An Analysis of Developments in Skills Shortages that Hampered Innovation using the 2003 and 2005 Australian Innovation Surveys

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INQUIRIES

Comments on the research presented in this paper are welcome. However, the contents should not be quoted without the permission of the author(s). For further information, please contact Dr Ewa Orzechowska-Fischer on Canberra (02) 6252 7766 or email <economic.indicators@abs.gov.au>.

CONTENTS

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ABSTRACT

The issue of the impact of skills shortages on the capacity of businesses to successfully conduct their innovation activities is at the forefront of business concerns and government policy considerations in Australia. In May 2007 the Australian Department of Industry, Tourism and Resources (DITR) released a study, "Aspects of Skills Shortages and Innovation in Australian Businesses" which used micro-data collected in the 2003 Australian innovation survey to investigate skills shortages and innovation in Australia. The present skills shortage in Australia was in only a nascent stage during the period covered by that study. This paper uses the main unit record data files for the 2003 and the more recent 2005 innovation surveys to investigate the nature and extent of changes in the association between key business characterisitics and the incidence of skill shortages that hampered innovation. An identically specified binary probit model is estimated on both the 2003 and 2005 innovation data sets. The model estimates the strength and direction of association between selected business characteristics and the probability of a business experiencing skill shortages that actually hampered its innovation during the period in question. Impact analysis is conducted on selected conditioning variables of a priori interest and statistical significance. In addition, the relative roles of changes in business characteristics, and changes in model 'structure' (estimated model coefficients) on the predicted probability of experiencing innovation-hampering skills shortages between the 2003 and 2005 innovation surveys is analysed. Although the proportion of all innovating businesses experiencing innovation-hampering skill shortages rose only from 25.6% to 27.9% between the two periods, there are large and significant changes in model predictions at more disaggregated industry, business size, and business location levels, with most of the change resulting from 'structural' change rather than average characteristic change. It is suggested that these 'structural' changes are reflective of the major macroeconomic changes taking place in the Australian economy over that period.

1. INTRODUCTION

Innovation is widely recognised as a major source of trend multi-factor productivity growth, economic growth, and ultimately growth in gross domestic product per capita. Moreover, this association between innovation and economic growth is particularly important in an economy which is subject to binding constraints on the rate of growth of its primary inputs. In the current economic environment, Australia is experiencing an increasing incidence of such constraints particularly in relation to labour markets.

Innovation and productivity growth are also critical to Australia's international competitiveness. The ability to offer new or qualitatively superior goods and services, and more competitively priced existing goods and services on international markets enhances Australia's international competitiveness and provides scope for additional gains from trade.

The issue of the supply of labour and the skill level and skill mix of that supply within the Australian economy is now a major focus of public policy. This is so not only because of the constraints that labour supply shortages per se impose on economic growth, but also because of a recognition of the opportunities that enhanced skills offer in terms of the productivity of labour. These opportunities for improved productivity result from a greater capacity within the economy to seek out, generate, and implement new ideas, together with an enhanced ability of the workforce to efficiently adopt (and adapt to) new products, new services and new production processes.

As the economy has grown strongly and the unemployment rate has fallen to 30 year lows, declining availability of skilled labour has become a binding constraint on growth for many businesses. Skilled labour shortages can be expected to detrimentally affect economic growth from two perspectives. First, any deficiency in growth in the generally available pool of labour will have a negative influence on the potential rate of economic growth, as growth in primary inputs is constrained. Second, if such skill shortages hold back innovation then potential productivity growth (and associated international competitiveness) is likely to be compromised. It is the impact of skill shortages on innovation that is the subject of this paper.

In May 2007 the Department of Industry, Tourism and Resources released the paper "Aspects of Skills Shortages and Innovation in Australian Businesses – An Analysis of the 2003 Innovation Survey Data" (DITR, 2007a). Based on an analysis of the main unit record file of the 2003 Australian innovation survey, the study sought to identify business characteristics which were statistically significantly associated with the probability of a business experiencing skill shortages that hampered innovation (henceforth abbreviated to 'SSHI'). However, as recognised in that paper, the acute

skills shortage problem in Australia was in a relatively nascent stage in the period covered by the first innovation survey (the three calendar years 2001 to 2003). Given the reported intensification of the skill shortage issue beyond 2003 and its potential impact on innovation, it is of interest to revisit the issue using the innovation survey data relating to the 2003 innovation survey (covering the years 2001, 2002 and 2003) and the 2005 survey (covering the years 2004 and 2005), and to analyse changes in the incidence of businesses experiencing SSHI over the two periods, as well as changes in the nature and strength of association between key business characteristics and the probability of businesses experiencing SSHI.

This paper compares and contrasts estimates of various relevant population proportions of innovating businesses experiencing SSHI across the two innovation surveys, and also estimates, compares and analyses across the two surveys, a binary probit model of the probability of a business experiencing SSHI conditional on certain key business characteristics (Readers interested in methodological aspects of binary probit modelling are referred to Wooldridge (2002, p. 453)). Separate estimates of a binary probit model based on the 2003 and on the 2005 innovation surveys are used to provide a decomposition of the change in the predicted probabilities of businesses experiencing SSHI into a business characteristics change effect, and a structural (model coefficient) change effect. These effects are disaggregated by business size, industry, and state/territory, and are heuristically discussed in the context of recent changes in the macro economy resulting largely from the intensity and duration of the current resources boom in Australia.

2. DATA: SOURCES, DESCRIPTION AND ISSUES

The data for this study are taken from the main unit record files of the 2003 and 2005 Australian Business Innovation Surveys (ABIS) conducted by the Australian Bureau of Statistics (ABS). These surveys were based on a random sample of approximately 8500 (2003 ABIS) and 6800 (2005 ABIS) businesses, stratified by Industry, State/Territory, and Number of employees. The surveys collected information on businesses with more than four employees in all ANZIC divisions with the exception of Agriculture, forestry and fishing; Government administration and defence; Education; Health and community services; and Personal and other services.

The survey questionnaire covered a wide range of innovation activities of businesses, related business characteristics, drivers of innovation and factors hampering innovation. Survey data were collected for both innovating and non-innovating businesses. However, as the objective of this study is to investigate the association between key business characteristics and the probability of experiencing skill shortages that hampered innovation, subsamples consisting of the 3298 (2003 ABIS) and the 2606 (2005 ABIS) businesses that reported innovating during the survey reference periods were used.

The key variable of interest – whether or not a business experienced SSHI during the relevant period – was derived from answers to Question 21 in 2003 ABIS and Question 19 in the 2005 ABIS. In these questions, respondents were asked what impediments to innovation they had experienced. One in the list of alternative impediments was a lack of skilled staff that had hampered the introduction of new goods, services or processes. A binary variable was constructed taking the value zero if no skill shortage impediment to innovation had been experienced, and unity if it had. Other business characteristics of interest in this study include business Employment size, Industry of operation, Degree of foreign ownership, State of location, Type of innovation, and whether or not the business collaborated.

As the probit models in this study are estimated using unweighted sample data, all the stratification variables – business employment size, industry of operation, and state of location – are included as conditioning variables in the estimation procedure. Table 2.1 lists all variables used in the modelling together with their average population values for the 2003 and the 2005 survey periods, beginning with the dependent binary variable 'experienced SSHI'. Average population values are obtained by ensuring each relevant sample unit is weighted-up to account for the number of population units it represents.

The mean values in table 2.1 indicate the population proportions of innovating businesses falling within the categories in question. For example, 25.6% of innovators experienced SSHI in the period covered by the 2003 survey and 27.9% experienced SSHI in the period covered by the 2005 survey.

The reader will observe that the mean value of the variable 'looks to find people within business' and the means of types of skill sought ('Engineering', General business, … , 'Other type of skill') have all fallen substantially between the 2003 and 2005 survey periods. This relatively uniform fall (of around 50%) in the mean parameter values of these variables reflects a change in the nature of the question between the 2003 and 2005 surveys. In the 2003 survey the question asked *which skill type is sought if engaging people*, while the 2005 survey first enquired as to whether the business actually engaged persons during the period, and directed the respondent past these questions if the answer to actual engagement was negative. It can be expected that an answer to the type of skill sought would generally be provided in the first survey whether or not engagements had actually taken place during the relevant period. The high degree of uniformity in the proportionate declines suggests some substantial similarity in the use-value of the questions between the two surveys, modulo the influence of the 'skip' ratio of 35% in the 2005 survey. Under not unreasonable assumptions for the purpose of indicative analysis (discussed in detail in Section 4 of the paper) this change in the nature of these two survey questions can be accommodated within the decomposition analysis of the changes in the predicted probabilities of businesses experiencing SSHI across the two survey periods.

It is important to note that in general the questions in the 2003 innovation survey covered the three calendar year period 2001, 2002 and 2003, while the 2005 survey covered the two calendar years 2004 and 2005. To the extent that certain outcomes on which data were sought are more likely, all-else-equal, to eventuate sometime in a three year period than in a two year period, there will be difficulties associated with comparisons between the two surveys. In addition, any such differences could not in general be expected to be uniform across different characteristics. However, with the dependent variable in the modelling as well as the conditioning variables being subject to the different length of survey period these problems of comparison may be attenuated in the modelling exercise.

In terms of the proportion of businesses experiencing SSHI, any increase in the incidence of SSHI from the 2003 to the 2005 survey periods is likely to be an understatement of the corresponding unobserved increase based on periods of equal duration.

