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RESEARCH PAPER

Vocational education and training: the *terra incognita* of innovation policy

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Is what is known from research on systemic innovation reflected in innovation policy, both as guiding principles and as actions? This paper highlights a major paradox in the translation of research on innovation into innovation policy in Australia. The innovation studies literature has established the central role of the vocational education and training (VET) system and VET-trained workers in technology generation, diffusion and incremental innovation. Research has also established that the pattern of innovation in Australia, compared with that in many other OECD countries, makes firms more reliant on VET skills to implement innovation. Despite this recognition in the innovation literature, this paper argues that the VET system is largely excluded from government innovation policy and programmes in Australia. Evidence for this exclusion is derived from a textual analysis of the principal Australian government policy statements and government-sponsored studies of the Australian innovation system, and from an analysis of the interest groups represented on government innovation advisory and policy structures. Tentative explanations are advanced for this exclusion and a number of important benefits are identified for the VET system and the wider innovation system arising from closer integration of VET into innovation policy

Introduction

Research into the drivers of innovation and economic development has demonstrated the importance of workforce skills and workplace learning in incremental innovation (Bessant, 2003). A central role in the formation of these skills and facilitating learning and innovation has been identified for vocational education and training (VET) systems (Tether *et al*., 2005; Edquist, 2005). Differences in the share and type of VET workforce skills across nations have also been shown to influence the dominant type of innovation (incremental *vs*. radical), the industrial structure (Hall and Soskice, 2001) and even the pattern of exports and imports (Oulton, 1996). The purpose of this paper is to argue that, despite the weight of academic evidence from the innovation studies discipline, the VET system is almost entirely excluded from Australian government innovation policy. Empirical data for this contention are drawn from a textual analysis of federal government innovation policy statements, government-sponsored reviews of the Australian innovation system, and from charting the membership of key government innovation policy advisory

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structures. It is further argued that this exclusion matters for the performance of the VET system and wider Australian innovation system. Greater formal recognition of the role of the VET system in innovation could arguably assist in addressing persistent deficiencies in the capacity of firms to innovate and in the VET system to meet the needs of industry. These deficiencies are enduring vocational skill shortages in innovation-intensive sectors and constraints on the ability of VET colleges to keep up to date with new technology.

The article is structured as follows. We briefly describe the Australian VET system before providing a short summary of the key evidence and arguments regarding the role of the VET system and the VET-trained workforce in innovation. Evidence is given of the low recognition of VET in innovation policy. We suggest a number of tentative reasons for this exclusion and argue that this lack of recognition matters, both for the performance of VET and for the broader innovation system.

The Australian VET system

The purpose of this section is to indicate briefly the scope and significance of the VET system in delivering workforce skills to the Australian innovation system. There is not the space, nor is it necessary, to detail key features, such as its history (Goozee, 2001), comparison with other national VET systems (Bosch and Charest, 2010) and evolution of the apprenticeship system (Knight, 2012).

The Australian VET system is a critical element in the post-school education and training system. Post-school education in Australia is essentially a binary system comprising a degree-granting university sector and a VET sector. The Australian VET system is remarkably diverse in terms of the characteristics of students and the range of subjects delivered and occupations receiving training. This training is directed primarily at new entrants to the workforce (such as apprentices in trade occupations) and employed workers seeking to upgrade their qualifications. The Australian VET system provides the bulk of post-school training for the workforce, with VET qualifications (such as certificates and diplomas) accounting for 56% of total post-school qualifications of employed persons [derived from Australian Bureau of Statistics (2011a, Table 10)]. In any given year, 12% of the total workforce is enrolled in a VET course (Skills Australia 2010: 26). The VET system also provides an important pathway into the university sector with around 10% of all university enrolments admitted on the basis of a VET qualification. Interestingly, around 10% of all persons enrolling in a VET course already possess a university degree (Curtis, 2009, p.4). These graduates enrol in VET courses to improve specific skills in fields such as ICT or management. It is unsurprising that the VET system is the prime source of post-school training in occupation categories such as tradespeople and technicians, accounting for 90% of post-school qualifications held by such workers. However, they are also important for professionals and managers, accounting for 20% and 51%, respectively, of total highest post-school qualifications held by these occupational groups [derived from Australian Bureau of Statistics (2011a, Table 11)].

