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The Labour Market and the Knowledge Intensification of Australian Jobs: A View to the Future

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*The importance of knowledge in the labour market and in economic activity has been recognized since as far back as the Industrial Revolution. A feature of employment change in Australia has been the knowledge intensification of occupations. This paper outlines and discusses why some knowledge sets might be more important than others in meeting the challenges of a rapidly changing labour market and how best to assess what sets are required by the economy to grow and to compete effectively in a complex and competitive economic global environment. The paper uses the Occupational Information Network (O*NET), an extensive US database that describes the attributes and characteristics of occupations and workers. It uses the O*NET data on knowledge which is made up of 33 distinct indicators and applies it to the Australian labour market context using the Monash Forecasting System, and presents detailed "knowledge" forecasts. The paper concludes that the knowledge intensity of Australian jobs has increased significantly historically and is expected to continue to grow in the future.*

JEL Codes: J31 and J38

1. Introduction

Over the last four decades, Australia and nearly all OECD member countries have experienced fundamental economic and social change. One of the key drivers of these changes has been the emergence of the global knowledge economy. This places knowledge and its exploitation at the centre of economic activity, which plays a principal role in wealth creation:

> It is not simply about pushing back the frontiers of knowledge; it is also about the more effective use and exploitation of all types of knowledge in all manner of economic activity (Forfás, 1996).

The importance of knowledge and skill in the labour market and in economic activity has been recognized since as far back as the Industrial Revolution: "The degree of incorporation of knowledge and information into economic activity is inducing quite profound structural changes" (Houghton and Sheehan, 2000, p. 1). These changes are directly impacting and transforming the world of work and the basis on which people conduct their day to day work and social activities. The place of knowledge and its accumulation is crucial in explaining the competitiveness of firms, regions and nations and in explaining the performance of labour markets. Knowledge per se is a concept that is embodied in the notion of "human capital", which is simply the skills and knowledge that make people productive. As such, it can be regarded as a basic form of capital, whereby investments in it can raise production (at the

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individual, firm or national level) to new scientific and technical levels, whilst at the same time impact positively on economic growth.

In trying to understand further the impact of knowledge in the Australian labour market, I use the O*NET measures of knowledge and Australian employment data drawn from the labour force survey to investigate:

- Whether the content of Australian jobs requires higher levels of knowledge (knowledge intensity); and
- Which knowledge areas are important in a labour market sense.

Hence, the analysis that follows considers changes in the knowledge requirements of occupations by analysing labour market change (historically) and forecasting the growth in 33 specific work related "knowledges" and ten knowledge areas relevant to Australian occupations.

2. Literature Review

Sheehan and Esposto (2001) have shown that job creation in Australia has been characterized by higher levels of knowledge intensity, placing greater demands on work activities. This evolution of the labour market has posed profound challenges not only for strategies of firms competing in global and local markets, but also for governments, regions and individuals, in terms of dealing with issues related to increasing inequalities, employability skills, training and retraining of the labour force, and other broader issues.

But what is knowledge in a labour market sense, especially in the context of a rapidly changing labour market and the current pace of implementation of new work practices, creation of new and diverse jobs, and implementation of new technologies? Just as the concept of skill is difficult to measure in studies of labour market change,[i] so is the concept of knowledge. While both terms are often used interchangeably, I make a distinction between them because, semantically and more importantly in a labour market sense, they are not the same thing.

The two concepts are difficult to distinguish because they overlap and can be seen as interdependent. Costanza *et al.* (1999) define knowledge as a collection of discrete but related and original facts, information and principles about a certain field of work.[ii] It is acquired through formal education or training, or accumulated through specific experience over a period of time. Skills are more dependent on learning and represent the product of training and learning certain job tasks. They are a general set of procedures required to perform tasks such as problem solving or managing and functioning in social interactions. In contrast, knowledge may be "known", but this does not necessarily mean that through "known" knowledge a set of tasks can be performed successfully. For example, a recently graduated medical doctor may possess a lot of knowledge on the anatomy of the heart, but this does not necessarily mean that they can perform open-heart surgery on a patient.

