was designed to have world-leading environmental performance. It has the lowest energy, chemical and water consumption of any comparably sized plant in the world. It operates a 'closed loop' system whereby all by-products are re-used in the production process so that there is no discharge of water, effluent or by-products from the plant. These advanced environmental control mechanisms are an integral part of the production process, and require considerable training for the plant to operate within set standards.

The final driver of training was that all of the firms had formal or informal consultation mechanisms with VET-level employees and all other employees on training requirements. The formal consultation mechanisms ranged from skills audits to annual staff performance reviews in which training needs are identified. Advice from the firms, including some employees, was that these training consultation mechanisms were effective in identifying training requirements and in stimulating management to make the necessary investment.

All firms also had formal or informal consultation mechanisms on means to improve quality and reduce costs. Again, there were a variety of formal consultation mechanisms, ranging from regular team meetings, which reviewed the efficiency and quality of production, to the operation of a suggestion scheme with prizes given for the best suggestions. Sometimes the advice resulted in a minor re-organisation of production processes, such as changes to the arrangement of machinery to improve work flows. On other occasions, the suggestions were sought during the process of capital expansion, so that the operators actively participated in the design of new equipment. On yet other occasions, the operator input resulted in new capital equipment purchases. In many instances, these suggestions resulted in training for the implementation of the changes. This association between innovation, productivity and consultation and communication systems is consistent with the findings in the literature survey.

In conclusion, the respondents suggested that most of the drivers of innovation were linked directly or indirectly to increased training intensity. In the case study firms there was a cumulative relation between innovation and training. Changes to products and processes necessitated training or re-training. Moreover, through formal or informal consultation mechanisms, additional incremental improvements are made to the original innovation, which induces further training.

The final key result is that within the case studies there were three distinct patterns to the recruitment of persons for VET occupations.

The first was where the entry-level training was supplied concurrently with employment upon entry to the firm. This was the case with the plastics manufacturing company and Visy, where training was provided in house by the firms due to unavailability of external provision. Optus and the Forensic Services Group also recruited and concurrently trained entry-level employees, although the bulk of this training was supplied externally by TAFE.

In the second pattern persons were recruited having completed the necessary entry-level qualifications, although support was provided for further qualifications upgrading. This pattern fits the hospital pathology laboratory and the Infrastructural and Environmental Services Branch. Getronics and Beringer-Blass provided both entry-level training and recruited persons already possessing the necessary qualifications.

These differences in recruitment and training patterns largely reflected differences in the availability of an external labour market with a sufficient number of skilled and qualified persons. For some firms, such as Optus, the external labour was too small, given the rapid growth in demand for skilled telecommunications technicians. While this external labour market did not exist, say for firms introducing firm-specific technologies novel within Australia, recruitment and training are necessarily supplied concurrently. A small, although still satisfactory, external labour market exists for VET-trained medical pathologists and technical officers in engineering and hydrology.

Typology of training and providers

The case studies illustrate the manifold linkages between innovative firms and training providers. While there was great variety in these linkages, a pattern or typology did emerge. All typologies are based to varying degrees on 'ideal types', in that real-world examples rarely fit discretely into a single category. The typology developed here is no exception, as most of the case study firms overlap, to varying degrees, across the categories. Nevertheless, the typology does reflect the systematic differences across the case studies in the sources of training, the methods, curricula and the reasons for the inter-firm differences. Aside from its analytical uses, the typology is intended to be of benefit to VET policy-makers as it catalogues and explains the patterns of interaction between VET and innovative firms. The following outlines the typology.

Standard model

The standard model is where new entrants or existing workers receive their vocational qualifications by participating in courses of study which are developed for the general industry and are based on national training packages with the course conducted in a TAFE institution. However, the case study firms did seek to have input into the design of course content either directly by contacting the TAFE teachers, or indirectly through an industry training advisory body (ITAB). In the case of the Forensic Services Group this involvement in curriculum development was very extensive. This model applied, in most respects, to VET training for the Pathology Unit, the Infrastructural and Environmental Services Branch and Forensic Services Group. The qualifications ranged from AQF level II to VI. Within these case studies the qualifications were regarded as essentially adequate to undertake the job with only limited additional on-the-job or off-the-job training undertaken. This training was typically provided on the job or by equipment vendors when new plant, products or processes were introduced, or in response to regulatory requirements such as occupational health and safety.

The standard model exists largely because the VET skills required by the case study firms are sufficiently generic for them to be demanded by a broad range of firms, and the level of demand is sufficiently high for the courses to be supplied on a continuing basis. In general, the standard model is based, in part, on imparting a knowledge of principles or theory, such as mathematics, engineering, biology or wine production. These are principles which, in the abstract, are not subject to much change. Secondly, the practical component of the courses involves the use of equipment or technologies which are also generic across firms. These two characteristics of the course content mean that the VET system, and in particular TAFE as the main supplier of such courses, can attempt to maintain their currency in the light of technical change.

External qualifications modified to firm requirements

In the second category, firms seek to have externally provided and recognised courses and qualifications, but significantly modify the content, assessment and delivery methods. For example, with Beringer-Blass, almost the entire VET training occurs on site. A variety of training providers are used. TAFE is the principal provider of training for the various Australian Qualifications Framework levels in the cellar procedure courses. The training is customised to the site's equipment and standard operating procedures (SOPs). Modules are selected from a variety of training packages to fit the requirements of the site, although the qualifications remain nationally recognised. The courses are conducted at times to suit the three shifts which run on site. (The site operates 24 hours per day.) TAFE is used mainly to provide the theoretical or classroom-based subjects. In-house workforce assessors are used to competency-test the practical subjects. Equipment suppliers are also a source of training, although much of the new and innovative equipment has been designed in house, along with the accompanying training manuals.

The main requirement for this model is a sufficiently large number of employees undertaking training to justify the expense of modifying and customising existing training packages. The fact that the firm also recently undertook major capital investments modernising almost all aspects of the plant, and that much of this equipment was designed in house and customised to the site, is also a spur to this form of training. The existence of an industrial agreement mandating that training result in recognised, transferable qualifications is also a factor in the use of experienced external providers. The development, over the last few years, of greater competition in the supply of vocational training is also likely to be a factor in the willingness of TAFE and other providers to customise their training.

