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Modelling the relationship between innovation and exporting: Evidence from Australian SMEs

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Abstract

Although economic theories predict a two-way relationship between innovation and exports, much of the empirical literature takes one of these as given. Using Australian microdata in a simultaneous equations framework, this paper shows that firm innovation and export behaviour are mutually driven processes. In both directions, the impact of product innovation is quantitatively larger than other forms of innovation. The paper also presents evidence of the self-selection of exporting firms into innovative activity, but not the other way around. Explicitly accounting for firm strategy and investment decisions, it is found that innovative and exporting activities are the products of distinct sets of strategies, and that business investment in worker training and information technology capital boosts the likelihood of innovation.

JEL Codes: F1, F14 O3, O31, C53, L1, L80
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Key points

- **Innovation and export behaviour of Australian small and medium businesses are interrelated.**
- **Innovative firms are 4–8 per cent more likely to be exporters, while exporters are 7–10 per cent more likely to be innovators.**
- **The evidence also suggests that exporting induces selection into innovative activity.**
- **Business investment in employee training and information technology capital boosts firm innovation performance.**

1. Introduction

A sizeable literature over the past half a century has documented the role of innovation[1] in determining firm performance (see Cohen 2010 for a survey). Moreover, while innovation-led improvements in international competitiveness can impact on firm export behaviour (Cantwell 2006), the evidence also shows that exporting firms — being unconstrained by the level of domestic demand — grow faster (Bernard & Jensen 1995). Hence, there is an enduring policy interest in both the innovation and export performance of firms.[2] An explorative analysis of the firm-level determinants of innovation and exporting can, therefore, be doubly beneficial for informing policy.

The evidence in favour of export-led productivity growth among firms is as scarce (Greenaway & Kneller 2007) as the evidence showing the self-selection of more productive firms into exporting is abundant (Bernard et al. 2007). Moreover, although innovation is a core driver of productivity growth (Productivity Commission 2008), less research has focused on the sources of the superior productivity performance of firms before they enter foreign markets (Damijan, Kostevc & Polanec 2010). A study of firm innovation behaviour and the decision to export will, therefore, be useful in improving our understanding of firm strategy for international expansion as well as the evolution of firm productivity. As such, the purpose of this research is to contribute to the literature through an investigation of the potential relationship between innovation and exporting activities of firms using longitudinal data on a sample of Australian small and medium businesses.[3]

Trade (e.g. Krugman 1979) and growth (e.g. Grossman & Helpman 1990) theories predict a mutual causation between innovation and exports. For example, new or significantly improved products can create export opportunities.

[1] For the purpose of this paper, innovation is defined as the introduction or application of a new or significantly improved product or process in business practices (OECD 2005).
[2] See, for example, *Powering Ideas: An Innovation Agenda for the 21st Century* (2009), *Industry Innovation and Competitiveness Agenda: An action plan for a stronger Australia* (2014) and *National Innovation and Science Agenda* (2015)—all policy documents published by the Australian Government of the time.
[3] Australian Bureau of Statistics (ABS) determines business size by employee number thresholds: small businesses employ 0–19 persons, while medium businesses employ 20–199 persons.

Moreover, innovation in the production process or in the organisation of business can increase firm productivity, a key determinant of foreign market entry or expansion. On the other hand, to the extent that exporters gain knowledge and technology from foreign markets, they should be more innovative than otherwise comparable non-exporters. In addition, given the more intense competition in foreign markets than at home, exporters may need to be more innovative than non-exporters. Finally, when market size is a determinant of profitability, the opportunity to export may enhance the incentive to invest in innovative activity. Knowledge spillovers and competitive pressures associated with trade in general, not just exporting, are also expected to stimulate innovation (Grossman & Helpman 1991a; Boone 2000).

Despite the general acceptance of the view that firm innovation and export behaviour are mutually driven processes, several researchers have implicitly assumed the exogeneity of one of these two activities of interest in their empirical analysis.[4] Nevertheless, other authors (e.g. Ebling & Janz 1999, Damijan et al. 2010) have attempted to model the firm-level relationship between innovation and exporting by explicitly incorporating bidirectionality. This paper adopts the latter approach based on the argument that both innovation and export activities are a manifestation of deliberate firm strategies, and hence are endogenous. By the same token, the analysis in this paper takes explicit account of firm strategy, which is uncommon in the existing literature.

The empirical analysis, using Australian longitudinal microdata, of the relationship between innovation outcome and export behaviour of firms is twofold.[5] First, using a simultaneous equations framework (Mallar 1977), it is found that both firm innovation outcome and foreign market participation have positive impacts on each other, and the relationship is contemporaneous and statistically significant. Second, using a binomial probit with selection model (Van de Ven & Van Pragg 1981) — to account for the dependence between the decisions to innovate and export, it is shown that exporting firms self-select into innovative activity, but not the other way around. The evidence thus suggests that Australian small and medium exporters 'learn' to innovate from their foreign market exposure. In other words, competitive pressures associated with export market participation force firms to be more innovative. These findings are robust to a number of alternative econometric specifications and indicators of innovative and exporting activities.

In contrast to several previous studies, this paper uses innovation output measures rather than innovation inputs (e.g. R&D expenditure or R&D labour input) as indicators of innovative activity since it is argued that it is the outcomes of innovation efforts, rather than the efforts themselves, that are more important for determining subsequent firm performance. Other novelties of the paper include explicitly controlling for firm strategy as well as a wider range of firm characteristics (e.g. firm collaboration status, e-commerce profile and geographic span of operation). Since the same firms are repeatedly observed

[4] For example, some studies that take innovation as given include Wakelin (1998), Basile (2001) and Roper & Love (2002), while export market activity is exogenous in Alvarez & Robertson (2004), Andersson & Loof (2012) and Seker (2012) among others.

[5] Besides information on international trading activity, the dataset contains time-varying information about the type of innovation — product vs. process — introduced by firms. Therefore, we are able to observe if the effect of innovation on exporting, and vice versa, vary by innovation type (Basile 2001, Caldera 2010, Becker & Egger 2013).

over the life of the panel, the analysis also controls for the unobserved firm heterogeneity.

The remainder of the paper is organised as follows. Section 2 provides a brief review of the economic literature most relevant to the current research. Section 3 contains a description of the data used for the analysis, and some summary statistics highlighting key firm characteristics including their innovative and trading activities. Econometric methodologies used for this research, along with key estimation issues, are detailed in Section 4. Results of the two modelling schemes, including sensitivity and limitations, are discussed in Section 5. The final section provides a summary of the key findings as well as a discussion of their policy implications.

2. Trade, innovation and firm behaviour

Two broad strands of theoretical literature predict a relationship between innovation and exports. On the one hand, certain theories of international trade stress the product-cycle features in the production of goods over time. These trade models tend to take innovation as exogenous and predict that innovation influences exports (e.g. Vernon 1966, Krugman 1979, Dollar 1986).[6] On the other hand, the endogenous growth models, by explicitly recognising the open-economy effects, endogenise the rate of innovation and predict dynamic effects of international trade on innovative activity (Grossman & Helpman 1990, 1991b; Rivera-Batiz & Romer 1991). While in some of these models these impacts stem from general equilibrium effects of knowledge spillovers, there are also two channels which stem directly from the presence of individual exporting firms in foreign markets. First, the fiercer competition on international markets forces exporting firms to improve their products and processes to remain competitive, thus increasing their probability of innovation (Lachenmaier & Wobmann 2006). Second, exporting firms may 'learn by exporting' in that they gain access to technical expertise from their buyers in foreign markets which non-exporting firms do not have (World Bank 1993).

Given the predictions of the product-cycle trade models and the global-economy growth models, a mutual causation of innovation and exports would be expected. This implies an empirical analysis of the relationship between innovation and exports ought to account for the endogeneity of both of these variables.