Skills, as defined by the US Department of Labor's Occupational Information Network (O*NET), are inherently tied to knowledge, practice and expertise.

They are not necessarily stable attributes, but are qualities or characteristics of the individual that develop as a function of experience within a certain area of work. According to Mumford and Peterson (1995), skills are situational and tend to improve with time, practice and learning. In contrast, knowledge does not have to be necessarily situational as it can be acquired in the abstract. For example, knowledge about changing a car tyre can be obtained by reading a car operational manual, but this does not mean that, after doing so, an individual is skilled in changing car tyres.

Skills and knowledge are complementary and dependent on each other, but knowledge is required so that skills can be applied in work situations. To acquire a certain skill, it is important to have knowledge about a certain collection of related facts and information in a given field of work. For example, a surgeon who is skilled in open-heart surgery is required to have knowledge of the anatomy and functions of the heart, and to possess information about the techniques needed to diagnose and treat diseases that are related to the heart. In contrast, skill in open-heart surgery cannot be acquired without knowledge about open-heart surgery.

Both knowledge and skill are human capital attributes; however, these concepts are not the same, nor should they be treated as synonymous. Defining knowledge is extremely difficult. The *Oxford Dictionary* defines it as "facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject". Such a definition is quite broad and makes it difficult to capture or measure knowledge for the purposes of labour market studies. I propose in this paper that one way of dealing with this limitation is to use the O*NET's approach to defining knowledge.

In trying to simplify and manage the complexity that constitutes and is suggested by the concept of knowledge, Costanza *et al.* (1999, p. 71) narrow their definition to focus on knowledge as a work requirement:

> a collection of discrete but related facts and information about a particular domain. It is acquired through formal education or training or accumulated through specific experiences. Jobs relevant knowledges are those facts and structures that are relevant for successful job performance.

Knowledge is acquired incrementally and can be used to acquire further knowledge and to develop skills. It is closely related to skills because it can assist in the development of skills while, at the same time, skills can aid the process of knowledge acquisition.

In the O*NET, knowledges[iii] form part of a structured taxonomy consisting of 33 knowledges belonging to different sets of general categories. Some categories are general and are regarded as being essential elements in the successful performance of occupational tasks. Others are narrower and can only be applied to a fine range of occupational groups, while others can be seen as being occupation specific.

In identifying a taxonomy of knowledge indicators, Fleishman *et al.* (1995) developed a knowledge classification by analysing job descriptors and looking for tasks and behaviours that were representative of underlying knowledges in

occupations. These underlying knowledges had to be general enough so that they could be transferable across occupations. Lists of knowledge descriptors were created and were further divided into categories or clusters of knowledges. Fleishman *et al.* (1995) arrived at a parsimonious set of 33 knowledges, grouped into ten knowledge areas (Table 1).

Table 1: Description of knowledge areas

Taxonomy	Taxonomy description	Number of descriptors
Business and Management	Principles and facts related to business administration and accounting, human and material resource management in organizations, sales and marketing, economics, and office information and organizing systems	6
Manufacturing and Production	Principles and facts related to the production, processing, storage and distribution of manufactured and agricultural goods	2
Engineering and Technology	Design, development and application of technology for specific purposes	5
Mathematics and Science	History, theories, methods and applications of physics, biology, mathematics and geography for specific work purposes	7
Health Services	Principles and facts regarding diagnosing, curing and preventing disease, and improving and preserving physical and mental health and wellbeing	2
Education and Training	Instructional methods and training techniques including curriculum design principles, learning theory, group or individual teaching techniques, design of individual development plans, and test design principles	1
Arts and Humanities	Principles and facts related to the branches of learning concerned with human thought, language and the arts	5
Law and Public Safety	Regulations and methods for maintaining people and property free from danger, injury or damage, the rules of public conduct established and enforced by legislation, and the political process establishing such rules	1
Communications	Science and art of delivering information	2
Transportation	Principles and methods for moving people or goods by air, rail, sea or road, including their relative costs, advantages and limitations	2

Source: Jeanneret *et al.* (1999).