Since their inception, VET institutions in Australia have had the central objective of imparting skills and knowledge to new workforce entrants and to existing workers through teaching. That is, the role of the VET system in Australia is primarily one of technology diffusion. This diffusion 'involves the dissemination of technical information and know-how and the subsequent adoption of new technologies and techniques by users. … In many cases, diffused technologies are neither new nor necessarily advanced, although they are often new to the user' (Shapira and Rosenfeld, 1996, p.1). The VET system plays a critical role in raising the absorptive capacity of the workforce by imparting practical skills and underpinning knowledge (Cohen and Levinthal, 1990). Pickersgill (2005, p.7) argues that the 'Australian system of innovation fits the pattern of incremental innovation and diffusion of technical knowledge. Historically, from colonial times to the advent of the present national system, the technical education and training institutions … have functioned to support this process'.

That VET-trained workers, notably tradespeople and technicians, perform an important role in the Australian innovation system is also captured in the official definition of these occupations. According to the *Australian and New Zealand Standard Classification of Occupations* (ANZSCO) (Australian Bureau of Statistics, 2006, p.335), 'Technicians and Trades workers perform a variety of skilled tasks, applying broad or in-depth technical, and trade or industry specific knowledge, often in support of scientific, engineering, building and manufacturing activities'. ANZSCO uses a range of verbs to describe the primary function of these occupations – to design, install, commission, adapt, operate and maintain equipment, software and other technologies. The role of VET differs from other elements in the Australian innovation system. Universities and public sector research agencies, for example, typically have a dual function of knowledge creation through research and knowledge diffusion through teaching and/or consulting to business (Marceau, 2007; Group of Eight, 2011).

VET and innovation

Evidence for the important role of VET-trained workers and VET systems in innovation is provided in extensive reviews, so only a brief account of the key approaches and findings is given here (Crouch *et al*., 1999; Brown, *et al*., 2001; Tether *et al*., 2005; Toner, 2007, 2011). The important role of artisans and technicians in technical change has long been recognised by historians of the industrial revolution. They have documented the significant contribution of the artisan to technological progress, made primarily through learning by doing and using in the production of improved capital goods (Lazonick, 2006, p.36). Landes (1972, p.345) emphasises the 'thousands of nameless mechanics who suggested and effected the kind of small improvements to machines and furnaces and tools that add up eventually to an industrial revolution'. Similarly, historians of the first scientific revolution have established the strong complementarity between the artisan and scientist, founded on an intellectual and manual division of labour in the innovation process (Mokyr, 2003, p.65). Hall (1994) specifies these complementarities as the accumulation of technological information, existence of practical problems that were open to scientific study, and the adaptation by science of techniques, apparatus and materials from craft-based manufacturing. More recently, Gay (2008), looking at English Victorian science, has demonstrated the dependence of scientists on people who worked in the skilled trades.

Contemporary innovation studies examine the effect of differences across nations in the quantity and quality of vocational education and training (VET) systems and the VET-trained workforce on the capacity of firms to innovate and compete (Streeck, 1989; Hall and Soskice, 2001; Thelen, 2004). They argue for the central role of skilled VET occupations, such as tradespersons and technicians, in incremental innovation in the production process. The ‘cumulative productivity impact of small incremental changes that are usually undertaken on the shop floor can be much greater than the initial introduction of a major technology’ (Dahlman and Nelson, 1995, p.95). So-called ‘matched plants’ studies have examined a great variety of industries, including metal product, clothing, kitchen cabinet manufacture, biscuit making and services, such as hotels (Prais, 1995); food processing (Mason *et al*., 1996); surgical instrument manufacture (Anderton and Schultz, 1999); residential construction (Clarke and Wall, 2000; Clarke and Hermann, 2004); and heating and air-conditioning installation (King, 2001). Large disparities across nations in production methods, quality, productivity and scope for product, service and process innovation have been revealed, and these have been plausibly attributed, in large part, to differences in workforce skills. More skilled and knowledgeable workers were found to be more adaptable in the introduction of new products, processes and services; to have greater facility in continuous improvement programmes because of their deeper understanding of production processes; and to have an enhanced ability to converse with plant engineers to make suggestions and effect changes.