Turning to empirical studies using firm-level data, the cross-country evidence on the self-selection of firms into export markets (Wagner 2007) falls short of a convincing explanation for the pre-export productivity advantage of firms. Not to mention, this literature ignores the role of foreign trade in driving intra-industry heterogeneity in firm productivity. Theories of firm behaviour and evolution suggest that both product and process innovation, resulting from investments in firm-specific assets in order to gain competitive advantage, are at the heart of firm productivity dynamics (Jovanovic 1982, Spence 1984, Hopenhayn 1992,

[6] In addition, Grossman and Helpman (1989) highlighted the role of product innovation in international trade in a more general setting, involving both inter- and intra-industry trade. However, they view innovation as endogenous — an outcome of deliberately committing resources to R&D by profit-seeking firms.

Melitz 2003). Investment in innovative activity thus helps firms to increase their market shares.

While trade increases competitive pressures on firms, Boone (2000) explicitly deals with product vs. process innovation and their relation with competitive pressure. When assuming that the aggregate efficiency can be measured by the (inverse of) average production cost, his analysis suggests that a higher level of competitive pressure cannot increase product and process innovation at the same time. Rather, an increase in the competitive pressure may increase the efficiency of each surviving firm but may lead to the exit of less productive ones, which is associated with a decline in product innovation. Overall, a positive impact of competitive pressure on process innovation is a possible, yet not a necessary outcome.

Using a general equilibrium model of the decisions of firms to innovate and to engage in international trade, Atkeson and Burstein (2007) analyse the impact of a reduction in trade costs on firm innovation behaviour. They show that, if only a subset of firms export, a decline in marginal trade costs raises process innovation among exporters. This reallocation of process innovation reinforces existing patterns of comparative advantage, and leads to an amplified response of trade volumes and output over time. In a quantitative version of the model, the authors also show that the increase in process innovation is largely offset by a decline in product innovation.

The work of Constantini & Melitz (2008), in addition, is an example of a model of industry dynamics that includes endogenous innovation and export decisions. They show that the anticipation of trade liberalisation may lead firms to bring forward the decision to innovate, in order to be ready for future participation in the export market. In these models, productivity distinguishes heterogeneous firms, and its evolution is endogenous — driven by investment-led innovation decisions at the firm level.

There is a large empirical literature testing the effect of innovative activity on export performance, and examining the impact of internationalisation on firm innovation behaviour. This literature can be organised into four quadrants, as is done in Table 2.1. First, some studies use industry-level data, while others use firm-level data. Second, a number of papers focus on innovation inputs (e.g. measures based on R&D expenditure) as indicators of innovative activity, while other papers use output-based metrics of innovation (e.g. binary indicators for different types of innovation/patents). Table 2.1 lists these papers in chronological order. For reviewing the evidence in this connection, this paper focuses more on the firm-level studies that use innovation output data. This is due to the similarity of the data used for the purpose of this research.

Table 2.1: Selected empirical studies of innovative and trading activities

	Studies using industry-level data	*Studies using firm-level data*
Studies using innovation inputs	Keesing (1966, 1967) Gruber et al. (1967) Mansfield et al. (1979) Hughes (1986) Soete (1987) Buxton et al. (1991)	Hirsch & Bijaoui (1985) Kumar & Siddharthan (1994) Sterlacchini (1999) Aw et al. (2007, 2008) Girma et al. (2008)
Studies using innovation outputs	Soete (1981, 1987) Fagerberg (1988) Greenhalgh (1990) Greenhalgh et al. (1994)	Wagner (1996) Wakelin (1998) Ebling & Janz (1999) Basile (2001) Roper & Love (2002) Bleaney & Wakelin (2002) Alvarez & Robertson (2004) Salomon & Shaver (2005) Caldera (2010) Damijan et al. (2010) Van Beveren & Vandenbussche (2010) Andersson & Loof (2012) Seker (2012) Becker & Egger (2013) Boermans & Roelfsema (2015)

Most studies in this area tend not to account explicitly for the possible endogeneity of innovation with respect to exports. Initial contributions compared the export performance of US industries to innovation proxies such as R&D expenditure and personnel (Keesing 1966, 1967; Gruber, Mehta & Vernon 1967). Subsequently, several studies looked at case studies of firms' R&D and exports (e.g. Hirsch & Bijaoui 1985) and the cross-country evidence linking trade data with R&D expenditure and patents (e.g. Soete 1981, 1987; Fagerberg 1988). Other contributions used industry-level time-series data relating exports to innovation proxies such as measures of R&D, innovation count data and patent counts, particularly for the UK (e.g. Greenhalgh 1990; Buxton, Mayes & Murfin 1991; Greenhalgh, Taylor & Wilson 1994). Mainly starting from the 1990s, an increased availability of the firm-level data has led to a proliferation of microeconomic studies of the potential relationship between innovative and exporting activities.

Assuming firm innovative activity as exogenous, some researchers (Wagner 1996, Wakelin 1998, Basile 2001, Rope & Love 2002, Bleaney & Wakelin 2002) have studied the effect of innovation outcomes on firm export behaviour; both the probability of exporting and the propensity to export have been the subject of interest. A dummy variable is generally used to distinguish innovative firms or to denote the type of innovation. In some instances, the number of innovations reported by firms is also used as the key explanatory variable. Most of these studies use cross-section data based on surveys of manufacturing firms in several advanced countries (namely, Germany, UK and Italy), and control for firm size based on total sales or number of employees as well as some measure of skill use. Overall, a positive and statistically significant impact of innovation on exporting activities is reported, albeit the results of these studies are less conclusive than might be expected.

Using a simultaneous equations framework[7] to allow for the endogeneity of innovative activity, Ebling & Janz (1999) investigate the innovation–exporting relationship among German services sector firms. They find strong support for the Schumpeterian hypothesis that firm innovative activity has a positive impact on foreign market participation. Moreover, the authors do not find evidence to suggest that there is a feedback from exports to innovation.

Caldera (2010) investigates the relationship between innovation and export behaviour of firms using data on a panel of Spanish manufacturing firms. After controlling for lags of exporting status, total employment, total factor productivity, firm age and foreign ownership status, she finds that lagged innovation indicators (R&D intensity and dummies for R&D and process and product innovation) have a highly significant positive impact on firm exporting status; with the effect of product innovation being larger than process innovation. Becker & Egger (2013) report similar results from their analysis using a panel data set of German firms. Viewing innovation as a 'treatment', they use propensity score matching to account for the self-selection of firms into innovative activity. The authors find that firms that introduce both process and product innovation have a higher probability of exporting than firms that do not innovate.

Damijan et al. (2010) study both directions of the relationship between innovation activity and decision to export. They apply a propensity score matching technique on Slovenian microdata to match innovators and non-innovators as well as exporters and non-exporters to compare their likelihood of, respectively, exporting and innovating. In estimating the export and innovation equations, the authors use lagged indicators of firm innovation and export behaviour, respectively, to identify the direction of causality between the two. They find no support for the hypothesis that either product or process innovations increases the likelihood of becoming an exporter; but find evidence that exporting increases the probability of becoming a process rather than a product innovator, and that exporting leads to productivity improvements. These findings, limited to a sample of medium and large first-time exporters, are in line with the learning-by-exporting hypothesis whereby export market participation may positively affect firm efficiency by stimulating process innovations.

Other studies reporting the evidence of learning by exporting include Alvarez & Robertson (2004), Salomon & Shaver (2005), Andersson & Loof (2012), Seker (2012) and Boermans & Roelfsema (2015). Of these, Salomon & Shaver (2005) and Andersson & Loof (2012) use data on Spanish and Swedish manufacturing firms, respectively, while the rest are multi-country studies using data from various developing countries including Mexico, Chile and several transitions economies. Therefore, although more prevalent, the evidence of export-driven innovation is not limited to developing countries. It is nevertheless possible that learning effects of exporting are systematically related to export destinations, whereby exporting to technologically advanced countries provides innovation-generating or productivity-improving knowledge feedback for exporters. However, the studies reviewed here do not explore this possibility — perhaps due to lack of necessary data.

