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Business Innovation and the Use of Information and Communications Technology

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Jessica Todhunter and Ruel Abello

Analytical Services Branch

AUSTRALIAN BUREAU OF STATISTICS

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BUSINESS INNOVATION AND THE USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY

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EXECUTIVE SUMMARY

This research investigates the hypothesis that there is a relationship between the intensity of the use of information and communications technology (ICT) by businesses, and innovation. Innovation refers to product, process, organisational and marketing innovations, as defined in the *OECD Guidelines for Collecting and Interpreting Innovation Data* (2005).

To estimate the relationship between business ICT use and innovation activity, this study makes use of firm level data from the ABS Business Longitudinal Database (BLD). We analyse data for 6,442 businesses from the 2005–06 and 2006–07 waves of the BLD. The BLD has detailed information on business demographics, innovation activity, ICT usage, market characteristics and many other variables.

The authors have developed a novel approach to summarising the diverse types of ICT usage into a single variable which can be used to categorise a firm's intensity of ICT use. The 'ICT intensity index' is an ordered variable, reflecting the business' highest degree of ICT sophistication. It takes account of factors such as broadband internet connection, business web presence, use of e-commerce and also the existence of automatic links between internal business systems and customer or supplier systems. As there is no standard method of combining the many types of ICT used by businesses in Australia, the authors propose the ICT intensity index as a convenient measure, which lends itself to straightforward and meaningful interpretation.

The analysis shows a strong link between business' use of ICT and innovative activity. Using a variety of ICT intensity specifications, businesses using successively more sophisticated types of ICT are each found to be significantly more likely to undertake some type of innovation. This result is further strengthened when we consider each type of innovation separately. The existence of automatic links between internal systems and customer or supplier systems, in particular, is strongly associated with innovative activity. Furthermore, we show that businesses which use ICT more intensely develop more novel innovations, engage in multiple types of innovation and are more likely to develop these innovations internally.

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ABSTRACT

The study uses data from the ABS Business Longitudinal Database (BLD) to examine the association between the intensity of use of information and communications technology (ICT) by businesses, and innovation. Firm level data for 6,442 businesses from the 2005–06 and 2006–07 waves of the BLD are used. An 'ICT intensity index' is constructed to represent the levels of sophistication in the business' ICT usage. The association of this indicator with different types of innovation is modelled using multivariate regression. The types of innovation considered include product, process, organisational and marketing innovations.

The analysis finds a strong relationship between ICT intensity and innovative activity at the firm level. Businesses which use sophisticated types of ICT are significantly more likely to undertake innovation of any type. The more intense ICT users are likely to undertake more types of innovation, more novel innovations and are more likely to develop the innovations internally. The relationship between ICT and innovative activity holds when controlling for a range of other business characteristics, such as employment size and industry division.

1. BACKGROUND

Business innovation is regarded as a key determinant of individual business success and national economic growth (Rogers, 2004, p. 141). For this reason, understanding the factors that enable or are at least associated with innovation, is of great interest to businesses and policy makers alike.

This research investigates the role of information and communications technology (ICT) in enabling business innovation. It uses data from the Australian Business Longitudinal Database (BLD). The study compares the relationships between ICT use and innovation in each of the member countries, but for such comparisons to be meaningful, members have agreed to use a common methodology to ensure the results are comparable at the completion of the project. Communication between analysts is facilitated by an electronic discussion board.

In undertaking the Australian study, this research required data at the firm or business level, such as that available in the BLD. The BLD includes information on business' innovative activity, use of information and communications technology and a range of other demographics. The data are collected from the same businesses through time, creating a longitudinal data set. In this paper, we use BLD data for 6,442 businesses from the 2005–06 and 2006–07 surveys.

The results of our analysis show that businesses which use ICT more intensely are more likely to undertake innovation of all types. This result is robust to a variety of ICT intensity specifications. In addition, these businesses are likely to undertake more types of innovation, more novel innovations and are more likely to develop their innovations in-house.

2. INTRODUCTION

Business innovation is regarded as a key determinant of both individual business success and national economic growth. At the micro level, business innovation has the potential to increase consumer demand through improved product or service quality and simultaneously decrease production costs. At the macro level, strong business innovation can increase multifactor productivity, thus lifting international competitiveness, economic growth and real per capita incomes. It is thus of great interest to businesses and policy makers to identify those factors which stimulate innovation and to understand how these factors interact.

This paper investigates the role of business use of ICT as an enabler of business innovation. We expect that ICT plays an important role as a source of business innovation because it enables closer communication and collaboration between the business and other organisations, allowing businesses to more quickly exploit opportunities for innovation. It also provides a platform from which businesses can build innovations, and provides significant efficiency gains. We find strong evidence that businesses which use ICT more intensely are more likely to innovate and furthermore, develop more types of innovation and also more novel innovations.

Innovation, as defined in the *Oslo Manual* (OECD, 2005, p. 46) encompasses more than just the strict research and development (R&D) activities which lead to the implementation of new goods and services. It also includes the application of new ideas to marketing and delivery activities, as well as the organisation of management structures. Many of these activities cannot be captured fully when using traditional measures of innovative activity, such as R&D expenditure or patent data. Instead, this paper uses survey data collected from Australian businesses in 2006–07, as part of the Business Characteristics Survey. We suggest that this approach is more encompassing of different types of innovative activity compared to the more traditional input or output-oriented measures.

2.1 Defining innovation

The *Oslo Manual* defines an 'innovation' as

> " ... the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." (OECD, 2005, p. 46)

Whilst an 'innovation' is restricted only to *implemented* products, processes, or methods, a firm is termed 'innovation-active' if it was engaged in innovation activities which were implemented, ongoing *or* abandoned during the period (OECD 2005, p. 59). For the purposes of this paper, innovation is considered in the broader sense of being 'innovation-active', because the focus of this paper is on innovation *effort*. As we only have two years of comparable data, our analysis is potentially restricted if we

focus only on those businesses which successfully developed and implemented an innovation, which may take many years to complete.

A *product* innovation is the introduction of a good or service that is significantly improved with respect to its characteristics or intended uses and includes significant improvements in technical specifications, components and materials, incorporated software and user friendliness or other functional characteristics (OECD, 2005, p. 48). Design changes which do not involve a significant change in the product's functional characteristics or intended use, such as a new flavour or colour option, are not product innovations. Product innovations in services can include significant improvements in how the product is provided, such as home pick-up or delivery services, or other features which improve efficiency or speed.

A *process* innovation is a new or significantly improved production or delivery method, including significant changes in techniques, equipment and/or software (OECD, 2005, p. 49). For example, introduction of a new automation method on a production line, or in the context of ICT, developing electronic system linkages to streamline production and delivery processes, are both process innovations. With respect to services, it is often difficult to distinguish a product and process innovation. The OECD (2005, p. 53) has developed the following guidelines to distinguish the two types of innovation:

- if the innovation involves new or significantly improved characteristics of the service offered to customers, it is a product innovation;
- if the innovation involves new or significantly improved methods, equipment and/or skills used to perform the service, it is a process innovation.

An *organisational* or *managerial* innovation is the implementation of a new or significantly improved method of the firm's business practices, workplace organisation or external relations (OECD, 2005, p. 49). It requires more than mere organisational change or restructure. In fact, the organisational method must not have been previously used by the business and must be the result of *strategic decisions* taken by management (OECD, 2005, p. 49). Examples include implementation a new method for distributing responsibilities and decision making among employees, decentralising group activity, developing formal or informal work teams, new types of external collaboration with research organisations or the use of outsourcing or sub-contracting for the first time (OECD, 2005, p. 52). It is important to note that mergers with, or acquisitions of, other firms are not of themselves organisational innovations. If during this merger process, however, the firm adopts a new organisational method, this may be considered an organisational innovation (OECD, 2005, p. 52).

A *marketing* innovation is the implementation of a new or significantly improved marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. The *marketing method* must not have been previously used by the firm and must be part of a new *marketing concept or strategy* representing a significant departure from the firm's existing methods (OECD, 2005, p. 50).

For this analysis, we prefer to use qualitative measures of innovation, as recommended also by the OECD (2005, p. 99). Other measures of innovation, such as R&D expenditure per employee, patents received or sales derived from new products will not encompass all the innovative efforts of a business. Instead, qualitative measures are more encompassing and are not biased towards particular types of innovation.

2.2 The role of ICT as a source of business innovation

ICT is a valuable source of business innovation because it provides substantial efficiency gains. Koellinger (2005, p. 6) states that "ICT makes it possible to reduce transaction costs, improve business processes, facilitate coordination with suppliers, fragment processes along the value chain (both horizontally and vertically) and across different geographical locations, and increase diversification." Each of these efficiency gains provides an opportunity for innovation. For example, ICT technologies which create automated system links lead to more streamlined businesses processes and allow staff to be more responsive to emerging customer needs. Similarly, technologies which allow staff to effectively communicate and collaborate across wider geographic areas will encourage strategies for less centralised management, and more flexible external relations, all of which involve different types of innovative activity.

Gretton, Gali and Parham (2003) have suggested two alternative reasons why business use of ICT encourages innovative activity. Firstly, they suggest that ICT is a 'general purpose technology' which provides an 'indispensable platform' upon which further productivity-enhancing changes, such as product and process innovations, can be based. For example, a business that establishes a web presence sets the groundwork from which process innovations, such as electronic ordering and delivery, can be easily developed. In this way, adopting general purpose ICT makes it relatively easier and cheaper for businesses to develop innovations.

Secondly, Gretton, Gali and Parham suggest that the spillover effects from ICT usage, such as network economies, can be sources of productivity gains. For example, staff in businesses which have adopted broadband Internet are able to collaborate with wider networks of academics and international researchers more closely on the development of innovations and keep abreast of current consumer trends. These are

spillover benefits because the R&D efforts of other researchers in the collaborative group can be appropriated by all.

Information and communication technologies can also be seen as a source of innovation because they enable closer links between businesses, their suppliers, customers and competitors and collaborative partners. These entities are all understood to be important sources of ideas for innovation. By enabling closer communication and collaboration, ICT assists businesses to be more responsive to innovation opportunities and provides significant efficiency gains. For example, having ICT technologies such as broadband Internet, web presence and automated system linkages, assists businesses to keep up with customer trends, monitor competitor's actions and get rapid user feedback, thereby assisting them to exploit opportunities for all types of innovations.

Previous econometric analysis confirms that ICT plays an important role in enabling business innovation. Gago and Rubalcaba (2007) find that businesses which invest in ICT, particularly those which regard their investment as very important, or strategically important, are significantly more likely to engage in services innovation.

2.3 Other factors associated with business innovation

2.3.1 Business size

Schumpeter (1950) reasons that larger firms are at an advantage in terms of innovation because they have large scale production and capacity, access to a wider range of knowledge and human capital skills and are likely to already have the infrastructure necessary to initiate further marketing and R&D activity. From a financial perspective, larger businesses also have a strong cash flows and are able to borrow against their equity. In contrast, smaller businesses are often forced to borrow, which makes innovation much more risky for small and medium sized businesses.

2.3.2 Market structure

The degree of competition in the market, or market structure, is also an important factor in business innovation (Bhattacharya and Bloch, 2004, p. 156; Rogers, 2004, p. 142). Businesses operating in markets where there is some degree of monopoly power are expected to be more innovative, because the profits and returns to innovative activity are easily appropriable. Whereas, businesses operating in highly competitive markets find it difficult to appropriate profits from innovative activity as competitors quickly copy the innovation. Note, however, that in markets which are *highly* monopolised, businesses may have few incentives to innovate as they face little to no competition for profits.

2.3.3 Networks and collaboration

The range and depth of skill and knowledge which are required to successfully develop and implement business innovations means that many innovations occur in conjunction with collaboration. Businesses, particularly small businesses, are often forced to seek complementary skills to those already in-house to successfully undertake innovation (Department of Industry Tourism and Resources, 2006, p. 1). Empirical analysis, using Australian data, has found that collaboration positively affects the likelihood of undertaking innovation that was new to the world. The diversity and intensity of collaboration, were both significantly related to 'new to the world' innovations (Department of Industry Tourism and Resources, 2006, pp. 12–17).

2.3.4 Foreign ownership

The degree of foreign ownership is another factor associated with innovation as it offers businesses wider access to skilled staff and ideas and potentially enables businesses to respond more quickly to opportunities overseas. However, there are conflicting theories on the effect of foreign ownership, as acknowledged by Rogers (2004, p. 144). Some suggest foreign ownership has a positive effect on innovation as it implies greater financial resources and greater access to knowledge and technology. On the other hand, a 'product life cycle' view implies that R&D and innovative activities are conducted close to home markets and therefore Australian domestic businesses may be merely adopting innovations which have already been developed and implemented by their company elsewhere. In this case, they cannot be classified as innovations.