At its most fundamental, the supply of higher level and quality VET skills is influential in determining not only what goods and services are produced in a national economy, but also how they are produced. ‘Firms’ product market choices are constrained by the availability of necessary skills’ (Estevez-Abe *et al*., 2001, pp.38–39). Emphasising this fact, studies show a correlation between the structure of a nation’s VET system and its pattern of exports and imports (Oulton, 1996; Crouch *et al*., 1999). A nation’s trade structure has a logical, if probably convoluted, relationship with the ability of its firms to undertake certain kinds of innovation. These studies show that countries with an above-average proportion of skilled vocational workers in their workforce, such as Germany and Japan, have a strong trade performance in products that intensively use these intermediate skills. By contrast, countries with a smaller workforce proportion of skilled VET qualifications, such as the United States and the United Kingdom, are more specialised in low skilled, undifferentiated products and high-skill intensive exports.

Skilled VET occupations are important, not only in direct production, but also in R&D. Official surveys reveal that tradespersons and non-university trained technicians constitute a large share of the R&D workforce in OECD nations. Such workers comprise, for example, 43% and 46% respectively of the total German and Swiss R&D labour force. They comprise 57% of the total Italian business R&D labour force (OECD, 2009). They comprise around 45% of the Australian R&D workforce employed by business (Australian Bureau of Statistics, 2011b). A large-scale study of Australian private and public enterprises conducting R&D found a distinct complementarity between the roles of tradespeople and technicians and scientists and engineers. Research managers overwhelmingly regarded the contribution of tradespeople and technicians to R&D as important (Toner *et al*., 2010). Similarly, Herrmann and Peine’s (2011) study of R&D in pharmaceutical firms across Europe found that both general and specific skills are required for radical and incremental product innovation in R&D. Specific skills ‘are taught through apprenticeships or similar vocational training programmes’; general skills denote primarily university-trained scientists (Herrmann and Peine, 2011, p.691). Further, the study found that:

> … interaction between a firm's scientists and its non-scientific employees seems to be a vital source of ideas for incremental or, respectively, radical product innovations … [and] that the combination of employee skills and scientific knowledge seems to facilitate different [innovation] strategies not in an additive but in a multiplicative manner. (Herrmann and Peine, 2011, p.698)

Indeed, such interaction was deliberately promoted by human resource practices.

Analysing VET in Australian innovation policy

Given these well-established findings on the role of VET in the innovation studies literature, a reasonable expectation is that they would be recognised in Australian innovation policy. Two metrics were employed to investigate the presence of VET in Australian federal government innovation policy. These were an analysis of VET in the principal government innovation policy documents, including reviews of the Australian innovation system, and the representation of VET on government innovation advisory bodies. To ensure the policy statements were representative, major policy documents from 2001 to 2011 were examined. This 11-year period covers periods of both conservative (Liberal–National party coalition) and Labor governments.[1] The major reports on Australia's innovation system were examined for references to 'vocational education and training', 'vocational', 'VET', 'technical and further education' ('TAFE'), 'craft', 'technician' and other related terms. Where the VET system is included in these reports, we further studied their content to identify the specific role assigned to VET in the national innovation system (NIS) and its importance in the NIS. In addition, it was also determined whether any specific policy measures were addressed to the VET system to improve its performance in the NIS. These archival data provide an understanding of what government considers the central constituents of the Australian NIS and the key actors involved in innovation policy formation.

Federal government innovation system reports

Backing Australia's Ability: An Innovation Action Plan for the Future (2001)

The purpose of this report was to set out 'the government's strategy to encourage and support innovation and enhance Australia's international competiveness, economic prosperity and social wellbeing' (Australian Government, 2001, p.7). The premise of the report was that 'innovation-developing skills, generating new ideas through research, and turning them into "commercial success" is key to Australia's future prosperity' (Australian Government, 2001, p.7). The importance of education to innovation was repeated a number of times, especially the importance of science and research training. There was no mention of VET.

