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Perspectives and Debates on Vocational Education and Training, Skills and the Prospects for Innovation

Perspectivas y debates acerca de la formación profesional, las capacidades, y las perspectivas de innovación

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ABSTRACT

This paper provides an overview of the theoretical perspectives and key debates regarding the role and contribution of the vocational education and training system (VET) and vocationally-trained workforce in technical innovation. It considers contributions to these debates from innovation studies, varieties of capitalism research, neoclassical human capital theory and the work organization discipline. Historically, the primary role assigned to the VET system in innovation has been in relation to technology diffusion, particularly the generation, adaptation and diffusion of technical and organizational change and incremental innovation. Differences between national VET systems have been linked to large disparities in the level of skills qualifications, which is in turn a major factor in determining differences in patterns of innovation and key aspects of economic performance between advanced economies. The article finishes by considering barriers to maximizing the contribution of VET to innovation linked to future social and economic challenges.

Keywords: vocational education and training system, skills, innovation, technical workforce.

RESUMEN

Este artículo proporciona una visión general de las perspectivas teóricas y debates clave en relación con el papel y la contribución de la educación y el sistema de formación profesional (FP) a la innovación técnica. Se consideran las contribuciones a estos debates, a partir de los estudios de innovación, la investigación sobre variedades de capitalismo, la teoría neoclásica del capital humano y la disciplina de la organización del trabajo. Las diferencias entre los sistemas nacionales de FP se han relacionado con grandes disparidades en el nivel de cualificación y de 'skills', que a su vez constituyen un factor importante en la determinación de las diferencias en los patrones de innovación y de desempeño económico en las economías avanzadas. El artículo concluye abordando las barreras existentes a la contribución de la EFP a la innovación para la resolución de futuros retos sociales y económicos.

Palabras clave: Formación Profesional, competencias, innovación, fuerza de trabajo técnica.

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INTRODUCTION

It is broadly accepted that the vocational education and training (VET) system plays an important role in technical innovation. A direct interrelationship is understood to exist between the VET sector, a skilled workforce and the capacity of organizations, and the economy as a whole, to innovate. This article will not disagree with the validity of this overall claim. However, it will point out subtleties in the literature regarding VET, skills and innovation that suggest the broad general argument should be adopted neither uncritically nor uniformly across economic or technology sectors.

The structure of the article is as follows. The following section introduces the broad theoretical arguments regarding the relationships between VET, the vocationally trained workforce and innovation, with attention to the key concept of skill. Section 3 provides an overview of each of the main approaches to the VET-skills-innovation nexus within the social science literature, including some critical commentaries on strengths and weaknesses. Section 4 then considers barriers that may be preventing economic and technological sectors in advanced economies from benefiting fully from their institutional vocational training endowments. It also points toward current and future social and economic challenges and transitions to which the VET sector will make a crucial contribution.

VOCATIONAL EDUCATION AND TRAINING, SKILLS AND INNOVATION

A persuasive case can be made that the topic of skills and their relation to the capacity for innovation, broadly conceived as technological and organisational change, has been a central concern of the social sciences since the early Industrial Revolution. For example, Adam Smith (1776) identified the fact that growth in the size of the market facilitates increased specialization, both of labour tasks (i.e., skill requirements) in production and of the capital equipment used by this labour. Marx (1867) described the role of machinery and large

scale industry, characterised by rapid increases in the capital-labour ratio, application of science to the capital goods sector, and an intensified division of labour in production. Subsequently, economic historians have demonstrated the role of particular occupations in innovation, such as the critical role of craftspeople in the genesis of the Industrial Revolution through their incremental improvements to machine tools, metallurgy, armaments, printing machines and steam engines (Landes, 1972). For example, an eighteenth century English wood worker was responsible for developing a marine chronometer sufficiently accurate to enable the precise calculation of longitude, which unpinned the subsequent growth of international trade and colonial empires (Sobel, 1995).

Despite this historical importance, a generally accepted definition of skill is often said to be lacking. “[A]n appropriate and robust definition of skill has proven elusive. It seems that skill is a more complex and abstract concept or idea than current approaches have been able to capture” (Esposito, 2008: 101). Reflecting the elusive character of skill, the literature on the impact of technological change on workforce skills has used a number of indirect indicators of skill level and/or change in skill level. These indicators include employment distribution by level of occupation (Cully, 1999), employment distribution by educational attainment (Colecchia y Papaconstantinou, 1996), wage differentials by educational attainment or occupation (Goldin y Katz, 2007) and change in job tasks and attributes required to perform a job (Howell y Wolff, 1991; Esposito, 2008). In other studies skills and skill levels are defined as some combination of education, training and experience (Machin y Van Reenan, 1998; Tether et al., 2005; Pro Inno Europe, 2007). This approach is also taken by many national statistical agencies in the classification and definition of occupations for the collection of labour market data. The US Department of Labor, in addition to using education, training and experience, has devised detailed taxonomies of skills comprising hundreds of different elements such as social perceptiveness, problem identification, equipment selection, identification of key causes or management of financial

resources. These are used to define the scope of occupations and provide an ordinal ranking of these skills in terms of their importance for each occupation and across occupations (Esposito, 2008).

However skill is understood, the empirical evidence supports a strong causal interrelation between the supply of higher levels of education, training and skills and increased demand for, and supply of, technical and organisational innovation. At the most fundamental level, investments in capital equipment, innovation and human capital have been shown to be broadly complementary and mutually reinforcing (Lloyd-Ellis y Roberts, 2002). A cumulative growth in the demand for skills has occurred: “[r]egardless of the measurement of skills... demand for high-skilled labour has risen since the 1970s. This trend is observed in both the manufacturing... and the service sector... as well as in the aggregate economy. The higher the skill level of jobs or occupations, the greater the skill upgrading is likely to be” (Kim, 2002: 91). The complementarity of education, training and innovation thus suggests a virtuous circle whereby a workforce with a higher initial level

of education stimulates employers to further develop their productive capacity through training and both of these improve the capacity of the workforce to deal with technical change (HM Treasury, 2004). The propensity of firms to provide employer-funded training, and the intensity of this training, has been shown to increase markedly the higher is the initial educational attainment and prior training of its workforce (Arulampalam y Booth, 1998; Wolbers, 2005). Conversely, persons with low educational attainment are much less likely to have the opportunity participate in employer-sponsored training or to invest in their own training (HM Treasury, 2004: 26).

Vocational education and training, and the skilled workforce it produces, is thus understood as key to innovation and to the development of national and regional innovation systems. VET systems are diverse sets of institutions and organizations delivering post-school, non-university education and training within public entities and private firms. In some countries, around half the population of working-age has a VET qualification, while this figure is much lower in some other countries (Table 1).

Table 1. Educational attainment of 25-64 year-olds, selected countries (2014)

	Percent with vocational qualifications*	Percent with tertiary qualifications**
Australia	35	30
France	43	17
Germany	60	25
Italy	43	16
Spain	22	23
Switzerland	48	37
United Kingdom	19	30
United States	45	32

Source: OECD Education at a Glance 2015: Table A1.1a. http://www.oecd-ilibrary.org/education/education-at-a-glance-2015_eag-2015-en.