2.1 Population mean estimates of variables of interest – 2003 and 2005 surveys

	Population means	
	2003	*2005*
Experienced SSHI	0.2561	0.2793
Employment size		
Employment – 5–19 employees*	0.6564	0.6210
Employment – 20–99 employees	0.2762	0.3184
Employment – 100+ employees	0.0674	0.0607
Degree of foreign ownership		
100% Australian owned*	0.9163	0.9075
Foreign owned – >0% to 50%	0.0225	0.0219
Foreign owned – >50%	0.0612	0.0706
Industry of operation		
Accommodation, cafés and restaurants	0.0672	0.1025
Communications	0.0046	0.0034
Construction	0.0816	0.0896
Cultural and recreational services	0.0344	0.0312
Electricity gas and water	0.0020	0.0019
Finance and insurance	0.0358	0.0349
Manufacturing*	0.1823	0.1607
Mining	0.0047	0.0051
Property and business services	0.2301	0.2311
Retail trade	0.2003	0.1781
Transport and storage	0.0370	0.0394
Wholesale trade	0.1199	0.1220
State of location		
New South Wales*	0.3719	0.3251
Victoria	0.2553	0.2597
Queensland	0.1590	0.1873
South Australia	0.0854	0.0773
Western Australia	0.0930	0.1099
Tasmania	0.0143	0.0171
Northern Territory	0.0067	0.0090
Australian Capital Territory	0.0144	0.0146
Type of innovation		
New goods only	0.1081	0.0973
New processes only	0.5239	0.4203
New goods and processes*	0.3680	0.4825
Type of skills sought		
Engineering	0.1895	0.0939
General business	0.4327	0.2296
Information technology	0.3176	0.1881
Management	0.2199	0.1026
Marketing	0.3618	0.1669
Scientific	0.0501	0.0229
Other type of skill	0.1436	0.0561
Other variables		
Business age – 4+ years	0.7474	0.7392
Capital city	0.7094	0.7090
Collaboration	0.2701	0.2197
Looks to find people within business	0.6847	0.3132

The variables denoted in table 2.1 as: Experienced SSHI (no/yes), Business age (less than four years, at least four years), Employment size, Degree of foreign ownership, Industry of operation, State of location, Type of innovation, Regional location (non-capital/capital city), Collaboration status (no/yes), Looks to find people within the business (no/yes) are all categorical variables, with reference category for the purpose of the probit estimation indicated by an asterisk for those categorical variables with more than two categories. The final seven variables listed in the table indicate various types of skill generally sought by businesses and are all dummy variables.

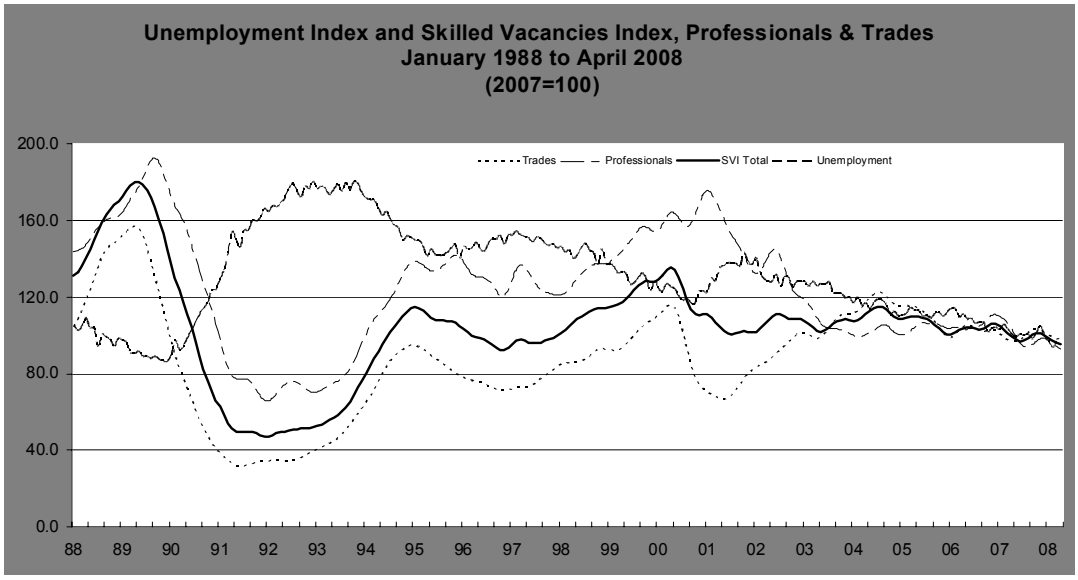
3. DESCRIPTIVE STATISTICS ON SKILL SHORTAGES AND INNOVATION

This section discusses some empirical observations on the development of skilled vacancies, changes in employment in general and in a couple of industries in particular, and the incidence of SSHI within selected key categories across the time period covered by the two innovation surveys. In respect of the discussion of the data coming out of the innovation surveys, additional pertinent observations arising from the econometric modelling in Section 4 are pre-emptively made where they help clarify certain observed phenomena in the survey data.

Some observations on developments in skilled vacancies and employment

Figure 3.1 shows the movements in the Department of Education, Employment and Workplace Relations (DEEWR) index of skilled vacancies from 1988 to 2008, with the aggregate index broken down by 'Trades' and 'Professionals'. During the period covered by the 2003 Innovation survey, calendar years 2001, 2002, and 2003, there was a substantial increase in the 'Trades' vacancy index, and a substantial decrease in the 'Professionals' index, with little change in the aggregate measure over the period. During the period covered by the 2005 innovation survey, calendar years 2004 and 2005, the skilled vacancy index for 'Professionals' rose a little and the 'Trades' index fell somewhat more.

3.1 Unemployment Rate Index and Skilled Vacancies Index



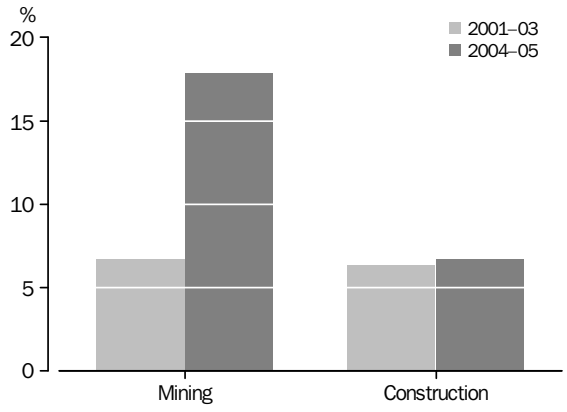
Source: DEEWR, April 2008, Skilled vacancies index
ABS, Labour Force cat. No. 6291.0.55.001 Mar 08

Vacancies are an indicator of (usually temporary) unmet demand for labour. Of particular relevance for a given level of vacancies is the potential supply of appropriate labour to fill those positions. Using relevant period mid points as indicators, the unemployment rate fell from 6.3% in June 2002 to 5.1% in January 2005 – for ease of comparison an index of the unemployment rate is also included in figure 3.1. The relatively large fall in the unemployment rate (while participation rates were generally rising) together with a relatively steady overall skilled vacancy index is consistent with the increasing reports by employers of developing skill shortages, particularly in the period covered by the 2005 innovation survey (and indeed beyond). The continuing trend decline in unemployment rates since then is consistent with the reported intensification of these shortages, although the aggregate skilled vacancy index has trended down since 2005.

It is widely recognised that a key driver of the increased demand for labour (and indeed additional capital) has been the very strong growth in demand for Australia's mineral resources. This has exerted both direct and indirect pressure on the demand for skilled labour in the mining sector and in related industries providing key inputs and complementary activities to the resources sector (e.g. Construction and certain manufacturing industries).

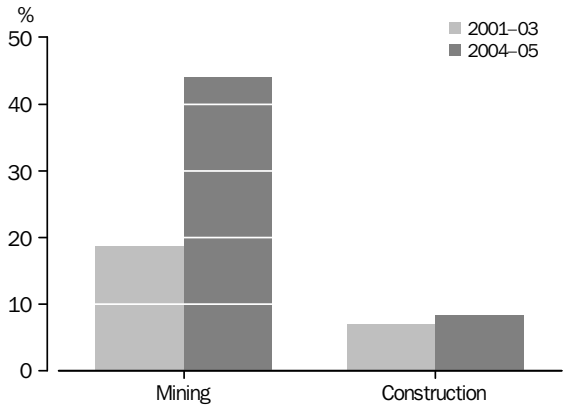
By way of example, figures 3.2, and 3.3 provide an indication of the rate of growth in the demand for labour and capital in the mining and construction sectors over the two periods covered by the innovation surveys. Such developments in the demand for primary inputs could be expected to be associated with the development of skill shortages in general in these industries, and more particularly in skill shortages that might hamper innovation.

3.2 Average annual growth rates in employment in Mining and Construction, 2001–2003 and 2004–2005



Source: ABS (2008c)

3.3 Average annual growth rates in capital expenditure in Mining and Construction, 2001–2003 and 2004–2005



Source: ABS (2008b)

The average annual growth rates in both charts have increased from the earlier to the later periods, in both industries. While the growth rate in the number of employees in figure 3.2 in the latter period is much higher for Mining (17.9%) than for Construction (6.7%) the base number of employees is much higher in Construction than in Mining. Indeed, between 2004 and 2005, employee numbers grew by around 18,000 in the mining industries and by around 54,000 in the construction industries.

Developments in the aggregate incidence of SSHI and in the disaggregated distribution of the incidence of SSHI across the two innovation surveys are consistent with the general propositions regarding skill shortages discussed above. Indeed, both the descriptive statistics and the econometric modelling that follows find that in aggregate there has been only a small increase in the incidence of SSHI, but when disaggregated by industry, state and business size there have been very substantial changes in the incidence of SSHI, with these changes generally consistent with the broader macroeconomic changes in economy.