[7] Hughes (1986) and Entorf, Krader & Pohlmeier (1988, cited in Becker & Egger 2013) also assume simultaneity between innovative and exporting activities in their analyses, and find evidence of bidirectional relationship between them.

Last but not the least, Lachenmaier and Wobmann (2006) claim to show that innovation *causes* exports among German manufacturing firms, as product-cycle models of international trade would predict. The authors attempt to identify variation in innovation due to specific impulses for and obstacles to innovative activity which they argue are exogenous to firm export performance. Using the innovation impulses and obstacles as instruments for actual innovation, they find that innovation leads to a 7 percentage point improvement, on average, in firm export propensity.

3. Data and descriptive statistics

For empirical analysis, this paper uses data from the Business Longitudinal Database (BLD) Confidentialised Unit Record File (CURF). The BLD CURF comprises several longitudinal datasets containing both characteristics and financial data for a cohort of small and medium businesses,[8] and thus allows analyses of business performance over time. The sample design is based on the use of consecutive panels drawn from the Australian business population at the point in time that each panel is introduced into the BLD.

Information included in the BLD comes from business characteristics data sourced from the Australian Bureau of Statistics (ABS) Business Characteristics Survey (BCS), and financial data sourced from two main administrative sources: the Australian Taxation Office (ATO) and the Australian Customs and Border Protection Service (Customs).

For the purpose of this paper, the first wave of the BLD is used — an independent sample (panel) drawn from the in-scope Australian business population. Each panel is directly surveyed once a year for a period of five consecutive years. Panel One contains data for the period from 2004–05 to 2008–09 on 2,732 businesses selected from a population of 1,563,857 businesses (as at 30 June 2005).

The sample for each BLD panel is stratified by industry division and business size.[9] Industry is based on Australia New Zealand System of Industrial Classification (ANZSIC) 1993 division, and business size is based on a derived employment size indicator — Derived Size Benchmark (DSB)[10]. Table 3.1 shows the distribution of the businesses in Panel One by their ANZSIC 1993 industry division and size as determined by number of employees. Although *Agriculture, forestry & fishing* has the largest share of in-sample firms, this is not the case in the business population. Indeed, industry composition of the sample is not proportionate with that of business population; hence, to get around this problem, we use design weights for weighting each observation included in the regression analysis.

[8] According to the ABS convention, businesses employing up to 19 employees (including non-employing businesses) are *small business*, while those employing between 20 and 199 employees are *medium business*.

[9] Once included in a panel, and irrespective of changes to business size or industry division, the selected business remains in the stratum for which it was originally selected

[10] DSB is a derived item using ATO data which models employment and formed a part of stratification for all ABS business surveys at the time of the panels' selection.

Table 3.1: BLD Panel One, Business sample counts by industry and employment size

Industry	*Non-employing*	*0–4 persons*	*5–19 persons*	*20–199 persons*	*All firms*
Agriculture, forestry & fishing	138	171	164	149	622
Mining	34	41	30	15	120
Manufacturing	99	144	110	96	449
Construction	22	43	38	39	142
Wholesale trade	70	83	68	64	285
Retail trade	42	50	43	39	174
Accommodation & food	28	64	50	41	183
Transport & storage	33	44	40	39	156
Communication services	36	50	33	20	139
Property & business services	29	45	41	43	158
Cultural & recreational	15	46	38	42	141
Personal & other services	27	54	44	38	163
Total in-scope sample	**573**	**835**	**699**	**625**	**2,732**

Notes: Sample count as at 30 June 2005. Non-employing businesses are those without an active ATO Income Tax Withholding role

Source: ABS Cat. No. 8168.0.55.001

3.1 Firm characteristics

Table 3.2 shows the percentage of businesses[11] that answered affirmatively against particular questions revealing key firm characteristics.

Averaging over the life of the panel, it is found that about 34 per cent[12] of businesses included in the sample report one or more innovation in a given year while about 18 per cent identify themselves as exporters[13]. Given the evidence from international literature (Bernard et al. 2007), it is unsurprising that a relatively small proportion of businesses export. In other words, most Australian SMEs primarily serve the domestic market. This is because, arguably, breaking into foreign markets is more difficult for smaller businesses than larger ones.

[11] In the data cleaning up process, several businesses drop out of sample each year. The number of businesses included in the econometric analysis is, therefore, progressively smaller than the initial sample size (2,732 businesses for Panel One). Missing data and business exits are the main causes of this discrepancy and the paper thus uses an unbalanced panel.

[12] This is higher than the proportion (about a fifth) of businesses reporting an increase in the range of products and services, because this includes process innovation and marketing methods innovation.

[13] This is higher than generally reported in the annual ABS publication titled Characteristics of Australian Exporters (see: ABS Cat. No. 5368.0.55.006). For an explanation of the discrepancy, see: http://www.abs.gov.au/ausstats/abs@.nsf/Products/8168.0.55.001~2006-07+to+2010-11~Main+Features~About+the+Business+Longitudinal+Database?OpenDocument.

Table 3.2: Percentage of businesses by various characteristics, BLD Panel One

	2004–05	*2005–06*	*2006–07*	*2007–08*	*2008–09*	*Avg.*
Innovator	25.3	38.9	33.3	38.5	38.0	34.4
Exporter	16.8	21.8	19.6	16.6	16.5	18.3
Multiple location	14.4	14.8	17.3	17.7	18.6	16.4
Homebased	34.3	34.1	34.3	36.0	34.6	34.6
5-19 employees	28.6	25.2	26.2	27.4	27.4	27.0
20-199 employees	18.0	19.9	19.6	19.8	20.4	19.5
Foreign ownership	4.2	4.0	4.2	4.0	4.4	4.2
Franchising agreement	4.8	4.6	4.9	4.8	4.6	4.7
Business focus on:						
Revenue/profit	68.9	67.7	69.8	67.4	66.3	68.1
Cost	64.0	60.9	64.5	63.3	62.4	63.0
Operations	51.2	49.1	53.2	52.5	51.6	51.4
Quality	53.3	63.5	65.2	65.7	65.3	62.2
Innovation	41.3	37.3	37.6	39.9	39.4	39.1
Human resources	46.2	46.9	47.1	44.5	41.2	45.4
Collaboration	--	9.6	9.1	12.2	13.7	11.0
Reported an increase in:						
Sales revenue	--	40.5	40.7	36.9	29.8	37.3
Range of products	--	22.6	22.2	17.9	15.2	19.8
Profitability	--	31.2	30.3	26.7	21.9	27.9
Productivity	--	29.1	27.9	24.4	20.1	25.7
Export mkt targeted	--	4.2	3.9	2.5	2.9	3.4
Outsourcing	--	8.0	8.2	7.5	5.6	7.4
Employee training	--	12.7	12.3	10.3	9.6	11.3
IT expenditure	--	19.8	19.3	17.5	15.8	18.3
Factors significantly hampering innovation:						
Cost of development	--	12.3	11.1	12.6	14.5	12.5
Skill shortage (own)	--	12.9	14.1	13.4	11.3	13.0
Skill shortage (mkt)	--	17.4	17.5	16.7	13.0	16.3
Non-access to tech	--	3.2	3.3	3.4	3.1	3.3
Uncertain demand	--	9.1	7.9	10.2	14.2	10.2
Received govt. assist.	13.4	16.2	18.8	21.5	20.4	17.7
Sought debt/equity	--	19.8	20.6	19.2	19.0	19.7
Operated State-wide	--	40.0	43.5	45.3	45.7	43.4
Operated nationwide	--	28.8	29.8	31.1	32.4	30.4
Had broadband Internet	--	57.5	68.8	74.0	81.9	69.7
Had web presence	32.5	31.7	34.2	37.4	38.5	34.6
Placed orders online	35.2	34.9	37.2	40.8	46.2	38.4
Received orders online	27.1	24.9	25.9	28.4	32.5	27.5
Importer	9.3	10.2	10.8	10.0	11.2	10.2
Effective no. of businesses	*2,305*	*2,126*	*1,942*	*1,768*	*1,659*	*1,960*

Source: Author's calculation based on data from the Business Longitudinal Database.