External qualifications supplemented by in-house training

In this model the firm relies on an external provider for the basic entry qualification, but this is supplemented concurrently with extensive in-house provision. This model is represented by Optus. In the Optus Cadet Program, all cadets undertake the Graduate Certificate in Telecommunications Engineering provided by TAFE. This is a part-time course run over three years. Optus maintains close ties with the course teachers to ensure the currency of curriculum and teacher skills. This is supplemented by concurrent in-house training provided through a dedicated Optus technical training facility. The in-house training covers both fundamental knowledge of electronics and specific in-house technologies. There is also vendor-supplied training related to proprietary technologies.

This model is based on technologies which are sufficiently generic for them to be demanded by a broad range of firms, and the level of demand is sufficiently high for the courses to be supplied on a continuing basis. Firms other than Optus put their employees through the graduate certificate program. However, there is a sufficiently large quantum of firm-specific technologies to justify in-house provision. It hardly needs to be added that the firm is of sufficient size that this internal provision is economically viable.

Largely in-house training provision with specialist VET assistance

For a number of reasons, some of the case study firms provide extensive in-house training provision, although also relying on the domestic VET system for specialist assistance. This assistance takes the form of curriculum development, designing and/or conducting competency assessments and ensuring that firm-specific training packages are consistent with national training packages so that recognised qualifications can be provided.

For example, the Visy Pulp and Paper Mill is the most advanced mill in the world, incorporating the latest automated process flow, quality control mechanisms and environmental management. The training for this plant was supplied largely by the overseas equipment suppliers, supplemented with in-house provision based on a Canadian training package for pulp and paper mills. The exclusion of the local VET system from training provision was based largely on the novelty of the equipment and processes in the plant, and the fact that existing courses dealt with much earlier technology. The Visy mill is the first integrated pulp and paper mill to be built in Australia since 1981.

However, the VET system is currently involved in a minor way, and the firm hopes to significantly increase local VET involvement. At present, local VET involvement is limited to the provision by TAFE of a two-day introductory course for recruits. The results of the formal student assessment at the end of the course are used in employee selection. Visy has made it clear that it does not want to be a large-scale training provider and is currently negotiating with the local TAFE for the development of training packages leading to AQF III and IV. The company acknowledges that, given the novelty of its technologies, its experienced operators will need to be actively involved in the TAFE teaching program. The expectation is that some form of apprenticeship will be developed.

The plastics manufacturing company developed a major new product after eight years of research and development. The existing Rubber, Cable Making and Plastics Industry Training Package was assessed as too generic for the company's purposes. With the assistance of the local TAFE, modules were written to integrate the company's training materials into the national training framework. This enabled the development of safety, technical and team development programs tailored for polymer technicians within the company. Teachers in the local TAFE ensured that these modules met the conditions and requirements of the training package for a Certificate Level III for Polymer Technician Operators and a Certificate Level IV for Shift Coordinators. The company undertakes its own training and assessment, although the company engages the local TAFE to audit the quality of training and assessments.

VET qualifications as a screening device with extensive post-recruitment training

Some firms require recruits to have VET or university qualifications, but these are regarded essentially as a screening device to demonstrate interest and aptitude for the type of work to be undertaken. For a variety of reasons, these firms supply extensive post-recruitment, in-house training, although this is not closely integrated into the wider VET system.

Getronics Australia is a multinational information technology firm involved with software and hardware design and procurement. It employs both VET and university graduates. The company supplies extensive training to employees through the Getronics Virtual University. This is an online teaching facility available free of charge to all Getronics employees around the world. The Getronics Virtual University provides training courses developed by Getronics; it is also a licensed trainer from the main software and hardware developers, such as Microsoft and Cisco and other vendor-specific certifications.

Although Getronics Australia is very reliant on in-house training provision, the company has very close links with the principal TAFE, which supplies diploma-level training to its new recruits. For example, Getronics Australia provides placements for TAFE staff within the firm to ensure that the skills of TAFE trainers remain current.

There are two main reasons for the focus on in-house training. Firstly, Getronics Australia believes that it is cheaper and more effective to provide comprehensive, online, self-paced learning than to bring in external private providers or send out staff to off-site training. Secondly, these vendor-provided and or licensed certificates have high recognition within the information technology industry and by the clients of Getronics Australia. Importantly, these vendor-provided certificates are not recognised within the Australian Qualifications Framework, largely because providers have not felt the need to seek such recognition. The high regard which vendor qualifications command in the industry is a function of the vendor-specific technologies used within the information technology industry and the rapidity of change in these technologies. The vendor-specific nature of technologies means that employers have a strong preference for training in these specific technologies as opposed to the more generic information technology training provided by public training institutions. The rapidity of change in the information technology industry is also a constraint on the ability of public institutions to adapt. Moreover, the proprietary nature of the technologies means that the manufacturers and vendors control the dissemination of the innovations and gain additional revenue by providing training directly or licensing such training.

Finally, anecdotal advice from public providers indicates that, in general, they do not see it as their role to provide solely vendor-based training. The goal of these providers is to supply courses based on more general principles, which train students to apply a deeper theoretical and critical understanding to particular workplace information technology problems. These providers question vendor-supplied training as it is viewed as locking in students to particular vendors, since the students only learn a particular vendor-based solution to an information technology problem. Without a knowledge of broad information technology principles, the currency of vendor-supplied training is also seen as having a limited effective life.

Chapter 6: Conclusion

The study has examined the relation between innovative industries and firms and VET and institutions. It is one of the firsts of such studies on this subject in Australia. The subject is important as innovation-intensive products and services are a rapidly rising share of world trade, and trade is a rapidly rising share of the output of developed countries. This situation is being driven by the transfer of the production of low- and middle-value goods and services to developing countries and the substantial rise in innovation-related investments in developed countries over the last two decades (Reich 1991; Wood 1994; Cully 1999; Maglen 2001). The skill intensity of these innovation-intensive industries is also rising. This is indicated by the rising share of professional and paraprofessional occupations, and a marked decline in the share of unskilled occupations in these industries. There are also demands for rising skill levels in VET occupations, especially trades and intermediate production workers, in the areas of literacy, numeracy, computer competencies, behavioural skills and improved theoretical or conceptual understanding of the production process (Australian Industry Group 1999; Australian Expert Group in Industry Studies 2002).

Competitive success in innovation-based products and services will be an increasingly important factor in long-term national prosperity. It is crucial that the linkages and communication between innovation-intensive firms and VET are well defined and efficient.