* ISCED 2011 Level 3 Upper secondary, Level 4 Post-secondary non-tertiary.

** ISCED 2011 Level 6 Bachelor's and Level 7 Master's degrees or equivalents.

Note: These data are not complete for some countries and therefore may not fully represent educational attainment in these countries.

The core role of the VET system in innovation is through the provision of training. Training is a mechanism for technology diffusion that allows effective and efficient deployment of technology and the ongoing improvement in operations and routines, through the involvement of a skilled workforce (Nelson y Phelps, 1966). The linkages between VET training and the economy are then shaped by the technology investments and product-market strategies of firms that characterize different sectors. The VET system has consistently been linked to the direct production and manufacturing workforce. In particular, the VET sector is charged with producing many of the technical competences on which technology diffusion depends. Technical competences enhance the capacity of the workforce to engage creatively in problem-solving and to continuously learn through the process of doing (Lundvall, 1998). The effectiveness and efficiency of innovation processes, particularly those directly linked to technology diffusion, thus depend critically on the quality and quantity of technical competences distributed across the workforce. The VET sector, by seeking to raise the overall level of technical competence workforce, improves the “absorptive capacity” (Cohen y Levinthal, 1990) of those organisations that play a critical role in technology diffusion.

The practical skills and underlying knowledge imparted by VET do not necessarily need to be new or advanced, but they need to provide the competences required to deal with something that is new to the user. A technically competent workforce can better cope with “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 y Rosenfeld, 1996: 1). Whilst there are numerous sources of innovation and technology diffusion, including competitors and new equipment/software for example, the capacity of firms, government agencies and other organizations to absorb, adapt and use these innovations will always depend to some extent on the technical competences of the internal workforce (Nelson y Phelps, 1966). The VET sector is thus vital

to innovation, whether in producing the life-long learning opportunities and developed competences that are diffused widely across the workforce, or in supplying the core body of personnel for some specialized technical occupations that are produced largely through VET institutions.

The overall provision of education and training includes both the supply of tertiary qualifications in sciences and engineering via universities and of post-secondary technical qualifications via VET. The heavy focus in academic and policy circles on the tertiary sector and the need for advanced knowledge to drive radical innovation via a linear science-based model (Filipetti y Guy, 2015) has, to some extent, obscured the importance of VET to innovation, particularly incremental innovation. An appropriate skill-mix, which includes both a university-formed knowledge base and VET acquired know-how and workforce skills, which is matched to a firms’ product-market strategy can drive the innovation performance and competitive advantage of firms (Herrmann y Peine, 2011). This includes the emergence of apparent complementarities between general and specific skills based capabilities within so-called “ambidextrous organisations” (O’Really y Tushman, 2004), particularly in sectors where R&D, production and marketing activities are interconnected and incorporate to some degree end-user innovation feedback loops. However, much remains to be clarified about the appropriate composition of the knowledge-base and skills attributes of the workforce that can best advantage specific firms.

It can be argued, however, that VET teaching institutions are more attuned to the role of meeting the immediate needs of industry for technology diffusion than universities. First, VET institutions tend to have a more direct and explicit role in local and regional economic development than higher education institutions. Addressing and satisfying the technology needs of industry, and being responsive to changes in those needs, is a stronger expectation of VET. Likewise, the matching of employment opportunities for students in a local/regional socio-economic context is more strongly in the purview of colleges embedded in these contexts

than the more general remit of universities. Second, VET is directly linked into the investment strategies of firms in their region through their joint provision of hybrid forms of paid on-the-job and classroom-based training. These inter-linkages underpin the greater responsiveness of VET to the demands of employers, particularly through the provision of customized training that require a significant degree of adaptability to regional and sectoral contexts.

Vocational education and training institutions have three distinct roles in the diffusion of knowledge. First, teaching in VET institutions is central to technology diffusion through the imparting of know-how, practical skills and knowledge of the operations of production processes. Second, VET institutions act also as technology intermediaries linking producers, service providing firms and other organizations in networks through which technology transfer and information exchange can occur. For example, a technology and software supplier can demonstrate new iterations of equipment to firms, students and other users through VET institution hosted events. Third, particularly in local or regional contexts lacking a strong university, polytechnic or R&D presence, VET colleges can be the leading source of technical expertise. According to Rosenfeld (1998: 1-6) these roles are particularly important for “small and medium sized employers, whose requirements for technology and innovation [are] something less than leading-edge research and who...[lack] the capacities and connections to effectively adapt already commercially available technologies and proven innovations”. Importantly, the second and third of these roles of VET knowledge diffusion have to be understood as essentially discretionary activities that depend, to a significant extent, on the management of VET organizations and the individual motivations of VET practitioners to enact the kinds of network-building activities that enable diffusion of knowledge to occur. These roles are secondary to the core role of teaching, but are vital for the full exploitation of the human capital and knowledge benefits of this activity in local and regional socio-economic contexts.

This is not the place to enter into a detailed discussion of the patchwork of studies conducted

in different national systems that have found indications of positive impacts of investment in VET at the firm, sectoral or societal levels. However, it is useful to highlight broad understandings regarding the impact on firms of investing in VET. The European Centre for the Development of Vocational Training (CEDEFOP) conducted a meta-analysis of the impact of training and vocational education on firm productivity and performance. A total of 236 studies from 26 single countries were included, with a further 28 multi-country studies also included. The largest numbers of studies were focused on the US (34), Finland (29), Belgium (21), UK (18) and Netherlands (16) (CEDEFOP, 2011: 50). Despite the problems associated with the heterogeneous conditions and forms of training investment associated with different national VET systems and the lack of consistent empirical indicators, the meta-analysis established a clear result - a positive and significant relationship between investments in training and firm productivity. A positive association was also found for other types of performance indicators, including innovation (CEDEFOP, 2011: 8). However, the variety of indicators used prevented reliable estimations of effect sizes. There are also some mixed messages, with a link to firm profitability being less clear (CEDEFOP, 2011: 8). Simply comparing the numerical balance of the studies reviewed supports the notion of positive impacts, with studies that find significant benefits to firms outweighing those that do not (CEDEFOP, 2011: 69).

Whilst the theoretical arguments for the positive impacts of VET on firm performance outlined above are strong, this meta-analysis highlights the difficulty of attributing empirical outcomes to the effect of VET in precise ways. Different countries tend to define skill in distinct ways (Clarke y Winch, 2006: 261-5). Performance indicators and VET indicators are varied between studies and a major problem is that the type of VET training that is being referred to (classroom, workplace, formal or informal) is not specified or only imprecisely described (CEDEFOP, 2011: 68). On the most easily measured indicator, productivity, firms in manufacturing were most likely to show positive results. However, the analysis notes that productivity is much more easily measured in

manufacturing firms in comparison to service firms. A further impression formed by the meta-analysis is that VET activities that are nested in a broader HRM strategy are associated with positive outcomes for firms (CEDEFOP, 2011: 68-9). Finally, the meta-analysis identifies innovation (along with job satisfaction and absenteeism) as topics which require further investigation as to the impacts of VET (CEDEFOP, 2011: 70). So, whilst isolated studies of certain types of VET interventions in specific contexts may find positive impacts arising from VET investment, this meta-analysis would suggest that in terms of generalizable results regarding the impact of VET on firms then a far greater number of systematically designed and statistically comparable studies are required to strengthen and add nuance to the empirical evidence base.