The remainder of this section presents descriptive statistics on developments, between the 2003 and 2005 innovation surveys, in the proportions of innovating businesses that experienced SSHI. Forward reference is made to the results of the econometric modelling in the following section where those results provide additional pertinent insights into the descriptive proportions set out below.

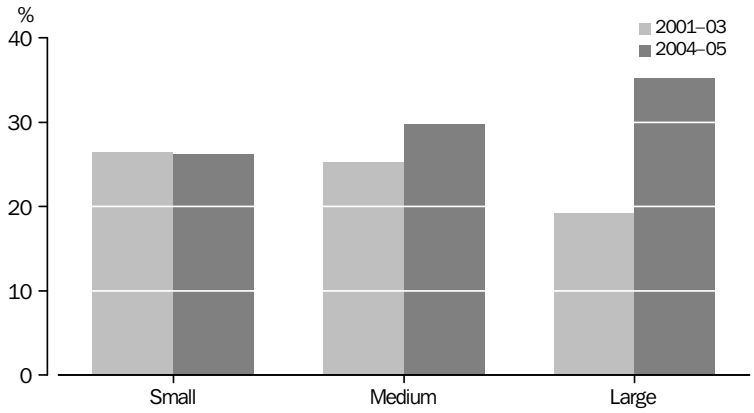
Business size

Figure 3.4 illustrates survey based estimates of the proportion of innovating businesses experiencing SSHI by employment size as defined in table 2.1. Estimates based on the 2003 survey indicate that the proportion of businesses experiencing SSHI fell as business size increased, and particularly so for large businesses. This finding is consistent with the econometric modelling presented in Section 4 of this

paper where the estimated coefficient of the 'large' business size variable is negative and statistically significant, implying a statistically significantly smaller predicted probability of experiencing SSHI for large businesses than for small, all other things held constant.

It might be speculated that larger businesses enjoy several advantages over smaller businesses in accessing skilled labour. For example, larger businesses may be in a better position to offer more financially attractive and flexible working arrangements for their employees. They may also be expected to enjoy better connections through labour market networks and employment brokers than do small businesses, and they may also generally enjoy a higher profile as a prospective employer due to their size-based prominence in the economy.

3.4 Proportion of innovating businesses experiencing skills shortages that hampered innovation, by business size, 2001–2003 and 2004–2005



However, the estimated proportions experiencing SSHI based on the 2005 survey stand in quite stark contrast to those derived from the 2003 survey data. First, the estimated proportions experiencing SSHI are considerably higher for medium and large businesses than in the earlier period, and particularly so for large businesses. In addition, the relationship of these proportions to business size is the opposite of that obtaining in the first period, and unambiguously so.

Notwithstanding these clear cut observations , the econometric modelling presented in Section 4 indicates an ongoing, though substantially smaller, negative association between large businesses and the probability of experiencing SSHI relative to small (and medium sized) businesses.

The apparently conflicting outcomes between the survey proportion estimates and the results of the econometric modelling in the 2005 survey period need to be considered in their proper respective contexts. The proportion estimates represent a simple count of the total number of innovating businesses of a given size category that experienced SSHI relative to the number of all innovating businesses in that size

category. Within such a size category there may be a particular preponderance of other business characteristics that are also systematically associated with the incidence of SSHI. If variables representing such business characteristics are included in the conditioning variables in the econometric modelling, the sign and magnitude of the association between size and the likely incidence of SSHI derived from the modelling will exclude the influence of these other characteristics. That is, the econometrically derived association will be conditional on all other included variables being held constant (referred to as 'ceteris paribus').

With these points in mind, there are at least two possible explanations for the difference in the econometric and simple proportions outcomes. First, the modelling indicates that being a collaborator is positively and significantly associated with a higher predicted probability of experiencing SSHI, and more so in the latter than in the former survey periods. Also, the survey data show that the proportion of larger businesses that collaborate (33%) is higher than the proportion of medium and smaller businesses that collaborate (27% and 25% respectively).

Second, ordered probit modelling of the association between key business characteristics and the degree of diversity of innovation types contained within the ABS submission to the Review of the National Innovation System (ABS 2008d) indicates that the predicted probability of the occurrence of both product (goods or services) and processes innovation by a business is higher for larger than for smaller businesses. In addition, the modelling in Section 4 of this paper indicates a statistically significant and positive association between innovating businesses which conduct both product and process innovation and the likelihood of experiencing SSHI.

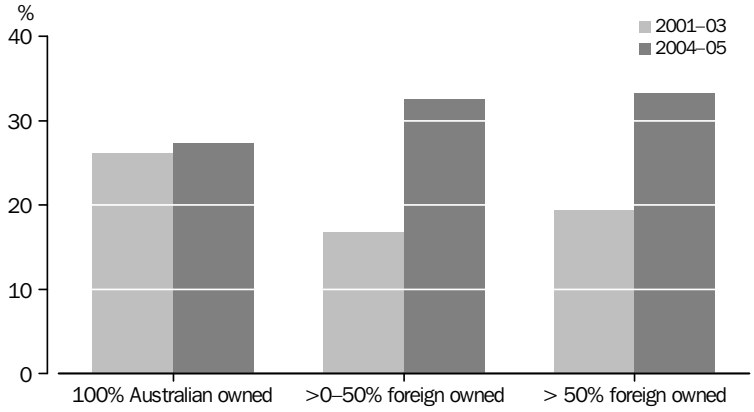
Both of these two factors, collaboration and product and process innovation, are positively correlated with business size and with the predicted probability of experiencing SSHI. In addition, their ceteris paribus effect on the probability of a business experiencing SSHI is stronger in the 2005 survey period than in the 2003 survey period, while the ceteris paribus effect of business size is substantially smaller (around one third) in the 2005 than in the 2003 survey period. As such they are candidates for explaining, at least in part, why in the latter survey period but not the former the proportion of large businesses experiencing SSHI is higher than the corresponding proportion for small businesses.

Finally, the contrast between the small increase in the estimated overall proportion of businesses experiencing SSHI across the two surveys (rising from 25.6% to 27.9%) and the relatively large increases in the corresponding proportions for medium and large businesses evident in figure 3.4 reflects the relatively small proportion of large and medium sized businesses in the overall population in both surveys (around 6% large, 30% medium, and 64% small).

Degree of foreign ownership

Figure 3.5 illustrates the estimated proportions of innovating businesses experiencing SSHI by degree of foreign ownership. The qualitative pattern across degree of foreign ownership, and across the two surveys is not unlike that for SSHI and business size in figure 3.4. In the 2003 survey period a smaller proportion of businesses with some degree of foreign ownership experienced SSHI than did businesses entirely domestically owned. This pattern is reversed in the period covered by the 2005 survey.

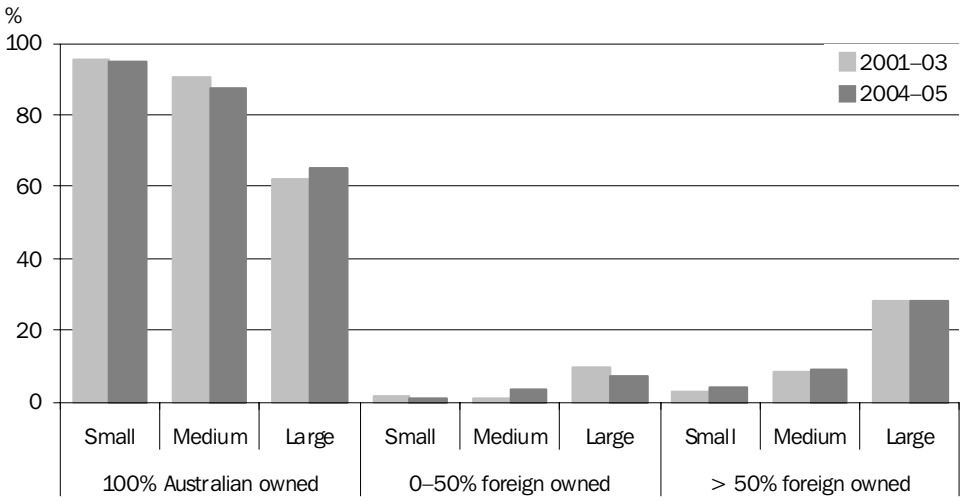
3.5 Proportion of innovating businesses experiencing skills shortages that hampered innovation, by type of ownership, 2001–2003 and 2004–2005



The proportions of entirely domestically owned innovating businesses experiencing SSHI in the two periods, 26.2% and 27.4%, are very close to the proportions of innovating businesses as a whole that experienced SSHI. This is because almost 95% of all businesses in scope are entirely domestically owned.

In a similar vein to the econometric estimation of the association between SSHI and business size, the econometrically determined association between foreign ownership and SSHI is negative, but once again it is somewhat larger in absolute size in the 2003 survey based estimation than in the 2005 survey based estimation. Moreover, as innovating businesses that have a positive degree of foreign ownership are predominantly larger businesses (figure 3.6), the preceding discussion regarding the possible drivers of the reversal of the relationship between business size and the proportion of businesses experiencing SSHI across the two surveys, could be expected to carry through to some extent for foreign ownership. That is, the decline in the magnitude of the ceteris paribus negative influence of foreign ownership on the predicted probability of SSHI may be sufficient for the positive impacts of collaboration and innovation type, hypothesised to be associated with higher levels of foreign ownership, to out-weigh the ceteris paribus foreign ownership effect on the estimated proportions experiencing SSHI.