A focus on financial indicators (e.g. sales and profits) appears to be the dominant business strategy, followed by an explicit emphasis on cost reduction. It is interesting that firms in this sample are more concerned about the quality of their products than their operational efficiency, while more firms focus on human resources than on innovation as business strategy alternatives.

Although just under 40 per cent of businesses focus on innovation outcomes as a measure of business performance, 11 per cent report being engaged in some form of collaboration — a key driver of innovation (DIIS 2010). In addition, more businesses report an increase in revenue (37.3 per cent) and profitability (27.9 per cent) than productivity (25.7 per cent). While outsourcing as well as human and physical capital accumulation are some of the key drivers of productivity growth, businesses are more inclined to increase information technology (IT) expenditure than employee training or outsourcing.

The limited appropriability of human capital (in the form of worker skills) is expected to make firms less inclined to invest in worker training than in IT capital. Moreover, firms incur additional transaction costs, and give up control over certain segments of the production process, as they outsource certain functions. As such, smaller firms may be less willing to engage in outsourcing activity, although it can be efficiency-improving.

Nearly a fifth of businesses seek debt or equity financing, while about 18 per cent receive government assistance of some form (e.g. grants, subsidies, rebates, etc.). This highlights the scarcity of financial resources experienced by smaller businesses, which is deemed to choke investment needed for business expansion and innovation. Nevertheless, skill shortages, not cost of development, are identified by surveyed businesses as the number one factor hampering innovation. Moreover, their geographic span of operation is less limited by their size — over 30 and 40 per cent, respectively, operate country- and State-wide. The use of broadband Internet is widespread while over a third of businesses have a website. A significant proportion of businesses are also engaged in online buying and selling.

3.2 Innovation and exporting by firm size and industry

Table 3.3 presents the number of innovators (Inn) and exporters (Exp) by business size, while Table 3.4 shows the percentage of such businesses by ANZSIC industry divisions. As expected, medium businesses (i.e. those employing between 20 and 199 persons) are disproportionately more likely to be innovators. For example, in 2004–05, medium businesses make up 23 per cent of the effective sample, but constitute 33 per cent of innovators. Moreover, 36 per cent of medium businesses, compared to 22 per cent of small businesses (i.e. those employing between 0 and 19 persons) report one or more type of innovation in the same year. This suggests the probability of innovation increases with business size. A similar trend is observed for exporting as well.

Table 3.3: Number of innovators and exporters by business size, BLD Panel One

Business size	*2004–05*		*2005–06*		*2006–07*		*2007–08*		*2008–09*	
	Inn	Exp	Inn	Exp	Inn	Exp	Inn	Exp	Inn	Exp
Non-employing	65	32	81	49	90	33	79	20	63	23
0–4 employees	158	92	225	117	170	96	174	67	162	63
5–19 employees	167	104	249	133	180	105	201	82	189	72
20–199 employees	193	159	271	165	207	147	227	124	216	115
Total	**583**	**387**	**826**	**464**	**647**	**381**	**681**	**293**	**630**	**273**

Source: Author's calculation based on data from the Business Longitudinal Database.

When viewed by industry, firms in the *Manufacturing* and *Wholesale Trade* industry divisions are most likely, respectively, to be innovators and exporters. It is unsurprising that goods producing industries (i.e. agriculture, mining and manufacturing) would top the list for exporting, but many smaller firms within these industries do not export directly. Rather, there are wholesalers that specialise in reselling agricultural, mining or manufactured goods abroad (Bernard et al. 2010). This is why, *Wholesale Trade* businesses appear to be most likely exporters in the sample. Businesses of the *Cultural & Recreational Services* division are a close second for their innovation likelihood; this may be because creativity is a key ingredient of the output of this industry. In addition, more than a third of businesses in most services industries identify themselves as innovators. Since most services are arguably less tradeable than goods, the exporter share for most services industries is relatively low.

Table 3.4: Percentage of innovators and exporters by industry, BLD Panel One

Industry divisons	*2004–05*		*2005–06*		*2006–07*		*2007–08*		*2008–09*	
	Inn	Exp	Inn	Exp	Inn	Exp	Inn	Exp	Inn	Exp
Agriculture, forestry, etc.	18.2	17.9	28.3	21.3	25.8	17.9	27.6	11.6	27.8	11.1
Mining	24.0	20.8	31.9	36.3	22.1	29.9	33.8	17.6	24.3	20.0
Manufacturing	29.8	27.0	45.6	27.2	47.7	27.6	48.7	29.3	46.5	29.1
Construction	21.3	3.3	29.1	1.8	27.2	7.8	35.4	5.2	33.3	6.5
Wholesale trade	27.6	28.9	46.3	40.2	36.5	31.5	44.8	34.8	43.8	31.4
Retail trade	25.0	7.9	46.3	12.5	31.2	12.0	44.2	13.3	40.4	9.6
Accommodation, cafes, etc.	28.1	5.9	36.4	18.6	25.0	13.7	36.8	8.5	39.6	11.9
Transport and storage	26.5	11.4	47.1	18.5	33.6	17.7	36.3	12.7	33.3	14.6
Communication services	26.6	17.4	46.6	25.2	36.6	23.7	43.0	17.4	48.1	22.2
Business services	28.1	15.6	35.8	15.8	27.7	20.5	40.6	10.4	41.6	10.1
Cultural services	31.4	11.6	49.5	17.8	38.8	10.2	44.4	14.4	48.3	9.0
Personal and other services	28.9	7.0	38.2	9.6	41.5	9.8	40.2	4.9	41.7	8.3

Source: Author's calculation based on data from the Business Longitudinal Database.

4. Empirical models and estimation issues

4.1 Exporting and innovation with simultaneity

In the dataset used in this paper, both exporting status (Exp_{it}) and innovation outcome (Inn_{it}) of firms are binary variables. If firm *i* exported in year *t* then Exp_{it} = 1, and 0 otherwise. Inn_{it} indicates whether firm *i* in year *t* introduced any new or significantly improved: (i) goods or services or (ii) operational processes or (iii) organisational/managerial processes or (iv) marketing methods. If firm *i* in year *t* reported the introduction of *any one of the four* then Inn_{it} = 1, and 0 otherwise.

Models for mutually exclusive binary outcomes focus on the determinants of the probability p of the occurrence of one outcome rather than an alternative outcome that occurs with a probability of 1 – p. Let p_{it}^{Exp} be the probability that firm *i* in year *t* is an exporter and p_{it}^{Inn} is the probability that firm *i* in year *t* is an innovator. Controlling for firm characteristics, this paper intends to quantify the impact on p_{it}^{Exp} of firm innovation outcome (Inn_{it}), and the impact on p_{it}^{Inn} of firm exporting status (Exp_{it}). In other words, whether innovation affects the likelihood that a firm is an exporter, and vice versa, are under investigation. As discussed earlier, there is no way of knowing a priori whether innovation drives exports or whether exporting stimulates innovation. Therefore, there are two primary models of interest.

Assume the following relationships to model exporting status (Exp_{it}) and innovation outcome (Inn_{it}) of firms.

$$Exp_{it} = f(Inn_{it}, Z_{it}^{Exp}) \quad (1)$$

$$Inn_{it} = g(Exp_{it}, Z_{it}^{Inn}) \quad (2)$$

Z_{it}^{Exp} and Z_{it}^{Inn} denote, respectively, the characteristics of exporting and innovating firm *i* in year *t*. Firm exporting status and innovation outcome are viewed as functions of each other along with other firm-level characteristics and exporting and innovation are modelled jointly (i.e. simultaneously).

