Innovation in Australian Workplaces:
An Empirical Analysis Using AWIRS 1990 and 1995 *

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Abstract

This paper investigates the determinants of innovation in a panel of 698 Australian workplaces. Innovation activity is proxied by four types of workplace change. Data on these workplace changes comes from the 1990 and 1995 AWIRS. Workplaces are allocated into one of three innovation groups – dynamic, periodic or infrequent – depending on whether they (a) reported the change in both the 1990 and 1995 surveys, (b) reported the change in only one year, or (c) never reported the change. Various workplace characteristics and environmental factors are investigated using both cross tabulations and an ordered probit model. The results suggest that better employee-management communications are associated with more change, and that workplaces with higher levels of training undergo more change.

1. Introduction

This paper investigates the determinants of innovation in a sample of Australian workplaces. Innovation can be defined as any change that adds value, where 'value' is interpreted broadly in terms of improving productivity, sales, customer satisfaction, etc.[1] As might be expected, it is often hard to track the impact of a 'change' to the 'value' it creates, hence many studies, including this one, assume that a change represents an innovation. While this may not be true in all cases, it is likely to be a good proxy: workplaces would not be expected to undergo (costly) change unless they perceive some potential value. Dynamic workplaces might be expected to undergo an ongoing process of change. A central aim of this paper is to try and identify which workplaces are 'dynamic' and then investigate the characteristics of these workplaces.

The determinants of innovation ultimately arise from the characteristics of the workplaces (firms) and the environment in which they operate. There is a vast literature that investigates these determinants which stretches across sociology, management, geography and economics. Internal firm characteristics include basic workplace characteristics (size, age, industry), as well as more complex characteristics such as management quality, organisational flexibility and level of human capital among employees.[2] External characteristics have traditionally – at least by economists – focused on market structure and technological opportunity. However, there has been considerable research on the idea of networks of innovators, which leads into the concept of national systems of innovation. This research stresses that a workplace or firm is only one part in a system of suppliers, customers, competitors and government institutions all of which are relevant in determining innovation outcomes.[3] This paper investigates a number of these issues by considering data on basic workplace characteristics (size, ownership, age, commercial focus and industry),

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[1] For example, the Business Council of Australia have defined innovation as, "In business, innovation is something that is new or significantly improved, done by an enterprise to create added value either directly for the enterprise or indirectly for its customers" (Business Council of Australia 1993, p.3)

[2] See, for example, the collection of papers in Marceau (1992).

[3] See Freeman (1995) for an introduction to some of these issues and the papers in Part 3 of Rothwell and Dodgson (1994).

market conditions, training, employee incentives, management-employee relations, and management-employee communications.

The paper's structure is as follows. In section 2 we define the measures of workplace change used in the paper (i.e. our proxies for innovation). To do this we make use of a two period (1990 and 1995) panel of Australian workplaces. Four types of workplace change are considered. Section 3 discusses the workplace characteristics variables. Section 4 provides an analysis of the bivariate association of each of the workplace characteristics with the measures of change using cross tabulations. Section 5 develops this analysis by using an ordered probit model. Section 6 concludes.

2. Measures of innovation and change

The data used for the analysis in this paper are from the Australian Workplace Industrial Relations Survey (AWIRS) 1990-1995 panel data set. This contains 698 workplaces that completed surveys in both 1990 and 1995. All the workplaces have 20 or more employees. The sample is based on the respondents to the 1990 survey that were willing to be re-interviewed in 1995 (and, of course, the workplaces that could be traced in 1995). This procedure means that the sample may have a bias towards innovative workplaces since some of the least innovative workplaces may have ceased trading between 1990 and 1995.

The proxies for innovativeness used in this paper come from four questions asked in the 'General Management Questionnaire'. Table 1 contains details of these questions and the abbreviations by which they are referred to later in the paper.

Table 1   Types of workplace change

Which, if any, of these changes have affected this workplace in the last two years?	Abbreviation
1) Major change in product or service	product
2) Major restructuring of how work is done	restruct
3) Reorganisation of management structure	manage
4) Introduction of major new plant, equipment or office technology	process

Using the responses from each of these questions, each workplace is allocated to one of three groups. These are an 'infrequent' innovator group (where the answer to the specific question was 'no' in both years), a 'periodic' innovator group (where one of the answers was 'yes'), and a 'dynamic' innovator group (where 'yes' was the response in both 1990 and 1995). Table 2 shows the percentages of workplaces falling into each of these groups.[4] Rogers (1998) discusses the fact that the AWIRS panel data indicates that there is some persistence in innovative activity (i.e. some workplaces appear highly innovative through time). This provokes the question of whether there are any significant differences between the three groups. The analysis that follows seeks to answer this question. Table 2 shows that the proportion (unweighted) of the workplaces experiencing different types of change varies substantially.[5] For example, only 4.4% of workplaces are in the 'dynamic' product change group, while over 26% are in the 'dynamic' management restructuring group.

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[4] While this method offers an improvement on previous studies that simply use a single year's data, it should be noted that there is no information for the period 1990 to 1993. Thus, the dynamic innovator group will contain workplaces that are continuously innovative (i.e every year), as well as workplaces that only undertook a change in, say, 1989 and 1994.

[5] This paper is concerned with the characteristics of the 698 firms in the sample, and does not attempt to infer population characteristics, hence unweighted data is used.

Table 2 Proportions in innovation intensity groups

Innovation intensity	Number of changes	Measure of workplace change							
		Product		Restruct		Manage		Process	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
Infrequent	No change	482	69.1	229	32.8	195	27.9	283	40.5
Periodic	1 change	185	26.5	320	45.9	318	45.6	309	44.3
Dynamic	2 changes	31	4.4	149	21.4	185	26.5	106	15.2
		698	100	698	100	698	100	698	100

3. Determinants of workplace innovation

This section outlines some of the previous literature and introduces the various explanatory variables used in the analysis below. For the purposes of exposition the explanatory variables are divided into basic workplace characteristics, environmental factors, and training, communications and management characteristics.