2.3.5 Export activity

It is expected that businesses which engage in export activity are more likely to innovate, as they are exposed to greater and more varied competition. Innovation, therefore, is necessary for business survival in these markets. Rogers (2004, p. 144) suggests that "firms that export also have access to improved knowledge flows and, possibly, higher incentives." In regards to businesses in South East Asia, Hobday (1995), cited in Rogers (2004, p. 144) argued that knowledge of how to innovate was effectively passed to exporting firms from overseas markets.

3. DATA

The ABS Business Longitudinal Database (BLD) contains data collected from small and medium-sized businesses in the annual Business Characteristics Survey (BCS), supplemented by administrative data provided to the ABS for statistical purposes by other government agencies. (See ABS, 2007, 2008a)

Since 2005–06, the BCS has been used as the survey vehicle for the collection of Business Use of Information Technology (BUIT) and Innovation data. Core BUIT and innovation questions are included in the annual BCS, but detailed questions are asked only in alternate years.

The database for this study was constructed from the responses of small and medium-sized businesses in the BLD, plus a sample of large and complex businesses who responded to the BCS. Only those businesses that provided reliable responses in respect of *both* 2005–06 and 2006–07 were retained. This resulted in a sample of 6,442 businesses.

A list of the data items available for use in this study is provided in Appendix A.

Appendix B reports descriptive statistics on the 6,442 businesses in our database, including the representation of small, medium and large businesses, the mix of industries represented and the proportion of businesses innovating.

Please note that these descriptive statistics pertain to the unique sample selected for our analysis. They have not been appropriately weighted, and should ***not*** be taken as representative of all businesses operating in Australia in the same period.

4. METHODOLOGY AND RESULTS

The research is organised into two sections. Firstly, cross-tabulation analysis is presented, where ICT usage and other business characteristics are compared across innovators and non-innovators. The second part of the analysis involves binary probit and ordered probit modelling. The aim of the modelling is to determine the association between ICT usage and innovation activity, while controlling for the effects of a range of business characteristics.

We expect that there is some feedback between business innovation and ICT usage. To try to control for this bi-causality, we study the effect of lagged ICT usage on innovation activity in the current period. That is, we model the effect of business ICT use in 2005–06 on business' innovative activity in 2006–07. Conveniently, this accords with the sequence in which the detailed ICT and innovation questions were surveyed.

4.1 Methodology

Appendix D explains the details behind the regression modelling that was undertaken. Binary probit and ordered probit regressions were used. The former was used to model the dichotomous or binary outcome variable (innovated or not), where the inverse standard normal distribution of the probability is modelled as a linear combination of the predictors. Ordered probit regression, on the other hand, was used in modelling innovation novelty, where there are more than two outcomes of the ordinal dependent variable.

4.2 Cross-tabulation and correlation analysis

4.2.1 Cross-tabulation results

Below are the results of the cross-tabulation analysis between various ICT variables in 2005–06 and innovative activity in 2006–07.

The innovation variable represents businesses which undertook any type of innovative activity, be it Product, Process, Organisational/Managerial or Marketing innovation, which was either implemented, ongoing or abandoned in 2006–07.

The results highlight the difference in the proportion of businesses innovating in 2006–07, according to their use of ICT in the previous year. We begin by looking at basic indicators of ICT usage, such as computer and internet use, and then extend the analysis to more sophisticated indicators, such as web presence and e-commerce variables. The proportions are unweighted as we are interested here in the relationships based on the raw data. In addition, only cross-sectional weights are available in the BLD and these are inappropriate for our longitudinal sample.

4.1 Comparison of innovative activity in 2006–07 and computer use in 2005–06

	Computer use in 2005–06							
	No		*Yes*		*No response*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Undertook any type of innovative activity in 2006–07								
No	501	83%	2850	49%	20	77%	3371	52%
Yes	106	17%	2959	51%	6	23%	3071	48%
Total	607	100%	5809	100%	26	100%	6442	100%

4.2 Comparison of innovative activity in 2006–07 and type of IT support in 2005–06 (for businesses using a computer in 2005–06)

	Type of IT support in 2005–06									
	Internal IT support		*External IT support*		*No IT support*		*No response*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Undertook any type of innovative activity in 2006–07										
No	1669	43%	662	54%	443	74%	96	62%	2870	49%
Yes	2191	57%	555	46%	159	26%	60	38%	2965	51%
Total	3860	100%	1217	100%	602	100%	156	100%	5835	100%

Computer use can be seen as the most basic indicator of ICT usage. Table 4.1 shows that businesses which used a computer in 2005–06 were more likely than average to undertake some type of innovative activity in 2006–07, while only 17% of businesses that did not use a computer undertook some type of innovative activity in 2006–07.

After excluding businesses that did not use a computer in 2005–06, table 4.2 presents a comparison of innovative activity in 2006–07 by the type of IT support in 2005–06.

Businesses which have some type of IT support, and particularly those using internal IT support, are substantially more likely to undertake innovative activity in 2006–07, compared with businesses that use no IT support. This highlights that in terms of innovation, it is important to have both the ICT hardware and skilled support staff.

Table 4.3 presents the cross-tabulation results for innovative activity according to the main type of Internet connection. As expected, there is a substantially higher proportion of innovators in 2006–07 among those which had an Internet connection the previous year, particularly among those with a broadband Internet connection.

4.3 Comparison of innovative activity in 2006–07 and internet connection in 2005–06

	Main type of Internet connection in 2005–06									
	Dial-up connection		*Broadband connection*		*No response (but uses Internet)*		*No Internet use*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Undertook any type of innovative activity in 2006–07										
No	482	60%	2137	46%	13	72%	739	79%	3371	52%
Yes	315	40%	2549	54%	5	28%	202	21%	3071	48%
Total	797	100%	4686	100%	18	100%	941	100%	6442	100%

4.4 Comparison of innovative activity in 2006–07 and web presence in 2005–06 (for businesses using the Internet in 2005–06)

	Had web presence in 2005–06							
	No		*Yes*		*Missing*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Undertook any type of innovative activity in 2006–07								
No	1248	64%	1369	39%	15	79%	2632	48%
Yes	717	36%	2148	61%	4	21%	2869	52%
Total	1965	100%	3517	100%	19	100%	5501	100%

For businesses that did use the Internet in 2005–06, table 4.4 presents a comparison of innovative activity and web presence. Note that 'web presence' includes businesses which have their own website, home page or have a presence on another entity's website, but excludes online listings or directories.

After excluding businesses not using the Internet, the results in table 4.4 show that the proportion of businesses engaged in innovative activity in 2006–07 is still substantially higher among those that did have a web presence compared against those did not have a web presence. Among those that did have a web presence in 2005–06, 61% undertook some type of innovation in the following year, compared with only 36% among businesses that did not have a web presence.

Tables 4.5 and 4.6 below present the proportion of businesses innovating according to the types of web facilities available (for those businesses which reported having a web presence in 2005–06).

4.5 Comparison of innovative activity in 2006–07 and on-line ordering facility in 2005–06 (for businesses with a web presence in 2005–06)

	Web presence included on-line ordering facility in 2005–06							
	No		*Yes*		*Missing*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Undertook any type of innovative activity in 2006–07								
No	1064	40%	277	33%	43	57%	1384	39%
Yes	1568	60%	551	67%	33	43%	2152	61%
Total	2632	100%	828	100%	76	100%	3536	100%

4.6 Comparison of innovative activity in 2006–07 and automated back-end system links in 2005–06 (for businesses with a web presence in 2005–06)

	Web presence included automated back-end system links in 2005–06							
	No		*Yes*		*Missing*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Undertook any type of innovative activity in 2006–07								
No	1215	40%	126	31%	43	57%	1384	39%
Yes	1833	60%	286	69%	33	43%	2152	61%
Total	3048	100%	412	100%	76	100%	3536	100%

Tables 4.5 and 4.6 show having sophisticated features available on a one's web site, such as a facility for on-line ordering or automated back-end system links, is associated with higher likelihood of engaging in innovative activity in the following year. Among all those businesses which had a web presence in 2005–06, 61% engaged in some type of innovative activity in 2006–07 (as shown in table 4.4), compared with 67% and 69% among businesses whose web presence also had on-line ordering and automated system links, respectively.

After excluding businesses not using the Internet in 2005–06, tables 4.7 and 4.8 present the cross-tabulation of innovative activity in 2006–07 and e-commerce activity.

4.7 Comparison of innovative activity in 2006–07 and whether business placed orders via the Internet or web in 2005–06 (for businesses using the Internet in 2005–06)

	Placed orders via the Internet or web in 2005–06							
	No		*Yes*		*Missing*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Undertook any type of innovative activity in 2006–07								
No	1376	56%	1243	41%	13	81%	2632	48%
Yes	1070	44%	1796	59%	3	19%	2869	52%
Total	2446	100%	3039	100%	16	100%	5501	100%

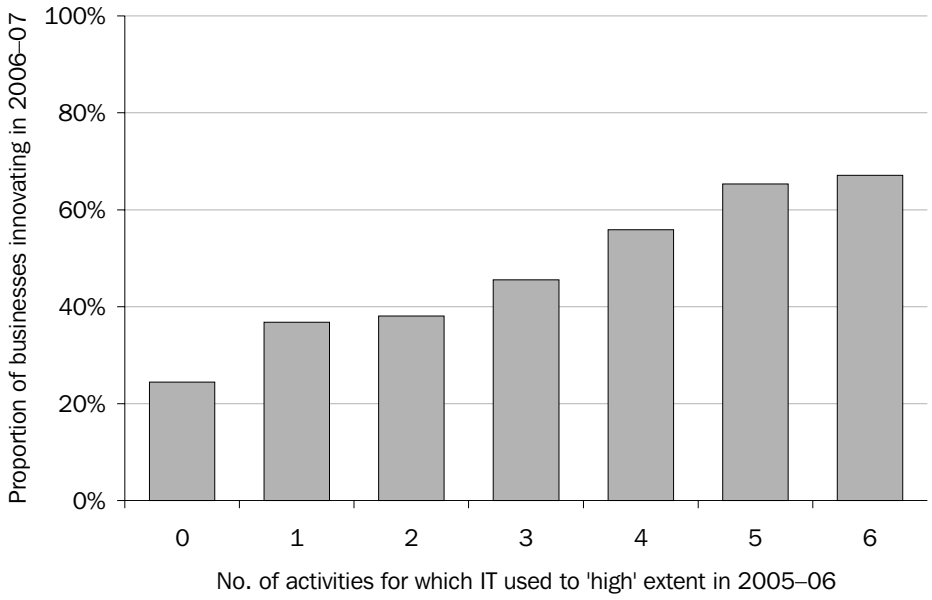
4.8 Comparison of innovative activity in 2006–07 and whether business received orders via the Internet or web in 2005–06 (for businesses using the Internet in 2005–06)

	Received orders via the Internet or web in 2005–06							
	No		*Yes*		*Missing*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Undertook any type of innovative activity in 2006–07								
No	1961	52%	661	38%	10	77%	2632	48%
Yes	1795	48%	1071	62%	3	23%	2869	52%
Total	3756	100%	1732	100%	13	100%	5501	100%

A substantially higher proportion of businesses which engage in e-commerce go on to undertake innovative activity, compared with those that don't. In particular, 59% of businesses that placed orders, and 62% of businesses that received orders via the Internet in 2005–06 , engaged in some type of innovative activity in the following year compared to less than 50% among businesses that did not engage in e-commerce. Of those businesses which both placed and received orders over the Internet in 2005–06, 64% (results not shown) engaged in some type of innovative activity in the following year.

Finally, figure 4.9 presents the proportion of businesses undertaking some type of innovation in 2006–07 according to the number of activities for which they used IT to a 'high extent' in six business activities: accounting, production/service operations, invoicing, stock control, marketing and human resources. Based on the figure, there is a positive association between strong IT use and business innovation. In particular, over 60% of businesses using IT to a high extent in five or more activities went on to innovate in the following year, compared with less than 40% among businesses using IT to a 'high' extent in only 0–2 activities.

4.9 Comparison of innovative activity in 2006–07 and extent of IT use in 2005–06



4.2.2 Correlation results

The results of correlation analysis between the individual ICT variables and innovation variables are presented in Appendix C. The polychoric correlation coefficients measure the degree of association between the ordered, categorical variables and range between –1 and 1. Larger positive values represent stronger positive association, whereas larger negative values represent stronger negative association between the variables.