3.6 Proportion of innovating businesses, by business size and degree of foreign ownership, 2001–2003 and 2004–2005



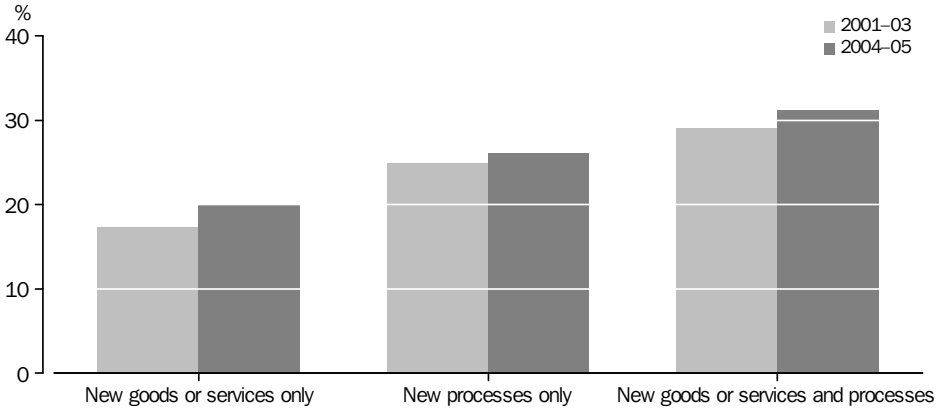
Type of innovation

The innovation surveys deliberately avoid the use of the word 'innovation' in the questions put to respondents, as the term means different things to different people, and explicitly defining the term would likely raise confusion and debate, and distract from the purposes of the questionnaire. However, in reporting the results of these surveys the term 'innovation' and 'innovator' are used for convenience to describe a positive response to the survey question of whether the business had introduced any new goods or services or implemented any new operational or managerial processes during the period in question.

Some businesses report not having introduced new goods or services nor having implemented new processes – the so called 'non-innovators'. Others report either introducing new goods or services, or implementing new processes, or both. It is of interest to investigate the extent to which these three 'types' of innovator – introducer of new goods or services only, implementer of new processes only, or both – might be differently associated with the incidence of SSHI.

Figure 3.7 illustrates the estimated proportions of innovating businesses that experienced SSHI by type of innovation as defined above.

3.7 Proportion of innovating businesses experiencing skills shortages that hampered innovation, by type of innovation, 2001–2003 and 2004–2005



It is clear from the figure that there is a small and essentially uniform increase from the 2003 to the 2005 innovation survey periods in the estimated proportions of innovating businesses experiencing SSHI across innovation types as displayed. In each survey period new goods or services only innovators exhibit the lowest proportion of SSHI followed next by new processes only innovators. The class of innovating businesses which conducted both types of innovation exhibited the highest proportion of SSHI. The qualitative nature of these findings are corroborated in the model estimations in Section 4.

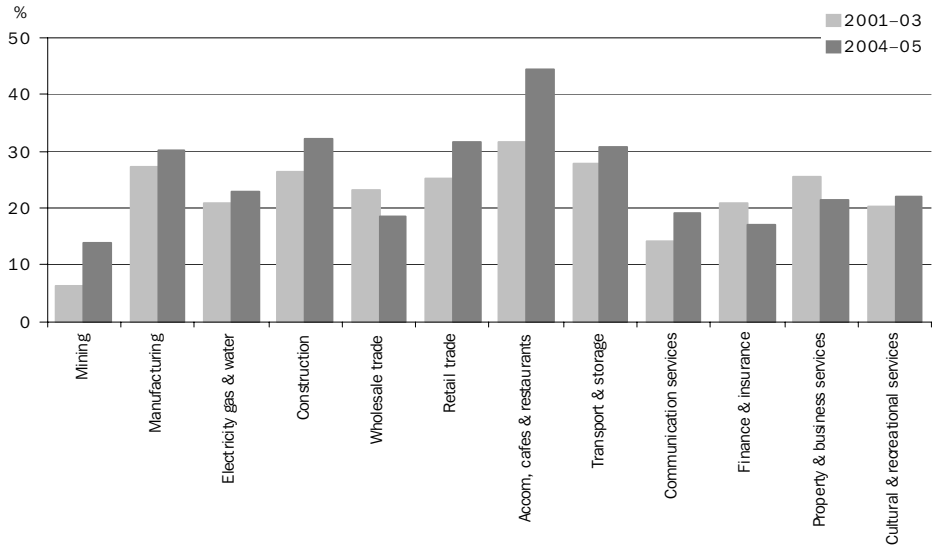
Industry of operation

In the context of the earlier discussion of the increase in the demand for labour in industries directly or indirectly stimulated by the resources boom, it might be expected that increases in SSHI would be apparent in these industries. In addition, industries from which labour has shifted to meet this increased demand may also experience an increase in the incidence of SSHI.

Figure 3.8 illustrates the estimated proportions of innovating businesses experiencing SSHI by industry. There are a number of points of note arising from the figure.

All but three (Wholesale trade, Finance and insurance and Property and business services) of the twelve industry sectors in scope exhibit a higher proportion of innovators experiencing SSHI in the 2005 survey period than in the 2003 survey period.

3.8 Proportion of innovating businesses experiencing skills shortages that hampered innovation, by industry, 2001–2003 and 2004–2005



The highest proportion of innovating businesses experiencing SSHI, in both the 2003 and the 2005 survey periods, is in the Accommodation, cafés and restaurant industry sector. This sector has a long history of skilled staff shortages, especially in the restaurant sub-sector where unfilled vacancies for chefs in particular seems to be perennial. Moreover, the industry has the largest absolute increase in the proportion of innovators experiencing SSHI, rising from 32% in the former survey period to 44.6% in the latter. Anecdotal evidence suggests that the mining industry has increased its demand for chefs to cater for the increased labour force at and around the mines, leading to an exacerbated outcome for the restaurant sub-sector.

The other industry sector of particular note is Mining itself. Although Mining exhibits the lowest proportion of innovating businesses experiencing SSHI in each survey period, this proportion has risen in proportionate terms much more for Mining – more than 100%; (from 6% to 13.9%) – than for any other industry sector.

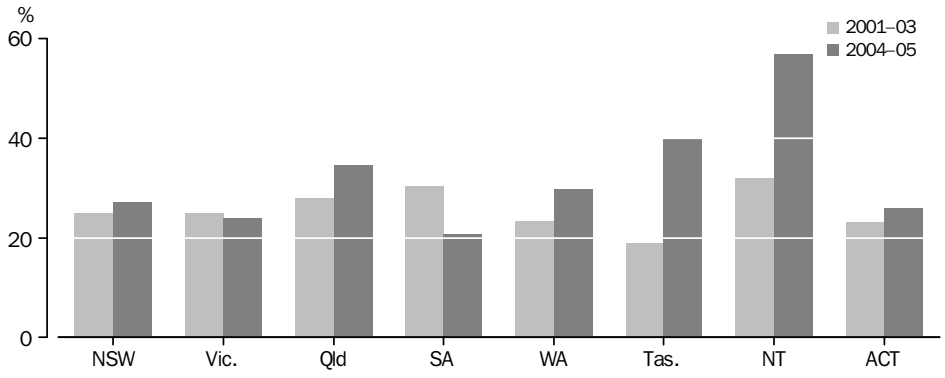
State of location

Figure 3.9 presents the distribution of proportions of innovating businesses experiencing SSHI across the various states and territories. In both survey periods the Northern Territory had a higher proportion of SSHI businesses than any of the other jurisdictions. It is also the jurisdiction with the largest absolute increase in the proportion of businesses experiencing SSHI between the two periods. Other jurisdictions experiencing substantial increases in SSHI proportions include Queensland, Western Australia, and Tasmania. South Australia experienced a significant fall in the proportion of innovating businesses experiencing SSHI from the former to the latter survey periods.

The substantial increase in the SSHI proportions for Queensland, Western Australia and the Northern Territory are consistent with prior expectations given the effect of the resources boom on employment growth in the mining sector (figure 3.2) and the fact that in these jurisdictions mining industry value added represents a substantial proportion of gross state product (GSP). In the 2006–07 financial year the respective proportions of GSP were 8%, 29% and 25% (ABS 2007b). Likely causes of the stand out increase in the proportion of SSHI in Tasmania remain to be established.

South Australia and Victoria are the only jurisdictions to register a fall in the proportion of businesses experiencing SSHI from the earlier to the later periods in question. Of these two, the fall is substantial in South Australia only. Possible causes for this fall remain to be established.

3.9 Proportion of innovating businesses experiencing skill shortages that hampered innovation, by state of location, 2001–2003 and 2004–2005



4. ECONOMETRIC MODELLING AND DECOMPOSITION

Background, approach and caveats

The econometric modelling in the DITR study of innovation and skills shortages, based on the 2003 innovation survey, found that among the industry sectors Mining stood out as having a substantially (and statistically significantly) lower probability of experiencing SSHI than most other industry sectors. Also of note in those estimates was the finding that businesses that generally sought skills in the Engineering, Product management, or 'other' (speculated in that study to be dominated by 'Trades') areas had a significantly higher probability of experiencing SSHI. All other things equal, large businesses, and businesses with at least 50% foreign ownership, were significantly less likely to experience SSHI than smaller or more domestically-owned businesses. This could reflect a number of likely advantages that large and foreign-owned business may hold relative to smaller and entirely domestically-owned businesses, including possibly higher wages (see discussion under business size in Section 3 of this paper). Unfortunately it was not possible in this study to control for the influence of wages in the regression models. Businesses with a degree of foreign ownership may also have better access to foreign labour markets.