3.1. Basic workplace characteristics

Various authors have considered how firm size may be related to innovative activity. In general these studies consider this relationship at the firm level (see Cohen, 1995 for a review of firm-level issues). Larger firms may have advantages such as access to capital, market power, skilled and experienced research base, and ability to access government programs. In contrast, small firms may have more process flexibility, faster communications within the firm, and the ability to rapidly enter new niche markets. How these various advantages and disadvantages net out is likely to depend on the industry concerned (a point made by Rothwell and Dodgson, 1994). Empirical studies that use the ratio of R&D to sales as an innovation proxy have found various size-innovation relationships, including a U-shaped relationship with small and large firms having higher R&D intensity (see Cohen, 1995, and van Dijk et al, 1997). A further issue is that our dependent variables are ordinal which may imply some size-

innovation link.[6] Previous studies on AWIRS data have found workplace size (measured by employment) influences the propensity to undergo some types of change (e.g. Nunes et al, 1993, find workplace size positively related to process change). Equally, Drago and Wooden (1994) include both employment and the square of employment in a regression using process change as the dependent variable, finding that process innovation initially increases and then decreases with workplace size (a similar result was found by Machin and Wadhwani, 1991). To investigate these issues the number of employees at the workplace is included, and a dummy variable for whether the workplace belongs to a firm with less than 500 employees in Australia.

A further potential factor in the propensity to undergo change is the extent of foreign ownership. The economic literature has suggested that the presence of foreign ideas, technology and finance may spur change. Some empirical studies of workplaces have indicated that foreign owned workplaces report higher levels of change. For example, Nunes et al (1993) find the coefficient on a dummy variable for foreign ownership is positive and significant in explaining whether a new product or service is launched. Love et al (1996) find foreign ownership is a positive influence on innovation for a sample of Scottish manufacturing plants. In contrast, Drago and Wooden (1994) find that foreign ownership reduces the likelihood of process change. Some caution may be necessary in interpreting such results since, as ever, causation is not proven. For example, a potential explanation of the positive relationship is that foreign firms may be more likely to locate in industries with a greater potential for change.

The role of unions in productivity and innovation has been extensively investigated by various authors using the AWIRS and other data sets (see, for example, Crockett et al, 1992, Drago and Wooden, 1994, and Nunes et al, 1993). To revisit this issue using the new panel-based change variables we include two previously used union variables: a dummy variable for workplaces that have no unions, and the proportion of the

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[6] For example, one of the types of change asks about the introduction of new products or services. A large workplace, that produces hundreds of products, may regularly release a new product. This may lead the respondent to answer 'yes' to question 1 in Table 1, depending on the interpretation of the word 'major'. A small workplace, with only one product, which may only change every five or so years, will respond 'yes' much less frequently even though its (relative) innovation effort may be high.

workplace's employees in a union. The nature of employee-management relations is included by using a dummy variable for whether the employee-management relations in the workplace are below average (as assessed by the employee relations manager). In addition to the above variables we also include a dummy variable for the age of the workplace, which indicates that the workplace has undertaken its main activity for less than five years.

3.2.   Environmental factors

An additional factor that is likely to affect innovation is whether the workplace operates in a commercial or non-commercial environment. To incorporate this possibility we include a variable for whether the workplace 'undertakes its activity for the purposes of making a profit'. A traditional economic argument would assert that a commercial focus may provide more stimulus for innovation. However, there is a substantial debate on the role of competition in innovation (see Cohen, 1995, Symeonidis, 1996). In general this research has not found any consistent relationship between the level of competition (often imperfectly proxied by variables such as market concentration) and innovative intensity. Nunes et al (1993), using AWIRS 1990 data, also found that various proxies for the level of competition had no significant association with various measures of change (specifically measures 1, 2, and 3 from Table 1).[7] In the main analysis below we investigate two aspects of competition. First, we include a dummy variable that indicates whether the demand for the product or service is declining. Second, a dummy variable which indicates whether the demand for the product or service is 'largely unpredictable'. Section 5.4 contains further analysis of the role of competition by including additional variables which are only available for the sub-set of commercial workplaces.

3.3.   Training, communications and management methods

One of the benefits of the AWIRS data is that it allows investigation of various characteristics that are not normally captured by financial or business data sets. In this

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[7] However, Nunes et al (1993) do find that some proxies for competition are related to 'job re-design' and the introduction of certain management methods.

paper we consider the role of training, employee share ownership schemes and the communications methods.

The extent of training and innovation are likely to be inter-related. Gospel (1991, p. 2) states "Other things being equal, a well educated and trained labour force has a comparative advantage in developing, adopting, and implementing new technologies. In turn, technological change has a profound effect on the quantity and quality of skills required by industry". Recent theoretical work has suggested that investment in training may be sub-optimal due to an interaction with imperfect labour markets (Acemoglu, 1997). Intuitively, when labour mobility and job matching is imperfect, future employers may not fully reward employees for past investments in training. Moreover, in an economy where employers choose whether to adopt a new technology – which is more profitable with a trained workforce – various equilibrium can occur, including the possibility of a 'no training, no new technology adoption' equilibrium. The AWIRS data does not allow a full investigation of these issues, however, one can investigate whether workplaces that offer training are more likely to undergo change. This was found to be the case in work by the Bureau of Industry Economics on small firms in 5 industries (motels, metal fabrication, computer software, florists and nurseries) (Gallagher, 1991). The reasons for such a link could be due to skilled employees increasing the rate of return on innovation, or that skilled employees contribute ideas that lead to innovation. If both reasons exist, raising innovation or training could lead to a virtuous circle of more innovation and more training, a similar idea to the one contained in Acemoglu's (1997) multiple equilibrium model.

To proxy the extent of training in the workplace three dummy variables are used. The first indicates whether a formal training program has been carried out in the last year. The second whether non-managerial employees had been on paid study leave, and the third if external consultants had been used for training.

Better communications within the workplace may allow ideas on change to filter up to managers which are subsequently implemented.[8] Equally, better communications may foster more trust within the workplace, making change easier and more beneficial, which may in turn raise the frequency of change. Three dummy variables are used to proxy communications: a dummy variable for whether the workplace has a suggestion scheme in place, a dummy for whether task forces or ad hoc committees operate, and a dummy for quality circles or productivity groups. Kersley and Martin (1997) provide a empirical study of the link between communications and productivity using a UK industrial relations survey. They find that informal communication methods (quality circles and briefing groups) exert a positive influence on productivity. They attribute this to the fact that "workers often make suggestions that lead to increased productivity or reductions in cost" (Kersley and Martin, 1997, p.496). If this is the case we should also see a link between communications and measures of innovation.[9]

The concepts of training and communications are also linked to the idea of the flexible firm or workplace. Lund and Gjerding (1996) provide evidence of the link between innovation and 'flexibility' from a survey of Danish firms. They define flexibility as "the capacity based on learning structures and processes to respond with new products and technology to a changing environment". They consider communications (proxied by the presence of working groups and quality circles) and the extent of training as components of flexibility.