There are also important systemic impediments to the degree of success that the VET sector is likely to have in fulfilling its core roles and by extension their contribution to innovation. First, many VET systems face stagnation or decline in the rate of growth in real funding investment. This can lead to compromises in terms of quality and/or scope of training and a reduction of the capacity of the VET to innovate and to remain up-to-date in terms of technology and techniques. Second, in many cases the development of linkages between VET institutions and firms and government agencies using, or wanting to use, emerging technologies, are not sufficiently well developed. The core focus on stable technologies and systematized training routines may not be complemented sufficiently in focusing on areas of uncertainty and change unless there is sufficient funding and available capacity to develop more forward looking activities. Third, the accent on acquiring university qualifications in many countries has been argued to reduce the pool of talented school leavers entering VET courses (Ashton et al., 2003; Hoeckel y Schwartz, 2010). This is reinforced, in some cultural settings, by a low level of social prestige or desirability being associated with VET qualifications in comparison to university degrees (OECD, 2000). Fourth, there is a suspicion that the expanding influence of competency based training (CBT), which places a heavy emphasis on the successful reproduction of

practical skills and less emphasis on the theoretical underpinnings of these tasks, can have a negative impact on technology diffusion. Finally, it has been noted that VET remains relatively excluded from national innovation systems and innovation policy thinking generally (Edquist, 2005; Jones y Grimshaw, 2012; Toner y Dalitz, 2012) An over-emphasis on higher education (HEd) policy and a failure to fully understand the potential benefits of better articulation between VET and HEd may thus also be reducing the priority given to technology diffusion in comparison to R&D, for example, in turn reducing the apparent importance of VET in innovation.

In summary, this section has outlined the broad links between VET institutions, workforce skills and technology diffusion that underpin the VET contribution to innovation. The argument advanced is that the training supplied by the VET sector enhances technology, through providing firms and other organizations with the skills need to adopt and customize equipment, software and other technical inputs to production or service-based activities. The following sections develop this broad argument by looking at a variety of perspectives that emphasize particular understandings of these relationships. We introduce perspectives from human capital theory, varieties of capitalism research, innovation studies and high performance work systems approaches which provide a variety of specific theoretical explanations for VET contribution to innovation performance. This allows us to expand our focus on links between VET, workforce skills and technology diffusion to also more adequately highlight the importance of knowledge, political economy and the presence of innovative firms in the complex of relationships that drive the propensity to innovate.

DEBATES ON THE ROLE AND CONTRIBUTION OF VET SYSTEMS AND THE VET-TRAINED WORKFORCE IN TECHNICAL INNOVATION

Vocational training, workforce skills and innovation have been studied in many different academic disciplines each with distinctive methods and assumptions. There is not space for a comprehen-

sive review of all these approaches (see Tether et al., 2005). Rather, the focus of this section is on summarizing the dominant schools of thought on the topic. First, we look at human capital theory and arguments about skill-biased technical change. Second, we consider the contribution of the field of innovation studies, whilst also questioning why a more expansive engagement with this topic is missing from the field. Third, we consider the quite extensive varieties of capitalism research that focuses on the set of institutional arrangements governing training, industrial relations, industry policy, education and welfare, and how the variation in these arrangements drives the level of workforce skills and the capacity of individuals and firms to engage in product and process innovation. Finally, we look at crossovers between management and organizational studies via the phenomenon of high performance work systems research, and how this globalised and competitive approach to organizational innovation is related to workforce skill levels and innovation.

Human Capital Theory and Related Approaches

The basic argument of ‘neoclassical’ economics and, more recently, endogenous growth theory, is that total output expands due to increases in the quantity of inputs, capital and labour, along with improvement in the quality of these inputs over time. These improvements stem from technical change embodied in improved capital and intermediate goods and improvements in the quality of labour through increased investment in education (Becker, 1962, 1994). Improving the quality of labour improves the productivity of labour as increased investment in “human capital” through education and training improves labour productivity (Becker, 1994; Romer, 1994).

This process in turn improves the complementarity between labour and capital, raising the productivity of capital that in turn stimulates further capital investment, which then raises the demand for skilled labour (Becker, 1994; Romer, 1994). Raising the level of skill of the workforce is thus argued

to be associated with economic growth. Statistical studies have shown a strong correlation between increments in human capital (proxied by either years of schooling or level of qualification) and hourly earnings (Card, 1999). Country comparisons also suggest links between workforce educational levels and per capita GDP (Krueger y Lindahl, 2000).

Over recent decades increases in the relative demand for more highly skilled labour have been argued to be explained by skilled biased technical change (SBTC), which results from “a significant complementarity of human capital with new technology” (Machin y Van Reenan, 1998: 1216). Indicators such as change in the R&D intensity of firms and industries (Machin y Van Reenan, 1998; Colecchia y Papaconstantinou, 1996), investment in computers and software (Krueger, 1993) and investment in machinery and equipment (de Laine, Laplagne y Stone, 2000) have been linked to indicators of workforce upskilling such as increases in the proportion of persons with post-school qualifications and/or increase in the proportion of persons in skilled white or blue collar jobs.

Later studies, especially those focussing on investment in ICT link technical change to change in the skill and occupational composition of the workforce (Autor, Levy y Murnane, 2003; Goldin y Katz, 2007). Autor and colleagues (2003) argue that higher level manual or cognitive skills are ‘non-routine’ in that they are mostly non-repetitive and cannot be reduced to a set of unambiguous rules. This means that “[t]asks demanding flexibility, creativity, generalized problem-solving and complex communications—what we call non-routine cognitive tasks—do not (yet) lend themselves to computerization” (Autor, Levy y Murnane, 2003: 5). On the other hand, Goos and colleagues (2010) argue the “routinization will result in larger falls in prices in industries that historically used a lot of routine labor, and this will tend to benefit all labour that is used in these industries” (Goos, Manning y Salomons, 2010: 30).

In summary, human capital theory focuses attention on the vital role of education, training and work experience in raising productivity and enhancing the

capacity for technical change. The SBTC hypothesis has attempted to account for key developments in the demand for skills in advanced economies, including a rising proportion of the workforce with higher educational qualifications and polarization in the demand for workforce skills. However Wolf (2004: 319) has advocated a more cautious view of the contribution of rising educational qualifications *per se*, by arguing that qualifications also act as a signaling device to prospective employers regarding differences across people in terms of innate desirable characteristics such as persistence and IQ. "Education imparts new and valuable skills and knowledge... correlated with underlying ability, and... education provides credentials... [which are] important in the labour market in rationing and controlling access to jobs" Wolf (2004: 319).