There is a strong, positive association between undertaking each of the type of innovation and the business' use of computers, web presence and e-commerce. The coefficient between innovation and type of internet connection implies a positive association between using the Internet, particularly broadband Internet, and innovation activity. There is also a strong relationship between innovation and the number of business activities for which IT is used to 'high' extent. Note that there is a negative correlation between innovation and IT support, as increasing values of the IT support variable imply less IT support.

Based on the initial, descriptive analysis presented in Appendix C, it appears that there is a positive relationship between ICT use and business innovation. However, this has not controlled for other, exogenous factors which may affect business' use of ICT and innovation activity. In the next section, regression analysis is performed to estimate the relationship between ICT use and business innovation, while controlling for other exogenous factors such as business size and industry. This will give a more reliable measure of the effect of ICT use on innovation.

4.3 Regression analysis

The dependent variable(s) used in the regression analysis relate to whether or not the business undertook innovation and its degree of novelty (See Appendix A for a description of the innovation variables). As the dependent variables are both categorical and ordinal, we use binary probit and ordered probit models. A detailed explanation of the methodology used can be found in Appendix D.

The independent variables used in the analysis include business ICT use, employment size, age of business, industry division and other business and market characteristics which are thought to be associated with innovation.

4.3.1 ICT intensity index

One of the potential problems in this type of analysis is multicollinearity, which occurs when many, closely related independent variables are included, leading to biased estimates. In this analysis specifically, we expect the ICT variables to be closely related, as was confirmed when we performed correlation analysis and estimated a series of probit regression models using the ICT variables individually (see Appendix E).

To overcome this problem, an ordered, categorical variable for ICT intensity was created which combined the most important ICT variables in a manner which could be used in modelling, and could be easily interpreted. The approach taken in this research, of using an ICT intensity index, has been developed by the authors as one way in which the multicollinearity problem may be overcome. There is yet no standard or accepted approach to using ICT variables for modelling, either in Australia or internationally.

The details of the ICT intensity variable are presented in table 4.10. The categories are mutually exclusive, with businesses classed according to the highest degree of ICT sophistication.

4.10 ICT intensity index I – based on ICT use in 2005–06

Values	*ICT intensity*	*Description*	*Frequency*	*Percent*
1	Very high	Business has broadband connection, web presence, receives orders via the Internet or web and uses IT to a 'high' extent in at least 5 business activities* in 2005–06	684	10.6%
2	High	Business has broadband connection, web presence and receives orders via the Internet or web in 2005–06, but uses IT to a "high' extent in less than 5 business activities in 2005–06	564	8.8%
3	Moderate	Business has broadband connection and web presence in 2005–06, but does not receive orders via the Internet or web in 2005–06	2051	31.8%
4	Low	Business has broadband connection in 2005–06, but has no web presence in 2005–06	1405	21.8%
5	Basic	Business does not use broadband connection in 2005–06	1738	27.0%

* Business activities surveyed included Accounting, Production/service operations, Invoicing, Stock control, Marketing and Human resources.

Approximately half the businesses in the sample have, at most, a broadband Internet connection and are characterised as having low or basic ICT intensity usage. Of those businesses which do have a web presence in 2005–06, almost 40% also receive orders via the Internet or web and are classified as having either high or very high ICT intensity. We chose to distinguish the highest two categories according to whether the businesses received, rather than placed, orders via the Internet because we consider this to be a more sophisticated use of Information and communications technologies which helps to streamline production and sales activity. At the highest ICT intensity level, approximately 1 in 10 businesses in the sample have a broadband Internet connection, a web presence, receive orders via the Internet *and* in addition, use IT to a 'high' extent in most of their business activities.

The results of correlation analysis, performed between innovation activity and the ICT-intensity index, are presented in Appendix C. Note that the coefficients are negative because increasing values of the ICT-intensity index imply that the business has more basic ICT use. Using either the ICT intensity index presented above, or one of the five alternative indexes presented in Appendix G, the polychoric correlation coefficients are very similar. They imply a positive association between the intensity of ICT use and business innovation activity.

4.3.2 ICT and innovation – Regression results

Table 4.11 presents the regression estimates for all types of innovation, using the ICT intensity index. In each model, additional independent variables are included, to test the sensitivity of the ICT intensity estimates. The dependent variable in each case is binary: whether or not the business had developed any type of innovation (Product, Process, Organisational and/or Marketing) which was either implemented, ongoing or abandoned in 2006–07. The estimates for each level of ICT intensity represent the impact of the technology on the likelihood of innovation, compared to a business in the least ICT-intense category. A positive estimate implies that businesses with these characteristic are more likely to innovate, all other things being equal. As the coefficients cannot be directly interpreted in terms of probabilities, marginal effects are presented in Section 4.3.3 to illustrate the impact on the probability of innovation.

The estimates presented in table 4.11 show that ICT intensity has a positive and significant effect on the likelihood of a business engaging in some type of innovative effort. Furthermore, the estimates are robust and remain stable with the addition of other variables that affect innovative effort, including export activity, market share, foreign ownership and collaboration. The positive, significant estimates for each level of ICT intensity suggest that businesses with broadband Internet, web presence and/or e-commerce are significantly more likely to engage in innovative effort, compared to businesses with no broadband connection. The gradual increase in the size of the coefficients also supports the conclusion that the ordering of technologies for ICT intensity does reflect increasing sophistication of ICT and increasing importance for innovation. Contrast analysis revealed that the estimates remain significant when the reference case is changed, implying that each higher category of ICT intensity does represent a significant increase in the probability of being an innovator.[1]

In Appendix F, the regression results for Model V are presented using alternative dependent variables. In these models, we consider the probability of businesses undertaking a specific type of innovative activity, such as product innovation, which is implemented, ongoing or abandoned in 2006–07. The results show that ICT intensity is still a robust and significant factor in determining each type of innovation. It is interesting to note that broadband connection alone is not strongly related with product or process innovation.

1 In particular, businesses with mid ICT-intensity (level '3') are significantly more likely to innovate, compared to those with low ICT-intensity (level '4'), at the 1% level. The estimates are also significantly higher between levels '2' and '3' at the 10% level, and between levels '1' and '2' at the 5% level.

4.11 Regression results for any innovative activity in 2006–07 using ICT intensity index

	Model I	*Model II*	*Model III*	*Model IV*	*Model V*
Intercept	–0.16 ***	–0.25 ***	–0.35 ***	–0.35 ***	–0.37 ***
ICT intensity					
ICT intensity = 1 (Most intense)	0.66 ***	0.61 ***	0.60 ***	0.61 ***	0.61 ***
ICT intensity = 2	0.49 ***	0.45 ***	0.46 ***	0.46 ***	0.45 ***
ICT intensity = 3	0.37 ***	0.35 ***	0.35 ***	0.36 ***	0.35 ***
ICT intensity = 4	0.13 ***	0.13 ***	0.13 ***	0.13 ***	0.12 ***
ICT intensity = 5 (Least intense)					
Number of employees					
Non-employing business	–0.39 ***	–0.39 ***	–0.35 ***	–0.35 ***	–0.36 ***
1–4 employees	–0.31 ***	–0.30 ***	–0.28 ***	–0.28 ***	–0.28 ***
5–19 employees					
20–199 employees	0.15 ***	0.13 **	0.11 **	0.12 **	0.13 **
200+ employees	0.26 ***	0.20 ***	0.15 ***	0.20 ***	0.17 ***
Industry Division					
Agriculture, forestry and fishing	–0.18 ***	–0.12 **	–0.09	–0.09	–0.09
Mining	–0.49 ***	–0.47 ***	–0.44 ***	–0.43 ***	–0.47 ***
Manufacturing					
Electricity, water, gas and waste services	–0.21	–0.09	–0.13	–0.15	–0.21
Construction	–0.45 ***	–0.37 ***	–0.35 ***	–0.36 ***	–0.34 ***
Wholesale	–0.13 **	–0.11 *	–0.11	–0.09	–0.07
Retail trade	–0.22 ***	–0.14 *	–0.12	–0.13 *	–0.12
Accommodation and food services	–0.41 ***	–0.30 ***	–0.31 ***	–0.32 ***	–0.30 ***
Transport, postal and warehousing	–0.31 ***	–0.23 ***	–0.24 ***	–0.25 ***	–0.24 ***
Information, media and telecommunications	–0.08	–0.01	–0.02	0.00	0.00
Financial and insurance services	0.08	0.16	0.22 *	0.22 *	0.23 **
Rental, hiring and real estate services	–0.37 ***	–0.27 **	–0.29 **	–0.29 **	–0.29 **
Professional, scientific and technical services	–0.20 ***	–0.18 **	–0.15 *	–0.15 *	–0.15 *
Administrative and support services	–0.35 ***	–0.25 ***	–0.23 ***	–0.24 ***	–0.22 ***
Health care and social assistance	–0.21 ***	–0.07	–0.05	–0.10	–0.10
Arts and recreation services	–0.17 *	–0.09	–0.09	–0.11	–0.10
Other services	–0.19 **	–0.12	–0.11	–0.12	–0.10
Age of business					
Less than one year old	0.50 ***	0.51 ***	0.51 ***	0.51 ***	0.52 ***
1–4 years old	0.07	0.07 *	0.07	0.08 *	0.08 **
5–9 years old	0.11 ***	0.11 ***	0.11 ***	0.11 ***	0.11 ***
10+ years old					
Export activity					
Non-exporter in 2006–07					
Exporter in 2006–07	..	0.27 ***	0.26 ***	0.30 ***	0.27 ***
Market structure					
Market share < 10% in 2006–07					
Market share 10–50% in 2006–07	..	..	0.21 ***	0.22 ***	0.22 ***
Market share > 50% in 2006–07	..	..	0.23 ***	0.24 ***	0.24 ***
Foreign ownership					
Foreign ownership 0%–50% in 2006–07					
Foreign ownership >50% in 2006–07	..	..	..	–0.23 ***	–0.22 ***
R&D agreement					
No joint R&D (co–operative) agreement in 2006–07					
Joint R&D (co–operative) agreement in 2006–07	..	..	..	..	0.47 ***

*** = significant at the 0.01 level; ** = significant at the 0.05 level; * = significant at the 0.10 level
.. not included in the model

Consistent with *a priori* expectations, business size, as proxied by the number of employees in a business, is also highly significant in predicting whether or not the business will engage in some type of innovative activity. The results show that, controlling for other factors, medium- and large-sized businesses are significantly more likely to innovate than those which are non-employing or have fewer than five employees. This is true also when considering specific types of innovation (see Appendix F). Interestingly, in regards to goods and/or services innovation, there is no significant difference in innovative effort between medium (5–19 employees) and large sized businesses (20–199 or 200+ employees).

The Industry within which the business operates also has an important association with business' innovative effort. Manufacturing businesses are the most likely to undertake innovation, particularly product and process innovations, compared to businesses in other industries when holding all other things equal. Some interesting results emerge when analysing individual types of innovation. For example:

- Mining and Construction businesses are significantly less likely to undertake innovation of all types, compared to manufacturing businesses.
- Retail businesses are significantly less likely to engage in product and process innovation, compared to manufacturing businesses, but there is no significant difference for other types of innovation.
- Wholesale businesses are significantly less likely to engage in process innovations, compared to manufacturing businesses, but there is no significant difference for other types of innovation.
- Financial and insurance services businesses are highly innovative and are significantly more likely to undertake product, process and marketing innovation, compared with a manufacturing business.

Other variables of interest which are included in the model are the business export activity, market share, foreign ownership and whether or not the business had a co-operative agreement for joint research and development. All of these variables are taken from the 2006–07 data and these estimates comply with a priori expectations. For example, exporting businesses and those with a greater degree of market power or a joint R&D co-operative agreement are significantly more likely to innovate.

The estimates for the effect of foreign ownership are worthy of particular note. According to the results, businesses which are majority foreign owned are significantly less likely to engage in innovative effort. This implies that their innovations may occur off-shore, with local franchises merely adopting the innovation(s) and therefore, these do not qualify as innovations in Australia. This is consistent with the findings of Rogers for Australian manufacturing firms (2004, p. 147).