Mapping Australia's Science and Innovation (2003)

The purpose of the encyclopaedic *Mapping Australia's Science and Innovation* was to 'present a detailed overview of our science and innovation system in Australia' [Department of Education, Science and Training (DEST), 2003, p.i]. Importantly, the VET sector receives recognition as an element in the supply of skills for innovation (DEST, 2003, p.240). Along with schools and higher education, vocational education and training plays the main role in building foundation knowledge and skills. However, aside from this, there is no further analysis of its role in innovation, nor is VET referred to in the key findings or recommendations. A later partial update of this study was provided in *The Australian Science and Innovation System: A Statistical Snapshot 2005*. It aimed 'to present the most recently available statistical data relating to the structure, trends and performance of the Australian science and innovation system' (DEST, 2005, p.ii). There is no mention of the VET sector in its 321 pages.

Public Support for Science and Innovation (2007)

This comprehensive analysis was conducted by the Productivity Commission, the Australian government's chief economic research agency. The Productivity Commission was asked to 'identify impediments to the effective functioning of Australia's innovation system including knowledge transfer, technology acquisition and transfer, skills development, commercialisation, collaboration between research organisations and industry, and the creation and use of intellectual property, and identify any scope for improvements' (Productivity Commission, 2007, p.vi). The issues of skills development and knowledge transfer are central to education and training, including VET. However, neither the VET system nor VET occupations are mentioned throughout the 830-page report. Interestingly, the exclusion of VET is mirrored in almost no discussion of university education. In the extensive discussion of universities, the focus was on their research function. The report adopted essentially the linear model, in which innovation is assumed to proceed from basic scientific research to applied research and then to production and diffusion (Godin, 2005).

Venturous Australia. Building Strength in Innovation (2008)

Upon coming into government at a national level in 2007, the new Labor government undertook a number of reviews of industry policy and the Australian NIS. *Venturous Australia* is also referred to as the Cutler Review, after the review chairman (Cutler, 2008). It states that the 'most fundamental drivers of innovation are the skills, knowledge and attitudes of the workforce' (Cutler, 2008, p.5). More specifically, it notes that the 'role of crafts and trades in innovation has been massively neglected, particularly in the important areas of continuing incremental innovation in the workplace' (Cutler, 2008, p.48). Despite this strong endorsement of skills development generally and the specific role of certain vocational occupations, the report made no further observations or recommendations regarding the VET system. It simply noted that 'building high quality human capital requires attention at all levels of education: from early childhood education and schooling, through vocational education and training and higher education, and into the workplace' (Cutler, 2008, p.xi). It could be observed that the Cutler Review did not expand on education and training issues because a separate *Review of Australian Higher Education* (2008), known as the Bradley Review, was being conducted in parallel [Department of Education, Employment and Workplace Relations (DEEWR), 2008]). The Cutler Review (2008, p.47) stated it would be 'careful not to duplicate the work underway in these significant areas of national human capital and education reform processes'. However, while the Bradley Review did make some important recommendations for the funding and governance of the VET system, it was not concerned with the role of VET in the innovation system. Indeed, Bradley was quite explicit on this point, arguing that our universities lie at the heart of the national strategy for research and innovation. Failure of the Cutler Review to address adequately the topic of VET and innovation reflects the tendency towards segmenting innovation into self-contained policy silos, of which the review was itself so critical (Cutler, 2008, p.47).

Powering Ideas. An Innovation Agenda for the 21st Century (2009)

Produced by the Department of Innovation, Industry, Science and Research (DIISR), this review was intended to be a definitive statement of the government's innovation policy, based, as it was, on a synthesis of the general and industry-specific innovation reviews and programme evaluations initiated by the Labor government after it was elected in 2007. It was intended to be the 'policy framework to guide the development of Australia's innovation system over the next ten years' (DIISR, 2009a, p.2). Its purpose was also to evaluate, in summary form, the performance of the Australian innovation system. The VET system and VET occupations were not considered.

Australian Innovation System Report (2011a)

Following the above 2009 report, the government promised to produce 'an annual report on innovation to keep track of the innovation system and measure progress against these priorities and targets' (DIISR, 2011a, p.iii). The second of these reports, which appeared in 2011, is significant as it argues for an important role for vocational education and training in innovation (DIISR, 2011a, p.3). VET is explicitly identified as an 'actor' in its conceptual model of the Australian NIS (DIISR, 2011a, p.36); recent research on the role of VET occupations in Australian R&D laboratories is referenced, and enhanced greater flexibility in the delivery of vocational training is noted (DIISR, 2011a, p.39). However, compared with other components of the NIS, VET is treated in a somewhat unusual manner, in a short discrete section. There are few references to VET elsewhere. It does not appear as a quantified input into the performance of the Australian NIS, unlike the extensive treatment given to research and university funding. Nevertheless, this report is a major advance in terms of the status and recognition afforded to the VET sector in the NIS by the national government.