Innovation Studies

The seminal contribution that continues to inspire much work in innovation studies (IS) is that of Nelson and Phelps (1966). They added to understandings of the relationship between human capital and technology (and other forms of capital), by specifying the role of education and training in reducing the costs of introducing new technology and in adapting or customizing existing technology to changing needs of organizations (Nelson y Phelps, 1966). The importance of education and training is thus amplified in times when technological change is occurring, or when a particular technology becomes mass produced and widely available to firms, because this is when productivity increases may flow directly to those organizations with sufficient workforce skills to accomplish the introduction or adaptation of technology effectively and efficiently. This effect has an indirect benefit as well, as the embedding of the technology by skilled workers will also raise the productivity of their unskilled workmates (Nelson y Phelps, 1966). The importance of this proposition for understanding the role and contribution of VET to innovation and productivity is clear.

It therefore remains somewhat a mystery that the subsequent IS literature has paid remarkably little attention to the VET sector, although there is

very recent evidence that this may be starting to change. From an IS perspective, it has been noted that there has been "little systematic knowledge about the ways in which the organization of education and training influences the development, diffusion and use of innovations" (Edquist, 2005: 185). In particular, the "innovation literature has been remarkably laggard in appreciating the need for detailed interrogation of the character and meaning of skills formation and training systems" (Jones y Grimshaw, 2012: 7). The focus of IS on the systemic interconnection of organizational actors would suggest a focus on the VET sector. However, the connections between VET institutions and firms through their training partnerships, the increasing articulation of the VET system with universities in some countries, and the centrality of VET organizations to supporting government industry and innovation agendas, have been largely overlooked.

The importance of incremental innovation in the IS literature would particularly seem to promote the importance of understanding the role and contribution of the VET sector. Gradual improvements in goods, services and organizational operations improve the performance and outcomes associated with the use of technology, with the overall accumulation of these changes accounting for productivity growth. Incremental innovation occurs in direct production activities and in the adapting and customizing of consumer goods and services, including through feedback from consumers (von Hippel, 2005). The "absorptive capacity" of the workforce (Cohen y Levinthal, 1990) has been demonstrated to be a key to this process of continuous incremental innovation. The capacity of the workforce to deploy generic problem-solving and communication skills and to use creative and team-based methods has been attributed largely to the quality of general education, the availability of quality post-school vocational training and the kinds of support and incentive structures available.

Tether and colleagues (2005) argue that there is an implicit awareness of the importance of skills formation systems in the innovation literature. In the sense that VET is a core element of the produc-

tion of a relatively innovation ready workforce, then the importance of the VET trained workforce is, at least implicitly, woven into the innovation studies literature. Filippetti and Guy (2015) suggest that despite the stated attention of foundational innovation systems literature to non-linear models of innovation (e.g. Freeman, 1994), IS has nevertheless stayed close to the science-driven and high-tech sectors of the economy - implicitly orienting attention toward university education and the production of scientists and engineers rather than the VET sector and the issue of workforce skills. Overall, it does seem that VET and the VET workforce remain underdeveloped topics within IS.

One emerging strand of IS literature is looking more closely at the mix of knowledge and skills required for the different types of innovation that are associated with firm product-market strategies (Freeman y Soete, 1997). In general, scientific knowledge is associated with radical innovation, while general and high level vocational skills are associated with incremental innovation (for the reasons described above). Herrmann and Peine (2011) find that both general and specific skills are required for radical and incremental product innovation in R&D. They argue that specific skills can only be used within one industry, are “taught through apprenticeships or similar vocational training programmes” and are associated with lengthy job tenure (2011: 691). General skills in their study denote primarily university-trained scientists and exclude the vocationally trained. Interestingly, they find 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 strategies not in an additive but in a multiplicative manner” (Herrmann y Peine, 2011: 698). Indeed, in industrial product development contexts such interaction was deliberately promoted by human resource practices (Herrmann y Peine, 2011: 697-98).

Leiponen (2000, 2005) uses a mixture of technical and science degrees in investigating knowledge

spillovers and innovation within large firms. Piva and Vivarelli (2009) use the ratio between white collar and blue collar employees in studying innovation in the automotive industry. Whilst these studies do take the diversity of the workforce very seriously, they are limited by the lack of information available on the type of training employees have received and the proxies for skills that are used. However, these studies do point out another potential rich vein of research through which innovation studies might develop a clearer understanding of the contribution of the VET system to innovation. More work that considers the combinations of the scientific knowledge and vocational skills that might best drive different forms of innovation seems desirable.

Some very recent work also suggests emerging interest in connections between the scientific knowledge base, the provision and evolution of skills, and innovation processes may be developing within IS. Filippetti and Guy (2015) look at whether having a stock of skilled labour helps firms to maintain investments in innovation during times of economic downturn or crisis, such as that which affected Europe from around the middle of 2008. Their basic proposition is that employment protection and unemployment insurance will enhance the chances individuals will choose to undertake riskier courses of study, diversifying the stock of skills available to firms and the economy (Filippetti and Guy 2015: 4), whilst also encouraging or restricting firms to maintain employees during difficult economic times. They find that high levels of VET qualifications combined with either relatively secure employment or access to unemployment benefits is most likely to enable organizations to maintain innovation efforts during crises.

Interestingly, it is not necessarily the general nature of initial training, but the availability of opportunities and support for re-training of even relatively specific skills that also contributes to the capacity of firms to maintain medium-term innovation programs. The continuity of formal and informal on-the-job training throughout the recessionary period can be anticipated to pay dividends in the future. Filippetti and Guy (2005) argue that their results

challenge the tendency within innovation studies to focus on university trained scientists and engineers and to assume only general vocational skills will be transferable and adaptable to cope with innovation and changing labour market demands. An important line of future investigation does appear to be to understand the packaging of general and specific skills provision as complementary dimensions of the human capital profiles required by firms and societies. Thinking about this challenge implies re-thinking the articulation between universities and VET institutions. It also suggests the need to consider both the diversity of skills training on offer in a national or regional system, plus the availability of appropriate incentives or support policies that will encourage the formation of skills that may appear as more risky from a perspective of labour market opportunities, as Filippetti and Guy (2005) argue.

Vona and Consoli (2015) focus on the challenge of knowledge systematization in forging links between technological change, education and innovation. They develop the heuristic of 'skills life-cycle' to move beyond a simplistic conceptualization of education institutions trying to 'keep up with technology' toward an understanding of the ways in which different forms of institutional adjustment will impact not just innovation and productivity but also labour market inequality. The systematization of practical know-how associated with radical technological innovation and/or the onset of new general purpose technologies (GPTs) such as computerized information technology (ICT) will proceed differently to that associated with incremental innovation in established technologies with widely diffused and standardized skill requirements. In their view "skills mismatches and qualitative changes in the educational supply are structural features of the diachronic adaptations between technology and education" (Vona y Consoli, 2015: 1400). However, the extent and nature of skill mismatches will always be contingent on the stage of the "skill-technology cycle" (Vona y Consoli, 2015: 1400).