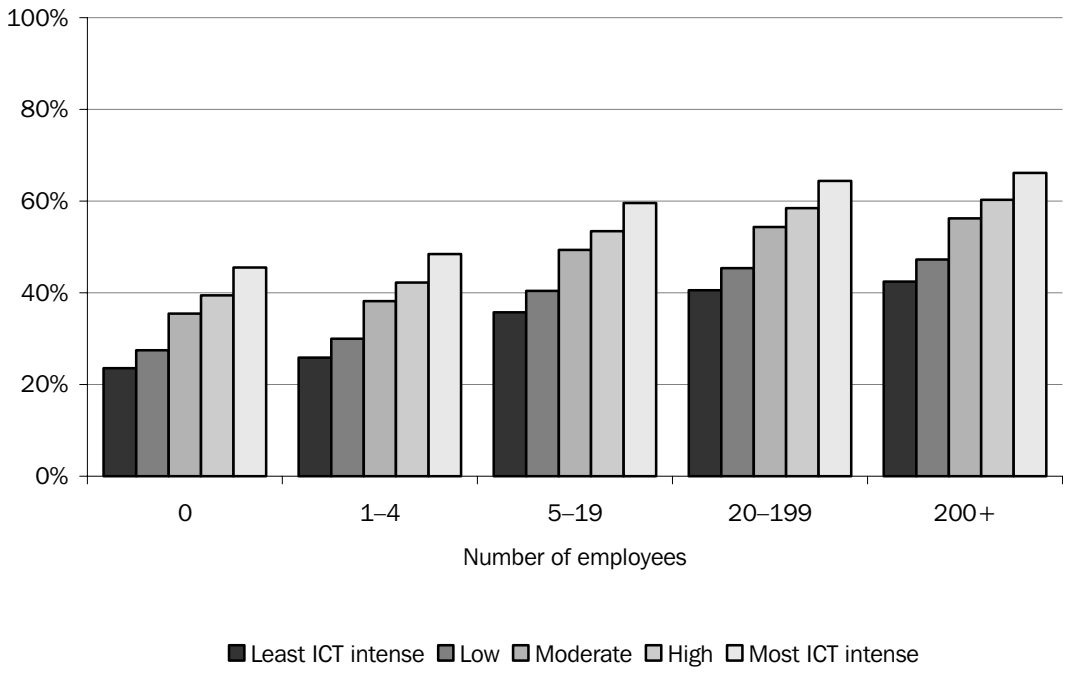
Overall, the results relating to ICT usage and other included variables, which have been discussed in the context of the most general innovation variable ('anyinnact07'), are reinforced by analysing the individual types of innovation and restricting the analysis to implemented innovations only. Those results are presented in Appendix F.

4.3.3 Marginal effects

The estimates produced by the probit model do not translate automatically into probability estimates. Therefore, in order to calculate the effect of ICT intensity and other variables on the probability of engaging in innovative activity, we must calculate marginal effects. For more detail, see Appendix D.

The figures below present the estimated probability that a business will engage in some type of innovative activity, which is implemented, ongoing or abandoned in 2006–07. The estimated probabilities in figure 4.12 are based on a hypothetical Manufacturing business which is at least ten years old, a non-exporter with less than 10% market share and no foreign ownership nor R&D co-operative agreement in 2006–07.

4.12 Estimated probability of engaging in innovative activity in 2006–07

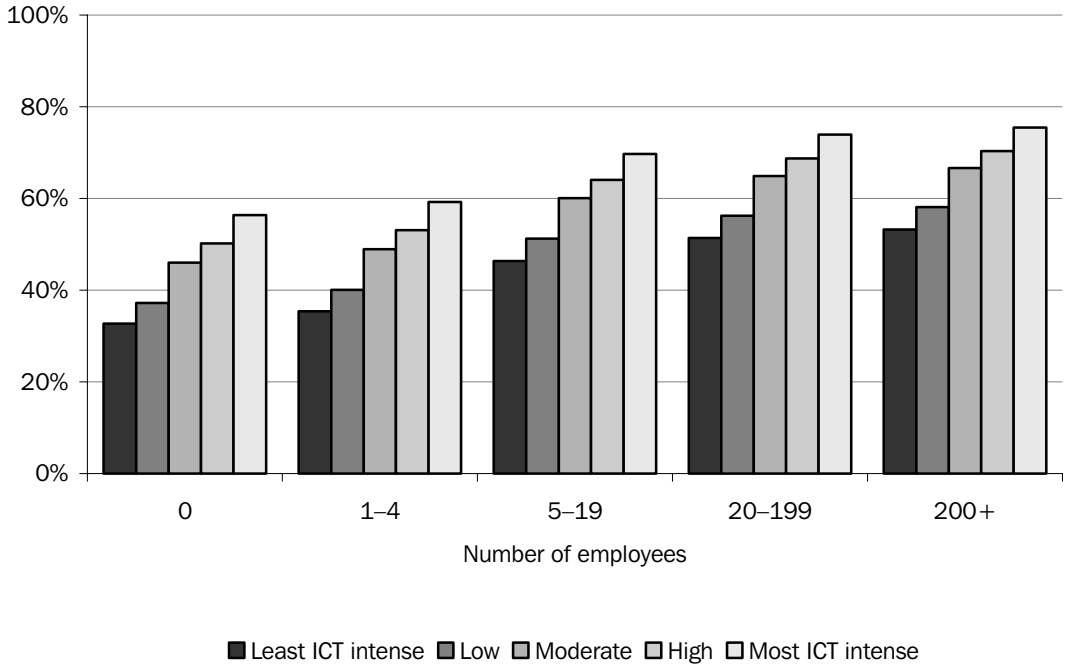


According to figure 4.12 a hypothetical business which has only a broadband connection and no other ICT features (ICT intensity = Low), is approximately four percentage points more likely to be an innovator in 2006–07 compared with the least ICT intense businesses, all other things being equal. However, comparing Low and Moderate ICT-intense businesses, figure 4.12 shows that having a web presence makes a business approximately eight to nine percentage points more likely to innovate. In cumulative terms, this means that businesses with broadband and web presence alone are 12–14 percentage points more likely to innovate, compared to the Least ICT intense businesses. Therefore, having a web presence substantially increases the probability of engaging in innovative activity, all other things being equal. Finally, comparing Moderate ICT-intense businesses to those in the highest two categories, shows that engaging in e-commerce and using ICT across most business activities makes businesses a further 10 percentage points more likely to innovate.

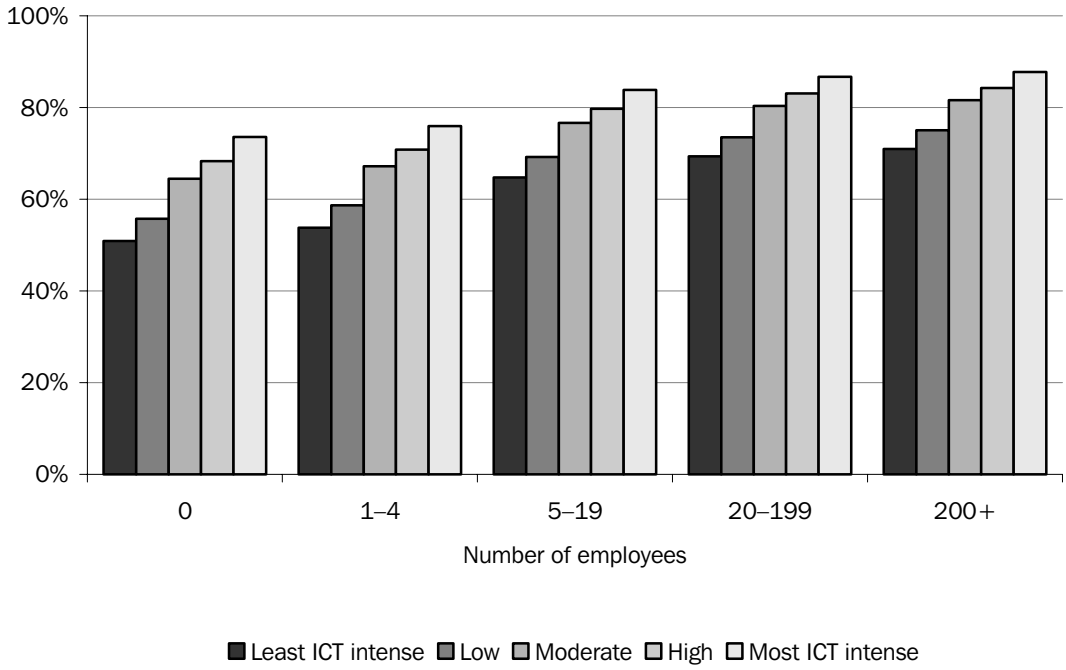
Regarding the effect of business size on innovation activity, figure 4.12 shows that the largest gains are for businesses that have 5–19 employees, compared to those with 1–4 employees. Across all levels of ICT intensity, businesses which have 5–19 employees are 10–11 percentage points more likely to innovate, compared to those with only 1–4 employees. Large businesses, particularly those with 200 or more employees, remain the most likely to innovate, which is consistent with Schumpeter's theories, discussed previously in Section 2.3.

Figures 4.13 and 4.14 demonstrate the impact of export activity and cooperative R&D agreements on the likelihood of innovation. Across all levels of business size and ICT intensity, those businesses which engage in export activity are approximately 10 percentage points more likely to innovate. In addition, businesses which report having a co-operative agreement for joint R&D are a further 17 percentage points more likely to innovate.

4.13 Estimated probability of engaging in innovative activity in 2006–07, exporting business



4.14 Estimated probability of engaging in innovative activity in 2006–07, exporting business with co-operative R&D agreement



4.3.4 Sensitivity analysis

We have constructed and analysed five alternative ICT intensity indexes, in order to test the sensitivity of the estimates. These alternative ICT intensity indexes are described in Appendix G, along with regression results.

The alternative ICT intensity indexes define the lowest levels of ICT intensity in a similar manner, but are differentiated in the way they define the 'most intense' categories. In particular, at the higher intensity levels, they each focus on a different aspect of ICT use which appears on the Business Characteristics Survey. These include:

- the features available on the business' web presence, in particular whether the business had on-line ordering or any automated links with back-end systems;
- the method for receiving orders via the Internet or web;
- whether the business' system for receiving orders via the Internet or web is automatically linked with internal and/or external systems; and
- the proportion of sales income derived from sales over the Internet

The estimates for each of the five alternative ICT intensity variables are very similar, implying that the results are robust. The estimated coefficients were slightly larger when focussed on businesses with automated external system links or sophisticated website features.

In order to test the sensitivity of the results when using ICT usage in 2005–06 and ICT usage in 2006–07, a regression analysis was also done based on an ICT intensity index which is comparable in both years. As only a core set of ICT questions were surveyed in 2006–07, the top category of the ICT intensity index is now differentiated according to whether or not the business *received* orders via the Internet or web in the relevant year. A description of the ICT intensity index which we used is presented in Appendix H, along with the regression results.

Comparing the intensity of business' ICT usage in 2005–06, we can see that many businesses became more ICT intense users over the two years. One in three businesses which did not have broadband Internet in 2005–06, took up a broadband connection in 2006–07, and many of these also introduced a web presence. However, there was less mobility between the low and moderate categories, implying that it is more difficult and/or less appealing for businesses to implement a web presence as compared with the take-up of broadband Internet. There was a particularly high degree of mobility among the three most ICT-intense categories, showing that once businesses have broadband Internet and a web presence, it is relatively easy to engage in e-commerce. The regression results illustrate that ICT intensity is again very important in predicting business innovation. Interestingly, the estimates based on ICT

usage in 2006–07 give stronger results, implying that current year's ICT usage is more indicative of innovative activity than previous years' ICT usage. It is important to note that the estimates for all other variables, such as export status, market share, degree of foreign ownership and R&D cooperative agreements remain unchanged when using the ICT intensity index in 2005–06 or 2006–07. Therefore, they also represent robust estimates of the effect of these variables on innovation activity.

4.3.5 ICT and innovation novelty

Another aim of this research is to determine the effect of ICT intensity on the sophistication of business' innovative activity. This involved estimating ordered probit models, where the dependent variable was an ordered, categorical ranking of innovators according to the degree of novelty of their innovation.

This paper presents the results for three ordered dependent variables. For detailed descriptions of each of the variables, see Appendix A. Firstly, businesses were ordered according to the 'uniqueness' of their innovation (anynovel07), with innovations that were new to the world considered the most novel, and innovations that were at best new to the business, ranked the least novel. Secondly, businesses were ordered according to who developed the innovation (anydevelop07), with businesses who developed their innovations internally considered to be more novel innovators compared against those whose innovations were developed completely externally. Finally, businesses were ordered according to the number of types of innovation in which they engaged, regardless of the stage of completion (mult_inn07). Businesses which engaged in all four types of innovation (Product, Process, Organisational and Marketing) were considered more novel than businesses which engaged in fewer types of innovation.

The frequency tables and results of the regression analysis are presented in Appendix I. The results show, once again, that ICT intensity is strongly linked with the degree of innovation novelty. Businesses which have sophisticated ICT usage, in that they have broadband Internet, a web presence and engage in e-commerce, are not only more likely to innovate, but are also likely to produce more novel innovations. In particular, ICT-intensity is significantly, positively related with innovations which are new to Australia or the world, as opposed to innovations which are only new to the business. Other things being equal, businesses which are more ICT intense are also more likely to develop their innovations internally or in co-operation with other businesses, rather than have them developed externally and are likely to engage in multiple types of innovation. These results reinforce the importance of ICT usage for strong business innovation in Australia.