Additional variables for various other management methods are also included. A dummy variable captures whether management formally measures productivity. Also a dummy variable indicates the presence of an employee share ownership or options schemes in the workplace. The former is a proxy for the quality of management and the latter for employee incentives. A final variable included is the percentage of

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[8] Fairtlough (1994, p.327) suggests that innovation requires "a flow of ideas, and this arises in a low-control organisation, which encourages 'bottom-up' initiatives …" and "innovative people have to have a wide range of information and much interchange between different scientific disciplines and between business functions".

[9] It should also be noted that the presence of a union(s) may also improve communications. Drago and Wooden (1992, p.144) state that unions " .. by helping to increase the flow of communications between workers and management, new ideas may be generated with direct consequences for productivity".

managers appointed from within the organisations. This is intended as a proxy for the degree of external awareness of the management since the ability of management to absorb new ideas from external sources is a potential factor in innovation. This variable, however, may be related to other processes. For example, high levels of externally appointed managers may indicate a period of rapid management change, which is obviously directly related to one of our measures of change. To try and control for this type of endogeneity problem the values for the explanatory variables are taken from 1990. This, of course, does not completely remove the problem since the dependent variables are based on 1990 and 1995 data. An obvious alternative is to use a 1995 dependent variable with 1990 explanatory variables (this is done in section 5.3). However, this prevents the use of the dynamic, periodic and infrequent innovator classification. Table 3 defines the full set of workplace characteristics variables used as explanatory variables.

Table 3   Variables for workplace characteristics

Abbreviation Description	Expected association with change	% equal to 1 (if dummy variable)
Workplace characteristic		
Number of employees (in 000's)	?	
Foreign ownership. (= 1 if some level of foreign ownership, = 0 otherwise)	+	20.7
Size of firm that workplace belongs to (=1 if number of employees in Australia greater than 500, = 0 otherwise)	?	27.3
Age of workplace (= 1 if main activity undertaken for less than 5 years, = 0 otherwise)	?	8.6
Union(s) present in workplace (= 1 if no, = 0 if union(s))	?	11.2
Estimated percentage of work force in union (union density)	?	
Employee-management relations (= 1 if relations below average, = 0 otherwise)	+	6.0
Environmental factors		
Commercial workplace (= 1 if commercial (profit is aim), = 0 if non-commercial)	+	66.2
Demand contracting for main product/service (= 1 for contracting, = 0 otherwise)	-	12.5
Demand for product unpredictable (=1 if largely unpredictable, = 0 otherwise)	-	17.9
Management methods		
Suggestion scheme in workplace (=1 if present, = 0 otherwise)	+	32.5
Study leave or financial assistance provided in last year (= 1 if yes, =0 if no)		67.1
External training consultants used (= 1 if yes, =0 if no)		13.3
Training in workplace (= 1 if formal instruction carried out in last year, = 0 otherwise)	+	68.0
Share ownership/option scheme (= 1 if present, = 0 otherwise)	+	12.2
Measure productivity (= 1 if management formally measure productivity, = 0 otherwise)	+	70.6
Task forces/ad hoc joint committees/working parties (= 1 if present, = 0 otherwise)	+	34.2
Quality circles/productivity improvement groups (= 1 if present, = 0 otherwise)	+	16.5
% of managers appointed from within the organisation	?	

Notes: All variables from 1990 survey.

4. Bivariate analysis of workplace characteristics

In this section we analyse the bivariate association between each of the dependent variables and the ordinal explanatory variables in Table 3 using cross tabulations. Bivariate analysis, by definition, cannot control for additional factors and should be used to gain a broad view of potential inter-relationships in the data. Table 4 contains

a summary of these results. A 'yes' in a cell indicates a significant association between the explanatory variable (row) and the measure of change (column).[10]

Table 4   Summary of cross-tabulation results

Abbreviation	Measures of workplace change			
	(1) product	(2) restruct	(3) manage	(4) process
Communication				
task forces in place	Yes	Yes	Yes	
quality circles in place	Yes			
suggest scheme in place	Yes	Yes	Yes	Yes
Workplace characteristics				
foreign ownership			Yes	
commercial		Yes	Yes	
part of small firm	Yes	Yes	Yes	
workplace under 5 yrs old				
poor manage.-employee relations		Yes	Yes	
union presence		Yes	Yes	
Market conditions				
demand contracting				
demand unpredictable				Yes
Training				
training (study leave)		Yes	Yes	Yes
training (formal program)		Yes	Yes	
training (consultants)	Yes	Yes	Yes	Yes
Management				
share ownership scheme			Yes	
measure productivity				
% internal managers		Yes		

Note: A "Yes" indicates that the characteristics (row) has a significant association with the measure of change (column). See Appendix 1 for full results.

Major change in product or service

Looking at the results for the 'major change in product or service' dependent variable in column (1), we can see that five explanatory variables show a significant association. The nature of the association requires inspecting the complete cross-tab results. Appendix 1 (available from author) shows that the communications variables all indicate that the presence of these management methods are associated with higher rates of change. Equally, being part of a large firm also appears to raise the rate of

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[10] 'Significant' means we cannot accept the null hypothesis of independence using a chi squared test at the 10% level.

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workplace change. The association between the use of external training consultants and product change is not straightforward. While workplaces that used external consultants were much more likely to be in the medium innovation group (40% versus 24%), there were less likely to be in the high innovation group (2% versus 5%).