In addition, four individual innovation outcome variables are defined: $Prod_{it}$ = 1 for goods or services innovation, Ops_{it} = 1 for operational process innovation, Org_{it} = 1 for organisational/managerial process innovation and Mkt_{it} = 1 for innovation in marketing methods by firm *i* in year *t*. Also, another variable to denote process innovation, $Proc_{it}$, is defined such that $Proc_{it}$ = 1 whenever Ops_{it} = 1 or Org_{it} = 1. These individual (types of) innovation indicators are used in the model in turn, instead of the overall innovation outcome (Inn_{it}). This allows the investigation of the relative importance of product versus process innovation when modelling the potential relationship between exporting and innovation.

4.2 Variable description

Table 4.1 lists the variables used in the econometric analysis.

Most firm-level studies report that firm size is one of the key firm characteristics that demonstrate considerable explanatory power in the analysis of firm-level activities (Bernard et al. 2007). Therefore, in order to control for firm size, two

dummy variables — $emp5\text{-}19_{it}$ and $emp20\text{-}199_{it}$ — are included in the regression equation.

Table 4.1: Descriptive statistics

Variables	*= 1 if firm i in year t:*	*mean (s.d.)*
Exp_{it}	exported	0.1835 (0.3871)
Inn_{it}	innovated	0.3436 (0.4749)
$multi_{it}$	operated in multiple locations	0.1637 (0.3700)
$home_{it}$	homebased business	0.3462 (0.4758)
$emp5–19_{it}$	employed 5–19 persons	0.2710 (0.4445)
$emp20–199_{it}$	employed 20–199 persons	0.1958 (0.3968)
$foreign_{it}$	foreign ownership	0.0415 (0.1995)
$franchise_{it}$	franchising agreement	0.0474 (0.2126)
$bf\_financial_{it}$	business focus on sales/profits	0.6809 (0.4661)
bf_cost_{it}	business focus on cost reduction	0.6304 (0.4827)
$bf\_operational_{it}$	business focus on operational efficiency	0.5145 (0.4998)
$bf\_quality_{it}$	business focus on product quality	0.6215 (0.4850)
bf_human_{it}	business focus on human resources	0.4540 (0.4979)
$Colla_{it}$	collaborated	0.1101 (0.3130)
inc_outs_{it}	increased investment in outsourcing	0.0743 (0.2623)
inc_emptr_{it}	increased investment in employee training	0.1133 (0.3170)
inc_IT_{it}	increased investment in IT	0.1825 (0.3863)
gov_assist_{it}	received assistance from government	0.1774 (0.3821)
$debt_{it}$	sought debt/equity finance	0.1971 (0.3978)
mkt_state_{it}	operated state-wide	0.4501 (0.4975)
mkt_nation_{it}	operated nationwide	0.3150 (0.4645)
$bband_{it}$	used broadband Internet	0.7001 (0.4583)
web_pr_{it}	had web presence	0.3455 (0.4756)
io_place_{it}	placed orders over Internet	0.3840 (0.4864)
$io\_receive_{it}$	received orders over Internet	0.2753 (0.4467)
Imp_{it}	imported	0.1021 (0.3029)

Source: Author's calculation based on data from the Business Longitudinal Database.

Since firm behaviour is governed by firm strategy, the empirical model includes variables denoting firm strategies. They indicate whether the business in question focused on the following from a moderate to a major extent when assessing the overall business performance: financial measures ($bf\_financial_{it}$), cost measures (bf_cost_{it}), operational measures ($bf\_operational_{it}$), quality measures ($bf\_quality_{it}$) and human resources (bf_human_{it}).

As documented in the *Australian Innovation Systems Report* (DIIS 2010), collaboration is an important determinant of innovation; to the extent that innovation and exporting are interrelated, collaboration is expected to impact them both directly and indirectly. $Colla_{it}$ indicates if firm *i* in year *t* was involved in

any collaborative arrangement (e.g. joint research and development, joint procurement, integrated supply chain, joint marketing or distribution or other cooperative arrangements).

Investments aimed at enhancing efficiency or increasing absorptive capacity play a key role in improving business competitiveness (Aw et al. 2007). As such, three dummy variables indicating if the firm in question increased *investment* compared to the previous year in: (i) outsourcing (inc_outs_{it}), (ii) employee training (inc_emptr_{it}), and (iii) information technology (IT) (inc_IT_{it}) are included in the analysis.

Both innovative activity and foreign market penetration involve initial and ongoing costs. Lack of own funds or lack of access to external finance to cover these costs can thus depress activity (Guariglia & Liu 2014, Brancati 2015). Hence, the empirical model controls for the availability or the necessity of external finance using two dummy variables indicating if firm *i* in year *t*: (i) received any financial assistance from Australian Government agencies (gov_assist_{it}) and (ii) sought any debt or equity finance ($debt_{it}$).

E-commerce is an important feature of doing business in the 21st century, especially in advanced countries. Thus four dummy variables are used to account for the e-commerce profile of firms: indicating whether broadband was the main type of Internet used ($bband_{it}$), if the business had a web presence (web_pr_{it}) and whether the business placed/received orders via the Internet (io_place_{it} and $io\_receive_{it}$).

When imported inputs are of higher quality or cheaper price or both, their use can be efficiency-improving. Moreover, imports are a vehicle for the inflow of foreign knowledge and technology (Grossman & Helpman 1991a). Hence, imports have the potential to impact both exporting and innovation. As such, an indicator of firm importing status (Imp_{it}) is included in the model. Additional dummy variables indicating whether the business: (i) operates in multiple locations ($multi_{it}$), (ii) is a homebased business ($home_{it}$), (iii) has some degree of foreign ownership ($foreign_{it}$), (iv) is involved in a franchising agreement ($franchise_{it}$), (v) operates outside the local area but within the state/territory (mkt_state_{it}) or nationwide (mkt_nation_{it}) are also included.

Finally, dummies for industry of activity and type of legal organisation — the only time-invariant firm characteristics in the dataset — are included as they may affect firm exporting status and/or innovation outcome. For example, goods-producing firms are more likely to export, while certain types of organisational structure may make it easier for firms to access credit.

4.3 Exporting and innovation with selection

Although the paper is concerned with the relationship between innovation and exporting, the dataset has both innovators and non-innovators as well as both exporters and non-exporters. Note that there are two decisions involved in the models described above — the choice to introduce new or improved products and/or processes and the decision to participate in export markets. While the two decisions may be simultaneous, the change of the expected value of the dependent variable(s), with respect to each regressor, has two components. One effect works by changing the probability that firm *i* in year *t* is, for example,

an exporter and the other by changing the probability that the firm in question is an innovator. This distinction is also important since the dataset has both exporters who are not innovators and innovators who are not exporters.

Therefore, it is reasonable to maintain that the explanatory variables may have different effects on the two choices firms face. Cragg (1971) proposed a two-stage specification which allows for the possibility that the 0 and 1 values of the binary choice variables of interest (i.e. exporting status and innovation outcome, in this case) are generated by different mechanisms. The first stage uses the whole set of data and models the probability of, for example, exporting conditional upon firm innovation behaviour. For the second stage, only the subset of firms that innovate are considered. However, the assumption underlying the author's specification is that the two stages — the decision to innovate and the decision to export — are independent of each other. This is a potential restriction on the model.

If the two stages are not independent, then the results of the second stage regression suffer from selection bias. Heckman's (1979) sample-selection model extends the model proposed by Cragg (1971) by relaxing the assumption that the two stages are independent. The basic idea of such a model is that the outcome variable is only observed if some criterion, defined with respect to a different set of variables, is met. The simplest form of such a model has two stages: in the first stage, a dichotomous variable (e.g. Inn_{it}) determines whether or not the outcome variable (e.g. Exp_{it}) is observed; Exp_{it} being observed only if $Inn_{it} = 1$. In the second stage, the expected value of Exp_{it} is modelled, conditional on it having been observed.