Businesses that conducted both goods or services, and process innovation were significantly more likely to experience SSHI than businesses conducting just one of these types of innovation, possibly reflecting a greater call on scarce innovation-specific skills by businesses with a broader range of innovation activity.

In order to investigate the change in the nature of SSHI among innovating businesses between the 2003 and the 2005 innovation surveys it is necessary to conduct analyses of the periods on the same basis. One of the questions in the 2003 survey that was used in the DITR modelling of SSHI (a question relating to 'training activities undertaken') was not asked in the 2005 survey. In addition, the 2003 data were enhanced after the DITR analysis had been conducted, in terms the number of observations available following post survey analysis. To ensure consistency of approach in analysing the change between the two surveys a new single specification is estimated on the enhanced 2003 survey data and on the 2005 survey data. This specification follows the DITR model except that the 'training activities undertaken' variable in that model is absent from the models estimated here, and collaboration is include here as a simple binary variable.

In the following paragraphs, developments in the association between key business characteristics and the probability of innovating businesses experiencing SSHI between the 2003 and 2005 innovation surveys are estimated and analysed. The analysis investigates the changes in the predicted probability of innovating businesses experiencing SSHI 'on average', by business size, industry, and state/territory, and

decomposes these changes into effects resulting from changes in the characteristics of business, and changes in the structural relationship (model coefficients) between these characteristics and the probability of experiencing SSHI.

For clarity of interpretation, it is worth emphasising again that the employment size coefficients indicate the effect of that parameter relative to the employment reference category, i.e. small (5–19 employees). Similarly the industry variable coefficients are indicative of the impact of the industry in question relative to manufacturing, and the state variable coefficients are relative to New South Wales. As expected, the key results of the DITR study discussed above are qualitatively (and to a large extent quantitatively) matched by those from the model reported in table 4.1(a). The qualitatively irrelevant differences in the coefficient estimates between these and the DITR estimates reflect the smaller sample used in the DITR analysis and the omission of the 'training' variable in the model presented here.

In addition to the usual caveats that should accompany all econometric modelling, the reader's attention is drawn to some specific limitations associated with the analysis presented here. First, the modelling has been conducted at two 'points in time' on only partially overlapping samples and as such it is not possible to establish in any analytical sense the existence or direction of 'causality' between the various conditioning (business characteristic) variables and SSHI. While there may be broadly or particularly held prior views in relation to causality, this analysis can establish only statistical association between the conditioning variables and innovation. Second, the predicted probabilities of dependent variable outcomes presented here are necessarily based on specifically assigned values of the conditioning variables, which will be more or less relevant to particular business types such as industry, size, state of location etc.. In this work the fixed values of the conditioning variables used in computing predicted probabilities are set at their estimated mean population values, to be as generally applicable across all groups as possible.

Comparison between models estimated on the 2003 and 2005 data sets reveal considerable instability in the value and statistical significance of the coefficient estimates of certain key conditioning variables. This outcome is likely to reflect the influence of changes in other variables not explicitly included in the modelling. The implications of the relatively large changes in the estimated model coefficients are, with but a few exceptions, generally consistent with the major reallocation of resources in the Australian economy resulting from the strong and sustained resources boom. To the extent these changes in coefficient estimates are indeed reflective of broader economic influences, it is these broader influences that are candidates for the 'cause' of the change in likelihood of outcomes of the dependent variable, notwithstanding that such 'causes' are manifesting themselves through

particular coefficient changes in the model. This phenomenon further emphasises the need for caution in attributing causation.

For each of the two models estimated below, the ceteris paribus incremental impact of each conditioning variable is also provided in the tables reporting the coefficient estimates. These are referred to as 'marginal' effects even though the dependent variable, and the conditioning variables in almost all cases, are discrete. These 'marginal' effects are computed at the estimated population means for all other conditioning variables in the model, and are expressed as decimals – thus a marginal effect of 0.1124 implies an increase in probability of 0.1124, or 11.24 percentage points. For binary variables the 'marginal' effect is the increment to the probability arising from varying the variable value from 0 to 1. For class variables the effect is the increment to the probability from moving from the reference value to the value in question.

Model estimation results

Tables 4.1(a) and (b) provide estimated coefficients for identically specified binary probit models of the likelihood of an innovating business experiencing SSHI, separately estimated using the 2003 and the 2005 innovation survey data respectively.

In table 4.1(a), the coefficients on medium and large business size are both negative with the coefficient on 'large' being highly statistically significant (the 'medium' coefficient is not quite statistically significant at the 95% confidence level). In absolute terms the coefficient on 'large' is significantly larger than that on 'medium' indicating a lower probability of SSHI for large businesses compared with both medium and small businesses. The marginal effects indicate that at mean values for other conditioning variables the predicted probability of SSHI is 14 percentage points, and 10 percentage points, lower for large businesses than for medium and for small businesses respectively.

A degree of foreign ownership in excess of 50% is associated with a significantly lower probability of SSHI compared with 100% domestic ownership. At otherwise mean values businesses with more than 50% foreign ownership are predicted to have a probability of SSHI 8 percentage points lower than entirely domestically owned businesses.

Relative to the manufacturing industry, only Communication services and Mining exhibited significantly different predicted probabilities of SSHI – 13 percentage points lower for Communications services and 18 percentage points lower for Mining.

4.1(a) Estimated coefficients for binary probit model of SSHI – 2003 innovation survey

	Coefficient	*Standard error*	*Probability > Chi-square*	*Marginal effect*
Intercept	–0.8412	0.1233	<.0001	–
Business age – 4+ years	0.0462	0.0665	0.487	0.0145
Employment – 20–99 employees	–0.1333	0.0703	0.058	–0.0424
Employment – 100+ employees	–0.5251	0.0725	<.0001	–0.1432
Foreign owned – >0% to 50%	–0.1649	0.1170	0.159	–0.0499
Foreign owned – >50%	–0.2575	0.0783	0.001	–0.0752
Accommodation, cafés and restaurants	–0.0382	0.1460	0.794	–0.0123
Communication services	–0.4743	0.1854	0.011	–0.1268
Construction	–0.0010	0.1289	0.994	–0.0003
Cultural and recreational services	–0.1871	0.1332	0.160	–0.0563
Electricity gas and water	–0.2695	0.1755	0.125	–0.0786
Finance and insurance	–0.1916	0.1269	0.131	–0.0576
Mining	–0.7758	0.2128	<0.001	–0.1798
Property and business services	–0.0437	0.0919	0.635	–0.0139
Retail trade	0.0900	0.1188	0.449	0.0298
Transport and storage	0.0090	0.1189	0.940	0.0029
Wholesale trade	–0.0741	0.1079	0.492	–0.0233
Victoria	–0.1234	0.0721	0.087	–0.0378
Queensland	0.0475	0.0869	0.585	0.0154
South Australia	0.0879	0.0901	0.329	0.0289
Western Australia	0.0325	0.0935	0.728	0.0105
Tasmania	–0.1734	0.1497	0.247	–0.0521
Northern Territory	0.3234	0.1669	0.053	0.1132
Australian Capital Territory	0.1158	0.1515	0.445	0.0384
New goods only	–0.2528	0.0943	0.007	–0.0781
New processes only	–0.1221	0.0579	0.035	–0.0395
Capital city	–0.0274	0.0683	0.689	–0.0087
Collaboration	0.1338	0.0579	0.021	0.0433
Looks to find people within business	0.2030	0.0694	0.006	0.0626
Engineering	0.2798	0.0634	<.0001	0.0935
General business	0.0702	0.0583	0.228	0.0223
Information technology	0.0211	0.0617	0.732	0.0067
Management	0.1579	0.0623	0.011	0.0515
Marketing	0.0222	0.0601	0.712	0.0070
Scientific	–0.0978	0.0910	0.282	–0.0300
Other type of skill	0.4337	0.0860	<.0001	0.1500

Probability of SSHI at population means for all variables is 0.249 or 24.9%.

4.1(b) Estimated coefficients for binary probit model of SSHI – 2005 innovation survey

	Coefficient	*Standard error*	*Probability > Chi-square*	*Marginal effect*
Intercept	–0.5934	0.1153	<.0001	–
Business age – 4+ years	–0.0198	0.0685	0.773	–0.007
Employment – 20–99 employees	0.1167	0.0817	0.153	0.039
Employment – 100+ employees	–0.1851	0.0769	0.016	–0.056
Foreign owned – >0% to 50%	–0.1487	0.1177	0.206	–0.047
Foreign owned – >50%	–0.2053	0.0808	0.011	–0.064
Accommodation, cafés and restaurants	0.1855	0.1338	0.166	0.065
Communication services	–0.4095	0.2084	0.049	–0.117
Construction	0.1585	0.1291	0.220	0.055
Cultural and recreational services	–0.2476	0.1427	0.083	–0.076
Electricity gas and water	–0.1322	0.1833	0.471	–0.042
Finance and insurance	–0.3361	0.1245	0.007	–0.099
Mining	–0.4429	0.1813	0.015	–0.125
Property and business services	0.0706	0.0927	0.446	0.024
Retail trade	–0.0868	0.1275	0.496	–0.028
Transport and storage	–0.0806	0.1279	0.529	–0.026
Wholesale trade	–0.2471	0.1154	0.032	–0.076
Victoria	–0.1571	0.0773	0.042	–0.048
Queensland	0.1651	0.0855	0.053	0.056
South Australia	–0.0247	0.1100	0.823	–0.008
Western Australia	0.2665	0.1025	0.009	0.093
Tasmania	–0.0088	0.1477	0.952	–0.003
Northern Territory	0.5704	0.1839	0.002	0.210
Australian Capital Territory	0.3095	0.1563	0.048	0.109
New goods only	–0.3016	0.1093	0.006	–0.093
New processes only	–0.0893	0.0622	0.151	–0.030
Capital city	–0.0653	0.0721	0.366	–0.022
Collaboration	0.1849	0.0635	0.004	0.062
Looks to find people within business	0.0412	0.0738	0.577	0.014
Engineering	0.1533	0.0778	0.049	0.052
General business	0.0591	0.0683	0.387	0.020
Information technology	–0.0432	0.0693	0.533	–0.014
Management	0.0760	0.0818	0.353	0.025
Marketing	–0.0186	0.0754	0.805	–0.006
Scientific	0.0779	0.1053	0.460	0.026
Other type of skill	0.0084	0.1107	0.940	0.003

Probability of SSHI at population means for all variables is 0.265 or 26.5%.