Major restructuring of how work is done

For the 'major restructuring of how work is done' dependent variable, the cross-tabs show 10 explanatory variables have statistically significant associations. Again, task forces and suggestion schemes appear to foster this type of change. For example, of those workplaces with a task force, only 25% reported no work restructuring, while for workplaces without a task force the proportion is 37%. There is a potential reverse causality here: workplaces who implement restructuring may also introduce task forces or suggestion schemes to provide feedback on the process of change. The presence of all types of training also raises the proportion of workplaces that undertake restructuring. Workplaces in a commercial environment appear less likely to undertake restructuring; while the presence of a union at the workplace raises the propensity for restructuring (although we should note that the number of workplaces with no union is small (78 out of 698). A workplace that is part of a small firm appears less likely to have undergone restructuring. Poor employee-management relations (as rated by the general manager) are also associated with more restructuring of how work is done. Lastly, although the association with the percentage of internal managers is significant, there appears to be no simple monotonic relationship.

Reorganisation of management structure

The third measure of change is whether a 'reorganisation of management structure' was reported. As for the previous type of change, the presence of employee-management communication methods and training appear to have a positive impact on the propensity to undergo this type of change. For example, of those workplaces that had formal training in 1989-90, only 22% reported no reorganisation of management structure in either 1990 or 1995, compared to 40% of workplaces that reported no formal training. The presence of a union appears to raise the likelihood of a management restructuring, as does being part of a large firm. A non-

commercial environment also suggests more of this type of change. The results for foreign ownership, employee-management relations and the presence of a share ownership scheme are again not easy to interpret, with the impacts on change not consistent across the low, medium and high innovation intensity categories.

Introduction of major new plant, equipment or office technology

For the process measure of change there are only four variables that show a significant association. The presence of a suggestion scheme is associated with higher rates of process change, while unpredictable demand is associated with lower rates of process change. Both measures of the extent of training are associated with higher rates of change.

A number of broad conclusions can be drawn form the results in Table 4. The variables for market conditions show little association with any measure of change (except unpredictable demand for process change). Similarly, the management methods variables – share ownership schemes, measuring productivity and the percentage of internal managers – show no strong links with our measures of innovation. The lack of results may, of course, be partly due to the crude method of quantifying some of these factors (i.e. simple dichotomous variables). Overall, the presence of employee-management communication methods show links to all of the measures of innovation. Equally, the various measures of the extent of training in the workplace seem to be important factors. The basic workplace characteristics (part of large firm, ownership, management-employee relations and union presence) also have associations with some of the measures of change.

5. Multivariate analysis of workplace characteristics

5.1. Introduction

In this section we complement the analysis of the previous section by estimating a series of ordered probit regressions. These allow more than one explanatory variable to be included in the model. Thus, we attempt to analyse the partial association between an explanatory variable and the dependent variable, controlling for the

influence of other variables.

The ordered probit model assumes that there is a latent variable *y* which is determined by various workplace characteristics. In the current context this can be interpreted as innovativeness or the propensity to undertake change. The vector of latent variable values for our data set can be expressed as

$$\bar{y} \quad X + \bar{\varepsilon} \quad ,$$

where *X* is a matrix of explanatory variables, β is a vector of coefficients to be estimated and is an error vector (normally distributed). Since we cannot observe the underlying innovativeness of a workplace we assume that higher levels of innovativeness will result in more changes being reported. Specifically,

$$c \quad 0 \quad \text{if} \quad y \quad \delta_1$$
$$c \quad 1 \quad \text{if} \quad \delta_1 < y \quad \delta_2$$
$$c \quad 2 \quad \text{if} \quad \delta_2 < y$$

where c represents the groupings shown in Table 2 (i.e. no change, 1 change or 2 changes). The represent so-called cut-off, or boundary, parameters which are estimated along with the coefficients using maximum likelihood.

One difference from the bivariate analysis above is that the workplace communications variables (quality circles, suggestion schemes and task forces) are now combined into a single dummy variable ('communications methods'), which takes the value of one should any of the methods be in use. This avoids multicollinearity problems. Table 5 contains the results of ordered probit regressions on each of the change variables. All the regressions also include a set of industry dummy variables (shown in Appendix 2 available from author). The sign of the coefficient shows the impact on the underlying latent variable 'innovativeness'. For the purposes of our discussion of the results we focus primarily on coefficients that are significantly different from zero at the 10% two-tailed significance level.

Interpreting the coefficients from an ordered probit regression is problematic (see, for example, Greene, 1993, p.672). A positive coefficient indicates that increasing the explanatory variable reduces the probability of a workplace being in the low group and increases the probability of workplace being in the high group. However, the effect on the medium group is not known without undertaking additional calculations. For ease of exposition, initially we focus on the effect on the explanatory variable on the high intensity group. The regression results for each type of change are now discussed in turn.

5.2. Regression results

Major change in product or service

The results for the product measure of change in Table 5 (regression (1)) indicate that a contracting market for the workplaces' product or service reduces the likelihood of a workplace being in the 'dynamic' group. The presence of some degree of foreign ownership also appears to reduces this likelihood. Similarly, commercial workplaces also appear less likely to have launched major new products or services. In contrast, younger workplaces (as measured in 1990) appear more likely to have launched new products or services in both 1990 and 1995. Lastly, workplaces that used external training consultants also appear to have a higher propensity to introduce new products or services.

Major restructuring of how work is done

Regression (2) shows that five coefficients are significantly different from zero. The coefficient on the communication methods variable is significant at the 1% level. The coefficient on the percentage of managers appointed from within the organisation is also positive and significant (indicating that a larger percentage of internal managers may foster restructuring of how work is done). As for regression (1), the use of external training consultants also appears important. There is a potential endogeneity issue here; work restructuring may have involved the re-training of employees as well as the use of external consultants. Note, however, that the other training variable is not significant. The coefficient on the employee-management relations variables

indicates that workplaces with a 'below average' rating have a higher propensity to restructure how work is done. Nunes et al (1993), using AWIRS 1990 data, also find that poorer management-employee relations increases the likelihood of restructuring. Lastly, larger workplaces appear more likely to restructure how work is done.

Reorganisation of management structure

The third regression in Table 5 uses the 'reorganisation of management structure' question as the dependent variable. In keeping with regression (2), the results show that the presence of communication methods fosters this type of change. Training (the presence of either formal training scheme or study leave) also has a positive and significant coefficient. The coefficient on the employee-management relations dummy variable is also positive and significant. In addition, the coefficient on the small firm dummy variable is negative and significantly different from zero, indicating that smaller firms are less likely to undergo this type of change (which might be expected given that small firms should have smaller management structures).