The conceptualization of mismatches developed by Vona and Consoli (2015) requires the fine-tuning of the supply of skills, to optimize and de-

pen the knowledge and skill base. To this extent it appears to share much with that of the varieties of capitalism literature (Estevez-Abe et al., 2001), in its significant reliance on degrees of institutional coordination and organizational cooperation. In relation to more radical mismatches associated with new GPTs for example, they point to the importance of increasingly specialized branches of engineering knowledge responsible for the documenting and systematization of the new knowledge and operative cognitive and practical task requirements. They reconstruct the importance of engineering specification in the process of standardizing rules (tasks), leading toward an increasingly abstract formal educational curriculum, in the transition to factory production, the adoption of ICTs and the transformation of aeronautical engineering through control volume analysis. Overall, the skills-technology life-cycle approach provides important nuances to the conceptualization of the responsiveness of universities and VET to changing labour market demands, particularly by insisting that any scenario of mismatch between technology and skills that reduces labour market efficiency will involve specific contingencies that will most likely need to be addressed through a tailored approach to knowledge systematization and diffusion that takes the content of cognitive and practical skills required directly into account.

In summary, the innovation studies literature has somewhat neglected VET and workforce skills in studying innovation, despite acknowledging their importance. However, recent scholarship in the field suggests at three potentially fruitful paths for IS research. First, attention to the mix of university and VET qualifications and skills that might best serve particular firms, using certain technologies in specific markets, may open avenues to more fine-grained analysis of the links between types of innovation and firm strategy and performance. Second, firms' stocks of particular types of skills, in combination with operative labour market settings, may be linked to the resilience of performance and speed of recovery from economic turbulence or market downturns. Third, a deeper understanding of the changing skill-composition of occupations in the face of technological and social transformation can

place renewed emphasis on the modes of responsiveness of VET institutions to changing demand for skills. In the case of broad and deep social and economic challenges such as environmental sustainability (Vona et al., 2015), for example, all of these lines of investigation seem to have potentially high significance and direct policy importance.

Varieties of Capitalism and National Differences in Skills Formation Regimes

Another line of scholarly research centres on comparative analyses of national skill formation systems, to provide important insights into the role of VET and the VET trained workforce in the generation and introduction of product and process innovation in contemporary advanced economies (Brown et al., 2011; Crouch et al., 1999; Culpepper y Finegold, 1999; Thelen, 2004). A key argument within this varieties of capitalism (VoC) literature is that different institutional arrangements underpinning national VET training systems lead to large differences in the quantity and quality of VET skills. In turn, such differences in the supply of intermediate skills are a key determinate of a country's industrial structure and pattern of innovation.

The VoC literature identifies three broad types of intermediate skills formation systems: occupational; internal; and flexible - that are linked to national intermediate training systems and the product of a complex historical process which create institutional complementarities. These are a set of self-reinforcing institutions, which create economic incentives and legal and social obligations on workers and firms to invest in particular forms of workforce training and for firms to adjust their production systems and products to these particular types and level of skill (Hall y Soskice 2001). Each of these systems has distinct effects on the type and level of VET skills, the participation of direct production workers in innovation and the type of innovation conducted within these systems.

An important empirical approach within this literature is matched plant studies which compare

the productivity, export and innovation performance of firms in the UK against those in continental Europe, especially Germany. These studies reveal large productivity and quality differences between UK and European firms across many industries (Ander-ton y Schultz, 1999; Clarke y Wall, 2000; King, 2001; Mason et al., 1996; Prais, 1995). Compared with continental Europe the UK workforce has a much higher proportion of production workers, including trade and technician occupations, with no qualifications or lower level vocational qualifications and, those with vocational qualifications are, on average, at a lower level than in Germany (Leitch, 2006: 39-53). "Firms' product market choices are thus constrained by the availability of necessary skills" (Estevez-Abe et al., 2001: 38-9).

The results obtained by the matched plant studies identify specific mechanisms whereby higher VET skills promote productivity, quality and innovation. Higher vocational workforce skills improve the scope for product and process innovation because of the enhanced capacity to deal with product customization, to adapt to technical change at a faster rate and to contribute suggestions for improvements to products, services and processes. Higher levels of initial VET education are also associated with higher rates of continuing employer-funded training; implying a self-reinforcing dynamic. Complementarity between human and physical capital means that higher level vocational qualifications and skills are also associated with higher capital per worker (Toner, 2011: 33).

A broad explanatory factor in these case studies is the divide between the English and Germanic conception of vocational skills (Brockmann et al., 2008). In the former, vocational skills are understood as the property of an individual and associated with the performance of discrete manual tasks not necessarily tied to a particular knowledge base or the possession of a qualification (Clarke y Winch, 2006: 261). Compared to their German counterparts in similar occupations, UK vocationally trained workers are less able to deal with technological change and more complex problem-solving "as people are required to perform to narrowly prescribed competencies,

they do not have the knowledge, skills or indeed, the motivation to perform tasks or deal with situations beyond the prescribed outcomes” (Brockmann et al., 2008: 553). In contrast German *berufsbildung* recognises production as an inherently social activity and focuses on the ability to apply theoretical knowledge in a practical context. Theoretical knowledge encompasses not just technical subjects but mathematics, work planning, autonomous working, problem solving and critical thinking and ties entry into vocational occupations and wage levels to the possession of specific qualifications (Clarke y Winch, 2006: 265).

VET institutions are foundations of the occupational labour markets of which the German apprenticeship system is regarded as the archetype. The German VET system is commonly interpreted as redressing ‘market failure’ in the delivery of employer-funded training in transferable skills for which there is demand in the external labour market. Employers are unwilling to invest in providing these skills to employees because workers who receive this training can leave to work for another firm before the employer has recouped the cost of training in terms of higher productivity and output. Thus firms that do not train, but instead poach skilled workers, gain a cost advantage over firms that do train.

A neoclassical perspective on the apprenticeship system views it as a response to this dilemma, as the costs of training are shared by the apprentice accepting a lower wage during their training than they can obtain in the external labour market, in return for the employer investing in imparting transferable skills (Becker, 1994). However, without a complex set of institutional supports such a system is likely to prove unstable, as evidenced by the long-run decline of apprenticeship systems in many other countries, such as the US and UK (Gospel, 1991). This is due to the “difficulty of securing mutually credible commitments from both parties to a training contract... Unless some mechanism is found to force firms to train well and to prevent them from exploiting apprentices, at the same time forcing apprentices to stay long enough for a company to recoup its investment, apprenticeship training is likely to deteriorate into cheap unskilled

labour” (Thelen, 2004: 18). Paradoxically, a system in which transferable skills are certified and their quality assured is likely to promote poaching, because certification overcomes information asymmetries regarding the quality of skilled labour between firms that train and those that do not (Thelen, 2004: 19-20).