5. CONCLUSION

The novel aspect of this research is the use of an ICT intensity index, which lessens the problem of multicollinearity caused by the close relationship between the many ICT variables. This ordered, categorical variable represents the levels of sophistication in the business' ICT usage.

Based on the cross-tabulation and regression analysis, we find a strong relationship between ICT intensity and business' innovative activity. Those businesses which use sophisticated types of ICT are significantly more likely to undertake innovation, when considering either any type of innovation, or a specific type of innovation. In addition, more intense ICT users are likely to undertake more types of innovation, more novel innovations and are more likely to develop the innovations internally. The effect of ICT on innovation holds when controlling for a range of other business characteristics, such as employment size and industry division.

The results showed that businesses (with or without broadband connection) who do not report having a web presence are 10 to 16 percentage points less likely to undertake some type of innovation, other things being equal. Those businesses which receive orders via the Internet are approximately five percentage points more likely to innovate compared to similar businesses who also have broadband Internet and a web presence. The ICT variables which were found to be most strongly related with innovative activity including having a web presence, receiving orders via the Internet particularly when these were received via on-line ordering or shopping cart and most importantly, having automated links between the business website or system for receiving Internet orders and customer and/or supplier systems. Other variables which were found to be significant included business' employment size, market share, whether or not the business exported and whether or not they had a cooperative agreement for joint R&D.

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APPENDIXES

A. VARIABLE LIST

A.1 Innovation variables

Variable name	*Description*	*Values*	*Sample*
anyinnact07	Any type of innovation activity (Product, Process, Organisational/Managerial or Marketing) which was implemented, ongoing or abandoned in 2006–07	(1,0)	All businesses
gsinnact07	Product (Good and/or Service) innovation which was implemented, ongoing or abandoned in 2006–07	(1,0)	
opinnact07	Operational Process innovation which was implemented, ongoing or abandoned in 2006–07	(1,0)	
ominnact07	Organisational or Managerial innovation which was implemented, ongoing or abandoned in 2006–07	(1,0)	
mainnact07	Marketing innovation which was implemented, ongoing or abandoned in 2006–07	(1,0)	
anyinn07	Any type of innovation (Product, Process, Organisational/Managerial or Marketing) which was *implemented* in 2006–07	(1,0)	
gsinn07	Product (Good and/or Service) innovation which was *implemented* in 2006–07	(1,0)	
opinn07	Operational Process innovation which was *implemented* in 2006–07	(1,0)	
ominn07	Organisational/Managerial innovation which was *implemented* in 2006–07	(1,0)	
mainn07	Marketing innovation which was *implemented* in 2006–07	(1,0)	
anynovel07	Any type of innovation (Product, Process, Organisational/Managerial or Marketing) which was *implemented* in 2006–07, classified by the highest degree of novelty of any type of innovation	0 = No implemented innovation 1 = Innovation was new to the business only 2 = Innovation was new to the industry only 3 = Innovation was new to Australia; 4 = Innovation was new to the world 5 = Business implemented innovation, but missing information on degree of novelty	Businesses which reported *implementing* an innovation

A.1 Innovation variables (continued)

Variable name	*Description*	*Values*	*Sample*
anydevelop07	Any type of innovation (Product, Process, Organisational/Managerial or Marketing) which was implemented in 2006–07, classified by who developed the innovation	0 = No implemented innovation 1 = Innovation was developed exclusively by other business(es) or institution(s) 2 = Innovation was developed by this business, in co-operation with other business(es) or institution(s) 3 = Innovation was developed by this business or a related company only 4= Business implemented innovation but missing information on 'who developed' the innovation	Businesses which reported *implementing* an innovation

A.2 Information and communications technology (ICT) variables

Variable name	*Description*	*Values*	*Sample*
comptr	Business used a computer in 2005–06	(1,0)	All businesses
itsup	Type of IT support used by the business in 2005–06	1 = Internal IT support 2 = External IT support 3 = No IT support	Businesses which have a computer
majorituse	Number of business activities in which IT was used to a 'high' extent in 2005–06. The six business activities surveyed are Accounting, Production/service operations, Invoicing, Stock control, Marketing and Human resources.	1–6	
itsecurity	Number of types of IT security measures used in 2005–06, including physical security, authentication software or hardware, virus checking or protective software, firewall, spam filter and off-site data back up and storage	1–6	
itbreach	Business experienced any IT security incident or breach in 2005–06. *Note*: data is also available on the results of IT security breaches, including corruption of hardware/software, loss of data, downtime of service, web site defacement, theft or loss of hardware, theft of confidential information, loss of income and staff productivity. Also, data available on the actions taken as a result of IT security breaches.	(1,0)	
intercon06 intercon07	Type of Internet connection in 2005–06 and 2006–07, respectively.	0 = No Internet 1 = Dial-up connection 2 = broadband connection	All businesses
broadcon06 broadcon07	Type of broadband connection in 2005–06 and 2006–07, respectively.	1 = DSL 2 = Cable 3 = Fixed wireless Internet access via point-to-point microwave, etc 4=Mobile Wireless Internet Access via WiFi, IEEE, 802.11x, 3G 5 = Satellite 6 = Other	Businesses with broadband

A.2 Information and communications technology (ICT) variables (continued)

Variable name	*Description*	*Values*	*Sample*
	Reasons why business did not use broadband connection in 2005–06:	(1,0) for each reason	Businesses with no broadband connection
nobrouna	Unavailable in business location		
nobrosta	Start-up connection costs too high		
nobroonc	Ongoing connection and usage costs too high		
nobrohar	Business' hardware incompatible		
nobrolac	Lack of perceived benefits		
nobrooth	Other		
nobronot	Not considered		
webpres06	Business has a web presence	(1,0)	Businesses which have an Internet connection
	Business' web presence features in 2005–06:	(1,0) for each feature	Businesses which have a web presence
webprinf	Information about business		
webprcon	Inquiry or contact facility		
webpronl	On-line ordering feature		
webprsho	Shopping cart facility		
webprolp	On-line payment facility		
webpracc	Capability for secure access or transactions		
webpracd	Account information		
webprord	Facility to track orders		
webprper	Personalised page for repeat customers		
webprbac	Automated link with back-end systems		
plorder06	Business places orders via the Internet or web in 2005–06	(1,0)	All businesses with Internet connection.
record06	Business receives orders via the Internet or web in 2005–06	(1,0)	All businesses with Internet connection.
	How business receives orders via the Internet or web in 2005–06:	(1,0) for each method	Businesses which receive orders via the Internet or web
recorema	Email not linked to web site		
recorweb	Web site with linked email		
recoronl	Web site with online order form		
recorsho	Web site with shopping cart		
recoroth	Other		
incordin	Estimated percentage of sales income which resulted from orders received via the Internet or web for goods and/or services in 2005–06	Proportion (0 – 1)	Businesses which receive orders via the Internet or web

A.2 Information and communications technology (ICT) variables (continued)

Variable name	*Description*	*Values*	*Sample*
extsystlinks	Business system for receiving orders via Internet or web has automatic links with customer's and/or supplier's business systems in 2005–06	(1,0)	Businesses which receive orders via the Internet or web
intsystlinks	Business system for receiving orders via Internet or web has automatic links with at least one internal business system in 2005–06. (Internal business systems include reordering replacement supplies, invoicing and payment, production or service operations, logistics and marketing operations.) *Note*: we could limit this variable to only a subset of the internal business systems.	(1,0)	Businesses which receive orders via the Internet or web
	Reasons business did not receive orders via the Internet or web in 2005–06	(1,0) for each reason	Businesses with Internet connection who did not receive orders via the Internet or web
intnogoo	Goods or services produced by the business unsuitable		
intnocus	Lack of customer demand		
intnosec	Security concerns		
intnotec	Costs to develop and maintain the technology too high		
intnolac	Lack of skilled employees to develop, maintain and use technology		
intnotim	Timing		
intnocur	Prefer to maintain current business model		
intnooth	Other		
	Purpose of Internet or web use in 2005–06	(1,0) for each purpose	Businesses with web presence
useintfi	Financial		
useintho	Enabling persons working for business to work from home (or other location)		
useintas	Information gathering or researching for – Assessing or modifying range of products, services, processes or methods		
useintde	Information gathering or researching for – Development of new or improved products, services, processes or methods		
useintmo	Information gathering or researching for – Monitoring competitors		
useintma	Information gathering or researching for – Identifying future market trends		
useintol	Online training / learning		
useintcu	Information sharing or data exchange with – customers or clients		
useintbu	Information sharing or data exchange with – Businesses or organisations		
elodge	Business electronically lodges documents with Government organisations via Internet or web in 2005–06, including Taxation forms, claims for grants and benefits, applications for licences and permits or payments.	(1,0)	Businesses with Internet connection

A.3 Other business demographic variables

Variable name	*Description*	*Values*
export07	Business received any income from exporting in 2006–07	(1,0)
market_share07	Degree of market share in 2006–07	0 = 0–9% market share 1 = 10–50% market share 2 = 51%+ market share
competitors07	Number of competitors in 2006–07	0 = Captive market/No effective competition 1 = One or two competitors 2 = Three or more competitors
forown07	Degree of foreign ownership in 2006–07	0 = 51%+ foreign owned 1 = 10–50% foreign owned 2 = 1–9% foreign owned 3 = No foreign ownership
coopjres	Business had a co-operative arrangement for Joint research and development in 2006–07	(1,0)

B. SAMPLE DISTRIBUTIONS

B.1 Employment size

Employment size	*Frequency*	*Cumulative frequency*	*Percent*
Non-employing	530	530	8.2%
1–4 employees	1662	2192	25.8%
5–19 employees	1204	3396	18.7%
20–199 employees	1020	4416	15.8%
200+ employees	2026	6442	31.5%

B.2 Industry Division

Industry Division (ANZSIC 2006)	*Frequency*	*Cumulative frequency*	*Percent*
Agriculture, forestry and fishing	942	942	14.6%
Mining	231	1173	3.6%
Manufacturing	1152	2325	17.9%
Electricity, water, gas and waste services	79	2404	1.2%
Construction	375	2779	5.8%
Wholesale	577	3356	9.0%
Retail Trade	373	3729	5.8%
Accommodation and food services	396	4125	6.2%
Transport, postal and warehousing	435	4560	6.8%
Information, media and telecommunications	172	4732	2.7%
Financial and insurance services	163	4895	2.5%
Rental, hiring and real estate services	135	5030	2.1%
Professional, scientific and technical services	318	5348	4.9%
Administrative and support services	321	5669	5.0%
Health care and social assistance	299	5968	4.6%
Arts and recreation services	186	6154	2.9%
Other services	288	6442	4.5%

B.3 Proportion of businesses innovating

	2005–06		*2006–07*	
Type of innovation	*Number*	*Percentage*	*Number*	*Percentage*
Implemented innovations				
Any type	3416	53.0%	2746	42.6%
Goods and services	1649	25.6%	1382	21.5%
Operational process	2192	34.0%	1680	26.1%
Organisational / Managerial	2052	31.9%	1535	23.8%
Marketing	1347	21.0%	999	15.5%
Implemented, ongoing or abandoned innovations				
Any type	3649	56.7%	3071	47.7%
Goods and services	1907	29.6%	1689	26.2%
Operational process	2431	37.7%	1968	30.6%
Organisational / Managerial	2199	34.1%	1704	26.5%
Marketing	1544	24.0%	1247	19.4%

C. CORRELATION ANALYSES

C.1 Correlation analysis for individual ICT variables (2005–06) and implemented, ongoing or abandoned innovation (2006–07)

	Any type (anyinnact07)	*Product (gsinnact07)*	*Process (opinnact07)*	*Organisation (ominnact07)*	*Marketing (mainnact07)*
Computer use (comptr)	0.45	0.36	0.41	0.44	0.36
IT support (itsup)	–0.39	–0.32	–0.36	–0.41	–0.26
Type of Internet connection (intercon06)	0.36	0.31	0.33	0.37	0.25
Web presence (webpres06)	0.45	0.37	0.40	0.43	0.34
Web presence has on-line ordering feature (webpronl)	0.29	0.25	0.28	0.25	0.30
Web presence has automated back-end system links (webprbac)	0.28	0.24	0.28	0.24	0.19
Places orders via the Internet (plorder06)	0.33	0.27	0.32	0.29	0.25
Receives orders via the Internet (record06)	0.29	0.27	0.28	0.18	0.32
Number of business activities for which IT used to a 'major' extent (majorituse)	0.40	0.32	0.39	0.38	0.29