In order to allow for the dependence between the two decisions (i.e. whether to export and whether to innovate), the binomial probit with selection model (Van de Ven & Van Pragg 1981) is used. It assumes that there exists an underlying relationship

$y_j^* = \mathbf{x}_j\lambda + u_j$ (latent equation)

such that only the binary outcome is observed

$y_j^{\text{outcome}} = (y_j^* > 0)$ (outcome equation)

The dependent variable, however, is not always observed. Rather, the dependent variable for observation *j* is observed if

$y_j^{\text{selection}} = (\mathbf{z}_j\mu + v_j > 0)$ (selection equation)

where u_j and v_j are panel-level heteroskedastic and corr (u, v) = ρ. Note that y_j^{outcome} and $y_j^{\text{selection}}$ are distinct binary variables. When $\rho \neq 0$, standard probit techniques applied to the outcome equation yield biased results. The binomial probit with selection model provides consistent, asymptotically efficient estimates for all the parameters in such models. For the model to be well identified, the selection equation should have at least one variable that is not in the probit (outcome) equation.[14]

[14] Otherwise, the model is identified only by functional form, and the coefficients have no structural interpretation. The additional variable(s) in the selection equation should be such that can generate nontrivial variation in the selection variable but does not affect the outcome variable directly.

Also note that y_j^{outcome} (the outcome variable) and $y_j^{\text{selection}}$ (the selection variable) are not functions of each other. The selection variable determines whether the outcome variable is observed. Therefore, by using the binomial probit with selection model, the direct effect of, for example, firm innovation on the likelihood of exporting cannot be quantified; this is unlike the simultaneous equations model proposed in Section 4.1. Rather, the sample-selection model helps to identify whether the decision to export and the decision to innovate are independent, and, if not, which one of these two decisions depend on the other. Besides, the impact of other firm characteristics on innovation and exporting can be quantified using this model.

5. Results and discussion

5.1 Simultaneous equations model of exporting and innovation

The analysis proceeds with the following latent simultaneous equations framework (Ebling & Janz 1999), where several variables considered as potential determinants of exporting status are also thought to be impacting the innovation outcome of firms.

$$Exp_{it}^{*} = \alpha Inn_{it}^{*} + \beta' Z_{it}^{Exp} + \varepsilon_{it}^{Exp} \quad (1')$$

$$Inn_{it}^{*} = \gamma Exp_{it}^{*} + \delta' Z_{it}^{Inn} + \varepsilon_{it}^{Inn} \quad (2')$$

Exp_{it}^{*} and Inn_{it}^{*} are underlying continuous unobservable (or latent) variables that satisfy models (1′) and (2′). While Exp_{it}^{*} and Inn_{it}^{*} are not observed, the following binary variables are observed:

$$Exp_{it} = \begin{cases} 1 \text{ if } Exp_{it}^{*} > 0 \\ 0 \text{ if } Exp_{it}^{*} \leq 0 \end{cases}$$

$$Inn_{it} = \begin{cases} 1 \text{ if } Inn_{it}^{*} > 0 \\ 0 \text{ if } Inn_{it}^{*} \leq 0 \end{cases}$$

Z_{it}^{Exp} and Z_{it}^{Inn} are column vectors of firm characteristics; they also include dummies for industries and years and a constant. It is assumed that firm exporting status and innovation outcome directly depend on each other (simultaneity), and that ε_{it}^{Exp} and ε_{it}^{Inn} are contemporaneously correlated and panel-level heteroskedastic. Note that both ε_{it}^{Exp} and ε_{it}^{Inn} may be decomposed into deterministic and stochastic components: (i) firm-specific, time-invariant unobserved heterogeneity that may influence firm behaviour and (ii) unobserved time-varying random shocks.

Nonlinear seemingly unrelated regression model is used to fit equations (1′) and (2′) simultaneously. This model fits a system of nonlinear equations by feasible generalized nonlinear least squares (FGNLS). It can be viewed as a nonlinear variant of Zellner's seemingly unrelated regression model (Zellner 1962, Zellner

& Huang 1962, Zellner 1963), and is therefore commonly called nonlinear SUR or nonlinear SURE.[15] Since, by assumption, ε_{it}^{Exp} and ε_{it}^{Inn} are correlated, fitting the two equations jointly leads to more efficient estimates.

Results of the simultaneous equations model indicate that both exporting (Exp_{it}) and innovation (Inn_{it}) have a statistically significant positive effect on each other. Coefficient estimates, presented in Table 5.1, show that, overall, innovation increases the probability of selling abroad by 5 per cent. On the other hand, relative to non-exporters, exporting businesses are 10 per cent more likely to introduce new or significantly improved products or processes. In both directions, product innovation ($Prod_{it}$) is associated with a larger impact than process innovation ($Proc_{it}$).[16]

Businesses with some degree of foreign ownership ($foreign_{it}$), as well as businesses that import (Imp_{it}), are much more likely to be exporters. Relative to wholly domestically owned businesses, firms with foreign ownership are 22 per cent more likely to be exporters. It is unclear, however, whether foreign ownership increases business export capability (e.g. by making businesses knowledgeable about foreign markets)[17] or whether businesses with greater export potential (e.g. firms with higher-than-average productivity levels) are more able to attract foreign capital. Moreover, foreign ownership is associated with higher likelihood of introducing new or significantly improved organisational/managerial processes, but has no impact on other types of innovation or innovation in general.

Relative to non-importers, importers are around 19 per cent more likely to be exporters. That importing is a strong, positive determinant of exporting suggests that businesses use imported inputs for export production; hence import protection can be counterproductive to export promotion. Moreover, firm importing status has a statistically significant positive impact only on product innovation, but no impact on innovation in general or other types of innovation.

Turning to various firm strategies, we find that the two decisions of interest (i.e. whether to export and whether to innovate) are determined by distinct strategies. Business focus on financial indicators has a statistically significant effect on the probability of exporting. On the other hand, business focus on operational and quality indicators as well as on human resources increases innovation likelihood.

Collaboration ($Colla_{it}$) is a statistically significant positive predictor of both firm exporting status and innovation outcome. Businesses that are involved in some form of collaborative arrangements (e.g. joint R&D, integrated supply chain, etc.) are 5 per cent more likely to export, and over 10 per cent more likely to innovate. Depending on the type of innovation, the effect of collaboration on innovation probability varies between 7 and 11 per cent. In addition, firms that increase outsourcing, employee training and information technology (IT) expenditure (denoted, respectively, by inc_outs_{it}, inc_emptr_{it} and inc_IT_{it}) relative to previous

[15] Stata's *nlsur* command is used to implement the model. In this case, the estimated coefficients denote the marginal change in the probability of an outcome of the dependent variable due to a change in explanatory variables from 0 to 1.

[16] These results are in line with those reported in, for example, Caldera (2010), Becker & Egger (2013), Salomon & Shaver (2005) and Damijan et al. (2010).

[17] This would be plausible if export destinations of a business were the same as the origins of its foreign ownership. Lack of such information, however, prevents further investigation along this line.

year are more likely to innovate; the impact on process innovation probability is particularly large — 10, 13 and 17 per cent respectively (see Table 5.1).