Innovating businesses conducting product only or process only innovation are predicted to have significantly lower probabilities of experiencing SSHI than businesses conducting both these types of innovation. The marginal effects indicate that businesses conducting just one type of innovation are between 4 and 8 percentage points less likely to experience SSHI that those conducting both types of innovation.

Innovating businesses that collaborate exhibit a predicted probability of experiencing SSHI 4 percentage points higher than those that do not collaborate.

Table 4.1(b) provides coefficient estimates for the same model as in table 4.1(a) but estimated on the 2005 innovation data. While the non-linearity of the model complicates meaningful direct comparison of coefficient values somewhat, a number of immediately pertinent observations are in order.

The magnitude and statistical significance of relative business employment size is smaller in the 2005 estimation than in the 2003, with the magnitude of the coefficient on large business falling by more than 50% of its 2003 value (the coefficient on 'medium' changes from negative to positive but in the 2005 estimation is not significant even at the 85% level).

The effect of industry sector relative to manufacturing in table 4.1(a) was significant only for communication services and mining. In table 4.1(b) the coefficients relating to the relative effects of Communication services; Finance and insurance; Mining; and Wholesale trade are significant. Furthermore, the coefficient on the mining variable has increased from –0.78 in table 4.1(a) to –0.44 in table 4.1(b), an increase of around 43%. While this result continues to indicate a significantly lower predicted probability of experiencing SSHI within mining than within manufacturing, the extent of this is significantly less than in the earlier period, with the otherwise average predicted probability of experiencing SSHI in mining compared with manufacturing falling from 18 percentage points less in the 2003 survey period to 13 percentage points less in the 2005 survey period. The impact of the changes in the industry (and other) coefficients on the probability of experiencing SSHI is discussed in further detail below.

In table 4.1(b) the Australian Capital Territory, Northern Territory, Victoria, and Western Australia exhibit statistically significant coefficients relative to New South Wales, where none does in table 4.1(a). In this regard the Northern Territory and Western Australia show a particularly large relative impact on the probability of experiencing SSHI in the 2005 survey period compared with the 2003 survey period.

Developments in the allocation of primary inputs within the Australian economy resulting directly and indirectly from the resources boom provide a backdrop consistent with the changes in the model coefficients discussed above. By 2004 and 2005, the period covered in the 2005 survey, the resources boom had become substantially more established than it had in the 2001 to 2003 period. In that regard,

the large increase in the association of 'state' on the probability of experiencing SSHI for Western Australia and the Northern Territory relative to New South Wales is consistent with the relatively higher growth in economic activity in those states. Similar considerations apply in relation to the change in the coefficient associated with being in the mining industry relative to manufacturing. Other notably large increases among industry coefficients relative to manufacturing are for accommodation cafes and restaurants, and for construction (although these were not statistically significant).

The dependent variable of consideration here is a binary measure of whether or not businesses experienced innovation-hampering skills shortages. Its binary nature precludes any discrimination on the grounds of intensity of such skill shortages within businesses. As a result one might expect that differences in the predicted probability of experiencing SSHI across business size, and perhaps even across type of skill sought, would be less in a generally tighter skilled labour market as the experience of encountering some degree of skill shortages became more wide spread. The changes in the coefficients associated with 'employment size' and 'skill type sought' across the two models are indeed consistent with such an expectation. The estimated proportion of innovating businesses in Australia that experienced SSHI rose from 25.6% in the 2003 survey to 27.9% in the 2005 survey. This 2.3 percentage point rise, while not very large in absolute terms, represents around a 9% increase in the proportion of those experiencing SSHI, and is statistically significant. The fact that the latter of the surveys covered a period only two thirds as long as the former may also be reflected in a smaller difference than might be expected had the duration of coverage been the same.

Table 4.2 provides 2003 and 2005 model estimates of the probability of an innovating business experiencing SSHI, conditional on that business displaying population mean parameter characteristics, except for business size and industry of activity which are permitted to vary, showing the ceteris paribus predicted impact of business size and industry. It is important to recognise that within the population in scope for these surveys the distribution of firm size is around 66%, 27% and 7% for small (5–19 employees), medium (20–99 employees) and large (100 or more employees) businesses respectively for the first survey period, and 62%, 32% and 6% for the second. Thus the predicted probability of experiencing SSHI 'on average' will reflect the much higher weighting applicable to small businesses in table 4.2.

It is immediately apparent from table 4.2 that the small 'at population means' change in the overall predicted probability of experiencing SSHI between the 2003 and 2005 innovation surveys hides very large changes when disaggregated by industry and business size. For large businesses the predicted probability of SSHI increased over the two surveys for every industry. In proportionate terms this increase was most marked in the mining industry where the probability increased from 3.0% to 10.4% – a

proportionate increase of around 250%. This is consistent with developments in the economy over the period 2001 to 2005. The largest absolute increase for large businesses is 13.8% for accommodation cafes and restaurants, a sector that has experienced significant skilled labour shortages for an extended period of time.

The increases in the predicted probabilities for medium-sized businesses from the 2003 to 2005 surveys are generally slightly larger than for large businesses in absolute terms, but somewhat less in proportionate terms. Mining again shows the highest proportionate increase, rising from 6.8% to 16.9% – an increase of around 158%.

4.2 Predicted probability of SSHI (%), by employment size and Industry – evaluated at population mean values – model estimates using 2003 and 2005 innovation survey data

	Large			*Medium*			*Small*		
	2003	*2005*	*change*	*2003*	*2005*	*change*	*2003*	*2005*	*change*
Accomm., cafés and restaurants	12.6	26.4	*13.8*	22.5	37.1	*14.6*	26.7	32.8	*6.1*
Communication services	5.7	11.0	*5.3*	11.7	17.8	*6.1*	14.5	14.9	*0.4*
Construction	13.4	25.5	*12.1*	23.6	36.1	*12.5*	27.9	31.8	*3.9*
Cultural and recreational services	9.8	14.4	*4.6*	18.3	22.3	*4.0*	22.0	19.0	*–3.0*
Electricity gas and water	8.4	17.1	*8.7*	16.2	25.9	*9.7*	19.7	22.2	*2.5*
Finance and insurance	9.7	12.4	*2.7*	18.2	19.7	*1.5*	21.9	16.7	*–5.2*
Manufacturing	13.4	20.7	*7.3*	23.7	30.3	*6.6*	28.0	26.4	*–1.6*
Mining	3.0	10.4	*7.4*	6.8	16.9	*10.1*	8.7	14.1	*5.4*
Property and business services	12.5	22.8	*10.3*	22.3	32.8	*10.5*	26.5	28.7	*2.2*
Retail trade	15.4	18.3	*2.9*	26.5	27.4	*0.9*	31.1	23.6	*–7.5*
Transport and storage	13.6	18.5	*4.9*	23.9	27.6	*3.7*	28.3	23.8	*–4.5*
Wholesale trade	11.8	14.4	*2.6*	21.4	22.3	*0.9*	25.5	19.0	*–6.5*

For small businesses the story is quite different. In six of the twelve industries in scope the predicted probability of SSHI in the 2005 model estimates is smaller than in the 2003 model estimates. Furthermore, for each industry in 2005 the predicted probability of SSHI is lower for small businesses that for medium-sized businesses. This is the opposite of the medium/small outcome for 2003, though this outcome is statistically insignificant.

It is of interest to investigate the extent to which the differences in predicted probabilities between the 2003 and 2005 surveys are a result of changes in the population mean characteristics (conditioning variables) versus changes in the estimated structure (coefficients) of the model over the two periods. Tables 4.1(a) and (b) provide the model coefficient estimates, and table 4.3 provides details on estimates of (and percentage changes in) the mean characteristics of the population of all innovators, for the two survey periods.