Research Skills for an Innovative Future. A Research Workforce Strategy to Cover the Decade to 2020 and Beyond (2011b)

The purpose of this review was to set out priorities and programmes to ensure a strong and productive Australian research workforce (DIISR, 2011b, p.viii). Importantly, the review does acknowledge the significant role of VET-trained workers in R&D: 'VET and bachelor-qualified trades and technicians have been and will continue to be fundamental to the ongoing maintenance and operations of the major facilities and infrastructure on which much modern research is grounded' (DIISR, 2011b, p.3). It also noted that limited opportunities for promotion and career progression for these workers in Australian R&D establishments are a significant impediment to retaining them in R&D (DIISR, 2011b, p.27). However, the focus of the study is on postgraduate researchers and all the recommendations to improve the supply of, and demand for, the research workforce relate to their needs.

Analysis of key policy documents has revealed that recognition of the VET system and VET workforce in the Australian NIS is highly variable. Secondly, even when acknowledged to play an important role and a sophisticated understanding of VET is displayed, it is dealt with in isolation from the other elements of the NIS. In other words, policy makers appear to have difficulty integrating VET into the broader policy understanding of the NIS. Finally, in the Australian context, VET is not the subject of specific policy action designed to improve the performance of the NIS.

Board membership of innovation advisory bodies

Another important indicator of the extent of inclusion of the VET system in innovation policy is representation on advisory bodies established by government to provide strategic leadership and co-ordination of innovation policy and programmes in Australia. The premise of this analysis is that representation reflects those whom government considers to be central actors in the NIS. The websites of these advisory bodies were searched to identify the composition and affiliation of each member. An obvious limitation of this method is that some members of these boards could hold multiple memberships; for example, on the innovation council and being on a consultative group for the VET sector. These multiple memberships, however, were not comprehensively indicated on websites. This is especially likely for representatives of unions and employer associations, though neither of these would necessarily be formal VET delegates.[2]

Membership of the three key national innovation advisory bodies was analysed. The Prime Minister's Science, Engineering and Innovation Council (PMSEIC), established in 1997, is the pre-eminent science advisory body to government. The terms of reference for the council include, in part, 'to advise on important issues of science and technology, broadly defined, including issues related to Australia's economy, public good, education, future industries and employment, security, and sustainable development in a modern world' (PMSEIC, 2012). The Co-ordination Committee on Innovation was created in 2009, and its primary purpose is to act as 'an information sharing forum for Australian Government innovation activities and for co-ordination of cross portfolio advice on innovation matters' (Co-ordination

Table 1. Board membership of national government innovation advisory bodies (June 2012)

	Total representatives on board	Number of VET system representatives
Prime Minister's Science, Engineering and Innovation Council (PMSEIC)	12 + other ministers as invited	1 (Minister for Education)
Co-ordination Committee on Innovation (CCI)	30 (all public sector)	1 (Minister for Education)
Industry innovation councils	143 (8 councils)	0

Committee on Innovation, 2012). Finally, in late 2010, the national government established eight industry innovation councils whose task, in part, is to provide strategic advice on innovation and economic development in broad industry sectors, such as automotive, ICT and aerospace. Members are described as 'innovation leaders from industry, unions and professional organisations, science and research agencies, and government [who] are appointed for their knowledge, experience and expertise'. The councils are expected 'to build skills and develop a highly flexible workforce for the 21st century through best practice in employment and training' (Industry Innovation Councils, 2012).

Table 1 summarises the results of the investigation into membership on each of the three boards. Apart from the federal minister for education (who represents both universities and VET sectors), there were no VET representatives on the boards. This omission is all the more interesting since each of the bodies is explicitly tasked to examine one or more of the following in its deliberations: education, training and workforce development.[3] In recent policy innovation documents a sophisticated portrayal of the role of VET in the NIS can be found. In contrast, it would appear that formal representation of the VET system in national innovation advisory bodies is all but excluded.