C.2 Correlation analysis for individual ICT variables (2005–06) and implemented (only) innovation (2006–07)

	Any type (anyinnact07)	*Product (gsinnact07)*	*Process (opinnact07)*	*Organisation (ominnact07)*	*Marketing (mainnact07)*
Computer use (comptr)	0.43	0.33	0.41	0.42	0.39
IT support (itsup)	–0.38	–0.29	–0.35	–0.40	–0.29
Type of Internet connection (intercon06)	0.37	0.30	0.33	0.36	0.30
Web presence (webpres06)	0.43	0.35	0.38	0.43	0.41
Web presence has on-line ordering feature (webpronl)	0.29	0.23	0.26	0.24	0.34
Web presence has automated back-end system links (webprbac)	0.26	0.21	0.25	0.24	0.22
Places orders via the Internet (plorder06)	0.32	0.25	0.31	0.28	0.28
Receives orders via the Internet (record06)	0.29	0.26	0.27	0.16	0.34
Number of business activities for which IT used to a 'major' extent (majorituse)	0.40	0.31	0.38	0.38	0.31

C.3 Correlation analysis for alternative ICT intensity indexes (2005–06) and implemented, ongoing or abandoned innovation (2006–07)

	Any type (anyinnact07)	*Product (gsinnact07)*	*Process (opinnact07)*	*Organisation (ominnact07)*	*Marketing (mainnact07)*
ICT intensity – Index I	–0.37	–0.32	–0.34	–0.34	–0.30
ICT intensity – Index II	–0.37	–0.31	–0.34	–0.36	–0.28
ICT intensity – Index III	–0.37	–0.32	–0.34	–0.34	–0.30
ICT intensity – Index IV	–0.37	–0.32	–0.34	–0.34	–0.29
ICT intensity – Index V	–0.36	–0.32	–0.34	–0.34	–0.29
ICT intensity – Index VI	–0.36	–0.31	–0.33	–0.33	–0.29

C.4 Correlation analysis for alternative ICT intensity indexes (2005–06) and implemented (only) innovation (2006–07)

	Any type (anyinnact07)	*Product (gsinnact07)*	*Process (opinnact07)*	*Organisation (ominnact07)*	*Marketing (mainnact07)*
ICT intensity – Index I	–0.37	–0.31	–0.34	–0.34	–0.35
ICT intensity – Index II	–0.37	–0.30	–0.33	–0.35	–0.33
ICT intensity – Index III	–0.37	–0.30	–0.33	–0.33	–0.35
ICT intensity – Index IV	–0.37	–0.31	–0.34	–0.33	–0.34
ICT intensity – Index V	–0.37	–0.30	–0.33	–0.33	–0.34
ICT intensity – Index VI	–0.36	–0.30	–0.33	–0.32	–0.34

Note: The polychoric correlation coefficient measures the degree of association between two ordered, categorical variables based on the assumption that both have an underlying bivariate normal distribution. Where both variables are binary, the polychoric correlation is also known as the tetrachoric correlation. The polychoric (or tetrachoric) coefficient ranges from –1 to 1 where larger positive values imply stronger positive correlation between the variables and larger negative values imply stronger negative correlation.

D. LIMITED DEPENDENT VARIABLE MODELS

The binary probit model is explained here using profit maximisation, similar to that developed by McFadden (1973).

One may assume that a business' decision to undertake innovation is dependent on its *unobservable preference* for higher profits, more varied and higher quality products or more streamlined managerial and logistic processes. This is not an exhaustive list, but highlights that there are many objectives of a business, the preferences for which are largely unobserved.

This underlying and unobservable preference for innovation can be represented by the index variable I_i:

$$I_i = \alpha + \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i$$

where X_{ki} is a vector of K explanatory variables which affect the business' preference for innovation and ε_i is the random error term.

In practice, the business' preference for innovation, represented by I_i is unobserved. What we observe is the binary outcome: either the business does (*Innovation* = 1) or does not (*Innovation* = 0) undertake the innovation depending on whether their preference exceeds some defined threshold value:

$$Innovation = \begin{cases} 1 & \text{if } I_i > 0 \\ 0 & \text{if } I_i \leq 0 \end{cases}$$

The conditional probability of observing a successful outcome, that is the business chooses to innovate, is given by the probability that the latent variable exceeds the threshold value of zero:

$$\begin{aligned} P\left(Innovation_i = 1 \middle| X_{ki}\right) &= P\left[I_i > 0\right] \\ &= P\left[\alpha + \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i > 0\right] \\ &= P\left[\varepsilon_i > -\left(\alpha + \sum_{k=1}^{K} \beta_k X_{ki}\right)\right] \\ &= P\left[\varepsilon_i \leq \alpha + \sum_{k=1}^{K} \beta_k X_{ki}\right] \end{aligned}$$

The probability that the business undertakes the innovation is now equal to the probability that the error term is less than the latent index.

The probit model assumes that the error term is normally distributed and therefore, the estimated probability comes from evaluating the area under the standard normal probability density function to the left of the index variable.

$$P\left(Innovation_i = 1 \middle| X_{ki}\right) = P\left[\varepsilon_i \leq \alpha + \sum_{k=1}^{K} \beta_k X_{ki}\right]$$
$$= \Phi\left(\alpha + \sum_{k=1}^{K} \beta_k X_{ki}\right)$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function.

E. REGRESSION RESULTS USING ICT VARIABLES INDIVIDUALLY

E.1 Regression results – Any innovative activity in 2006–07, using separate ICT variables

	Model I	*Model II*	*Model III*	*Model IV*	*Model V*
Intercept	–0.35 ***	–0.41 ***	–0.43 ***	–0.53 ***	–0.58 ***
Number of employees					
Non-employing business	–0.33 ***	–0.30 ***	–0.30 ***	–0.25 ***	–0.22 ***
1–4 employees	–0.31 ***	–0.28 ***	–0.27 ***	–0.24 ***	–0.21 ***
5–19 employees					
20–199 employees	0.21 ***	0.13 **	0.13 **	0.11 *	0.08
200+ employees	0.41 ***	0.24 ***	0.25 ***	0.22 ***	0.16 ***
Industry Division					
Agriculture, forestry and fishing	–0.23 ***	–0.15 **	–0.13 **	0.11 *	–0.09
Mining	–0.53 ***	–0.52 ***	–0.48 ***	0.47 ***	–0.47 ***
Manufacturing					
Electricity, water, gas and waste services	–0.25 *	–0.25 *	–0.22	0.22	–0.20
Construction	–0.50 ***	–0.46 ***	–0.43 ***	0.43 ***	–0.41 ***
Wholesale	–0.12 *	–0.11 *	–0.13 **	0.13 **	–0.15 **
Retail trade	–0.22 ***	–0.21 ***	–0.20 ***	0.20 ***	–0.21 ***
Accommodation and food services	–0.39 ***	–0.37 ***	–0.36 ***	0.34 ***	–0.33 ***
Transport, postal and warehousing	–0.31 ***	–0.28 ***	–0.28 ***	0.28 ***	–0.28 ***
Information, media and telecommunications	–0.04	–0.08	–0.13	0.14	–0.14
Financial and insurance services	0.07	0.05	0.07	0.06	0.06
Rental, hiring and real estate services	–0.35 ***	–0.37 ***	–0.38 ***	0.39 ***	–0.40 ***
Professional, scientific and technical services	–0.20 ***	–0.23 ***	–0.23 ***	0.24 ***	–0.24 ***
Administrative and support services	–0.37 ***	–0.34 ***	–0.34 ***	0.33 ***	–0.31 ***
Health care and social assistance	–0.27 ***	–0.26 ***	–0.20 **	0.20 **	–0.16 *
Arts and recreation services	–0.14	–0.18 *	–0.18 *	0.17 *	–0.16
Other services	–0.18 **	–0.16 *	–0.15 *	0.14	–0.12
Age of business					
Less than one year old	0.50 ***	0.47 ***	0.49 ***	0.49 ***	0.48 ***
1–4 years old	0.07	0.07	0.08 *	0.08 *	0.07 *
5–9 years old	0.10 **	0.10 **	0.11 ***	0.12 ***	0.12 ***
10+ years old					
Internet					
Dial-up Internet	0.38 ***	0.29 ***	0.21 ***	0.09	0.04
Broadband Internet	0.48 ***	0.34 ***	0.23 ***	0.11	0.03
No Internet					
Web presence					
Business has a web presence	..	0.37 ***	0.29 ***	0.27 ***	0.23 ***
Business does not have a web presence					
Business places orders via the Internet					
Business places orders via the Internet	..	..	0.17 ***	0.16 ***	0.13 ***
Business does not place orders via the Internet					
Business receives orders via the Internet					
Business receives orders via the Internet	..	..	0.22 ***	0.22 ***	0.20 ***
Business does not receive orders via the Internet					
IT support					
Business has internal IT support	..	..	..	0.28 ***	0.19 ***
Business has external IT support	..	..	..	0.24 ***	0.16 ***
Business has no IT support or no computer					
IT use in business activities					
IT used to a 'major' extent in 1–3 business activities	..	..	..	..	0.16 ***
IT used to a 'major' extent in 4–6 business activities	..	..	..	..	0.37 ***
IT not used to a 'major' extent in any business activities					

*** = significant at the 0.01 level; ** = significant at the 0.05 level; * = significant at the 0.10 level
.. not included in the model

F. REGRESSION RESULTS WITH ALTERNATIVE DEPENDENT VARIABLES

F.1 Regression results – Individual types of innovative activity in 2006–07 (implemented, ongoing or abandoned)

	Product		*Process*		*Organisation*		*Marketing*	
Intercept	–0.84	***	–0.71	***	–1.09	***	–0.99	***
ICT intensity								
ICT intensity = 1 (Most intense)	0.53	***	0.50	***	0.44	***	0.70	***
ICT intensity = 2	0.39	***	0.37	***	0.31	***	0.41	***
ICT intensity = 3	0.29	***	0.16	***	0.35	***	0.25	***
ICT intensity = 4	0.09	***	0.10	*	0.15	***	0.04	
ICT intensity = 5 (Least intense)								
Number of employees								
Non-employing business	–0.20	**	–0.31	***	–0.55	***	–0.38	***
1–4 employees	–0.14	***	–0.32	***	–0.43	***	–0.23	***
5–19 employees								
20–199 employees	0.06		0.22	***	0.18	***	–0.04	
200+ employees	–0.02		0.40	***	0.31	***	–0.11	**
Industry Division								
Agriculture, forestry and fishing	–0.42	***	–0.09		0.19	***	–0.07	
Mining	–0.74	***	–0.40	***	–0.30	***	–0.71	***
Manufacturing								
Electricity, water, gas and waste services	–0.79	***	–0.20		–0.09		–0.49	**
Construction	–0.42	***	–0.43	***	0.02		–0.34	***
Wholesale	–0.06		–0.24	***	0.04		0.05	
Retail trade	–0.20	**	–0.35	***	–0.04		0.10	
Accommodation and food services	–0.32	***	–0.43	***	–0.13		0.11	
Transport, postal and warehousing	–0.40	***	–0.19	**	0.02		–0.27	***
Information, media and telecommunications	0.11		–0.12		0.04		0.20	*
Financial and insurance services	0.31	***	0.13		0.47	***	0.42	***
Rental, hiring and real estate services	–0.39	***	–0.50	***	0.00		–0.13	
Professional, scientific and technical services	–0.27	***	–0.17	**	0.08		–0.18	*
Administrative and support services	–0.24	***	–0.36	***	0.06		–0.05	
Health care and social assistance	–0.14		–0.27	***	0.18	**	–0.17	*
Arts and recreation services	–0.22	**	–0.19	*	0.26	**	0.32	***
Other services	–0.14		–0.32	***	0.12		0.05	
Age of business								
Less than one year old	0.17		0.08		0.61	***	0.32	
1–4 years old	0.10	**	0.06		0.08	*	0.04	
5–9 years old	0.11	**	0.01		0.05		–0.01	
10+ years old								
Export activity								
Non-exporter in 2006–07								
Exporter in 2006–07	0.32	***	0.21	***	0.17	***	0.17	
Market structure								
Market share < 10% in 2006–07								
Market share 10–50% in 2006–07	0.21	***	0.19	***	0.11	***	0.07	
Market share > 50% in 2006–07	0.19	***	0.21	***	0.14	***	–0.09	
Foreign ownership								
Foreign ownership 0%–50% in 2006–07								
Foreign ownership >50% in 2006–07	–0.15	***	–0.26	***	–0.07		–0.14	
R&D agreement								
No joint R&D (co–operative) agreement in 2006–07								
Joint R&D (co–operative) agreement in 2006–07	0.41	***	0.28	***	0.34	***	0.10	