4.3 Population mean estimates of model parameters – 2003 and 2005 surveys

	Population means		
	2003	*2005*	*Percentage change*
Experienced SSHI	0.2561	0.2793	9.0%
Business age – 4+ years	0.7474	0.7392	–1.1%
Employment – 5–19 employees	0.6564	0.6210	–5.4%
Employment – 20–99 employees	0.2762	0.3184	15.3%
Employment – 100+ employees	0.0674	0.0607	–10.0%
100% Australian owned	0.9163	0.9075	–1.0%
Foreign owned – >0% to 50%	0.0225	0.0219	–2.7%
Foreign owned – >50%	0.0612	0.0706	15.3%
Accommodation, cafés and restaurants	0.0672	0.1025	52.6%
Communications	0.0046	0.0034	–27.6%
Construction	0.0816	0.0896	9.8%
Cultural and recreational services	0.0344	0.0312	–9.2%
Electricity gas and water	0.0020	0.0019	–5.8%
Finance and insurance	0.0358	0.0349	–2.5%
Manufacturing	0.1823	0.1607	–11.9%
Mining	0.0047	0.0051	8.4%
Property and business services	0.2301	0.2311	0.4%
Retail trade	0.2003	0.1781	–11.1%
Transport and storage	0.0370	0.0394	6.6%
Wholesale trade	0.1199	0.1220	1.8%
New South Wales	0.3719	0.3251	–12.6%
Victoria	0.2553	0.2597	1.7%
Queensland	0.1590	0.1873	17.8%
South Australia	0.0854	0.0773	–9.5%
Western Australia	0.0930	0.1099	18.2%
Tasmania	0.0143	0.0171	19.3%
Northern Territory	0.0067	0.0090	34.8%
Australian Capital Territory	0.0144	0.0146	1.8%
New goods only	0.1081	0.0973	–10.0%
New processes only	0.5239	0.4203	–19.8%
New goods and processes	0.3680	0.4825	31.1%
Capital city	0.7094	0.7090	–0.1%
Collaboration	0.2701	0.2197	–18.7%
Looks to find people within business	0.6847	0.3132	–54.3%
Engineering	0.1895	0.0939	–50.4%
General business	0.4327	0.2296	–46.9%
Information technology	0.3176	0.1881	–40.8%
Management	0.2199	0.1026	–53.3%
Marketing	0.3618	0.1669	–53.9%
Scientific	0.0501	0.0229	–54.3%
Other type of skill	0.1436	0.0561	–60.9%

The population means of types of skill sought have all fallen substantially from the 2003 to 2005 survey periods. As discussed earlier in this paper, this relatively uniform fall (of around 50%) in the mean parameter values (as well as that associated with whether businesses look within or outside for people) reflects a change in the nature of the question between the 2003 and 2005 surveys. In the 2003 survey the question asks *which skill type is sought if engaging people*, while the 2005 survey first enquires as to whether the business actually engaged persons during the period, and directs the respondent past these questions if the answer to actual engagement is negative. It can be expected that an answer to the type of skill sought would generally be provided in the first survey whether or not engagements had actually taken place during the relevant period. The high degree of uniformity in the proportionate declines suggests some substantial similarity in the use-value of the questions between the two surveys, modulo the influence of the 'skip' ratio of 35% in the 2005 survey.

If the 65% of innovators in the 2005 survey that did not 'skip' the questions relating to skill type and to whether staff were sought from inside the business are, on average, representative of all innovators in regard to 'skill type' and 'seek within' characteristics, then we can adjust the 2005 mean population proportions for these variables to put them on an (approximately) equal footing with their 2003 counterparts for the purpose of the decomposition procedure described below. Although the strict accuracy of this technique relies on the assumption of representativeness, experimentation shows that the qualitative, and indeed to a large extent, quantitative, results of the decomposition of aggregate 2003 to 2005 changes in the predicted probability of SSHI described below are very robust to variation in that assumption.

Tables 4.5(a), (b) and (c) provide the differences in the predicted probabilities of SSHI by industry and business size shown in table 4.2, together with a decomposition of these into two components, one resulting solely from the change in population mean characteristics between the two periods (applied to a fixed model) and the other resulting solely from the change in the estimated model coefficients over the period (applied to a fixed set of population mean characteristics).

There are two ways to approach such decomposition:

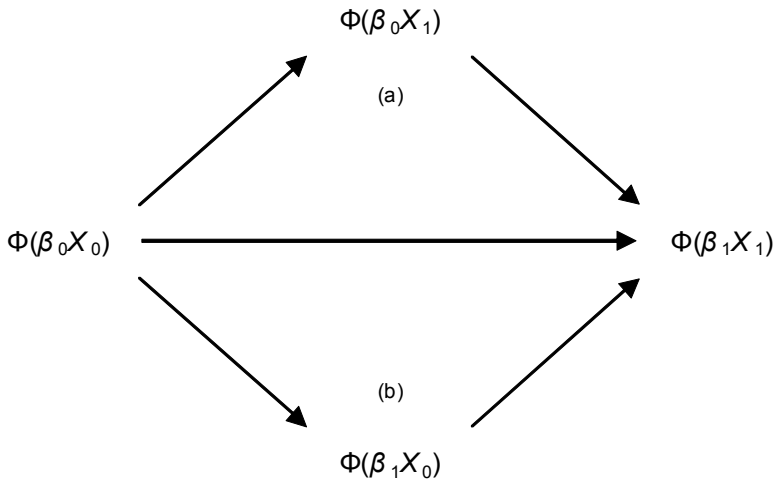
(a) using the 2003 estimated model, take the difference in predicted probability using 2003 mean characteristics and using 2005 mean characteristics; then, using only the 2005 mean characteristics take the difference between the predicted probabilities using the 2003 model estimates and then using the 2005 model estimates – the sum of these two differences is identically the difference between the predicted probabilities as presented in table 4.2; and

(b) using only the 2003 mean characteristics take the difference between the predicted probabilities using the 2003 model estimates and then using the 2005 model estimates, then using just the 2005 model estimates take the difference in predicted probability using 2003 mean characteristics and using 2005 mean characteristics; again, the sum of these two differences is identically the difference between the predicted probabilities as presented in table 4.2.

The two approaches yield a slightly different allocation of the overall differences to characteristic change versus structural (model) change. The arithmetic averages of these two different allocations (which of course necessarily also sum to the differences in table 4.2) are frequently taken, as they are here, as the preferred single decomposition. The two approaches are set out in figure 4.4 in diagrammatic form.

In each model (subscript = 0 for 2003 and subscript = 1 for 2005) the predicted probability of a business experiencing SSHI, conditional on the set of mean population business characteristics X_j, is given by $\Phi(\beta_i X_j)$ where $\Phi(.)$ stands for the standard normal cumulative distribution function and β_i is the set of coefficient estimates. The decomposition described above as (a) corresponds to the upper path and that described by (b) the lower path in figure 4.4.

4.4 Schematic of decomposition of change in predicted probabilities of SSHI



When the 2005 mean population characteristics are inserted into the 2003 model we need to adjust the values for skill type and 'look inside' to account for the relative proportion skipping the question (65% answered the question in the 2005 survey, and 95% answered the question in the 2003 survey). Thus we multiply the 2005 mean values for skill type and 'look within' by 1.46 (=95/65) when inserting into the 2003 model. Other 2005 mean values are unchanged from table 4.3. Similarly, when inserting the 2003 mean values into the 2005 model we multiply the skill type and 'look within' mean values by 0.68 (=65/95), with all other mean values as in table 4.3.

From tables 4.5(a), (b) and (c) it is clear that characteristic change accounts for only a very small (absolute) proportion of the overall change in predicted probabilities of SSHI for medium and large businesses, with by far the largest influence being structural. However, there is quite a large degree of variation in the relative and absolute size of the two components across industries for all business sizes. The characteristic effects are all negative and vary from –1.8 percentage points for small retail businesses to –0.4 percentage points for large mining businesses. There is much more variation in the structural effects across industries, varying from 16.1 percentage points in medium-sized accommodation cafes and restaurant businesses to –5.7 percentage points for small retail trade businesses.

The direction and relative size of the characteristic and structural effects is similar for large and medium-sized businesses, but quite different for small businesses. This difference reflects the small sometimes positive and sometimes negative difference between the 2005 predicted probability of SSHI and the 2003 predicted probability of SSHI for small businesses, in contrast to the larger and universally positive differences for medium and large businesses across all industries (table 4.2).

4.5(a) Decomposition of change in predicted probabilities of SSHI, 2005–2003 – Large businesses, by industry (percentage points)

	Difference in predicted probability of SSHI, 2005–2003		
	Average characteristics effect	*Average structural effect*	*TOTAL*
Accommodation, cafés and restaurants	–1.1	14.9	13.8
Communication services	–0.6	5.9	5.3
Construction	–1.1	13.8	12.1
Cultural and recreational services	–0.9	5.5	4.6
Electricity, gas and water	–0.8	9.5	8.7
Finance and insurance	–0.9	3.6	2.7
Manufacturing	–1.1	8.4	7.3
Mining	–0.4	7.8	7.4
Property and business services	–1.0	11.4	10.3
Retail trade	–1.2	4.1	2.9
Transport and storage	–1.1	6.0	4.9
Wholesale trade	–1.0	3.5	2.6

4.5(b) Decomposition of change in predicted probabilities of SSHI, 2005–2003 – Medium size businesses, by industry (percentage points)

	Difference in predicted probability of SSHI, 2005–2003		
	Average characteristics effect	*Average structural effect*	*TOTAL*
Accommodation, cafés and restaurants	–1.5	16.1	14.6
Communication services	–1.0	7.1	6.1
Construction	–1.6	14.0	12.5
Cultural and recreational services	–1.3	5.3	4.0
Electricity, gas and water	–1.2	10.9	9.7
Finance and insurance	–1.3	2.9	1.5
Manufacturing	–1.6	8.2	6.6
Mining	–0.7	10.8	10.1
Property and business services	–1.5	12.0	10.5
Retail trade	–1.7	2.5	0.9
Transport and storage	–1.6	5.2	3.7
Wholesale trade	–1.5	2.3	0.9

Table 4.5(c) Decomposition of change in predicted probabilities of SSHI, 2005–2003 – Small businesses, by industry (percentage points)

	Difference in predicted probability of SSHI, 2005–2003		
	Average characteristics effect	*Average structural effect*	*TOTAL*
Accommodation, cafés and restaurants	–1.7	7.8	6.1
Communication services	–1.1	1.5	0.4
Construction	–1.7	5.6	3.9
Cultural and recreational services	–1.5	–1.6	–3.0
Electricity, gas and water	–1.4	4.0	2.5
Finance and insurance	–1.5	–3.8	–5.2
Manufacturing	–1.7	0.1	–1.6
Mining	–0.8	6.2	5.4
Property and business services	–1.7	3.9	2.2
Retail trade	–1.8	–5.7	–7.5
Transport and storage	–1.7	–2.7	–4.5
Wholesale trade	–1.6	–4.9	–6.5

So, the analysis suggests that the predicted probability of experiencing SSHI has risen for large and medium-sized businesses, though by quite different amounts across industries. Among large and medium-sized businesses, wholesale trade, retail trade, and finance and insurance exhibit relatively small increases in their predicted

probabilities of SSHI. Accommodation cafes and restaurants, Construction and Property and business services exhibit relatively large increases in predicted probability of experiencing SSHI. While exhibiting the lowest predicted probability of experiencing SSHI in both periods across all business size categories, Mining exhibits the largest proportionate rise in the predicted probability of experiencing SSHI across the two survey periods.