The literature review found that there was a plausible connection between countries' export success in a broad range of innovation-intensive manufactures and a comparatively high proportion of qualified production, trade and technician occupations in the industries producing these goods. This was especially the case for small-to-medium-sized countries which do not have the internal market size to employ production strategies which rely on very high capital intensity, an extreme division of labour within plants using a high proportion of semi-skilled labour, and a small number of highly skilled tertiary trained managers and engineers.

In the case of manufacturing industry, a number of specific mechanisms were identified whereby higher-level VET skills promoted competitiveness and innovation within the firm and innovation. The linkages between improved VET skills and competitiveness include:

- Higher-level production and maintenance skills result in lower defect and re-work rates. The presence of more skilled production and maintenance workers permitted the use of more complex machinery using automated control and sensing devices and closer tolerances of work. Work organisation systems which focused on quality assurance, in contrast to quality control, were also important. The operation of effective quality assurance was linked to firms' reliance on higher-level production and maintenance workers as these workers have a greater capacity to identify faults in production processes and product design, to suggest incremental improvements in processes and products, and an enhanced capacity to implement production and design changes.
- The employment of higher skilled production and maintenance workers allows for flatter management structures with fewer forepersons, supervisors, clerical support and quality checkers.
- Higher maintenance skills leads to higher machinery utilisation rates due to effective preventative maintenance programs.
- Higher production and maintenance skills enable the operation of flexible specialisation production processes using programmable equipment such as computer numerically controlled devices. This equipment permits the economical customisation of products in small batches and

reduces cycle times for the introduction of new products. Reducing cycle times is a key competitive strength in markets in which innovations in product design and performance are critical to success.

Given the relative novelty of this study in Australia, the primary focus of the research questions was largely on descriptive and structural aspects of VET and innovation, with some discussion of the policy implications of the findings. While the subject of the study is broad, there were a range of important fields of investigation which were outside the scope of the study. For example, the study could not pursue other important questions, such as the linkages between VET and research and development institutions like cooperative research centres and universities which are at the forefront of innovation. Other research has identified problems in these linkages, despite their being best-practice models of cooperation (Ferrier, Trood & Whittingham 2001; Trood 2002).

Synthesis of the key findings

The following provides a synthesis of the key findings of this study drawn from the literature review, quantitative analysis and case studies and is structured around the specific research questions which framed the scope of the study.

Which industries are most significant in undertaking innovation in Australia?

A clear hierarchy is apparent in the innovation intensity of Australian industries. Mining, manufacturing, communication services and property and business services emerge as the most innovation-intensive, based on a wide range of indices. It is of interest to note that this group comprises two of the most traditional producers of goods, as well as the most recently developed and fastest growing service industries. It reveals that the more popular notion of what constitutes technologically dynamic industries requires change. These are industries with comparatively high rates of expenditure on research and development, capital investment and training. They make a disproportionate contribution to total Australian expenditure on these investments. They have the highest rates of labour productivity growth. In 2001 these four industries accounted for 33.5% of gross domestic product and 26.3% of employment. The fact that the share of gross domestic product significantly exceeds the share of employment indicates the comparatively high productivity of these industries.

There is also considerable variation in the degree of innovation intensity within these industries. For example, engineering, computer consultancies and private research and development establishments within business services account for the bulk of the innovation-related expenditures within the property and business services industry. The bulk of manufacturing industry's innovation expenditures are accounted for by just three of the nine sub-divisions within the industry. These include machinery and equipment; petroleum and chemicals; and food, beverages and tobacco.

It is also important to acknowledge the limitations of a purely 'data driven' identification of innovation-intensive industries, especially an approach based on highly aggregated data. This study sought to redress these problems, at least in part, through the selection of the case studies which included certain high-innovation activities within public sector organisations which would otherwise have been excluded from the analysis.

The broader literature on innovation and the case studies identified an interrelated set of factors which are strongly associated with innovation intensity. The factors associated with high innovation intensity include:

- large firm size
- regular upgrading of capital equipment
- strong linkages between producers and suppliers of capital equipment and other inputs

- competition within the respective industries and product markets based on product differentiation, reducing cycle times for introducing new products to markets, customisation, reliability, quality, design and integrating products and services
- well-functioning linkages between external research and educational institutions and firms
- demanding customers
- regulatory requirements which allow for novel solutions in meeting prescribed standards
- high expenditure on training.

The eight case study firms demonstrated most or all of these characteristics.

What is the role and significance of VET provision in Australian innovation?

The case studies have demonstrated that innovation-intensive firms regard VET as a critical transmission mechanism in the diffusion of knowledge and development of practical skills for a very broad range of occupations. The survey data indicate that innovation-intensive industries have higher expenditure on structured training as a share of gross wages and salaries, and provide notably higher hours of training per employee. The case study firms spent two to four times more on training as a share of gross wages and salaries than other firms.

A common element across all case studies was that training was seen as an essential element in the maintenance and growth of their business, and flowed automatically from their decisions regarding the pursuit of product and process improvements. This reflects the bases of competition within the industries and the markets into which they sell.

A key role was identified for VET skills in the development of innovation. The ABS surveys of innovation-intensive industries found that firms identified VET occupations among the principal sources of ideas for technological innovation. Skilled production, trade and technician occupations are essential for the *generation, design, installation*, *adaptation* and *maintenance* of new technologies.

A virtuous circle was evident in many of the case studies, where training was included as an essential element in the introduction of innovation, and through mechanisms such as quality assurance systems and employee/management consultative committees, suggestions for productivity and quality improvements were promoted and implemented. In turn, these changes in equipment and operating procedure often induced additional training requirements.

An important finding of the study is that most of the factors which were identified by the case studies as stimulating innovation were also identified as stimulating training. Upon reflection, this is not a surprising result. The fundamental purpose of vocational training is, after all, the transmission of economically useful knowledge.[21] Industries which experience comparatively rapid changes in the knowledge base of their processes and products require more intensive training to transmit this knowledge. Both the literature on inter-industry differences in training propensity and intensity and the case studies, indicated that the following factors were identified as drivers of training. These drivers include, firm size, investment in new capital equipment, introduction of new products and production processes and work organisation changes, such as quality assurance, consultative mechanisms and regulatory requirements.

The literature review argued for a circular and cumulative interaction between the development of higher-level production, maintenance and technician skills; the use of more complex and productive equipment; and the growth of productivity, quality and scope for product and process innovation. This is an important finding for the tradable goods sector of Australian industry. (The tradable goods sector comprises those goods-producing industries which export and are subject to import competition.) Of manufacturing industry, for example, it has been argued that the high road of skill and innovation-

[21] Other studies reported in the literature review found a similar result (Laplagne & Bensted 1999).

intensive production is the key to success. 'Given both the smallness of Australia's domestic market and the proximity of large amounts of relatively cheap labour, the American route of mass production of manufactured goods is clearly not a viable option' (Maglen & Hopkins 1998, pp.22–3).