*** = significant at the 0.01 level; ** = significant at the 0.05 level; * = significant at the 0.10 level

F.2 Regression results – Individual types of innovative activity implemented in 2006–07

	Any type	*Product*	*Process*	*Organisation*	*Marketing*
Intercept	–0.49 ***	–0.97 ***	–0.83 ***	–1.15 ***	–1.12 ***
ICT intensity					
ICT intensity = 1 (Most intense)	0.66 ***	0.50 ***	0.56 ***	0.44 ***	0.76 ***
ICT intensity = 2	0.45 ***	0.36 ***	0.36 ***	0.25 ***	0.48 ***
ICT intensity = 3	0.36 ***	0.26 ***	0.23 ***	0.36 ***	0.28 ***
ICT intensity = 4	0.18 ***	0.10 *	0.14 ***	0.12 **	0.03
ICT intensity = 5 (Least intense)					
Number of employees					
Non-employing business	–0.37 ***	–0.23 ***	–0.31 ***	–0.53 ***	–0.47 ***
1–4 employees	–0.27 ***	–0.17 ***	–0.27 ***	–0.41 ***	–0.29 ***
5–19 employees					
20–199 employees	0.14 **	0.04	0.20 ***	0.15 **	–0.02
200+ employees	0.18 ***	–0.04	0.34 ***	0.31 ***	–0.06
Industry Division					
Agriculture, forestry and fishing	–0.12 *	–0.48 ***	–0.14 **	0.17 **	–0.19 **
Mining	–0.56 ***	–0.79 ***	–0.48 ***	–0.31 ***	–0.73 ***
Manufacturing					
Electricity, water, gas and waste services	–0.40 ***	–0.72 ***	–0.41 ***	–0.18	–0.50 **
Construction	–0.36 ***	–0.42 ***	–0.38 ***	–0.02	–0.48 ***
Wholesale	–0.05	0.05	–0.22 ***	0.02	0.00
Retail trade	–0.13 *	–0.13 *	–0.36 ***	–0.03	0.02
Accommodation and food services	–0.33 ***	–0.32 ***	–0.42 ***	–0.09	–0.01
Transport, postal and warehousing	–0.23 ***	–0.39 ***	–0.26 ***	0.03	–0.41 ***
Information, media and telecommunications	–0.02	0.06	–0.21 *	0.08	0.18
Financial and insurance services	0.17	0.24 **	0.09	0.40 ***	0.38 ***
Rental, hiring and real estate services	–0.35 ***	–0.40 ***	–0.65 ***	–0.05	–0.12
Professional, scientific and technical services	–0.16 **	–0.29 ***	–0.19 **	0.04	–0.22 **
Administrative and support services	–0.18 **	–0.20 **	–0.40 ***	0.09	–0.08 *
Health care and social assistance	–0.18 **	–0.17 *	–0.37 ***	0.07	–0.21 **
Arts and recreation services	–0.10	–0.24 **	–0.23 **	0.23 **	0.30 ***
Other services	–0.08	–0.08	–0.29 ***	0.11	–0.05
Age of business					
Less than one year old	0.45 ***	0.12	0.13	0.55 ***	0.19
1–4 years old	0.04	0.09 *	0.05	0.06	0.01
5–9 years old	0.08 **	0.09 *	–0.02	0.05	–0.01
10+ years old					
Export activity					
Non-exporter in 2006–07					
Exporter in 2006–07	0.24 ***	0.29 ***	0.19 ***	0.13 ***	0.12 **
Market structure					
Market share < 10% in 2006–07					
Market share 10–50% in 2006–07	0.21 ***	0.22 ***	0.15 ***	0.11 ***	0.07
Market share > 50% in 2006–07	0.25 ***	0.19 ***	0.18 ***	0.15 ***	–0.04
Foreign ownership					
Foreign ownership 0%–50% in 2006–07					
Foreign ownership >50% in 2006–07	–0.22 ***	–0.18 ***	–0.24 ***	–0.06	–0.13 **
R&D agreement					
No joint R&D (co–operative) agreement in 2006–07					
Joint R&D (co–operative) agreement in 2006–07	0.41 ***	0.41 ***	0.27 ***	0.34 ***	0.09

*** = significant at the 0.01 level; ** = significant at the 0.05 level; * = significant at the 0.10 level

G. FIVE ALTERNATIVE ICT INTENSITY INDEXES

G.1 ICT intensity index II: Features on business' web presence

Value	*ICT intensity*	*Description*	*Frequency*	*Percent*
1	Very high	Business has broadband connection, web presence, and web presence has on-line ordering feature and automated links with back-end systems in 2005–06	232	3.6%
2	High	Business has broadband connection, web presence and web presence has on-line ordering feature but does not have automated links with back-end systems in 2005–06	552	8.6%
3	Moderate	Business has broadband connection and web presence but web presence does not have on-line ordering feature in 2005–06	2,515	39.0%
4	Low	Business has broadband connection but no web presence in 2005–06	1,405	21.8%
5	Basic	Business does not use broadband connection in 2005–06	1,738	27.0%

G.2 ICT intensity index III: Method of receiving Internet / web orders

Value	*ICT intensity*	*Description*	*Frequency*	*Percent*
1	Very high	Business has broadband connection, web presence and receives Internet orders via (a) on-line ordering or (b) shopping cart facility in 2005–06	537	8.3%
2	High	Business has broadband connection, web presence and receives Internet orders via (a) website with linked email or (b) email not linked to website in 2005–06	711	11.0%
3	Moderate	Business has broadband connection and web presence but does not receive orders via Internet or web in 2005–06	2,051	31.8%
4	Low	Business has broadband connection but no web presence in 2005–06	1,405	21.8%
5	Basic	Business does not use broadband connection in 2005–06	1,738	27.0%

G.3 ICT intensity index IV: External system linkages

Value	*ICT intensity*	*Description*	*Frequency*	*Percent*
1	Very high	Business has broadband connection, web presence, receives Internet orders and system for receiving Internet orders is linked with customer and/or supplier systems in 2005–06	285	4.4%
2	High	Business has broadband connection, web presence and receives Internet orders but system for receiving Internet orders is neither linked to customer nor supplier systems in 2005–06	963	15.0%
3	Moderate	Business has broadband connection and web presence but does not receive orders via Internet or web in 2005–06	2,051	31.8%
4	Low	Business has broadband connection but no web presence in 2005–06	1,405	21.8%
5	Basic	Business does not use broadband connection in 2005–06	1,738	27.0%

G.4 ICT intensity index V: Internal system linkages

Value	*ICT intensity*	*Description*	*Frequency*	*Percent*
1	Very high	Business has broadband connection, web presence, receives Internet orders and system for receiving Internet orders is linked with at least one internal system* in 2005–06	442	6.9%
2	High	Business has broadband connection, web presence and receives Internet orders but no links with internal systems 2005–06	806	12.5%
3	Moderate	Business has broadband connection and web presence but does not receive orders via Internet or web in 2005–06	2,051	31.8%
4	Low	Business has broadband connection but no web presence in 2005–06	1,405	21.8%
5	Basic	Business does not use broadband connection in 2005–06	1,738	27.0%

* Internal systems include systems for reordering replacement supplies, invoicing and payment, production and service operations, logistics and marketing operations.

G.5 ICT intensity index VI: Proportion of income from sales received over Internet / web

Value	*ICT intensity*	*Description*	*Frequency*	*Percent*
1	Very high	Business has broadband connection, web presence, receives Internet orders and Internet sales account for more than 25% of sales income in 2005–06	238	3.7%
2	High	Business has broadband connection, web presence and receives Internet orders but Internet sales account for less than or equal to 25% of sales income in 2005–06	1,010	15.7%
3	Moderate	Business has broadband connection and web presence but does not receive orders via Internet or web in 2005–06	2,051	31.8%
4	Low	Business has broadband connection but no web presence in 2005–06	1,405	21.8%
5	Basic	Business does not use broadband connection in 2005–06	1,738	27.0%

G.6 Regression results – Any innovative activity in 2006–07, using alternative ICT intensity indexes

	ICT intensity					
	I	*II*	*III*	*IV*	*V*	*VI*
Intercept	–0.37 ***	–0.35 ***	–0.36 ***	–0.37 ***	–0.37 ***	–0.37 ***
ICT intensity						
ICT intensity = 1 (Most intense)	0.61 ***	0.67 ***	0.59 ***	0.70 ***	0.56 ***	0.62 ***
ICT intensity = 2	0.45 ***	0.52 ***	0.49 ***	0.48 ***	0.51 ***	0.50 ***
ICT intensity = 3	0.35 ***	0.39 ***	0.34 ***	0.34 ***	0.34 ***	0.33 ***
ICT intensity = 4	0.12 ***	0.12 ***	0.12 ***	0.12 ***	0.12 ***	0.12 ***
ICT intensity = 5 (Least intense)						
Number of employees						
Non-employing business	–0.36 ***	–0.36 ***	–0.35 ***	–0.35 ***	–0.35 ***	–0.36 ***
1–4 employees	–0.28 ***	–0.28 ***	–0.28 ***	–0.28 ***	–0.28 ***	–0.28 ***
5–19 employees						
20–199 employees	0.13 **	0.12 **	0.13 **	0.13 **	0.13 **	0.13 **
200+ employees	0.17 ***	0.16 ***	0.18 ***	0.18 ***	0.19 ***	0.20 ***
Industry Division						
Agriculture, forestry and fishing	–0.09	–0.10	–0.09	–0.09	–0.09	–0.09
Mining	–0.47 ***	–0.49 ***	–0.47 ***	–0.47 ***	–0.47 ***	–0.47 ***
Manufacturing						
Electricity, water, gas and waste services	–0.21	–0.23	–0.21	–0.20	–0.20	–0.20
Construction	–0.34 ***	–0.36 ***	–0.35 ***	–0.34 ***	–0.35 ***	–0.34 ***
Wholesale	–0.07	–0.08	–0.08	–0.08	–0.07	–0.07
Retail trade	–0.12	–0.13	–0.12	–0.11	–0.11	–0.11
Accommodation and food services	–0.30 ***	–0.30 ***	–0.30 ***	–0.30 ***	–0.30 ***	–0.30 ***
Transport, postal and warehousing	–0.24 ***	–0.25 ***	–0.24 ***	–0.24 ***	–0.24 ***	–0.24 ***
Information, media and telecommunications	0.00	0.00	0.00	0.01	0.01	0.01
Financial and insurance services	0.23 **	0.20 *	0.23 **	0.23 **	0.23 **	0.24 **
Rental, hiring and real estate services	–0.29 **	–0.30 ***	–0.29 **	–0.29 **	–0.28 **	–0.28 **
Professional, scientific and technical services	–0.15 *	–0.17 **	–0.15 *	–0.15 *	–0.15 *	–0.15 *
Administrative and support services	–0.22 ***	–0.24 ***	–0.23 ***	–0.22 ***	–0.23 ***	–0.23 ***
Health care and social assistance	–0.10	–0.27	–0.11	–0.10	–0.10	–0.10
Arts and recreation services	–0.10	–0.11	–0.10	–0.09	–0.10	–0.09
Other services	–0.10	–0.11	–0.11	–0.11	–0.11	–0.10
Age of business						
Less than one year old	0.52 ***	0.51 ***	0.52 ***	0.52 ***	0.52 ***	0.52 ***
1–4 years old	0.08 **	0.08 *	0.08 *	0.08 *	0.08 *	0.08 *
5–9 years old	0.11 ***	0.11 ***	0.11 ***	0.11 ***	0.11 ***	0.11 ***
10+ years old						
Export activity						
Non-exporter in 2006–07						
Exporter in 2006–07	0.27 ***	0.28 ***	0.28 ***	0.27 ***	0.28 ***	0.27 ***
Market structure						
Market share < 10% in 2006–07						
Market share 10–50% in 2006–07	0.22 ***	0.22 ***	0.23 ***	0.23 ***	0.23 ***	0.23 ***
Market share > 50% in 2006–07	0.24 ***	0.24 ***	0.24 ***	0.24 ***	0.24 ***	0.24 ***
Foreign ownership						
Foreign ownership 0%–50% in 2006–07						
Foreign ownership >50% in 2006–07	–0.22 ***	–0.23 ***	–0.22 ***	–0.23 ***	–0.22 ***	–0.22 ***
R&D agreement						
No joint R&D (co–operative) agreement in 2006–07						
Joint R&D (co–operative) agreement in 2006–07	0.47 ***	0.47 ***	0.47 ***	0.47 ***	0.47 ***	0.47 ***

*** = significant at the 0.01 level; ** = significant at the 0.05 level; * = significant at the 0.10 level

H. COMPARABLE ICT INTENSITY INDEX FOR 2005–06 AND 2006–07

H.1 Alternative ICT intensity indexes using comparable data from 2005–06 and 2006–07