Introduction of major new plant, equipment or office technology

Regression (4) again shows that the presence of communication methods and workplace size are linked to increased process change. In addition, the presence of foreign ownership reduces the likelihood of process change. In this regression we find that smaller workplaces are more likely to undergo process change – in contrast to the results from regression (3). Greater demand unpredictability reduces the likelihood of process change. Finally, as in regressions (1) and (2), the presence of external training consultants have a positive association with process change.

Table 5   Results of ordered probits

Explanatory variable	Measures of workplace change			
	(1) product	(2) restuct	(3) manage	(4) process
communication methods	0.177 (1.40)	0.364*** (3.28)	0.24** (2.17)	0.112 (1.01)
internal managers (%)	0.001 (0.64)	0.003* (1.75)	0.001 (0.48)	0.000 (0.20)
'train' or 'study'	-0.038 (-0.23)	0.152 (1.01)	0.305** (2.05)	0.15 (1.01)
share ownership scheme	0.118 (0.66)	-0.044 (-0.28)	-0.088 (-0.57)	-0.142 (-0.89)
measure productivity	0.075 (0.57)	0.01 (0.09)	-0.109 (-0.95)	-0.026 (-0.22)
external train cons.	0.358** (2.26)	0.244* (1.67)	0.22 (1.50)	0.366** (2.51)
market decreasing	-0.388** (-2.06)	0.162 (1.05)	0.043 (0.28)	-0.041 (-0.26)
market unpredictable	0.155 (0.99)	0.156 (1.13)	0.046 (0.33)	-0.229* (-1.64)
poor employee-manage. relations	0.071 (0.31)	0.446** (2.18)	0.516** (2.45)	-0.155 (-0.75)
union(s) present	-0.287 (-0.97)	-0.212 (-0.82)	0.03 (0.12)	-0.355 (-1.39)
union density	-0.001 (-0.28)	0.001 (0.57)	0.001 (0.58)	-0.001 (-0.29)
number of employees	-0.073 (-0.65)	0.266** (2.46)	0.165 (1.58)	0.303*** (2.90)
foreign owned	-0.277* (-1.68)	-0.094 (-0.66)	-0.112 (-0.80)	-0.359** (-2.49)
commercial	-0.512* (-2.17)	0.119 (0.61)	0.092 (0.47)	-0.09 (-0.46)
small organisation	-0.173 (-1.13)	-0.158 (-1.21)	-0.319** (-2.45)	0.274** (2.09)
age less than 5 years	0.375* (1.71)	0.113 (0.55)	0.293 (1.44)	0.059 (0.30)
No. of obs.	543	543	543	543
LogL	-380.0	-519.5	-522.1	-513.9
Boundary value (1)	-0.01	0.61	0.06	-0.43
Boundary value (2)	1.28	2.01	1.48	1.01

Notes: All regressions include industry dummies (1 digit ANZSIC level). t-statistics shown in brackets. A * indicates coefficient significant at 10% (two tailed), ** 5% and *** 1%.

Industry dummies

As stated above, all the regressions in Table 5 contain a set of industry dummies (at the one digit level). This is to control for the fact that rates of change are likely to vary across industries due to technological or other factors. The coefficients on these dummies suggest two broad conclusions (full results in Appendix 2). First, there are significant differences between industries in the propensity to change. Second, these differences are not consistent across the measures of change. For example, the mining industry appears less likely to undergo product change but more likely to undergo a restructuring of how work is done and process change.

Economic significance

As indicated above one of the drawbacks of using an ordered probit model is the difficulty in interpreting the coefficients. Below we use an alternative method to provide a more intuitive explanation of some of the coefficient estimates. Since this method requires a separate table for each variable of interest we focus attention on two variables only: communications and use of external training consultants.

Table 6 shows the method of assessing the impact of the coefficient on the external training variable (which is significant and positive in regressions 1, 2 and 4). The table uses the fitted values from the above regressions to allocate each workplace to a 'predicted change group'. However, the fitted values are modified to provide two hypothetical scenarios (see Kersley and Martin, 1997 for a previous example of this method). In the first, the impact of external training is added to the fitted values of all workplaces (i.e. for those work places that reported no external training we *add* the coefficient of the variable to their fitted values). In the second hypothetical scenario we *subtract* the coefficient value from the fitted values of those work places that reported external training. This provides a hypothetical comparison between a case when all workplaces used external training to a case where none did. The net difference between these two cases is shown in the row labelled 'implied impact'. The table shows that the implied effects can be quite large. One interpretation of the coefficient on the external training variable is that it proxies both the workplaces commitment to a skilled labour force and also its attitude to using external skills.

The latter factor may be a proxy for its overall ability to benefit from external linkages with suppliers, customers, competitors, and government institutions.

Table 6   Implied effect of 'external training'

	Predicted % of workplaces in each group	
	1 change	2 change
Product change		
All workplaces use	30.6	0
No workplaces use	3.1	0
Implied impact	27.5	0
Restructuring of how work is done		
All workplaces use	80.3	12.3
No workplaces use	77.7	5.3
Implied impact	2.6	7
Process change		
All workplaces use	93.4	2.6
No workplaces use	77.5	0.6
Implied impact	15.9	2

Table 7 shows a similar set of calculations for the communications dummy variable in regressions (2) and (3) which indicates whether a suggestion scheme, quality circle or task force is in use in the workplace (i.e. the 'communication methods' dummy variable). Again the implied impact row suggests that the importance of communication methods is potentially large.