For small businesses in some sectors the predicted probability of SSHI rose between the 2003 and the 2005 innovation surveys, and in other sectors it fell. Also, in most but not all cases the absolute size of the changes in predicted probabilities of SSHI for small businesses by industry is much smaller than for medium and large businesses. Notable exceptions to this include retail trade, wholesale trade, finance and insurance, and transport and storage where, additionally, the predicted probability of SSHI for small businesses fell.

Given the differential impact of the more recent developments in economic growth and resource allocation across states and territories as well as industries, it is instructive to conduct the decomposition discussed above by state/territory also. Tables 4.6(a), (b) and (c) provide the decomposition of the total changes in predicted probabilities of SSHI by jurisdiction and business size.

Again, except for small businesses in NSW, the absolute value of the structural effects across jurisdictions are larger than those of the characteristics effects. As expected, total effects are large for the mining intensive jurisdictions of Western Australia, the Northern Territory, and Queensland. Indeed, as discussed in Section 3, in these jurisdictions mining industry value added represents a substantial proportion of GSP (in the 2006–07 financial year the respective proportions of mining value added in GSP were 29%, 25%, and 8%)

Total effects are also large for the Australian Capital Territory and Tasmania, consistent with the descriptive statistics in Section 3, but less expected on prior grounds.

The quantitative and qualitative modelling-based results reported in this section are generally intuitively appealing in light of the developments in labour resource allocation across industries over the 2001 to 2005 period together with the related development in skill shortages in particular industries, and more generally. The closing of the gap in predicted probabilities of SSHI between larger and smaller businesses over the two survey periods is consistent with smaller businesses already having relatively high SSHI incidence in the earlier survey period, and a general widening of the skill shortage phenomenon from the earlier to the later survey periods.

4.6(a) Decomposition of change in predicted probabilities of SSHI, 2005–2003 – Large businesses, by state/territory (percentage points)

	Difference in predicted probability of SSHI, 2005–2003		
	Average characteristics effect	*Average structural effect*	*TOTAL*
Australian Capital Territory	–1.3	14.4	13.1
Northern Territory	–1.5	18.6	17.1
Queensland	–1.2	11.1	10.0
South Australia	–1.2	4.7	3.5
Tasmania	–0.9	10.2	9.3
Victoria	–0.9	5.6	4.6
Western Australia	–1.2	14.7	13.6
New South Wales	–1.1	7.3	6.2

4.6(b) Decomposition of change in predicted probabilities of SSHI, 2005–2003 – Medium size businesses, by state/territory (percentage points)

	Difference in predicted probability of SSHI, 2005–2003		
	Average characteristics effect	*Average structural effect*	*TOTAL*
Australian Capital Territory	–1.7	14.6	12.9
Northern Territory	–1.9	17.9	15.9
Queensland	–1.7	11.3	9.7
South Australia	–1.7	3.4	1.7
Tasmania	–1.4	11.3	9.9
Victoria	–1.4	5.2	3.8
Western Australia	–1.6	15.6	13.9
New South Wales	–1.6	6.9	5.3

4.6(c) Decomposition of change in predicted probabilities of SSHI, 2005–2003 – Small businesses, by state/territory (percentage points)

	Difference in predicted probability of SSHI, 2005–2003		
	Average characteristics effect	*Average structural effect*	*TOTAL*
Australian Capital Territory	–1.9	5.8	3.9
Northern Territory	–2.0	8.3	6.3
Queensland	–1.8	2.9	1.1
South Australia	–1.8	–4.8	–6.6
Tasmania	–1.5	3.9	2.4
Victoria	–1.6	–2.0	–3.5
Western Australia	–1.8	7.0	5.2
New South Wales	–1.7	–1.1	–2.8

5. SUMMARY AND KEY FINDINGS

The proportion of innovating businesses experiencing SSHI rose from 25.6% in the earlier 2003 survey period to 27.9% in the 2005 survey period.

The model-based predicted likelihood of an innovating business experiencing SSHI is significantly less for large businesses than for small (statistical significance is too weak to comment unambiguously on medium-sized businesses). Foreign ownership in excess of 50% is also strongly associated with a lower probability of experiencing SSHI. Unsurprisingly, innovating businesses that introduced both 'new goods or services' and 'new processes' rather than only one or the other are more likely to experience SSHI, as are innovating businesses that engage in collaboration. Businesses that seek to engage engineers are also more likely to experience SSHI, consistent with the long-standing reports of shortages of engineers.

The small but statistically significant rise in the proportion of innovating businesses experiencing SSHI between the 2003 and 2005 surveys hides substantial changes across industry, business size, and state/territory of location, with generally smaller changes for small businesses than for medium and large businesses. Among the industries in scope the mining industry exhibits the largest proportionate increase in the predicted probability of experiencing SSHI from the 2003 to the 2005 survey periods, although that probability is still the lowest among all industry groups. Other industries where the predicted probability of SSHI has risen substantially include accommodation cafes and restaurants, construction, and property and business services.

Anecdotal evidence suggests that the increase in SSHI in the accommodation cafes and restaurants industry is likely to have been due, at least in part, to a loss of relative attractiveness, particularly in relation to chefs, as the mining industry has attracted (through higher wages) more workers with key skills to service the growing mining workforce. On the other hand, the increase in SSHI in property and business services, and in construction is likely to have developed from increased demand for their products as demand by the mining sector for these has grown.

Consistent with the growth in resource sector related activity in the economy, the rise in the predicted probability of an 'average' innovating business experiencing SSHI from the 2003 to the 2005 innovation survey period is substantially higher than average in the resource intensive jurisdictions of Queensland, Western Australia, and the Northern Territory.

The key specific findings from this analysis are:

1. Overall, the proportion of businesses that experienced skills shortages that hampered their innovation was slightly higher in the period covered by the 2005 innovation survey (27.9%) than in the period covered by the 2003 survey (25.6%). However, this small change on average hides some much larger changes at more disaggregated levels.

2. In both survey periods, larger innovating businesses exhibit (all else equal) a lower predicted probability of experiencing skills shortages that hamper innovation (SSHI) than do smaller businesses. However this gap is much smaller in the more recent 2005 innovation survey period than in the 2003 innovation survey period. In the earlier period small businesses were predicted to be more than twice as likely as large businesses to experience SSHI. In proportionate terms this gap fell from a little over 100% to around 30%. The closing of the gap in predicted probabilities of SSHI between larger and smaller businesses over the two survey periods is consistent with smaller businesses already having relatively high SSHI incidence in the earlier survey period, and a general widening of the skill shortage phenomenon.

3. Among the industries in scope, mining recorded the largest proportionate increase in 'on average' predicted probability of experiencing SSHI, rising (for medium size businesses) from around 7% in the 2003 survey period to 17% in the 2005 survey period – around a 160% increase. The largest absolute increase in predicted probability of experiencing SSHI was for accommodation cafes and restaurants, rising by around 14 percentage points for large and medium size businesses and by 6 percentage points for small businesses. This industry has been experiencing significant skilled labour shortages for an extended period of time.

4. Between the 2003 and 2005 survey periods, the 'on average' predicted probability of experiencing SSHI for both large and medium-sized businesses rose for every industry. Absolute changes in the predicted probability of SSHI were much smaller for small businesses, with cultural and recreational services, manufacturing, finance and insurance, retail trade, transport and storage, and wholesale trade registering falls from the 2003 to the 2005 survey periods.

5. As expected, increases across the two survey periods in the predicted probability of an 'average' business, experiencing SSHI are relatively large for the mining intensive jurisdictions of Western Australia, the Northern Territory, and Queensland. In the 2003 innovation survey period, 'average' businesses in these jurisdictions were, respectively, approximately 1 percentage point, 11 percentage points, and 2 percentage points more likely to experience SSHI than 'average' businesses in New South Wales. In the 2005 survey period these differences had risen to 9 percentage points, 21 percentage points, and 6 percentage points respectively.

6. In general, the 'on average' changes in the predicted probability of experiencing SSHI from the 2003 to 2005 survey periods result much less from changes in the 'on average' characteristics of businesses over the periods than from changes in the structure of the estimating model. These changes appear consistent with the major developments in the economy over the period, including growth in the share of economic resources flowing to the mining industry and its supplying industries, and consistent with a general worsening of skilled labour shortages.

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