			2005–06		2006–07	
Value	*ICT intensity*	*Description*	*No.*	*%*	*No.*	*%*
1	Highest / Most intense	Business has broadband connection, web presence, places orders via the Internet or web and receives orders via the Internet or web in the relevant year	1,019	15.8%	1,060	16.5%
2	Moderate / High	Business has broadband connection, web presence and places orders via the Internet or web, but does not receive orders via the Internet or web in the relevant year	1,206	18.7%	1,302	20.2%
3	Moderate	Business has broadband connection and web presence, but does not place orders via the Internet or web in the relevant year	1,074	16.7%	1,167	18.1%
4	Low	Business has broadband connection, but has no web presence in the relevant year	1,405	21.8%	1,706	26.5%
5	Basic	Business does not use broadband connection in the relevant year	1,738	27.0%	1,207	18.7%

H.2 Cross-tabulation of ICT intensity in 2005–06 by ICT intensity in 2006–07

	ICT intensity in 2006–07					
	1	*2*	*3*	*4*	*5*	*Total*
ICT intensity in 2005–06						
1	618	193	168	36	4	1,019
	58.3%	14.8%	14.4%	2.1%	0.3%	15.8%
2	161	751	239	47	8	1,206
	15.2%	57.7%	20.5%	2.8%	0.7%	18.7%
3	161	255	579	72	7	1,074
	15.2%	19.6%	49.6%	4.2%	0.6%	16.7%
4	55	77	90	1,110	73	1,405
	5.2%	5.9%	7.7%	65.1%	6.0%	21.8%
5	65	26	91	441	1,115	1,738
	6.1%	2.0%	7.8%	25.8%	92.4%	27.0%
Total	1,060	1,302	1,167	1,706	1,207	6,442
	16.5%	20.2%	18.1%	26.5%	18.7%	100.0%

H.3 Regression results – Any innovative activity in 2006–07, using alternative ICT intensity indexes based on comparable data from 2005–06 and 2006–07

	2005–06 ICT intensity		*2006–07 ICT intensity*	
Intercept	–0.36	***	–0.48	***
ICT intensity				
ICT intensity = 1 (Most intense)	0.57	***	0.79	***
ICT intensity = 2	0.41	***	0.57	***
ICT intensity = 3	0.30	***	0.41	***
ICT intensity = 4	0.12	***	0.18	***
ICT intensity = 5 (Least intense)				
Number of employees				
Non-employing business	–0.35	***	–0.32	***
1–4 employees	–0.28	***	–0.25	***
5–19 employees				
20–199 employees	0.13	**	0.10	*
200+ employees	0.17	***	0.15	***
Industry Division				
Agriculture, forestry and fishing	–0.09		–0.06	
Mining	–0.48	***	–0.49	***
Manufacturing				
Electricity, water, gas and waste services	–0.22		–0.26	*
Construction	–0.35	***	–0.36	***
Wholesale	–0.07		–0.08	
Retail trade	–0.11		–0.12	
Accommodation and food services	–0.29	***	–0.31	***
Transport, postal and warehousing	–0.24	***	–0.23	***
Information, media and telecommunications	–0.01		–0.05	
Financial and insurance services	0.22	*	0.20	*
Rental, hiring and real estate services	–0.30	***	–0.32	***
Professional, scientific and technical services	–0.17	**	–0.19	**
Administrative and support services	–0.23	***	–0.21	***
Health care and social assistance	–0.12		–0.13	
Arts and recreation services	–0.10		–0.14	
Other services	–0.11		–0.09	
Age of business				
Less than one year old	0.52	***	0.53	***
1–4 years old	0.08	*	0.07	*
5–9 years old	0.11	***	0.10	***
10+ years old				
Export activity				
Non-exporter in 2006–07				
Exporter in 2006–07	0.28	***	0.25	***
Market structure				
Market share < 10% in 2006–07				
Market share 10–50% in 2006–07	0.23	***	0.22	***
Market share > 50% in 2006–07	0.24	***	0.25	***
Foreign ownership				
Foreign ownership 0%–50% in 2006–07				
Foreign ownership >50% in 2006–07	–0.22	***	–0.21	***
R&D agreement				
No joint R&D (co–operative) agreement in 2006–07				
Joint R&D (co–operative) agreement in 2006–07	0.46	***	0.47	***

*** = significant at the 0.01 level; ** = significant at the 0.05 level; * = significant at the 0.10 level

I. ICT INTENSITY AND DEGREE OF INNOVATION NOVELTY

I.1 Frequency counts for dependent variable = Implemented innovations in 2006–07, by degree of novelty

Value	*Description*	*Frequency*	*Percent*
0	No implemented innovation	3,696	57.4%
1	Implemented an innovation which was, at best, new to the business	1,564	24.3%
2	Implemented an innovation which was, at best, new to the industry	153	2.4%
3	Implemented an innovation which was, at best, new to Australia	176	2.7%
4	Implemented an innovation which was new to the world	130	2.0%
5	Missing*: Business implemented an innovation, but did not provide information on the degree of novelty	723	11.2%

* These businesses are excluded from the innovation novelty models.

I.2 Frequency counts for dependent variable = Implemented innovations in 2006–07, according to who developed

Value	*Description*	*Frequency*	*Percent*
0	No implemented innovation	3,696	57.4%
1	Implemented an innovation which was developed exclusively by other business(es) or institution(s)	95	1.5%
2	Implemented an innovation which was developed by the business, in co-operation with other business(es) or institution(s)	283	4.4%
3	Implemented an innovation which was developed exclusively internally (by the business or a related company)	1,762	27.4%
4	Missing*: Business implemented an innovation but did not provide information on who developed the innovation	606	9.4%

* These businesses are excluded from the innovation novelty models.

I.3 Frequency counts for dependent variable = Number of types of innovative activity in 2006–07

Value	*Description*	*Frequency*	*Percent*
0	No innovative activity of any type	3,371	52.3%
1	Business engaged in a single type of innovative activity (Product, Process, Organisational or Managerial) which was either implemented, ongoing or abandoned.	1,095	17.0%
2	Business engaged in two types of innovative activity (Product, Process, Organisational or Managerial) which was either implemented, ongoing or abandoned.	891	13.8%
3	Business engaged in three types of innovative activity (Product, Process, Organisational or Managerial) which was either implemented, ongoing or abandoned.	609	9.5%
4	Business engaged in all four types of innovative activity (Product, Process, Organisational and Managerial) which was either implemented, ongoing or abandoned.	476	7.4%

* These businesses are excluded from the innovation novelty models.

I.4 Ordered Probit regression results – Implemented innovations in 2006–07, according to degree of novelty

Intercept		
Non-innovators	–0.57	***
Innovation new to the business	–1.81	***
Innovation new to the industry	–2.04	***
Innovation new to Australia	–2.48	***
ICT intensity		
ICT intensity = 1 (Most intense)	0.67	***
ICT intensity = 2	0.50	***
ICT intensity = 3	0.43	***
ICT intensity = 4	0.18	***
ICT intensity = 5 (Least intense)		
Number of employees		
Non-employing business	–0.92	***
1–4 employees	–0.39	***
5–19 employees		
20–199 employees	–0.16	**
200+ employees	–0.15	***
Industry Division		
Agriculture, forestry and fishing	–5.08	
Mining	–0.58	***
Manufacturing		
Electricity, water, gas and waste services	–0.43	***
Construction	–0.41	***
Wholesale	–0.08	
Retail trade	–0.21	***
Accommodation and food services	–0.42	***
Transport, postal and warehousing	–0.44	***
Information, media and telecommunications	–0.09	
Financial and insurance services	0.02	
Rental, hiring and real estate services	–0.33	***
Professional, scientific and technical services	–0.24	***
Administrative and support services	–0.25	***
Health care and social assistance	–0.29	***
Arts and recreation services	–0.13	
Other services	–0.24	***
Age of business		
Less than one year old	0.27	**
1–4 years old	0.04	
5–9 years old	0.05	
10+ years old		
Export activity		
Non-exporter in 2006–07		
Exporter in 2006–07	0.26	***
Market structure		
Market share < 10% in 2006–07		
Market share 10–50% in 2006–07	0.17	***
Market share > 50% in 2006–07	0.27	***
Foreign ownership		
Foreign ownership 0%–50% in 2006–07		
Foreign ownership >50% in 2006–07	–0.12	**
R&D agreement		
No joint R&D (co–operative) agreement in 2006–07		
Joint R&D (co–operative) agreement in 2006–07	0.40	***

*** = significant at the 0.01 level; ** = significant at the 0.05 level;
* = significant at the 0.10 level

I.5 Ordered Probit regression results – Implemented innovations in 2006–07, according to who developed the innovation

Intercept		
Non-innovators	–0.61	***
Innovation developed externally	–0.67	***
Innovation developed in co-operation	–0.84	***
ICT intensity		
ICT intensity = 1 (Most intense)	0.66	***
ICT intensity = 2	0.48	***
ICT intensity = 3	0.41	***
ICT intensity = 4	0.20	***
ICT intensity = 5 (Least intense)		
Number of employees		
Non-employing business	–1.04	***
1–4 employees	–0.44	***
5–19 employees		
20–199 employees	0.16	***
200+ employees	0.22	***
Industry Division		
Agriculture, forestry and fishing	–5.05	
Mining	–0.50	***
Manufacturing		
Electricity, water, gas and waste services	–0.36	**
Construction	–0.31	***
Wholesale	–0.05	
Retail trade	–0.14	*
Accommodation and food services	–0.32	***
Transport, postal and warehousing	–0.27	***
Information, media and telecommunications	–0.07	
Financial and insurance services	0.24	**
Rental, hiring and real estate services	–0.26	**
Professional, scientific and technical services	–0.17	**
Administrative and support services	–0.15	*
Health care and social assistance	–0.18	**
Arts and recreation services	–0.01	
Other services	–0.13	
Age of business		
Less than one year old	0.39	***
1–4 years old	0.05	
5–9 years old	0.06	
10+ years old		
Export activity		
Non-exporter in 2006–07		
Exporter in 2006–07	0.26	***
Market structure		
Market share < 10% in 2006–07		
Market share 10–50% in 2006–07	0.18	***
Market share > 50% in 2006–07	0.23	***
Foreign ownership		
Foreign ownership 0%–50% in 2006–07		
Foreign ownership >50% in 2006–07	–0.16	**
R&D agreement		
No joint R&D (co–operative) agreement in 2006–07		
Joint R&D (co–operative) agreement in 2006–07	0.34	***

*** = significant at the 0.01 level; ** = significant at the 0.05 level;
* = significant at the 0.10 level

I.6 Ordered Probit regression results – Number of types of innovative activity in 2006–07

Intercept		
Non-innovators	–0.31	***
1 type of innovation	–0.82	***
2 types of innovation	–1.33	***
3 types of innovation	–1.87	***
ICT intensity		
ICT intensity = 1 (Most intense)	0.62	***
ICT intensity = 2	0.42	***
ICT intensity = 3	0.31	***
ICT intensity = 4	0.11	***
ICT intensity = 5 (Least intense)		
Number of employees		
Non-employing business	–0.39	***
1–4 employees	–0.30	***
5–19 employees		
20–199 employees	0.14	***
200+ employees	0.18	***
Industry Division		
Agriculture, forestry and fishing	–0.10	*
Mining	–0.51	***
Manufacturing		
Electricity, water, gas and waste services	–0.32	**
Construction	–0.33	***
Wholesale	–0.06	
Retail trade	–0.13	*
Accommodation and food services	–0.23	***
Transport, postal and warehousing	–0.22	***
Information, media and telecommunications	0.07	
Financial and insurance services	0.38	***
Rental, hiring and real estate services	–0.28	***
Professional, scientific and technical services	–0.14	**
Administrative and support services	–0.17	**
Health care and social assistance	–0.10	
Arts and recreation services	0.02	
Other services	–0.09	
Age of business		
Less than one year old	0.35	***
1–4 years old	0.08	**
5–9 years old	0.06	*
10+ years old		
Export activity		
Non-exporter in 2006–07		
Exporter in 2006–07	0.25	***
Market structure		
Market share < 10% in 2006–07		
Market share 10–50% in 2006–07	0.18	***
Market share > 50% in 2006–07	0.16	***
Foreign ownership		
Foreign ownership 0%–50% in 2006–07		
Foreign ownership >50% in 2006–07	–0.19	***
R&D agreement		
No joint R&D (co–operative) agreement in 2006–07		
Joint R&D (co–operative) agreement in 2006–07	0.34	***

*** = significant at the 0.01 level; ** = significant at the 0.05 level;
* = significant at the 0.10 level

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