The institutional supports that underpin the German occupational labour market include:

- 1.) A high average level of educational attainment in schools that facilitates apprenticeship training with more academically and technically demanding content;
- 2) Co-ordination between employer associations, unions and the state in order to strike the right balance between employers and employees in terms of the scope and duration of training (Thelen, 2004: 18-19);
- 3) A statutory basis for apprenticeship that governs the contract of employment and training between the apprentice and employer and specifies the rights and duties of both parties;
- 4) State financial support of quality training infrastructure is essential, along with ‘licence to practice’ laws for skilled technical occupations;
- 5) Industry level industrial relations bargaining that ensures more or less uniform wages and conditions for qualified trades and technicians in the same occupation across firms. This is important in overcoming ‘poaching’;
- 6) Industry policy to diffuse the latest production technology and workforce organisation methods to sustain industries that intensively use higher level workforce skills;
- 7) Generous welfare provisions in the event of unemployment and constraints on redundancies through legislation and co-determination at a firm level.

VET institutions are thus central to features 1-4 and 6, above, of the German apprenticeship and occupational labour market system.

In turn, the system of training within an occupational labour market encourages product and process innovation through the following mechanisms:

1) High wages for tradespersons and technicians have the effect of “forcing employers to maximise the productivity return on skills” and of encouraging labour displacing capital investment whilst deterring low pay-low skill firm strategies (Green y Sakamoto, 2001: 70).

2) A strong commitment to training minimizes skill shortages and reduces the incentive to poach workers. In addition, widely recognised and accepted qualifications facilitate labour mobility;

3) The breadth and depth of practical and theoretical skills in apprenticeship training encourages multi-skilling and adaptability which facilitates the introduction of new products and processes;

4) Considerable effort is made to ensure curricula and pedagogy in apprenticeship training is kept up to date. Apprenticeship training curricula also operates as a form of technology diffusion as it alerts firms to newer technologies and work practices;

5) A skilled intermediate workforce promotes the transfer of knowledge within a firm from engineering and scientific staff to the direct production workforce and vice versa.

6) Cumulative interactions between a large skilled workforce and publicly supported technology diffusion institutions (in Germany including Fraunhofer, Max Planck and Steinbeis Foundations).

The occupational labour market model thus produces vocational skills characterised by “deep competencies within established technologies” (Estevez-Abe et al., 2001: 174). Such competencies are particularly “suited to incremental innovation and problem-solving but are inappropriate to a world where competition is dependent on rapid changes in basic innovation” (Lauder, 2001: 170). The VET system is thus a core institution that drives German competitiveness in middle technology industries that make intensive use of intermediate skills.

In contrast to the German system, large Japanese corporations develop extensive internal labour markets (ILMs), recruiting school-leavers with better than average literacy and numeracy results and, hence, a presumed capacity to undertake high

level vocational training. The core permanent workforce receives mostly on the job training designed to meet the particular needs of the firm. These workers are prepared to invest in this firm-specific training in return for employment security and a career path within the firm (Thelen, 2004).

Training is directed at producing multi-skilled workers through job rotation and a capacity and willingness to engage in group problem-solving.

Rather than relying on groups of differently skilled workers with general knowledge of their specialty to solve problems that arise in production, the Japanese attempt to respond to problems that arise in production by creating groups appropriate to the task... Apprenticeship is replaced by participation in collective problem-solving on the shop floor (Herrigel y Sabel, 1999: 89).

Multi-skilling and a high level of functional flexibility (or low levels of occupational demarcations) are encouraged by the linking of pay to experience and time served with the firm rather than to current production tasks undertaken. Job security significantly reduces resistance to both the introduction of potentially job-displacing new technologies and concern by older, experienced workers at passing on valuable job knowledge to cheaper new recruits. Another feature of the Japanese VET system is the high degree of co-operation, especially in technology transfer, including skills training, between larger firms and their sub-contractors and across sub-contractors (Fujimoto, 2000).

The foundations of the ILM model were seriously undermined by rising competition in world markets, especially from developing nations which led major Japanese corporations to off-shore some manufacturing to lower cost alternatives. Younger workers are also less attached to traditional career paths. In response to these changes large corporations have significantly increased the share of their workforce in non-standard forms of employment- or increased their peripheral workforce and reduced the core which are generally not to workforce participation in innovation at a firm level (Gaston y Kishi, 2005).

A flexible labour market and VET training model is common to the UK and the USA. The flexible VET system is typified by a polarisation of skills, with a large proportion of university educated graduates, a large proportion of the workforce with no or minimal post-school qualifications and a comparatively small share of persons with high level intermediate qualifications (Green y Sakamoto, 2001: 126). Both the UK and US have been effective at innovation based on high level elite skills in science and technology derived from world class universities. A variety of indicators, such as R&D intensity, trade performance and patenting activity, attest to the strength of this high level science base in industries such as pharmaceuticals, chemicals, electronics, software, defence and aerospace. High level skills also underpin international competitiveness in financial services and creative industries like advertising, publishing, design, entertainment and management consulting (Tether et al., 2005: 70).

The absence of labour market regulations on hiring and firing and high levels of job mobility, including amongst the scientific, engineering and managerial elites, is well suited to industries such as software, finance and biotechnology that are reliant on “rapid product innovation strategies” and a “high responsiveness to new business opportunities” (Estevez-Abe et al., 2001: 174). A high level of labour mobility, especially amongst the technical elites, is also a critical means of technology diffusion in industries in which change in technology and markets is particularly rapid (Finegold, 1999).

Educational inequality underpins skewed skill distributions, with the UK and the US having a higher proportion of their adult population that are functionally illiterate and innumerate, compared, for example to many countries in Europe and Japan (Tether et al., 2005: 52-3). This polarisation in outcomes from the general education system is not redressed through the VET system. The US does not have a national system of vocational qualifications and the weak educational attainment of a large proportion of the workforce leads employers to provide “non-graduates...[with] firm specific types

of training” characterised by “narrow skill sets” (Tether et al., 2005: 58).

Individuals can acquire good vocational skills through community colleges, but this often requires them to invest in their own training for up to two years. The UK has, with a few exceptions, a poorly performing VET sector (Gospel, 1991; HM Treasury, 2004). For example, the level of skill certified under an apprenticeship in the UK is low compared to that in many European countries and Australia (King, 2001; Toner, 2008). The range of skills required for these qualifications is also narrow so that the qualification system militates against broad based multi-skilling (Clarke y Wall, 2000: 697). In addition, ‘competency based’ training in the UK is based on the demonstration of practical skills within a given workplace with little consideration given to imparting or testing theoretical underpinnings. A multiplicity of private and public training VET providers of greatly varying quality also reduces the value and recognition of such qualifications for both workers and employers.