Table 7   Implied effect of 'communications methods' in use

	Predicted % of workplaces in each group	
	1 change	2 change
Restructuring of how work is done		
All workplaces use	84.0	9.2
No workplaces use	73.1	2.2
Implied impact	10.9	7
Reorganistion of management structure		
All workplaces use	82.9	12.9
No workplaces use	80.8	6.8
Implied impact	2.1	6.1

5.3.   Endogeneity

One of the issues raised above was the potential endogeneity between the measures of workplace change and some of the explanatory variables. For example, workplaces that introduce change may also introduce new communications methods (suggestion schemes, quality circles, etc). Similar issues may influence the interpretation of the results for the training and employee-management relationship variables. One method of assessing the importance of this issue is to use a 1995 measure of change as the dependent variable, with explanatory variables taken from 1990. The drawback of this approach is that the measure of change in 1995 is a dichotomous variable which does not allow the distinction between dynamic, periodic and infrequent innovators (i.e. there is a trade off between the ability to control for endogeneity and the 'information' present in the dependent variable). Nevertheless, additional probit regressions were run with the 1995 responses to the questions in Table 1 as the dependent variable and the same set of explanatory variables as in Table 5. The results suggest that endogeneity may be a problem. The coefficient on the training variable, although positive, is no longer significant in the management reorganisation regression. The coefficient on the communications variable is still positive and significant in the 'restructuring' regression, but not significant in the management reorganisation equation. Similarly, the coefficient on the employee-management relations variable, although positive, is no longer significant. Lastly, the external training variable is no

longer significant in any of the regressions. These results suggest caution in interpreting the results in Table 5.

5.4. Alternative specifications

Various alternative specifications were also investigated to check the robustness of the results in Table 5. As in Drago and Wooden (1994) the square of employment and the square of union density were added (separately) to the regressions. In each case the coefficient on the squared term was insignificantly different from zero and the coefficients on the other explanatory variables were little changed. Separate regressions were also run for commercial workplaces. This allows a more detailed investigation of the influence of market conditions (since there are additional questions in AWIRS relating to competition for commercial workplaces). Three additional explanatory variables were included in the ordered probit regressions in Table 5. These are the intensity of competition, the number of competitors, and the presence of international competition (i.e. whether imports were important or whether output was exported). The coefficients and t-statistics for these variables are shown in Table 9. For product change, international competition appears to raise the chance being a dynamic innovator, while having many competitors reduces the likelihood. Equally, having many competitors appears to reduce the chances of being dynamic in process change. Lastly, intense competition appears to increase the chances of regular management reorganisation.

Table 9   Results for additional competition variables

Explanatory variable	Measures of workplace change			
	(1) product	(2) restuct	(3) manage	(4) process
Competition intense	0.185 (0.82)	0.149 (0.76)	0.388** (1.98)	-0.125 (-0.65)
Many competitors	-0.441* (-1.92)	-0.083 (-0.41)	0.113 (0.56)	-0.422** (-2.12)
International competition	0.397* (1.89)	0.266 (1.46)	-0.132 (-0.72)	-0.124 (-0.68)
No. of obs.	239	239	239	239
LogL	-155.5	-214.3	-218.4	-210.1

Notes: Dependent variables the same as for Table 5. Other explanatory variables (including industry dummies) are included as in Table 5 but not reported. 'Competition high' is a dummy variable for whether competition was as 'intense' or 'very intense' by the general manager (in 1990) (64.6% of workplaces). 'Many competitors' is a dummy for the number of competitors in the workplace's main product or service market (61.1%). 'International competition' is a dummy variable for whether the workplace's market is 'domestic with import competition' or primarily export' (40.9%).

6. Conclusions

This paper has sought to investigate some of the characteristics that are associated with workplace change using data from the AWIRS panel. There are various difficulties with this type of analysis including the problems of measuring innovation and the complex nature of the innovation process. Given these difficulties the paper has taken a broad approach using both bivariate and multivariate analysis.

The extent of innovation is proxied by using four survey questions on workplace change. These concern the introduction of new products or services, changes to how work is done, management reorganisation, and investment in new equipment. For each of these four measures a workplace is categorised into a dynamic, periodic or infrequent innovator group, based on whether they reported the change in (a) both the 1990 and 1995 surveys (b) either 1990 or 1995, or (c) neither the 1990 or 1995 surveys. This method of grouping innovators provided the dependent variables for the analysis and represents an approach that has not been previously explored.

The explanatory variables investigated relate to basic workplace characteristics

(workplace size, firm size, union presence, employee-management relations, foreign ownership, age); environmental factors (commercial, declining demand, unpredictable demand); and also management methods (suggestion schemes, share ownership programs, task forces and quality circles). Initially, bivariate associations are investigated using cross-tabulations. These show that the presence of suggestion schemes, task forces and, possibly, training schemes are associated with higher rates of change. In addition, workplaces that are part of large firms, non-commercial workplaces and those with union(s) present are associated with higher rates of change.

The second stage of analysis uses an ordered probit model. This model controls for industry effects and seeks to investigate the partial correlation of each of the variables with innovation activity. In the ordered probit model the presence of either suggestion schemes, quality circles or task forces is represented by a single communications dummy variable. This is found to be a significant explanatory variable for 2 of our 4 measures of change. The analysis also suggested that the use of external training consultants is associated with more change. However, further analysis suggests that this may be due to reverse causality (i.e. a change is implemented which requires external training). The ordered probit results also suggest that larger workplaces have a higher likelihood of 'restructuring of how work is done' and 'reorganisation of management structure'. However, small firms appear more likely to undergo process change. The presence of some level of foreign ownership reduces the propensity of new product and process innovation. Lastly, there is some limited evidence that poor external demand conditions reduce the likelihood of new product and process innovation. When only the commercial workplaces are analysed we also find that the presence of many competitors reduces the likelihood of product and process change.

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Appendices

Appendices 1, 2 and 3 are available by direct download from the Melbourne Institute web page:

http://www.ecom.unimelb.edu.au/iaesrwww/home.html

Appendix 1

Results of cross tabulations with 'introduction of major new product or service'

(only those with significant chi-squared tests shown)

	External training consultants used?				Task forces			
	No	Yes	Total			Task forces	No task force	Total
No change	428	54	482		No change	153	329	482
	70.74	58.06	69.05			64.02	71.68	69.05
1 change	148	37	185		1 change	72	113	185
	24.46	39.78	26.5			30.13	24.62	26.5
2 change	29	2	31		2 changes	14	17	31
	4.79	2.15	4.44			5.86	3.7	4.44
Total	605	93	698		Total	239	459	698
	100	100	100			100	100	100

	Suggestion schemes in place				Quality circles in place			
	No	Yes	Total			No	Yes	Total
No change	338	144	482		No change	415	67	482
	71.76	63.44	69.05			71.18	58.26	69.05
1 change	113	72	185		1 change	143	42	185
	23.99	31.72	26.5			24.53	36.52	26.5
2 changes	20	11	31		2 changes	25	6	31
	4.25	4.85	4.44			4.29	5.22	4.44
Total	471	227	698		Total	583	115	698
	100	100	100			100	100	100

	Total Australia employees < 500		
	No	Yes	Total
No change	287	124	411
	65.08	74.7	67.71
1 change	131	36	167
	29.71	21.69	27.51
2 changes	23	6	29
	5.22	3.61	4.78
Total	441	166	607
	100	100	100

Appendix 1   cont.