As noted before, large parts of American manufacturing produce high-volume standardised products using mass-production techniques with an extreme division of labour requiring low vocational skills and heavy reliance on university-trained engineers and managers for plant coordination, quality improvement and direction of innovation. This is not a feasible direction for Australian innovation-intensive industries

However, it is essential for policy-makers to recognise that improved skills and higher qualifications are a necessary, but not sufficient condition for the growth of innovation-intensive industries. Just as higher-level VET skills are only an element in what the National Institute of Economic and Social Research describes as the 'joint complex' of decisions made by firms regarding products and production processes, so also are skills only one element in the retention and attraction of mobile capital into Australia.

> The danger of policies and institutional devices … which concentrate on boosting the supply of qualifications and formalised skills and knowledge is that they appear to offer a relatively swift and simple short cut to a wide-ranging set of desired outcomes—increased GDP, and greater social inclusion—without having to confront complex and difficult choices about how businesses choose to compete. (Keep & Mayhew 1999, p.12)

Other complementary policies, in addition to improved skills, are essential. These include, for example, taxation policies which favour innovation, such as accelerated equipment depreciation and research and development investment allowances. Targeted development policies, which have stringent performance criteria relating to levels of research and development, investment and exports, have been shown to be highly effective in stimulating output and exports of innovation-intensive industries. Recent examples include the steel, automotive, pharmaceuticals, shipbuilding and aerospace industry development plans of the 1980s and the later 'Partnerships for Development'—also targeted industry development plans (Sheehan, Pappas & Cheng 1994; Sheehan et al. 1995). The case studies confirm findings in the literature review that work organisation practices within firms which encourage worker consultation and input into product and process improvement result in a more active use of skills learnt through on- and off-the-job training (Maglen & Hopkins 1998, p.27).

What is the occupational profile of innovative industries and which occupations within innovative industries rely on VET providers?

Innovation-intensive industries as a whole have a disproportionately large share of managers/professionals and trades and advanced clerical occupations. This is indicated by the fact that innovation-intensive industries comprise 32% of the total Australian workforce, but 39.5% of all managers/professionals are employed in innovation-intensive industries, as are 36% of all trades and advanced clerical workers.[22] All other occupational groups are under-represented in these industries. However, within the four industries comprising innovation-intensive industries—manufacturing, mining, communication services and property and business services—there is very considerable diversity in their occupational structures. Indeed, the degree of variation in the occupational structure across these four industries is as great as that across all industries.

In other words, taken collectively, there are significant differences in the occupational structure between innovation and non-innovation-intensive industries, although as separate industries, these differences become much less distinct. The fact that the association between occupational structure

[22] This estimate of innovation industries' share of total employment is based on the 1996 census. The figure cited earlier, which showed a smaller share of employment, is based on estimates from the ABS Labour Force Survey, August 2001.

and innovation intensity of industries depends on the level of analysis undertaken suggests that the association is not robust. The implications of this are dealt with below.

Another important and related finding is that the variation in educational attainment within the innovation-intensive industries is as great if not greater than that across all industries. This is primarily due to the large variation in occupational structure across the four innovation-intensive industries. These results suggest strongly that the principal occupational groups play a different role, and are of differing significance in the innovation process within each of the industries. For example, in manufacturing industry, only 11% of employees have graduate or post-graduate degrees, compared with 33.6% for property and business services. In the composite index of innovation, manufacturing industry was substantially ahead of property and business services. However, there is also a significantly higher share of persons with diploma and certificate qualifications in manufacturing compared with property and business services. This is consistent with the evidence in earlier chapters that, in manufacturing industry, VET skills play an especially important role in the innovation process.

These results also suggest that by itself, educational attainment—that is, a high proportion of an industry's workforce with university qualifications—is not a strong predictor of innovation intensity. For example, of all industries, the health and community services industry has the highest share of persons with university qualifications at 40.4%, although it is classified to the low-innovation group.[23] This finding is consistent with the literature on innovation, which finds that a very broad range of factors, both internal and external to a firm and industry, determine the intensity of its investments in innovation-related activities.

Analysis of ABS data on training also reveals few systematic differences of any significance across all industries in the propensity to use different types of training providers or the choice of structured or unstructured training for the delivery of this training. The main differences were a higher propensity by innovation-intensive industries to use universities and professional associations as training providers, and that innovation-intensive industries have higher expenditures on structured training as a share of gross wages and salaries and provide notably higher hours of training per employee.

The case studies revealed that a very broad range of occupations received formal training leading to recognised vocational qualifications. In the great majority of cases, TAFE supplied this training. In addition, there was a wide variety of post-entry-level training supplied by a wide range of providers. The occupations receiving the formal recognised qualifications ranged from production process and skilled plant operator (certificate AQF II or III) to technical officers with qualifications in engineering, computing, hydrology or biological sciences (diploma AQF IV or advanced diploma AQF V).

How do innovation-intensive industries recruit, maintain and update their skills? What problems, if any, do innovation-intensive industries have in recruiting, maintaining and updating skills provided by the VET sector?

On the basis of the quantitative data and the case studies, innovation-intensive firms use a wide range of training providers. These include TAFE, private providers, equipment and other vendor suppliers, professional associations and in-house training. Amongst higher-level VET occupations such as technical officers or forensic investigators with diplomas and advanced diplomas, conferences, journals and professional associations were an important means of keeping up to date with advances in their fields. Nevertheless, a key role was identified for TAFE in that six of the eight case study firms used TAFE to supply entry-level qualifications. The term 'entry level' training covers both minimum VET qualifications for recruitment into the range of VET occupations as well as upgrading of qualifications by existing employees who seek entry into higher-level positions within the firm. Of the two firms which do not use TAFE as a provider, one firm is currently

[23] It will be recalled, however, that the aggregation of health and community services obscures the relatively high innovation intensity of the health industry.

negotiating with TAFE to develop a course covering key production occupations. The other firm delivers its own training with a course developed in conjunction with TAFE and in which TAFE plays an important role in maintaining the quality of workplace competency assessment.