2.1 O*NET Applications in Labour Market Research

As noted, the O*NET is an occupational database which offers an important resource that can be applied in the study of labour market change. Given its recent and continuing development, a number of studies have used the O*NET to study and analyze the labour market, to identify occupational skill requirements and to provide forecast of short-term demand for skills.

One of the first studies to use the O*NET database was conducted by the Minnesota Department of Economic Security (MDES) (2000). The report, titled “Minnesota’s Most Marketable Skills”, identified the occupational skill requirements considered to be most marketable. Marketable skills were defined as those occupational requirements that are meant to be associated with high wages and/or employment growth. Out of 57 requirements that measure the knowledge, ability and skill dimensions of an occupation, 18

were found to be extremely “marketable”. The finding were used by the state of Minnesota to apply to areas of policy related to the labour market and to align the skill requirement of occupations to education curricula.

In 2002, the MDES conducted a forecast of the demand for skills in the short term, using 46 skills, 52 abilities, 33 knowledge and 38 generalized work activity measures found in the O*NET database. The report summarized research into the feasibility and appropriate methodology for developing short-term, skill-based forecasts in order to direct public resources more effectively. It concluded that the O*NET was an effective data system that could be applied for the analysis of forecasts of short-term demand for skills. Another application of the O*NET measures was in a study designed to identify occupations that are comparable in earnings to primary and post-primary teachers in the US. Using the generalized work activities, basic and cross-functional skills and educational level scales embodied in the O*NET, Milanowski (2003) performed a variety of cluster analysis methods, and was able to identify comparable work activity and skills for US occupations.

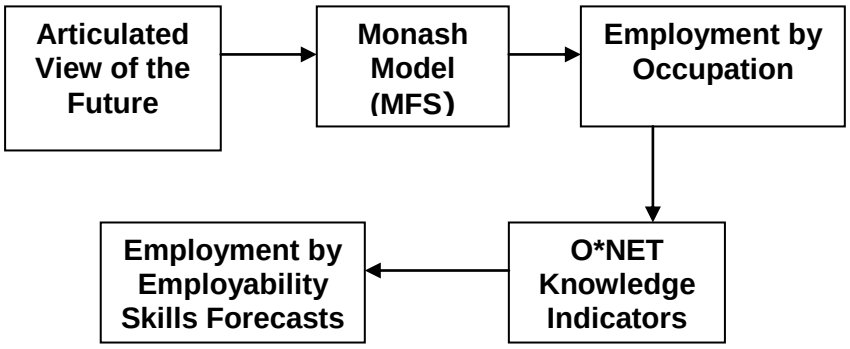
Rotundo and Sackett (2004), using the O*NET database, conducted a job-level evaluation of whether specific skills or abilities could be identified that were most strongly linked to wage or whether broad skill/ability factors accounted for a majority of wage variance. They found that most wage variance explainable by skills/abilities could be attributed to a general cognition factor. Esposto (2008) applied the O*NET database to study labour market change in Australia by investigating how skill should best be measured in addressing the issue of skill-bias in the demand for labour and the long-term upskilling of the labour force.

3. Methodology: The O*NET and the Monash Forecasting System (MFS) interface

The O*NET’s first version was launched in 1998 and the information detailed in this paper refers to this version, also known as O*NET 98. The O*NET is considered to be the most comprehensive standard source of occupational information in the US. It offers statistical information that can be applied to the Australian context to analyze labour market change.[iv] The O*NET was developed by a consortium led by the US Department of Labor to replace the Dictionary of Occupational Titles (DOT), which was conceived in the 1930s and was last published in 1991. The O*NET was a response to a growing demand for an expanding public employment service and was intended to assist, among other things, in job placement activities. It follows a different strategy from DOT, providing very detailed information on about 1,120 occupations rather than more limited information on over 12,000 occupations. The O*NET is continually updated to reflect the dynamic and ever-changing nature of employment, with the latest version being O*NET 14.[v] The occupational information is organized in a relational database which identifies, defines and describes the comprehensive elements of job performance. There are hundreds of information items on job requirements, worker attributes and the content and context of work, capturing what people do in their day-to-day activities. It contains detailed data on skills, knowledge, abilities, as well as many other descriptors of occupations.