This flexible skill formation model has given rise to the notion of “low-skill equilibrium” (Finegold y Soskice, 1988). The notion of low-skill equilibrium can be viewed as an example from the economics literature of the widely researched and accepted concept of “technological lock-in” (Arthur, 1994). Low-skill equilibrium describes a set of self-reinforcing financial incentives and institutions in which the existence of a large pool of low skill, low productivity workers constrains many firms to produce standardised, low quality goods and services. In the UK, vocational training “provided within firms...has resulted in the formation of narrow, firm-specific skill sets...[that] are not particularly adaptable for engaging with innovation” (Tether et al., 2005: 59). Workers have a reduced incentive to participate in training due to the lack of demand for higher level skills. The low wages of this workforce creates a market for the output of such industries (Keep y Mayhew, 2001: 10). The problems created by the flexible labour market model in terms of a comparatively large proportion of the workforce in low productivity, low wage industries and high in-

come inequality have been increasingly recognised in public policy (HM Treasury, 2004)¹.

The research on comparative national skill formation systems demonstrates the important role of workforce skills in the generation and diffusion of innovation in advanced economies. It also identifies specific mechanisms that translate differences in the quality and quantity of VET skills available to firms into differences in innovation performance. The central role of incremental innovation, or the use and adaptation of existing knowledge and techniques to improve the stock of products, services and processes, would strongly suggest that predominantly VET-trained occupations, especially at trade and technician level, should be key agents in incremental innovation processes. However, the matched plant studies and trade performance would suggest that great diversity exists between different advanced economies in the skill level and role of direct production workers in national innovation systems.

Whilst the literature on the institutional foundations of national skill formation systems is compelling in its explanatory power, it is important to

note it has been the subject to some criticism. First, individual countries are not internally uniform but exhibit characteristics that are consistent with the flexible, occupational and ILM labour market models. Second, from a policy makers' viewpoint the complex array of different inter-locking and reinforcing institutions and social obligations that typify each model seem too complicated to change. The institutional literature does not provide clear guidance for change because, as it does not identify the necessary and/or sufficient conditions for a model to operate, thus reducing the potential to formulate rationales for change (Allen, 2004; Hancke, Rhodes yThatcher, 2007).

Work Organization Driven Demand for Skills

A final line of research linked to VET and workforce skills to be considered here emerges from management and organizational studies and focuses on a demand side understanding of innovation dynamics. Systems of work organization have been associated with a higher propensity and intensity of innovation in firms, particularly those that require very specific workforce skills and high levels of VET sector responsiveness (OECD, 2010). So-called 'high performance work systems' (HPWS) require quite specific workforce skills for innovation and the utilization of the skills requires a supportive work organization. Arundel and colleagues (2006: 4) describe HPWS as entailing "the diffusion of Japanese-style organizational practices in the US and Europe and... the diffusion of specific organizational practices and arrangements that are seen as enhancing the firm's capacity for making incremental improvements to the efficiency of its work processes and the quality of its products and services".

There is much variation in the implementation of HPWS across industries, firm sizes and cultures, however a number of central features can be identified²:

1 According to the UK Cabinet Office (2001: 33), "Though the 'low skills equilibrium' is not a true representation of all sectors of the UK economy, and is, in part, an exaggeration of the actual situation, it provides helpful conceptual insights, including recognition that innovation in products and processes may be discouraged by perceptions of skill shortages. This model also highlights the issue of 'path dependency': once managers adopt a strategy based on a given skill level, it is not easy to adopt a different strategy. Indeed if a previous strategy based on low skills has been successful, management may be reluctant to develop new or enhanced strategies even if a skilled workforce is available. A survey undertaken by the NSTF [National Skills Task Force] found that roughly half the employers surveyed foresaw skills-related problems if they sought to respond to competitive market pressures by developing higher value-added product strategies. Case studies carried out for the NSTF indicated that if companies attempted to move towards higher value-added strategies without complementary changes to human resource strategies, latent skills gaps would be revealed. Once locked into a particular path, it may be difficult to change even if the economy as a whole would benefit from doing so".

2 The principal features of HPWS in both empirical and theoretical studies have remained more or less constant (Appelbaum et al., 2001; Ramsay et al., 2000).

1) Rigorous selection procedures, as HPWS needs workers with a range of superior attributes such as communication, numeracy, problem solving and team working.

2) Broad job classifications requiring functional flexibility in the deployment of workers and requiring them to be competent across a broader range of tasks - which also requires broad based training.

3) Job rotations that move workers through a range of the production tasks within and between work teams, expanding flexibility and enabling better understanding of the variety of tasks that contribute to continuous improvement.

4) Production is organised around work teams composed of workers who are responsible for planning and carrying out production tasks.

5) Managerial authority is delegated to the shop floor, including the design of jobs, routine maintenance and ability to stop production if a fault is detected. Team members are expected to actively pursue continuous product and process improvement to ensure conformity of a product or service with specifications.

6) A consequence of broad job classifications and delegation of authority is relatively few steps in the job hierarchy between team members and senior management.

7) Aside from decentralised work teams, formalised mechanisms for workers collectively negotiating change are an important element in HPWS, including unions (Black y Lynch, 2004; Michie y Sheehan 2003) and work councils (Zwick, 2004).

8) A key part of HPWS is that active participation in innovation is expected of team members; ideas and improvements are sometimes rewarded with cash bonuses or other benefits and at a broader workforce level profit sharing or employee share ownership schemes may operate. The level of engagement in productivity and quality improvement is one criterion used to assess individual workers for promotion.

9) Devolution of responsibility for innovation is accompanied by measures to capture learning, by monitoring, evaluating, and diffusing improvements that are devised in one team to others and potentially to operations around the globe in the

case of multinationals. This has been described as “an internal process of variety generation, screening, retention and diffusion” (Fujimoto, 2000: 276) and a key aspect of converting the insights of individuals and teams into organisational learning (Teece, Pisano y Shuen, 2000: 344).

10) Extensive training is driven by the broad based occupational classifications and participation in product and process improvement. Undertaking root cause analysis of defects and Quality Assurance requires not only occupational specific technical skills but also higher level problem solving skills. It is well-established that firms implementing a broad cluster of HPWS elements have a much higher rate of training across all occupational groups (Whitfield, 2000).

There is great variation in the extent to which firms implement HPWS, such that most innovating firms can be represented as being on a continuum from complete to minimal implementation. VET institutions are most likely to be required to respond to demands for the types of broad-based skills from firms that face intense competition, where ICTs are integral to design, production and delivery of products and services, where consumer demand is for quality and customization of these products and services, and where firm level bargaining gives individual organizations flexibility in the design of jobs and work processes (Gospel, 2007). VET institutions supplying skills to HPWS will be required to impart a variety of attributes aside from technical skills. These include: social communication skills; leadership, initiative and accepting responsibility; vigilance regarding quality; teamwork and cooperation; flexibility; analytical skills and creative problem solving; and the capacity to learn and capacity to teach others in a team (Lafer, 2002; Keep y Payne, 2004; Martin y Healy, 2008).

The critical literature on HPWS points out that individual firms are free to adopt some elements of HPWS purely to pursue cost-cutting and other features of lean production. The context created by the particular competitive strategy adopted by a firm is thus vital, as is the broader labour market and institutional contexts which facilitate or inhibit the pursuit of a ‘low road’ or ‘high road’ strategy in

terms of training, technology diffusion, work organisation and innovation.