Across the cases studies there was a universal requirement for entry-level VET training to result in formal qualifications. For some firms, such as Beringer-Blass, an enterprise bargaining agreement provides that training leads to the acquisition of recognised, transferable qualifications. The widespread adoption of formal quality assurance methods typically requires that employees can document their competency to perform the range of work they undertake. The attainment of formal qualifications is the most common method to demonstrate these competencies. It is also the case that larger firms with formalised human resource management are more likely to use formal qualifications as criteria in recruitment and promotion.

Emerging from the case studies was a typology describing and explaining the systematic differences in training sources, methods and curricula. There is great variety in the methods and sources used to recruit, maintain and update vocational skills. The picture which emerges from this typology is a highly adaptive training system. The key features of the typology include:

- A standard model is identified where new entrants or existing workers receive their vocational qualifications by participating in courses of study developed for a general industry based on national training packages with the course conducted in a TAFE institution.
- In the second model firms seek to have externally provided and recognised courses and qualifications, but significantly modify the content, assessment and delivery methods.
- The firm relies on an external provider for the basic entry qualification, but this is supplemented concurrently with extensive in-house provision.
- In the fourth model some firms provide extensive in-house training provision, although also relying on the domestic VET system for specialist assistance.
- Some firms require recruits to have VET or university qualifications, but these are regarded essentially as a screening device to demonstrate interest in and aptitude for the type of work to be undertaken. For a variety of reasons these firms supply extensive post-recruitment, in-house training, although this is not closely integrated with the wider VET system.

In addition, within the case studies there were three distinct patterns in the recruitment of persons for VET occupations. These recruitment patterns are:

- Entry-level training is supplied concurrently with employment upon entry to the firm.
- Persons are recruited having completed the necessary entry-level qualifications, although support was provided for further qualifications upgrading.
- Some firms combined both approaches to recruitment and training.

These differences in recruitment and training patterns largely reflected differences in the availability of an external labour market with a sufficient number of skilled and qualified persons. Where this external labour market did not exist, say for companies introducing firm-specific technologies that are novel within Australia, recruitment and training are necessarily supplied concurrently.

What are the strengths and weaknesses of VET provision within Australia's innovation-intensive industries?

The case studies revealed, overall, a high level of satisfaction with the public and private VET system. Staff interviewed for the case studies all commented very positively on training provided by TAFE, especially in relation to its emphasis on the acquisition of practical skills. A number of firms explicitly contrasted the general and theoretical orientation of university education to the more pragmatic training provided by TAFE. The firms especially valued training with a practical and applied orientation. This form of training was valued because it reduced the amount of on-the-job training required for employees to become productive. Firms also commented positively on the linking of off-the-job training with on-the-job work experience, allowing students to apply their knowledge.

An important implication of this finding is that VET training providers must understand their competitive strengths and avoid the siren song of converting polytechnics into quasi-universities. This, of course, is not to argue against the role of TAFE in the provision of higher-level theoretical skills, especially in fields of rapid technical advancement which require these skills. Rather, the issue is to ensure an appropriate balance of practical and theoretical skills. Close collaboration and consultation with industry partners is the best method to ensure this balance.

An obvious, although nevertheless key, finding was the importance of consultation. It is concluded that the satisfaction expressed by firms regarding TAFE training was due to the high level of consultation between the firms and TAFE. Consultation is intended to ensure that the training offered meets the firms' needs.

This consultation takes two forms. In the first instance, the firms were actively involved, either directly with TAFE or indirectly through industry training advisory boards (ITABs), in the design of national training packages. These packages are intended to provide industry-specific training linked to various levels of the Australian Qualifications Framework. The second form of consultation involves direct contact between the firm and the TAFE teachers who are going to deliver the training. In this case industry training packages are modified to the particular needs of the firm, or indeed new curricula are developed. The majority of firms engage in this second form of consultation. Importantly, however, where these modifications occur, the new training packages are consistent with national standards, so that training based on these packages results in nationally recognised qualifications.

It must be recognised, however, that a crucial basis for the generally high level of satisfaction and high level of consultation is the large size of the case study firms. The scale of training sought by the firms made it economically feasible for TAFE and other providers to customise course content, assessment and delivery. The scale of training also made it feasible for the VET providers to invest in staff development. This was the case, for example, with the Visy Pulp and Paper Mill where TAFE teachers needed to become familiar with the world's most advanced pulp and paper technologies, and with Getronics which offers placements to TAFE teachers to upgrade their computer skills.

The introduction of a more competitive training regime, in which TAFE must contest for public and private funds, is an important consideration in the responsiveness of both TAFE and private providers.

The importance of the size of the training market, within the firm, cluster of firms, region or industry in engendering responsiveness and customisation, has been recognised in other studies of VET and innovative industries. Trood's (2002) detailed study of the photonics industry identified a range of problems confronting newly established innovative industries in accessing suitable vocational training. These problems range from the obvious issues of a lack of suitable teachers, curricula and training materials, to systemic problems such as the new technology requiring teaching skills which range over several different TAFE divisions. In some cases these divisions are resistant to inter-divisional cooperation. (The strength of these difficulties varies across the states reflecting differences in TAFE structures.)

All of the case study firms emphasised the need for employees to develop behavioural skills such as effective team work and to develop problem-solving and communication skills, including improved literacy, numeracy and information technology skills. In turn, the demand for these behavioural and communication skills resulted from:

- the demands of formal quality systems
- the automation of production requiring operators to have a higher-level conceptual understanding of production processes

- work organisation change leading to flatter management structures and devolution of responsibility to supervisors and operators
- the expectation that employees contribute to product and process improvement through various consultative mechanisms.

These are skills required of both new entrants and existing workers, and appear to be acquired almost entirely on the job. Other studies have also identified the importance of these so-called 'behavioural skills' and the need for their incorporation into formal entry-level vocational training (Smith et al. 1995, p.7; Australian Industry Group 2000, p.xi; Dumbrell, de Montfort & Finnegan 2002, pp.22–3).

A considerable amount of post-entry-level training was provided, mostly in the form of short courses, typically with a duration not exceeding two to three days. The case studies and survey data indicate that a wide variety of training providers were used for this post-entry-level training. In approximate order of importance, they included: equipment and other input suppliers; in-house training; private providers; and TAFE. A high level of satisfaction was expressed by the case study interviewees regarding the quality, cost and flexibility of the training supplied by all of these providers. Firms sought flexibility in training arrangements for this post-entry-level training, especially the capacity for on-the-job delivery and customisation of training to conform to firm-specific operating procedures and equipment. On the basis of these case studies, this flexibility was provided to them.