In preparing forecasts for the Australian economy, we begin with the idea of requiring a view of the future in terms of "knowledges". The Monash model[vi] is used to obtain specific employment forecasts for 340 occupations at the four-digit level of Australian Standard Classification of Occupations (ASCO). These are then assigned or connected to the O*NET occupational classification to obtain knowledge forecasts or employment forecasts. The MFS begins with a macroeconomic scenario derived from the Access Economics Macro Model. This econometric modelling takes a view of what is happening in the economy of our trading partners, by looking at the global economy and by answering questions such as "Will China continue to grow at current rates?" and "Will the US economy continue to grow or will it slow down over the next economic cycle?". This is supplemented with industry-specific information obtained from Australian Bureau of Agricultural and Resource Economics (ABARE) and Tourism Forecasting Council (TFC). The MFS also uses information from the Productivity Commission (PC) which models government policy in terms of variables used in our model. Finally, the MFS incorporates the Structure of Technical Change which is generated by Monash University's Centre of Policy Studies. From here, it makes a labour market extension by providing employment forecasts for the 340 four-digit occupations of ASCO and is then connected to the O*NET to obtain employability skill forecasts (see Table 2).

Figure 1: The Monash Forecasting System



Source: Esposto and Meagher (2007, p. 6)

3.1 Forecasting O*NET knowledges

Table 2 presents the growth in demand for the 33 O*NET knowledge descriptors and for the ten areas of knowledge under consideration. All forecast values are lower than the historical values. The reason for this is that the aggregate employment growth, which is obtained from the Access Economics forecast, is forecast to grow at 1.14 per cent per annum. Thus, the forecasts reflect the aggregate forecast of employment growth as specified by Access Economics for the period 2004-05 to 2012-13. The forecasts of employment growth in hours range from 0.73 per cent per annum for 304 Building and Construction to 1.42 per cent for 101 Administration and Management.

The average annual growth rate of 1.42 per cent for Administration and Management translates into a total growth rate of 11.36 per cent over the eight years of the forecast period. A substantial part of the hours spent

performing this knowledge area is contributed by workers belonging to the occupation Managers and administrators (19.7 per cent in the base period). Their employment is forecast to increase more rapidly than average employment (18.74 per cent as compared to 9.52 per cent).

Table 2: Average Annual Growth Rates, O*NET Knowledge Groups, Australia, Hours, Per Cent Per Annum

	Knowledge groups	Historical data 1996-97 to 2004-05 p.a. growth	Forecast 2004-05 to 2012-13 p.a. growth	Total historical growth 1996-97 to 2004-05	Total forecast to 2012-13
100	**Business and Management**	**1.78**	**1.29**	**14.24**	**10.32**
101	Administration and management	2.00	1.42	16.00	11.36
102	Clerical	1.44	1.12	11.52	8.96
103	Economics and accounting	1.82	1.38	14.56	11.04
104	Sales and marketing	1.87	1.34	14.96	10.72
105	Customer and personal service	1.76	1.20	14.08	9.60
106	Personnel and HR	1.86	1.30	14.88	10.40
200	**Manufacturing and Production**	**1.28**	**1.00**	**10.24**	**8.00**
201	Production and processing	1.38	1.04	11.04	8.32
202	Food production	1.14	0.93	9.12	7.44
300	**Engineering and Technology**	**1.45**	**0.90**	**11.60**	**7.20**
301	Computers and electronics	1.55	1.16	12.40	9.28
302	Engineering and technology	1.48	0.92	11.84	7.36
303	Design	1.43	0.88	11.44	7.04
304	Building and construction	1.55	0.73	12.40	5.84
305	Mechanical	1.25	0.78	10.00	6.24
400	**Mathematics and Science**	**1.61**	**1.12**	**12.88**	**8.96**
401	Mathematics	1.67	1.19	13.36	9.52
402	Physics	1.40	0.91	11.20	7.28
407	Chemistry	1.42	0.93	11.36	7.44
404	Biology	1.35	0.98	10.80	7.84
405	Psychology	1.88	1.31	15.04	10.48
406	Sociology and anthropology	1.81	1.28	14.48	10.24
407	Geography	1.65	1.13	13.20	9.04
500	**Health Services**	**1.73**	**1.18**	**13.84**	**9.44**
501	Medicine and dentistry	1.62	1.09	12.96	8.72
502	Therapy and counselling	1.83	1.27	14.64	10.16
600	**Education and Training**	**1.90**	**1.42**	**15.20**	**11.36**
700	**Arts and Humanities**	**1.63**	**1.17**	**13.04**	**9.36**
701	English language	1.70	1.23	13.60	9.84
702	Foreign language	1.63	1.15	13.04	9.20
703	Fine arts	1.55	1.09	12.40	8.72
704	History and archaeology	1.59	1.16	12.72	9.28
705	Philosophy and theology	1.56	1.13	12.48	9.04
800	**Law and Public Safety**	**1.72**	**1.17**	**13.76**	**9.36**
801	Public safety and security	1.66	1.09	13.28	8.72