In summary, this section has provided an overview of four approaches to the role of the VET system and the VET trained workforce in innovation. It is common to all these approaches that the VET system is a key driver of technology diffusion through the provision of a skilled workforce that contributes primarily to incremental technical and organizational change. The different interlocking sets of institutions that characterise national contexts have been shown to condition the depth of vocational skills in the workforce and the types of skills that are held. This has a direct impact on the types and patterns of innovation that are engaged in and the observable outcomes in terms of economic performance. Individual firms also influence these outcomes by the choices they make in terms of work organization features which, in turn, shape the demands for particular types of skills that local and regional VET institutions respond to. The rise of whole of workforce approaches to innovation has meant that VET sectors are required to provide generic skills in problem solving, troubleshooting and a creative and team-oriented approach to work. Such workforce skills are part of the backbone of many innovative firms' product-market strategies along with the knowledge base provided by science and engineering educated employees. VET institutions and the VET trained workforce can thus be understood as essential to technical and organisational innovation in many contexts within both the goods and services sectors of developed economies. The next section moves on from this conclusion to briefly discuss some broad barriers and specific impediments to a fuller realization of the potential for VET and the VET-trained workforce to contribute to innovation and desirable socio-economic outcomes. It also points toward future challenges that will reply a VET sector response.

THE VET SYSTEM AND FUTURE CHALLENGES

As this article has described in some detail, the VET system makes an important contribution to innovation.

VET training organisations are part of the 'institutional endowment' that supports the agglomeration of firms and other innovation system actors in clusters, towns, cities and regions (Maskell, 2001). The extent to which the VET sector can maximize its contribution to innovation depends on many socio-political factors that can vary from country to country, including for example the extent and rate of growth of direct financial contributions to the sector from government. In this last section we focus on three generic impediments to the full flowering of VET contribution to innovation that are more systemic in nature and therefore require long-run policy attention to address.

The first general impediment relates to the quality and rate of technology diffusion. In many contexts linkages between research institutions, VET organisations and technology adopting firms are often not sufficiently close or effective when it comes to the opportunities presented by emerging technologies (Whittingham, 2003; Toner, 2005). It is obvious that VET institutions focus their teaching activities on established and widely used technologies, where student demand is predictable in the medium-term. In contrast, emergent technologies have uncertain futures and the responsiveness that VET institutes should ideally have to these technologies is also therefore uncertain. A major challenge and restriction on VET responsiveness is "more timely skills development in new and existing technologies" (Ferrier, Trood y Whittingham, 2003: 87) that can support industries and firms that are willing to invest in taking advantage of new technologies. Without sufficient policy support for activities that build direct firm-VET linkages and sufficient resources to initiate training in new or modified techniques then technology diffusion will remain harnessed to risk averse processes associated with curriculum and trainer updating.

A second problem that is common across many OECD nations is the long run decline in the academic outcomes of VET entrants. The massification of higher education opportunities has led to disproportionate number of school leavers opting to pursue a university education (Hoeckel y Schwartz, 2010). This has resulted in the lowering of the average education performance of students that enter the VET system.

Without good competence in mathematics and literacy and, increasingly important, communication and social skills, VET students will struggle to obtain the highest level skills certificates that are vital for many craft-based and other technical occupations that are particularly important in the R&D and high-technology production work. This can lead to skills shortages precisely in those occupations and sectors in which high level skills and generic problem-solving capabilities are most important. This preference for university degrees is reinforced by a lack of social desirability that still attaches to vocational formation in some countries.

The third problem relates to the relationship between government policy and VET. Historically, VET was linked directly to industry policy but the shift to innovation policy has resulted in VET being left to some degree out in the cold. National innovation systems thinking, embodied in the innovation studies literature, does not integrate VET and the vocationally trained workforce in a systematic and profound way. It is little wonder then that Government innovation policy and the advisory structures that shape the design and implementation of incentives and other forms of support do not typically treat the VET sector as a first order concern. Explanations for this lack of integration of VET and innovation policy include the predominance of the focus on doctoral STEM training in universities, coupled with the lack of interest on the part of governments and researchers in the general production workforce despite their importance to incremental innovation. The justifiable focus on radical innovation and S&T advances thus probably contributes considerably to a failure to maximize the contribution the VET could be making to innovation in advanced economies. This is perhaps no better illustrated in the glacial progress toward a better articulation between the VET and HEd systems. In such a world, hybrid courses that combine knowledge and skill in ways that satisfy market demand could be more commonly developed. In addition, systemic pathways could be promoted for the transfers of students between the two arms of education as their capabilities and interests take shape and are revealed in the ongoing course of their education trajectory.

A final question concerns the role of VET and innovation in social and economic development more generally speaking, particularly via the mechanism of labour market participation. The focus in this article has been on VET in relatively high-income countries, but VET potentially has an important role to play in low- and middle-income countries as well. Following a thorough effort to assemble the best available evidence, Tripney and colleagues (2013) conducted a meta-analysis of the impact of VET on the employability and employment outcomes of young people in low- and middle-income countries (LMICs). They found that “participation in VET improves the labour market situation of youth in LMICs, on average, when compared to youth who do not participate with the strength of the evidence strongest for formal employment and monthly earnings” (Tripney y Hombrados, 2013: 10). There are important limitations to this review, not least the low number of acceptable quality studies feeding the analysis and the de-linking of outcomes from any particular model of vocational education and training. The results are also based largely on studies of interventions focused on “short-term semi-skilled training in specific occupations demanded in the private sector” (Tripney y Hombrados, 2013: 6), and no studies of apprentice-type training are included. Nevertheless, it can be argued on a very limited basis that VET does impact positively on youth labour market outcomes. This would also suggest that, if implemented at national level, such training may also incrementally improve the capacity of firms and other employers in LMICs to adopt existing technologies more easily.

While it is quite clear that further and higher quality studies are needed before the contours of links between VET, employment and innovation in low- and middle-income countries can be clearly defined, revitalizing the role of VET in youth employment outcomes in some high-income countries also appears critical. According to OECD data for 2014, unemployment among those in the 15-24 years age bracket is at unacceptable levels in many European countries, including Spain (53.2%), Greece (52.45), Italy (42.7%), Portugal (34.8%), Ireland (26.7%) and Poland (23.9%) (OECD, 2015). The role of VET

in equipping young people with sought after and adaptable skills will be crucial in reducing the levels and contours of this mass labour market exclusion among young people.

Despite these serious concerns, recent work on skills and innovation does present some potentially rich avenues for thinking about the roles and contributions of VET in addressing future social and economic challenges, in which technical and organizational innovation will most certainly need to play a central role. The transitions associated with the need to develop economically and environmentally sustainable societies of the future are likely to involve new work tasks, reconfigured skills content in existing occupations and an evolving division of labour between high-end knowledge workers and a skilled and flexible workforce (Consoli et al., 2016). The challenge of outfitting societies with the necessary green skills to address energy transitions

(Vona et al., 2015), for example, will thus require a systemic and coordinated policy and institutional response. The role of VET in the technical and organizational innovations to come will be just as crucial as it has been in the industrial and technological changes of the past.

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