Understanding the exclusion of VET from innovation policy, programmes and advisory bodies

This section proposes a number of tentative explanations for the apparent contradiction of the poor integration of VET into national innovation policy and advisory structures despite the innovation studies literature attributing an important role to the VET system and to VET-trained workers in innovation. First, the Cutler Review identified the adverse effects of bureaucratic silos on innovation policy. Over several decades, responsibility for innovation and vocational education has been located in separate federal departments. However, in late 2011, these portfolio responsibilities were combined in the Department of Industry, Innovation, Science, Research and Tertiary Education, with tertiary education comprising both university and vocational education. It is too soon to assess the implications of this co-location.

Second, Dodgson *et al*. (2011) argue that while Australian innovation policy increasingly reflects a complex evolutionary systems approach, actual government intervention in the Australian NIS is still primarily shaped by the neo-classical economic notion of market failure. Innovation programmes are thus focussed on redressing risk in knowledge creation through public support of R&D and commercialisation of R&D through support of venture capital markets and direct grants to firms to help them bring innovations to market. The focus on knowledge creation leads to an emphasis on higher-level science and engineering training systems and labour markets. Government intervention also addresses the limited excludability of new knowledge through public support of intellectual property rights. The VET system, or at least its function within an NIS, does not fit neatly into current policy for innovation based on notions of market failure.[4] At the same time, the complex evolutionary systems approach is difficult to translate into concrete action (Dodgson *et al*., 2011). The systems approach is itself a complex theory entailing multiple interactions of institutions, firms and economic incentives (Lundvall, 1992; Nelson, 1993). Compared with the market failure approach, complex evolutionary theory has many more 'moving parts' and convoluted linkages operating via feedback loops rather than simple uni-directional cause and effect, as in the market failure model. Complex evolutionary theory thus presents fewer simple rules and suggests fewer simple policy levers to intervene in an NIS. This is arguably a factor in the continuing dominance of the market failure model in NIS intervention and the consequent exclusion of the VET system.

The argument that there is a disjunction between the complex evolutionary view of innovation recently adopted by Australian innovation policy makers and actual government interventions illuminates one of the key findings of this paper. The *Australian Innovation System Report* (DIISR, 2011a) included VET as one element in its description of the Australian NIS, and advocated the importance of increased co-ordination and knowledge flows across these elements, but did not position the VET system in programmes to improve the NIS.

Third, institutional rivalries over the distribution of funds for innovation may also operate to exclude VET. Creating another 'seat at the innovation table' for VET could be viewed by the existing beneficiaries of government innovation policy and funding as inviting a diversion of scarce resources to the VET sector. Moodie (2004, p.95) argues that higher education's capture of innovation policy has resulted in an excessively high weighting to R&D support programmes, especially within universities and the public sector, and low priority given to technology diffusion through workforce development.

Fourth, school education and delivery of VET have traditionally been the responsibility of state governments and this is another explanation for national innovation advisory bodies and policies not including a VET perspective. By contrast, the Commonwealth government has the dominant role in universities, both financially and in policy terms. Hence the Commonwealth has always tended to focus on the role of universities (and the Commonwealth's own science agencies, such as CSIRO) as well as its other policy levers, such as R&D tax concessions, as the main instruments of its innovation policy. With less control over (and interest in) VET, the Commonwealth is understandably (albeit not sensibly) less inclined to involve the VET sector in its NIS thinking.

Finally, since there are few, if any, innovation metrics which relate specifically to the VET system, there is a major problem incorporating the VET system into Australian innovation policy. The purpose of innovation indicators is to enable a description, analysis and evaluation of the structure and performance of activities and organisations that comprise a NIS. For example, the *Australian Innovation System Report* (DIISR, 2011a, p.6) notes that 'where possible, this report's concepts, definitions and methodology are based on the Australian Government's *Innovation Metrics Framework Report*'. The latter is a comprehensive analysis of existing innovation metrics and proposals to 'fill some of the gaps in the available innovation metrics for Australia' (DIISR, 2009b, p.12). However, there are no specific indicators in the *Framework Report* for the VET system or VET occupations in the measurement of the structure and performance of the NIS system. This, in turn, is itself a legacy of previous low recognition of the VET system or VET occupations in the major international measurement protocols of innovation and R&D (OECD, 2002; OECD and Eurostat, 2005).[5]