Results of cross tabulations with 'major restructuring of how work is done'

(only those with significant chi-squared tests shown)

	Suggestion schemes in place				Task forces			
	No	Yes	Total		Task forces	No force	task	Total
No change	177	52	229	No change	60	169		229
	37.58	22.91	32.81		25.1	36.82		32.81
1 change	201	119	320	1 change	107	213		320
	42.68	52.42	45.85		44.77	46.41		45.85
2 changes	93	56	149	2 changes	72	77		149
	19.75	24.67	21.35		30.13	16.78		21.35
Total	471	227	698	Total	239	459		698
	100	100	100		100	100		100

	Formal training in last year?				Commercial environment		
	No	Yes	Total		No	Yes	Total
No change	96	133	229	No change	57	172	229
	43.05	28	32.81		24.15	37.23	32.81
1 change	98	222	320	1 change	118	202	320
	43.95	46.74	45.85		50	43.72	45.85
2 changes	29	120	149	2 changes	61	88	149
	13	25.26	21.35		25.85	19.05	21.35
Total	223	475	698	Total	236	462	698
	100	100	100		100	100	100

	Union(s) present in workplace				Total Australia employees < 500		
	Yes	No	Total		No	Yes	Total
No change	189	40	229	No change	118	67	185
	30.48	51.28	32.81		26.76	40.36	30.48
1 change	289	31	320	1 change	204	75	279
	46.61	39.74	45.85		46.26	45.18	45.96
2 changes	142	7	149	2 changes	119	24	143
	22.9	8.97	21.35		26.98	14.46	23.56
Total	620	78	698	Total	441	166	607
	100	100	100		100	100	100

2

Appendix 1   cont.

Results of cross tabulations with 'major restructuring of how work is done' (cont.)

	External training consultants used?				Training (paid study leave)		
	No	Yes	Total		Yes	No	Total
No change	212	17	229	No change	136	93	229
	35.04	18.28	32.81		29.06	40.61	32.86
1 change	275	45	320	1 change	217	103	320
	45.45	48.39	45.85		46.37	44.98	45.91
2 changes	118	31	149	2 changes	115	33	148
	19.5	33.33	21.35		24.57	14.41	21.23
Total	605	93	698	Total	468	229	697
	100	100	100		100	100	100

Proportion of managers promoted from within the organisation

	None	1-10%	11-25%	26-50%	51-75%	76-90%	>90%	Total
No change	43	28	10	28	26	17	77	229
	47.78	29.17	26.32	45.9	40.62	26.98	27.11	32.9
1 change	41	48	22	23	22	29	134	319
	45.56	50	57.89	37.7	34.38	46.03	47.18	45.83
2 changes	6	20	6	10	16	17	73	148
	6.67	20.83	15.79	16.39	25	26.98	25.7	21.26
Total	90	96	38	61	64	63	284	696
	100	100	100	100	100	100	100	100

Poor employee-management relations

	No	Yes	Total
No change	224	5	229
	34.2	11.9	32.86
1 change	294	25	319
	44.89	59.52	45.77
2 changes	137	12	149
	20.92	28.57	21.38
Total	655	42	697
	100	100	100

Appendix 1   cont.

Results of cross tabulations with 'reorganisation of management structure'
(only those with significant chi-squared tests shown)

	Poor Employee-management relations				Union(s) present in workplace		
	No	Yes	Total		Yes	No	
No change	189	6	195	No change	162	33	195
	28.85	14.29	27.98		26.13	42.31	27.94
1 change	298	19	317	1 change	291	27	318
	45.5	45.24	45.48		46.94	34.62	45.56
2 changes	168	17	185	2 changes	167	18	185
	25.65	40.48	26.54		26.94	23.08	26.5
Total	655	42	697	Total	620	78	698
	100	100	100		100	100	100

	Suggestion schemes in place				Share ownership/option scheme in place?		
	No	Yes	Total		No	Yes	Total
No change	148	47	195	No change	171	24	195
	31.42	20.7	27.94		27.9	28.24	27.94
1 change	205	113	318	1 change	271	47	318
	43.52	49.78	45.56		44.21	55.29	45.56
2 changes	118	67	185	2 changes	171	14	185
	25.05	29.52	26.5		27.9	16.47	26.5
Total	471	227	698	Total	613	85	698
	100	100	100		100	100	100

	Formal training in last year?				Task forces		
	No	Yes	Total		Task forces	No task force	Total
No change	90	105	195	No change	47	148	195
	40.36	22.11	27.94		19.67	32.24	27.94
1 change	86	232	318	1 change	112	206	318
	38.57	48.84	45.56		46.86	44.88	45.56
2 changes	47	138	185	2 changes	80	105	185
	21.08	29.05	26.5		33.47	22.88	26.5
Total	223	475	698	Total	239	459	698
	100	100	100		100	100	100

Appendix 1   cont.

Continued …. Results of cross tabulations with 'reorganisation of management structure'

(only those with significant chi-squared tests shown)

Wholly Australian owned?

	Yes	No	Total
No change	150	45	195
	27.12	31.25	27.98
1 change	242	75	317
	43.76	52.08	45.48
2 changes	161	24	185
	29.11	16.67	26.54
Total	553	144	697
	100	100	100

Total Australia employees < 500

	No	Yes	Total
No change	97	60	157
	22	36.14	25.86
1 change	214	71	285
	48.53	42.77	46.95
2 changes	130	35	165
	29.48	21.08	27.18
Total	441	166	607
	100	100	100

Commercial environment

	No	Yes	Total
No change	38	157	195
	16.1	33.98	27.94
1 change	116	202	318
	49.15	43.72	45.56
2 changes	82	103	185
	34.75	22.29	26.5
Total	236	462	698
	100	100	100

External training consultants used?