In contrast, one of the case study firms in the information technology industry was heavily reliant on extensive post-entry-level training occurring over weeks or months. Equipment or software vendors supplied this training. The inability or unwillingness of TAFE and universities to supply vendor-licensed and certified training, such as the Microsoft Computer Systems Engineer, may be a cause for concern as it restricts the range of suppliers. The very high cost of this training from private providers, in excess of $10 000 for courses of a few months' duration, may raise equity concerns. On the other hand, anecdotal reports are that TAFE and universities do not see it as their legitimate role to provide this form of training. This study was able to identify, if not resolve, this issue. Further work is warranted on this matter.

In most cases, vendor-supplied and short private provider courses do not lead to recognised qualifications or have standing for external skill recognition. Some have argued for the incorporation of these courses into the Australian Qualifications Framework system (Smith et al. 1995, p.8). Given the considerable list of costs and benefits which can be arrayed for and against this proposition, it is perhaps best to leave the decision to pursue accreditation to the suppliers of such training. The national training authorities could, however, market to training suppliers the competitive benefits of seeking accreditation for their courses.

Finally, while larger innovation-intensive firms have the financial capacity and willingness to invest in structured training, other sectors have significantly reduced their VET investments. For example, over the last ten years there has been a 40% reduction in the number of metal and electrical apprentices across Australia (Toner 2002). This has contributed significantly to skill shortages in occupations, which are critical, for example, to success in exports markets and competing against imports of manufactured products. This is a concern given, that to be competitive, innovation-intensive sectors depend on efficient and technically flexible suppliers of components and services from all sectors. A number of recent reports have suggested means to redress these skills shortages, such as:

- improved marketing
- differential government financial incentives for training in occupations experiencing skill shortages
- re-introducing pre-apprenticeship programs

- improving the quality of services provided by group training companies (Australian Centre for Industrial Relations Research and Training 2002; Australian Expert Group in Industry Studies 2002; Toner 2003).

Without the presence of these clusters of high-quality and technically agile smaller supplier firms, the survival of larger innovation-intensive firms is imperilled.

References

ABS (Australian Bureau of Statistics) 1993, *Australian and New Zealand standard industrial classification,* 2nd edition, cat. no.1292.0, ABS, Canberra.

—— 1995, *Innovation in selected Australian industries 1994*, cat. no.8118.0, ABS, Canberra.

—— 1996, *Employer training expenditure July to September 1996,* cat. no.6353.0, ABS, Canberra.

—— 1996–2001, *Business operations and industry performance,* cat. no.8140.0, various issues, ABS, Canberra.

—— 1997a, *Innovation in Australian manufacturing 1996–97*, cat. no. 8116.0, ABS, Canberra.

—— 1997b, *Innovation in mining 1996–97*, cat. no.8116.0, ABS, Canberra.

—— 1997c, *National income, expenditure and product 1996–97*, cat. no.5206.0, ABS, Canberra.

—— 1997d, *Employer training practices, Australia,* cat. no.6356.0, ABS, Canberra.

—— 2000, *Research & experimental development: All sector summary,* cat. no.8112.0, ABS, Canberra.

—— 2001a, *Education and training experience Australia,* cat. no.6278.0, ABS, Canberra.

—— 2001b, *Education and work,* cat. no.6227.0, ABS, Canberra.

—— 2001c, *Australian system of national accounts*, cat. no.5204.0, ABS, Canberra.

Adler, P S (ed.) 1992, T*echnology and the future of work*, Oxford University Press, New York.

ANTA (Australian National Training Authority) 1998, *Impact of the growth of labour hire companies on the apprenticeship system*, ANTA, Brisbane.

Australian Centre for Industrial Relations Research and Training (ACIRRT) 1999, *Australia at work, just managing?,* Prentice Hall, Melbourne.

—— 2002, *Renewing the capacity for skill formation: The challenge for Victorian manufacturing,* report for the Victorian Learning, Employment and Skills Committee/Manufacturing Industry Consultative Committee, Melbourne.

Australian Expert Group in Industry Studies (AEGIS) 1999a, *Innovation in the furnishings product system*, AEGIS, Sydney.

——1999b, *Mapping the building and construction product system in Australia*, Department of Industry, Science and Technology, Canberra.

—— 2002, *The emerging training needs of the NSW manufacturing and engineering sector,* NSW TAFE Commission Board, Sydney.

Australian Expert Group in Industry Studies & Australian Business Foundation 2001, *Selling solutions: Emerging patterns of product-service linkage in the Australian economy,* ABF, Sydney.

Australian Industry Group (AIG) 1999, *Training to compete: The training needs of industry,* AIG, Sydney.

Ball, M 1988, *Rebuilding construction: Economic change and the British construction industry*, Routledge, London.

Black, S & Lynch, L 1997, *How to compete: The impact of workplace practices and information technology on productivity*, NBER (National Bureau of Economic Research) working paper 6120 (August), pp.1–39.

Booth, A & Snower D 1996, *Acquiring skills: Market failures, their symptoms and policy responses*, Cambridge University Press, Cambridge.

Braverman, H 1974, *Labour and monopoly capital*, Monthly Review Press, New York.

Campbell, A 1991, 'Issues of training strategy in British manufacturing', in *Training and competitiveness*, eds J Stevens and R Mackay, Kogan Page Ltd., London, pp.150–67.

Campbell, I 2000, 'The spreading net: Age and gender in the process of casualisation in Australia', *Journal of Australian Political Economy,* no.45, pp.68–98.

Cantwell, J 1999, 'Innovation as the principal source of growth in the global economy', in *Innovation policy in a global economy*, by D Archibuigi, J Howells & J Michie, Cambridge University Press, Cambridge, pp.225–41.

Cole, R E 1992, 'Issues in skill formation in Japanese approaches to automation', in *Technology and the future of work*, ed. P Adler, Oxford University Press, New York, pp.187–209.

Construction Training Australia 1999, *Building and construction workforce 2005: Strategic initiatives*, Construction Training Australia, Melbourne.

Crouch, C, Finegold, D & Sako, M 1999, *Are skills the answer? The political economy of skill creation in advanced industrial countries*, Oxford University Press, Oxford.

Cully, M 1999, 'A more or less skilled workforce? Changes in the occupational composition of employment, 1993–1999', *Australian Bulletin of Labour*, vol.25, no.2, pp.96–104.