802	Law, government and jurisprudence	1.79	1.24	14.32	9.92
900	**Communications**	**1.66**	**1.20**	**13.28**	**9.60**
901	Telecommunications	1.57	1.13	12.56	9.04
902	Communications and media	1.75	1.26	14.00	10.08
1000	**Transportation**	**1.51**	**1.08**	**12.08**	**8.64**
9999	**All Knowledge Groups**	**1.63**	**1.14**	**13.04**	**9.12**

Source: Esposto and Meagher (2006, pp. 37-8).

3.2 The knowledge requirement trends for employment in Australia

Table 2 shows changes to the ten areas of knowledge in employment. All experienced significant increases historically and in terms of forecasts. The strong rise in Education and Training can be attributed to the rapid expansion of the sector in Australia over the last 35 years. This area is concerned with instructional methods and training techniques designed to improve productivity. Training and retraining has become a common feature of many workplaces. The increasing importance of education has also been driven by government reform which has focused on expanding the vocational and tertiary sectors. The internationalization of the Australian education system has also seen thousands of international students coming here to complete secondary and post-secondary study programs.

Business and Management knowledge grew second fastest and is forecast to grow by more than 10 per cent by 2013. The continuous change in employment practices has placed new demands on managers and administrators. They now perform a variety of roles including obtaining new types of business related information; gathering and analysing strategic business information and data, both external and internal; monitoring work related processes; detection and resolution of work related problems with corresponding solutions internally and externally; a sound understanding of the economic climate; identification of change and its implementation; and management of human resources across the organization.

Health Services saw historical growth and is expected to grow strongly in the future. Over the last 35 years, the sector has undergone rapid expansion resulting from an ageing population which requires increasing levels of medical attention, new technological discoveries and applications of technology, increased awareness of mental health issues as well as a rapid expansion of knowledge, including alternative treatments, rehabilitation equipment and new methodologies focused on evaluation of treatments and their impacts on patient care. The labour force has required increasing levels of knowledge and skill in palliative care, preventative medicine and new medical technological advances. Increasingly, workers in this field required constant upgrading of skills and knowledge in areas related to therapy and counselling, physical and mental rehabilitation as well as the testing of new forms of treatments and drug administration.

Knowledge of Law and Public Safety has increased significantly. This area is concerned with having an understanding of the regulations and methods for maintaining people and property free from danger, injury or damage. The increases may be due to the rise of the security industry in Australia since the

late 1980s, and an increase in awareness of health and safety issues at work. The security industry has created a vast number of new forms of employment which require increasing levels of knowledge related to public safety, security operations, rules and regulations, prevention and protection of people and property, and data management. Specialized knowledge of new rules and regulations has also become a feature of the knowledge economy.

Communications knowledge also experienced considerable growth. This area is concerned with how employees interact within the organization and with members of other organizations. One important aspect relates to explaining to colleagues what strategic information is or is not important to the firm. This requires a set of knowledges that relate to how to communicate effectively with subordinates, peers and supervisors. It also involves appropriate knowledge in terms of how best to communicate with the general public, government or other businesses. This involves knowledge that facilitates the establishment and maintenance of interpersonal relationships, assisting others, and selling, persuading and influencing other people.