Table 5.1: Results of nonlinear seemingly unrelated regression

Explanatory variables	*Dependent variables Simultaneous equations set 1*		*Dependent variables Simultaneous equations set 2*		*Dependent variables Simultaneous equations set 3*	
	Exp_{it}	Inn_{it}	Exp_{it}	$Prod_{it}$	Exp_{it}	$Proc_{it}$
Exp_{it}		0.1038		0.1064		0.0737
		(0.000)		(0.000)		(0.000)
Inn_{it} / $Prod_{it}$ / $Proc_{it}$	0.0541		0.0789		0.0429	
	(0.000)		(0.000)		(0.000)	
$multi_{it}$	0.0186	0.0172	0.0199	–0.0054	0.0190	0.0143
	(0.260)	(0.348)	(0.231)	(0.741)	(0.251)	(0.422)
$home_{it}$	–0.0063	–0.0187	–0.0062	–0.0137	–0.0067	–0.0135
	(0.591)	(0.198)	(0.595)	(0.248)	(0.565)	(0.288)
$emp5\text{-}19_{it}$	–0.0150	0.0240	–0.0138	0.0014	–0.0155	0.0392
	(0.293)	(0.151)	(0.335)	(0.918)	(0.279)	(0.010)
$emp20\text{-}199_{it}$	–0.0189	0.0355	–0.0138	–0.0390	–0.0194	0.0539
	(0.330)	(0.106)	(0.476)	(0.045)	(0.319)	(0.009)
$foreign_{it}$	0.2267	–0.0378	0.2282	–0.0526	0.2240	0.0266
	(0.000)	(0.231)	(0.000)	(0.121)	(0.000)	(0.424)
$franchise_{it}$	–0.0249	0.0098	–0.0267	0.0304	–0.0245	0.0000
	(0.204)	(0.790)	(0.172)	(0.330)	(0.209)	(0.999)
$bf\_financial_{it}$	0.0310	0.0053	0.0319	–0.0087	0.0314	–0.0023
	(0.019)	(0.749)	(0.016)	(0.514)	(0.017)	(0.877)
bf_cost_{it}	–0.0306	0.0247	–0.0306	0.0186	–0.0294	0.0012
	(0.017)	(0.131)	(0.017)	(0.179)	(0.022)	(0.936)
$bf\_operational_{it}$	–0.0177	0.0321	–0.0156	–0.0030	–0.0178	0.0414
	(0.139)	(0.032)	(0.191)	(0.818)	(0.136)	(0.004)
$bf\_quality_{it}$	0.0029	0.0651	0.0034	0.0386	0.0047	0.0373
	(0.815)	(0.000)	(0.783)	(0.002)	(0.697)	(0.010)
bf_human_{it}	0.0058	0.0463	0.0065	0.0230	0.0053	0.0687
	(0.583)	(0.001)	(0.537)	(0.057)	(0.614)	(0.000)
$Colla_{it}$	0.0498	0.1087	0.0482	0.0925	0.0512	0.1081
	(0.004)	(0.000)	(0.005)	(0.000)	(0.003)	(0.000)
inc_outs_{it}	0.0061	0.0904	0.0056	0.0698	0.0064	0.1021
	(0.727)	(0.000)	(0.750)	(0.001)	(0.715)	(0.000)
inc_emptr_{it}	–0.0432	0.1124	–0.0444	0.0952	–0.0431	0.1334
	(0.005)	(0.000)	(0.004)	(0.000)	(0.005)	(0.000)
inc_IT_{it}	–0.0060	0.1614	–0.0032	0.0765	–0.0046	0.1683
	(0.648)	(0.000)	(0.806)	(0.000)	(0.725)	(0.000)
gov_assist_{it}	0.0440	0.0210	0.0442	0.0107	0.0437	0.0372
	(0.001)	(0.174)	(0.001)	(0.439)	(0.001)	(0.013)
$debt_{it}$	–0.0017	0.1142	0.0004	0.0528	0.0001	0.1015
	(0.891)	(0.000)	(0.977)	(0.000)	(0.991)	(0.000)
mkt_state_{it}	0.0050	0.0207	0.0061	0.0006	0.0055	0.0159
	(0.619)	(0.100)	(0.546)	(0.957)	(0.589)	(0.171)
mkt_nation_{it}	0.1873	0.0443	0.1874	0.0232	0.1891	0.0238
	(0.000)	(0.004)	(0.000)	(0.071)	(0.000)	(0.097)
$bband_{it}$	–0.0078	0.0134	–0.0065	–0.0066	–0.0068	–0.0064
	(0.438)	(0.322)	(0.516)	(0.544)	(0.499)	(0.606)
web_pr_{it}	0.0744	0.0792	0.0759	0.0328	0.0771	0.0415
	(0.000)	(0.000)	(0.000)	(0.026)	(0.000)	(0.009)
io_place_{it}	–0.0098	0.0770	–0.0082	0.0335	–0.0091	0.0797
	(0.402)	(0.000)	(0.482)	(0.008)	(0.436)	(0.000)
$io\_receive_{it}$	0.0472	0.0331	0.0439	0.0628	0.0483	0.0192
	(0.001)	(0.043)	(0.001)	(0.000)	(0.000)	(0.222)
Imp_{it}	0.1886	0.0220	0.1831	0.0774	0.1899	0.0075
	(0.000)	(0.386)	(0.000)	(0.001)	(0.000)	(0.758)
constant	–0.0414	0.1175	–0.0421	0.0915	–0.0373	0.0466
	(0.035)	(0.000)	(0.033)	(0.001)	(0.058)	(0.091)
Observations	7,200	7,200	7,200	7,200	7,200	7,200
R-sq	0.2428	0.2319	0.2428	0.1378	0.2429	0.2191

Note: Coefficients are marginal effects; p-values in parentheses. Regression equations include industry, year and type of organisation dummies.

Source: Author's estimation based on the econometric methodology detailed in Section 4.1

Businesses that receive some form of financial assistance from Australian Government organisations (denoted by $govt\_assist_{it}$) are 4 per cent more likely to be exporters. As reported earlier, there is indirect evidence that the initial cost firms have to incur when starting to export can be prohibitive for small and medium businesses. Combining these two results, it may be argued that government assistance is useful in covering, albeit partially, the sunk cost of breaking into foreign markets.

Firms seeking external finance ($debt_{it}$) of some form are, depending on the type of innovation, between 5 and 11 per cent more likely to be innovative.[18] This result implies that innovative activity is costly, and hence demands external funding. Note that SMEs generally are less creditworthy, lack collateral and face higher interest rates for their business borrowing (Matic, Gorajek & Stewart 2012). Hence, it may be argued that policy solutions to ease SME access to finance may boost their innovative activity.

Firm geographic span of operation is positively correlated with its exporting status and innovation outcome. Relative to businesses that operate only within the local area (i.e. immediate area, town or city) of its primary establishment, those operating nationwide (mkt_nation_{it}) are 19 per cent more likely to be exporters and 4 per cent more likely to be innovators. Firms operating over a larger geographic area are likely to be larger in size (e.g. by employment or by sales, etc.). This may be the reason why the coefficients of $emp5\text{-}19_{it}$ and $emp20\text{-}199_{it}$ (variables indicating business size by number of employees) turned out to be insignificant.[19] However, the coefficients of business size indicators ($emp5\text{-}19_{it}$ and $emp20\text{-}199_{it}$) vis-à-vis those of geographic span of operation indicators (mkt_state_{it} and mkt_nation_{it}) remain unchanged when they are dropped (in group) alternately.

Firm e-commerce characteristics are important in explaining both exporting status and innovation outcome. Web presence (i.e. having a website, denoted by web_pr_{it}) increases the likelihood, by about 7 per cent, of both exporting and innovation. Businesses that place orders via the Internet (io_place_{it}) increase their chances of innovating. This impact is larger for process innovation than product innovation. In contrast, businesses receiving orders via the Internet ($io\_receive_{it}$) are about 4 per cent more likely to be exporters.

Other variables in equations of firm exporting status and innovation outcome turned out to be statistically insignificant. However, even the variables that are significant in neither equation generally have expected signs. For example, businesses operating in multiple locations are thought to be larger in size, and hence more likely to both export and innovate. The variable denoting this characteristic ($multi_{it}$) has generally a positive sign in both equations. In contrast, homebased businesses ($home_{it}$), assuming they are smaller in size, would be less likely to export or innovate; the coefficient of $home_{it}$ is negative in both equations. In addition, businesses involved in a franchising agreement ($franchise_{it}$) are more domestically focused, but part of older principals; hence such businesses are less likely to be exporters, but more likely to innovative; the

[18] Similar results are obtained when this variable is replaced with an indicator of whether firms received (as opposed to sought) external finance.