Curtain, R 1987, 'Skill formation and the enterprise', *Labour and Industry*, vol.1, no.1, October, pp.8–38.

Curtain, R 1994, 'Skill formation in Japan: The broader context and recent developments', *Labour and Industry*, vol.6, no.1, November, pp.66–88.
Cutler, T 1992, 'Vocational training and British economic performance: A further instalment of the "British labour problem"', *Work, Employment and Society*, vol.6, no.2, pp.161–83.
Denniss, R & Toner, P 1999, 'On the wrong track? An analysis of the suitability of contracting-out for rail track maintenance', *Economic Analysis and Policy*, vol.29, no.2, September, pp.117–31.
Department of Industry, Science and Technology 1990, *Strategic alliances in the internationalisation of Australian industry*, AGPS, Canberra.
—— 1996, *Australian business innovation: A strategic analysis*, AGPS, Canberra.
—— 1999, *Shaping Australia's future, innovation: Framework paper*, AGPS, Canberra.
Department of Trade and Industry 1998, *Our competitive future,* white paper on competitiveness, HMSO, London.
Dockery, A , Koshy, P & Stromback, T 1996, *The cost to employers of apprenticeship training in Australia*, Centre for Labour Market Research, Curtin University of Technology, Perth.
Dore, R 1973, *British factory–Japanese factory: The origins of national diversity in industrial relations*, Allen & Unwin, London.
Dumbrell, T, de Montfort, R & Finnegan, W 2002, *New skills in process manufacturing*, NCVER, Adelaide.
Eatwell, J 1982, *Whatever happened to Britain? The economics of decline*, Duckworth, London.
Elbaum, B 1991, 'The persistence of apprenticeship in Britain and its decline in the United States', in *Industrial training and technological innovation*, ed. H Gospel, Routledge, London and New York, pp.194–212.
Estevez-Abe, M, Iversen, T & Soskice, D 2001, 'Social protection and the formation of skills: A reinterpretation of the welfare', in *Varieties of capitalism: Institutional foundations of comparative advantage*, eds P Hall & D Soskice, Oxford University Press, Oxford.
Fagerberg, J 2001, 'Technology and the wealth of nations: A critical essay on economic growth theory', presented at the conference, *The future of innovation studies,* Eindhoven University of Technology, The Netherlands, September.
Ferrier, F, Trood, C & Whittingham, K 2001, *Going boldly into the future: A VET journey into the national innovation system,* NCVER, Adelaide.
Finegold, D & Soskice, D 1988, 'The future of training in Britain: An analysis and prescription', *Oxford Review and Economic Policy*, vol.4, no.3, pp.21–53.
Gann, D & Senker, P 1998, 'Construction skills training for the next millennium', *Construction Management and Economics,* February, vol.16, pp.11–25.
Gospel, H (ed.) 1991, *Industrial training and technological innovation*, Routledge, London and New York.
—— 1994a, 'The survival of apprenticeship training in Australia', *Journal of Industrial Relations,* March, pp.37–56.
—— 1994b, 'The decline of apprentice training in Britain', discussion paper no. 189, Centre for Economic Performance, University of London, London.
Gospel, H & Okayama, R 1991, 'Industrial training in Britain and Japan', in *Industrial training and technological innovation*, ed. H Gospel, Routledge, London and New York, pp.13–37.
Gregory, R 1993, 'Aspects of Australian and US living standards: The disappointing decades 1970–1990', *Economic Record,* March, pp.61–76.
Guerrieri, P 1999, 'Patterns of national specialisation in the global competitive environment', in *Innovation policy in a global economy*, by D Archibuigi, J Howells & J Michie, Cambridge University Press, Cambridge, pp.94–119.
Hall, P & Soskice, D 2001, *Varieties of capitalism: Institutional foundations of comparative advantage*, Oxford University Press, Oxford.
Hall, R & Bretherton, T 1999, *'It's not my problem': The growth of non-standard work and its impact on vocational education and training in Australia*, NCVER, Adelaide.
Harrison, B 1997, *Lean and mean: The changing landscape of corporate power in the age of flexibility*, Guildford Press, New York.
Industry Commission & the Department of Industry, Science and Technology 1997, *A portrait of Australian business: Results of the business longitudinal survey,* AGPS, Canberra.
Kaldor, N 1972, 'The irrelevance of equilibrium economics', *Economic Journal*, vol.LXXXII, December, pp.1237–55.
—— 1985, *Economics without equilibrium*, ME Sharpe Inc., New York.
Keep, E & Mayhew, K 1999, 'The assessment: Knowledge, skills and competitiveness', *Oxford Review of Economic Policy*, vol.15, no.1.
Kersley, B & Martin, C 1997, 'Productivity growth, participation and communication', *Scottish Journal of Political Economy*, vol.44, no.5, pp.485–501.
Koike, K 1988, 'Human resource development and labor-management relations', in *The political economy of Japan: Volume 1: The domestic transformation*, K Yamamura & Y Yasuba, Stanford University Press, Stanford, California, pp.289–330.
Landes, D 1972, *Prometheus unbound*, Cambridge University Press, Cambridge.

Laplagne, P & Bensted, L 1999, *The role of training and innovation in workplace performance,* staff research paper, Productivity Commission, Canberra.

Maglen, L 2001, 'Australian's working in a global economy and what this means for education and training', Centre for the Economics of Education and Training', working paper no.39, Monash University, Melbourne.

Maglen, L & Hopkins, S 1998, 'Linking VET to productivity differences: An evaluation of the Prais Program, and its implications for Australia', working paper no. 18, Centre for the Economics of Education and Training, Monash University, Melbourne.

Marceau, J, Manley, K & Sicklen, D 1997, *The high road or the low road? Alternatives for Australia's future*, Australian Business Foundation, Sydney.

Marshman and Associates 1996, *The employment of apprentices: The barriers*, ANTA, Brisbane.

Marx, K 1867, C*apital: A critique of political economy,* vol. 1, International Publishers, New York.

Mason, G, Van Ark, B & Wagner, K 1996, 'Workforce skills, product quality and economic performance', in *Acquiring skills: Market failures, their symptoms and policy responses*, eds A L Booth & D J Snower, Cambridge University Press, Cambridge, pp.175–93.

NCVER (National Centre for Vocational Education Research) 2002, *Issues affecting skill demand and supply in Australia's education and training sector,* NCVER, Adelaide.

OECD (Organisation for Economic Co-operation and Development) 1994, *The measurement of scientific and technical activities,* OECD, Paris.