The growth in Arts and Humanities knowledge can also be explained in terms of the increasing importance of education in employment. This area is concerned with the facts and principles related to the branches of learning that deal with human thought, language and the arts. It includes knowledge of English and foreign languages, fine arts, history and archaeology, philosophy and theology. Its increasing importance in employment creation is due to the significance of learning as an ongoing activity, which includes learning on the job and life-long learning.

Knowledge of Mathematics and Science grew significantly historically and is forecast to grow quite solidly by 2013. This area is concerned with the use of numerical and scientific concepts to solve work related problems. The need for knowledge in numerical ability can be attributed to a rapid expansion in a number of service sectors, including finance, property, banking, and the explosion of the information and communications technology sector.

Knowledge of Transportation experienced historical growth of 12.08 per cent and is expected to grow by 8.64 per cent by 2013. This area is concerned with the principles and methods for moving people or goods by air, rail, sea or road. The rapid process of globalization of economic activity, in spite of the global financial crisis, does not seem to be abating.

The forecast growth in the knowledge area of Engineering and Technology is consistent with the increasing importance of the commodities sector in Australia. This is concerned with the design, development and application of technology in different settings. It consists of knowledge related to engineering and technology, design, building and construction, mechanical, and computer and electronics.

Finally, Manufacturing and Production experienced the least historical growth. This area is concerned with the principles and facts related to the production, processing, storage and distribution of products ranging from manufacturing to farming. Its smaller historical rise may be closely tied to a strong decline in

employment in the manufacturing sector in Australia, accompanied by a corresponding shift towards the services sector. Another reason is that the farming sector has faced many significant changes over the last two to three decades. These have manifested themselves in the form of increasing farm sizes, declines in employment opportunities, and use of higher levels of technology for crop production and animal husbandry. Similarly, manufacturing has experienced a strong decline resulting from cost competition from East Asia, particularly China, and a shift towards more efficient technology based processes, requiring lower employment levels.

4. Conclusion

The analysis in this paper supports the proposition that there has been a major change in the knowledge intensification of employment in Australia. This is consistent with Sheehan and Esposto (2001) and Esposto (2008) who analyzed increased knowledge intensification over a long-term horizon (1971-2001). The data demonstrates a persistent trend towards the increased demand of knowledge intensity in employment. These include both historical and forecast trends, indicating continued increasing demand for "high knowledge" intensive jobs.

Both the historical and forecast analysis show that all areas of knowledge analyzed are central to the continuing development and growth of the Australian economy. There is high growth in education and training knowledge, business and management knowledge, and communication knowledge. This appears to indicate their importance in meeting the needs of a more integrated and interconnected global knowledge economy. The lower relative historical and forecast growth seen in manufacturing and production knowledge and engineering knowledge may point towards a long-term adjustment of the Australian labour market from a manufacturing base, towards a services centred and commodities exporting sector economy. In trying to explain these effects, two factors may be at play: a substitution of low knowledge intensive jobs in manufacturing by labour replacing intensive technologies; and an increase in the knowledge intensification of work in manufacturing, where employment creation is biased towards those occupations which require higher levels of knowledge, hence, replacing occupations which possess lower levels of knowledge intensity.

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[i] See Esposto (2008) for a discussion on the limitations of measuring skill in labour market studies.

[ii] The application side is missing here. Knowledge also implies a prior acquisition of experience, practice, understanding, familiarity etc.

[iii] The plural is used here to show that knowledge is not a unique singular thing but a collection of diverse entities and concepts.

[iv] For example, Pappas (2001) used the DOT to analyze the causes of increasing earnings inequality in Australia, while Sheehan and Esposto (2001) used the O*NET to study the characteristics of Australian jobs.

[v] This database was released in June 2009 and can be accessed at <http://www.onetcenter.org/dataPublication.html>.

[vi] A detailed technical explanation of the operations and application of the MFS can be found in Dixon and Rimmer (2002).