	No	Yes	Total
No change	184	11	195
	30.41	11.83	27.94
1 change	273	45	318
	45.12	48.39	45.56
2 changes	148	37	185
	24.46	39.78	26.5
Total	605	93	698
	100	100	100

Training (paid study leave)

	Yes	No	Total
No change	101	94	195
	21.58	41.05	27.98
1 change	225	93	318
	48.08	40.61	45.62
2 changes	142	42	184
	30.34	18.34	26.4
Total	468	229	697
	100	100	100

Appendix 1   cont.
Results of cross tabulations with 'introduction of major new plant, equipment or office technology'

(only those with significant chi-squared tests shown)

	Suggestion schemes in place				Market demand		
	No	Yes	Total		Fairly predictable	Largely unpredict-able	Total
No change	205	78	283	No change	219	63	282
	43.52	34.36	40.54		38.29	50.4	40.46
1 change	201	108	309	1 change	261	48	309
	42.68	47.58	44.27		45.63	38.4	44.33
2 changes	65	41	106	2 changes	92	14	106
	13.8	18.06	15.19		16.08	11.2	15.21
Total	471	227	698	Total	572	125	697
	100	100	100		100	100	100

	External training consultants used?				Training (paid study leave)		
	No	Yes	Total		Yes	No	Total
No change	257	26	283	No change	178	105	283
	42.48	27.96	40.54		38.03	45.85	40.6
1 change	268	41	309	1 change	207	101	308
	44.3	44.09	44.27		44.23	44.1	44.19
2 changes	80	26	106	2 changes	83	23	106
	13.22	27.96	15.19		17.74	10.04	15.21
Total	605	93	698	Total	468	229	697
	100	100	100		100	100	100

Appendix 2

Industry coefficients from ordered probits (in Table 5)

Explanatory variable	Measures of workplace change			
	(1) product	(2) restuct	(3) manage	(4) process
Mining	-1.111* (-1.94)	0.679* (1.97)	-0.234 (-0.67)	0.759* (2.12)
Electricity, Gas & Water	-0.936* (-2.69)	0.797* (2.97)	0.600* (2.21)	-0.13 (-0.49)
Construction	-0.886* (-2.52)	0.034 (0.12)	0.606* (2.17)	-0.818* (-2.80)
Wholesale	-0.059 (-0.15)	0.936* (2.72)	0.602* (1.74)	-0.13 (-0.37)
Retail Trade	-0.151 (-0.65)	-0.043 (-0.21)	-0.078 (-0.39)	-0.181 (-0.90)
Accommodation/Cafes /Restaurants	0.215 (0.53)	0.173 (0.48)	-0.609 (-1.58)	-0.651* (-1.66)
Transport & Storage	-0.133 (-0.50)	0.271 (1.17)	-0.302 (-1.29)	-0.298 (-1.27)
Communications	0.215 (0.64)	1.193* (3.45)	0.793* (2.42)	0.444 (1.37)
Finance & Insurance	0.129 (0.49)	0.925* (3.79)	0.41* (1.71)	-0.123 (-0.51)
Property & Business Services	-0.341 (-1.13)	0.202 (0.79)	0.287 (1.14)	-0.189 (-0.74)
Government	-0.868* (-2.63)	0.748* (2.67)	1.048* (3.69)	-0.341 (-1.22)
Education	-0.431 (-1.33)	0.51* (1.81)	0.214 (0.76)	-0.622* (-2.17)
Health & Community Services	-0.523* (-1.70)	0.412 (1.60)	0.143 (0.56)	-0.475* (-1.84)
Cultural & Recreational Services	-0.245 (-0.55)	0.108 (0.27)	0.449 (1.15)	-0.597 (-1.49)
Personal & Other Service	-0.136 (-0.37)	0.553* (1.68)	0.153 (0.47)	-0.326 (-0.98)

Notes: Manufacturing is the omitted industry group (this is the largest group with 127 of the 543 observations).

Appendix 3

Table 5 Results of probit regressions with 1995 dependent variable

Explanatory variable	Measures of workplace change			
	(1) product	(2) restuct	(3) manage	(4) process
communication methods	0.078 (0.51)	0.325 (2.51)	0.106 (0.84)	-0.023 (-0.17)
internal managers (%)	0.001 (0.51)	0.001 (0.53)	0.001 (0.77)	0.001 (0.61)
'train' or 'study'	0.000 (0.00)	0.017 (0.10)	0.299 (1.76)	0.176 (0.97)
share ownership scheme	0.038 (0.18)	-0.19 (-1.02)	-0.005 (-0.03)	-0.069 (-0.36)
measure productivity	0.107 (0.68)	-0.219 (-1.62)	0.023 (0.17)	-0.261 (-1.95)
external train cons.	0.011 (0.06)	0.206 (1.19)	0.162 (0.96)	0.183 (1.09)
market decreasing	-0.421 (-1.79)	0.214 (1.19)	0.042 (0.24)	-0.06 (-0.32)
market unpredictable	-0.073 (-0.39)	0.048 (0.30)	-0.036 (-0.23)	-0.14 (-0.84)
poor employee-manage. relations	0.026 (0.10)	0.371 (1.50)	0.255 (1.07)	0.222 (0.95)
union(s) present	-0.005 (-0.02)	-0.066 (-0.22)	0.163 (0.57)	-0.19 (-0.61)
union density	-0.002 (-0.46)	0.005 (1.79)	0.003 (1.22)	0.001 (0.41)
Number of employees	0.076 (0.61)	0.698 (3.16)	0.073 (0.61)	0.18 (1.53)
foreign owned	-0.123 (-0.63)	-0.152 (-0.91)	-0.27 (-1.67)	-0.337 (-1.95)
commercial	-0.337 (-1.24)	0.299 (1.32)	0.151 (0.68)	0.389 (1.68)
Small organisation	-0.015 (-0.08)	-0.047 (-0.31)	-0.218 (-1.47)	0.192 (1.25)
Age less than 5 years	0.295 (1.14)	0.236 (1.00)	0.273 (1.18)	0.234 (1.01)
No. of obs.	531	543	543	543
LogL	-233.6	-325.7	-343.4	-316.6

Notes: All regressions include industry dummies (1 digit ANZSIC level). t-statistics shown in brackets.
A * indicates significant at 10% (two tailed), ** 5% and *** 1%.