Discussion

Exclusion of the VET system from innovation policy matters. The Australian pattern of innovation is more dependent on VET skills than that of other OECD nations. It has a low share of R&D to GDP, especially business R&D, and a much higher share of low–medium technology manufacturing industry. Conversely, its innovation expenditures are heavily weighted to investment in equipment and software. The dominant form of innovation is incremental, particularly oriented to the adoption and adaptation of products, processes and services developed locally by other firms and industries, or sourced from overseas. This view is supported by the finding that 'most other OECD countries appear much more likely to develop innovations that are new to international markets than Australia' (DIISR, 2011a, p.3). Scott-Kemmis (2004, p.69) suggests Australian innovating firms are predominantly systems integrators. This is a particular capability to add value by integrating or assembling systems, resources and technologies rather than by developing from scratch. The core competencies of systems integrators relate to project management, logistics, problem solving and adaptation to particular circumstances. These are core competencies of trade and technician occupations. This is confirmed by official innovation surveys of Australian firms, which find that for industries such as manufacturing, construction and other services (where repair and maintenance of machinery and equipment is a primary activity) tradespeople are, by a large margin, the most frequently cited source of skills used for innovation (Australian Bureau of Statistics, 2008). Amongst all innovating firms, trades are the most frequently cited occupation used for innovation that are also identified as being in short supply (Australian Bureau of Statistics, 2011c).

Aside from recognising the comparative dependence of Australian innovation on VET skills, there are other arguments for the improved integration of the VET system into innovation policy and programmes. It is suggested that improved integration will be beneficial to both the VET system and the broader Australian NIS. It hardly needs stating that, in the absence of a counter-factual (that is, actual examples of closer integration), the identified benefits are speculative, though plausible. In summary, we argue that improved recognition and integration of VET into innovation policy could assist in countering a number of long run trends that have adversely affected the capacity of the VET system to perform its important role in providing workers with the skills needed to adopt and adapt new technologies.[6]

There are persistent constraints on the capacity of the VET system to maintain the knowledge and skills of technical college teachers and the equipment and software they use. The increased rate of technological redundancy and reduced public funding for the VET system are to blame (Toner, 2005). Between 2004 and 2008, real government recurrent expenditure on publicly funded VET training fell 11.5% per hour of training (Skills Australia, 2010, p.57). 'This decline in funding per student contact hour raises concerns about quality and the ability of the sector to innovate' (Skills Australia, 2010, p.6). Over the same period, real Australian government funding of science, research and innovation, excluding VET, increased by approximately 30% [derived from DIISR (2011a, Appendix 1, Table 1)].

Second, the VET sector lacks the capacity to meet the training needs of firms commercialising emerging technologies (Ferrier *et al.*, 2003). Because of budget constraints, the VET system focuses its teaching activities on technologies which are widely implemented and for which there is a stable and predictable level of student demand. These are technologies with established technical standards and protocols for operation and maintenance, and strong supplier networks. Meeting the skill needs of small, highly innovative firms can be expensive because of the need to customise training, upgrade teachers' skills and knowledge, and possibly purchase new equipment. Whittingham (2003) found that a vicious circle can operate where the lack of external training capacity constrains the supply of suitable production skills, which constrains production activity. In turn, this reduces the incentive both for firms to invest in training and for the VET system to meet these training needs.

Third, improved integration of VET into innovation policy and advisory structures could also improve knowledge transfer between the higher education and VET sectors, assisting the VET sector to keep abreast of new technologies that may have implications for future vocational training provision. There may also be benefits for higher education, especially engineering and applied sciences, in having a better understanding of the application of technologies in industry. Finally, the government has issued a number of reports on the task of meeting the labour supply needs of the research workforce. These reports refer to the important role of VET-trained occupations in this workforce. However, they do not consider these occupations in their recommendations. Improved integration of VET into NIS strategy could result in a more explicit consideration of VET-trained occupations in future planning of the Australian research workforce and, more broadly, in addressing shortages in these occupations.