—— 1996, *Employment and growth in the knowledge economy*, OECD, Paris.

—— 1997, *Proposed guidelines for collecting and interpreting technological innovation data*, OECD, Paris.

Oulton, N 1996, 'Workforce skills and export competitiveness', in *Acquiring skills: Market failures, their symptoms and policy responses*, eds A Booth & D Snower, Cambridge University Press, Cambridge, pp.190–230.

Pavitt, K & Patel, P 1999, 'Global corporations and national systems of innovation', in *Innovation policy in a global economy*, by D Archibuigi, J Howells & J Michie, Cambridge University press, Cambridge, pp.94–119

Porter, M 1985, *Competitive advantage*, The Free Press, New York.

—— 1990, *The competitive advantage of nations*, Macmillan, New York.

—— 1992, *Capital choices: Changing the way America invests in business*, Council on Competitiveness, Washington, DC.

Prais, S 1995, *Productivity, education and training: An international perspective*, National Institute of Economic and Social Research, occasional papers XLVII, Cambridge University Press, Cambridge.

Rainbird, H 1991, 'Labour force fragmentation and skills supply in the British construction industry', in *Restructuring a traditional industry: Construction employment and skills in Europe*, eds H Rainbird & G Syben, Berg Publishers Ltd, Oxford, pp.201–40.

Reich, R 1991, *The work of nations*, Simon & Schuster, London.

Ridoutt, L, Dutneall, R, Hummel, K & Selby Smith, C 2002, *Factors influencing the implementation of training and learning in the workplace*, NCVER, Adelaide.

Rogers, M 2000, *Understanding innovative firms: An empirical analysis of the GAPS,* Melbourne Institute working paper no.8/2000, Melbourne.

Rosenberg, N 1982, *Exploring the black box: Technology and economics*, Cambridge University Press, Cambridge.

Sako, M 1996, 'Suppliers associations in the Japanese automobile industry: Collective action for technology diffusion', *Cambridge Journal of Economics*, vol.20, pp.651–71.

Senker, J 1988, *A taste for innovation: British supermarkets' influence on food manufacturers*, Bradford Horton Publishing, United Kingdom.

Sheehan, P, Pappas, N & Cheng, E 1994, *The rebirth of Australian industry: Australian trade in elaborately transformed manufacturers,* Centre for Strategic Economic Studies, Victoria University Press, Melbourne.

Sheehan, P, Pappas, N, Tikhomirova, G & Sinclair, P 1995, *Australia and the knowledge economy*, Centre for Strategic Economic Studies, Victoria University Press, Melbourne.

Smith, A 1776, *An inquiry into the nature and causes of the wealth of nations*, eds R H Campbell, A S Skinner & W Todd, Clarendon Press, Oxford, 1976.

Smith, A, Oczkowski, E, Noble, C & Macklin, R 2002, *New management practices and enterprise training*, NCVER, Adelaide.

Smith, A, Roberts, P, Noble, C, Hayton, G & Thorne, E 1995, *Enterprise training: The factors that affect demand*, Office of Training and Further Education, Melbourne and ANTA, Brisbane.

Smith, K 2000, 'What is the "knowledge economy"? Knowledge-intensive industries and distributed knowledge bases', DRUID Summer Conference on the Learning Economy—Firms, Regions and Nation Specific Institutions, 15–17 June, Copenhagen.

Snower, D J & Booth, A L 1996, 'Conclusions: Government policies to promote the acquisition of skills', in *Acquiring skills: Market failures, their symptoms and policy responses*, eds A L Booth & D J Snower, Cambridge University Press, Cambridge, pp.335–49

Solow, R 1956, 'A contribution to the theory of economic growth', *Quarterly Journal of Economics*, vol.LXX, February, pp.65–94.

Stevens, J & Mackay, R (eds) 1991, *Training and competitiveness*, Kogan Page, London.

Toner, P 1998, 'Trends in NSW Government apprenticeship intake: Causes and implications', *Australian Bulletin of Labour,* vol.24, no.2, June, pp.141–57.

—— 1999a, 'Appendix II: A statistical summary of the building and construction industries' in Australian Expert Group in Industry Studies, *Mapping the building and construction product system in Australia*, Department of Industry, Science and Technology, Canberra.

—— 1999b, *Main currents in cumulative causation: The dynamics of growth and development*, Macmillan, London.

—— 2000a, 'Manufacturing industry in the Australian economy: Its role and significance', *Journal of Australian Political Economy,* vol.45, June, pp.18–45.

—— 2000b, 'Changes in industrial structure in the Australian construction industry: Causes and implications', *Economic and Labour Relations Review,* vol.11, no.2, December, pp.291–307.

—— 2000c, 'Trade apprenticeships in the Australian construction industry', *Labour and Industry*, vol.11, no.2, December, pp.39–58.

—— 2002, 'The occupational and skill structure of new apprenticeships: A commentary', *Labour and Industry*, vol.13, no.1, August, pp.55–72.

—— 2003, 'Supply-side and demand-side explanations of declining apprentice training rates', *Journal of Industrial Relations,* vol.45, no.4, December, pp.457–84.

Toner, P & Wixted, B 2002, *The emerging training needs of the NSW manufacturing and engineering sector,* New South Wales TAFE Commission Board, Sydney.

Toner, P, Green, R, Croce, N & Mills, B 2000, 'No case to answer: Productivity performance of the Australian construction industry', *Economic and Labour Relations Review*, vol.12, no.1, June, pp.104–25.

Trood, C 2002, 'The national innovation system, technology transfer and VET: Who's playing?', Co-operative Research Centre Education Workshop, May, Sydney.

VandenHeuval, A & Wooden, M 1999, *Casualisation and outsourcing: Trends and implications for work related training*, NCVER, Adelaide.

von Hippel, E 1988, *The sources of innovation*, Oxford University Press, New York.

Wagner, K 1991, 'Training efforts and industrial efficiency in West Germany', in *Training and competitiveness*, eds J Stevens & R Mackay, Kogan Page, London, pp.132–49.

Wood, A 1994, *North–south trade, employment and inequity: Changing fortunes in a skill-driven world*, Oxford University Press, Oxford.

Wooden, M 1996a, 'Firm size and the provision of training: An analysis of the 1993 survey of training and education', *Australian and New Zealand Journal of Vocational Education*, vol.4, no.3, pp.89–120.

Wooden, M 1996b, *The experience of immigrants in work-related training*, National Institute of Labour Studies, Adelaide.