Conclusion

This paper has highlighted a major paradox in the translation of research on innovation into Australian innovation policy and practice. The innovation studies literature points unambiguously to the important role of the VET system and vocationally trained workers in generating, adapting and diffusing incremental innovation in production and R&D. Research also indicates that the pattern of innovation in Australia, compared with many other OECD nations, makes firms more reliant on VET skills to implement innovation. Recognition has never been given to the VET system in national Australian innovation policy and advisory structures. On the positive side, recent national government reports reveal a sophisticated appreciation of the role of VET in innovation. Yet, in these same documents, the VET system is poorly integrated into government policy and programmes for the NIS. Several explanations were advanced for this paradox, and benefits that might be gained from closer integration were discussed. Several national VET agencies were identified which could competently contribute to innovation policy formulation and representation. The straightforward implication of this paper is that innovation policy and consultative mechanisms should connect more deeply with the vocational education and training system.

Several topics for further research flow from this analysis. First, is the Australian case an outlier or is it representative of a generalised exclusion of VET from innovation policy and programmes across other OECD nations? If the former, are the potential benefits of enhanced integration identified in this paper realised in practice. If the latter, how do the causes of poor integration and any adverse effects compare with the Australian case? Secondly, it was argued that one reason for the exclusion of VET from innovation policy was the general absence of innovation metrics that can be used to describe and evaluate its performance in an NIS. Such metrics could be a useful tool in improving these linkages. They might include representation of VET in innovation advisory structures, improved measures of the engagement of persons with VET qualifications in R&D, proportion of technology start up companies headed by VET-trained personnel, and measures of the capacity of VET colleges and teaching staff to keep up to date with the demands of industry for technological upgrading.

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Notes

1. During the 1980s in Australia, there was considerable policy activism under a newly elected Labor government which established a corporatist economic development and industrial relations model. A key element of this was closer integration of 'active labour market' policies, with a particular focus on workforce training, and sectoral industry development policies (Ewer *et al*., 1987). These policies were relatively short-lived and were eventually abandoned as governments, both Labor and conservative, adopted neo-liberal oriented policies (Hampson, 1996).
2. A number of organisations either singly or jointly could competently represent the VET system in such advisory roles. These include Skills Australia, an independent statutory body providing advice to the government on Australia's current and future workforce development needs. Industry skills councils (ISCs) are government funded and tripartite managed agencies responsible for setting the training and competency standards of VET occupations. In developing these standards, ISCs perform 'environmental scans' and labour market forecasting, examining issues such as technological change and its implications for training demand and training content (Industry Skills Councils, 2012). The Australian TAFE directors association represents the CEOs of publicly owned vocational colleges. Private VET colleges are represented by the Australian Council for Private Education and Training. The National Centre for Vocational Education Research, a publicly funded centre for data collection and research on VET, has an active research programme on VET and innovation.
3. An earlier study of innovation councils operating in each of the six Australian states revealed a similar membership pattern (Toner, 2008). Of the 80 members across all states, just two formally represented the VET sector.
4. The concept of market failure is, of course, central to the neo-classical understanding of labour markets and the tendency of firms to under-invest in general skills. The apprenticeship is viewed as a means of redressing this market failure by sharing the costs of training between the employer and apprentice and limiting labour mobility by tying the apprentice to the firm through an enforceable contract of employment (Becker, 1994). VET occupations and institutions are an important part of neo-classical analysis of market failure in relation to the operation of labour markets, but they are not the subject of the conventional apparatus of market failure when applied to the study of innovation.
5. Toner *et al*. (2010) provides a discussion of the treatment of VET in the *Frascati Manual* (OECD, 2002). Some nations, such as Germany and Switzerland, collect cross-classified data on broad occupation (researcher, technician and other supporting) employed in R&D by highest level of qualification, such as doctorate, bachelor degree, diploma etc. This cross-classification permits an improved identification of VET *versus* university trained R&D workers as different qualification levels are predominately granted by each educational sector. As noted earlier, this reveals a quite high proportion of VET qualified R&D workers in some nations. These cross-classified data are not collected in Australia.
6. It is not suggested that exclusion of VET from innovation policy and programmes is the sole cause of difficulties in the VET system. There are, of course, many causes of poor performance of national VET systems and of failure of VET to meet the innovation

needs of firms. These causes include, 'low skill equilibrium', poor initial educational standards of students, skill under-utilisation by firms, the rapid growth of universities diverting more able students away from VET (Hoeckel and Schwartz, 2010) and, of course, traditional market failure arguments, which can lower the incentive of firms to invest in general VET training and of individuals to invest in vocational firm-specific training (Toner, 2011).

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