[19] Recall that $emp5\text{-}19_{it}$ and $emp20\text{-}199_{it}$ indicate, respectively, whether firm *i* in year *t* employed 5–19 or 20–199 employees.

coefficient of $franchise_{it}$ is negative in Exp_{it} equation and positive in Inn_{it} equation.

5.2 Maximum-likelihood probit models of exporting and innovation with selection

Since the particular nature of the relationship that may exist in the dataset between firm exporting status and innovation outcome is unknown a priori, both Exp_{it} and Inn_{it} are used in turn as the outcome variable (y_j^{outcome}), so the corresponding selection variables ($y_j^{\text{selection}}$) are Inn_{it} and Exp_{it}, respectively.

When Exp_{it} is the outcome variable, excluded from the outcome (probit) equation are the variables denoting business: (i) firm *strategy* to focus on operational and quality measures as well as human resources, (ii) firm *investment* in outsourcing, employee training and information technology, (iii) whether the firm in question sought any *external finance* in the form of debt or equity and (iv) if the firm placed orders via the Internet. The selection equation, with Inn_{it} as the selection variable, includes all variables.

In contrast, when Inn_{it} is the outcome variable, the following variables are excluded from the outcome (probit) equation: (i) *foreign* ownership status, (ii) involvement in a *franchising* agreement, (iii) firm *strategy* to focus on financial and cost measures, (iv) whether the firm in question received any *external finance* in the form of financial assistance from Australian Government agencies and (v) if the firm is an *importer*. The selection equation, with Exp_{it} as the selection variable in this case, includes all variables.

These exclusion restrictions follow from the results of the simultaneous equations model of exporting and innovation (discussed in Section 5.1). The variables that are consistently insignificant in the exporting equation are left out from the outcome equation when Exp_{it} is the outcome variable, and similarly when Inn_{it} is the outcome variable.

Results of the binomial probit with selection models indicate that exporting firms self-select into innovative activity, but not the other way around. A number of explanations exist for this finding. First, competitive pressures associated with trade likely induce firms to introduce new or significantly improved products or processes in order to stay in business. In other words, innovation is a survival response to trade-related competition; without such a response, firms risk being competed out of market. Second, exporting firms, especially persistent ones, are likely to be older and larger than the average firm in the sample. Hence, these firms are capable of taking up expenditure required for innovation; such capability then naturally leads to their selection into innovative activity. Third, internationally trading firms interact with other traders — including foreign buyers, suppliers and producers — around the world. Firms engaged in international trade thus benefit from the learning effects of such interactive exchanges. These firms have better access to foreign market intelligence (e.g. changing patterns of demand, and determinants of such changes), foreign technology and foreign inputs — which are vital ingredients of successful innovation.

In contrast, while innovative firms are more likely to be exporters (as discussed in Section 5.1), export market participation is not critically dependent on firm

innovation outcome. Results presented in Table 5.2, with exporting and innovation as the outcome and the selection variables, respectively, show the null hypothesis that the decision to export is independent of the decision to innovate (i.e. $\rho = 0$, see Section 4.3) cannot be rejected.[20] However, the modelling of innovation outcomes of exporters only (whereas innovation and exporting are the outcome and the selection variables, respectively) shows that exporters systematically differ from non-exporters regarding the decision to innovate.

As seen in Table 5.3, a Wald test of the null hypothesis that the decision to innovate (outcome) is independent of the decision to export (selection) is strongly rejected. The marginal effects of various firm characteristics on firm innovation outcome are broadly similar to what is found in simultaneous equations models of exporting and innovation. With the exception of firm strategy to focus on the operational or quality measures and the online order receipt status, a similar set of firm characteristics turn out to be significant in explaining firm innovation outcome in both modelling schemes. However, in the latter case of a binomial probit with selection model, where the sample consists of exporters only, the marginal effects are generally larger by a few percentage points. For example, in the full sample, collaboration is associated with a nearly 11 per cent higher likelihood of innovation; but when the sample is restricted to exporters only, the marginal effect of collaboration on innovation jumps to about 13 per cent.

Nevertheless, certain differences between the two modelling schemes emerge in terms of the significant predictors of the innovation probability when product and process innovation are observed separately.[21] For example, business focus on product quality has a statistically significant positive impact on product innovation outcome when it is modelled using the simultaneous equations framework, but not when sample selection model is used. Similarly, business focus on human resources is a significant determinant of product innovation in sample selection, but not in simultaneous equations, model. Certain variables (e.g. foreign ownership status) with no impact on innovation in simultaneous equations framework turn out to be significant in sample selection models. Such variables must, therefore, impact on innovation outcome through their direct effect on firm exporting status. For individual types of innovation, generally fewer firm characteristics appear to be statistically significant in sample selection models than in simultaneous equations models.

[20] In this scheme, only the innovative firms can be observed for the purpose of modelling the firm export behaviour based on the variables included in the exporting equation.
[21] Detail results not presented here, but may be obtained from author.

Table 5.2: Results of the binomial probit with selection model, export status is the outcome and innovation is the selection variable

Explanatory variables	*Dependent variables*		$z = Pr(Exp_{it} = 1 \mid Inn_{it} = 1)$
	$y_j^{outcome} = Exp_{it}$	$y_j^{selection} = Inn_{it}$	*dz/dx*
$multi_{it}$	0.1266 (0.185)	0.0533 (0.337)	0.0229 (0.223)
$home_{it}$	–0.0727 (0.500)	–0.0617 (0.203)	–0.0118 (0.528)
$emp5\text{-}19_{it}$	–0.0426 (0.692)	0.0762 (0.136)	–0.0086 (0.640)
$emp20\text{-}199_{it}$	–0.2278 (0.065)	0.0909 (0.165)	–0.0383 (0.036)
$foreign_{it}$	0.7755 (0.000)	–0.0245 (0.814)	0.2040 (0.000)
$franchise_{it}$	–0.4547 (0.013)	0.0176 (0.868)	–0.0617 (0.001)
$bf\_financial_{it}$	0.2602 (0.028)	0.0409 (0.454)	0.0429 (0.018)
bf_cost_{it}	–0.1520 (0.124)	0.0735 (0.157)	–0.0290 (0.120)
$bf\_operational_{it}$		0.0926 (0.043)	–0.0014 (0.456)
$bf\_quality_{it}$		0.2392 (0.000)	–0.0037 (0.408)
bf_human_{it}		0.1406 (0.001)	–0.0021 (0.397)
$Colla_{it}$	0.2237 (0.016)	0.3357 (0.000)	0.0384 (0.043)
inc_outs_{it}		0.2917 (0.000)	–0.0042 (0.389)
inc_emptr_{it}		0.3243 (0.000)	–0.0047 (0.405)
inc_IT_{it}		0.4621 (0.000)	–0.0066 (0.387)
gov_assist_{it}	0.3211 (0.000)	0.0851 (0.074)	0.0630 (0.001)
$debt_{it}$		0.3465 (0.000)	–0.0050 (0.394)
mkt_state_{it}	0.0946 (0.221)	0.0796 (0.045)	0.0157 (0.244)
mkt_nation_{it}	0.9445 (0.000)	0.1937 (0.000)	0.2042 (0.000)
$bband_{it}$	0.1062 (0.355)	0.0618 (0.184)	0.0175 (0.365)
web_pr_{it}	0.3909 (0.000)	0.2426 (0.000)	0.0705 (0.000)
io_place_{it}		0.2278 (0.000)	–0.0034 (0.407)
$io\_receive_{it}$	0.1650 (0.036)	0.1135 (0.019)	0.0289 (0.053)
Imp_{it}	0.6138 (0.000)	0.1107 (0.144)	0.1418 (0.000)
constant	–2.5136 (0.000)	–1.1930 (0.000)	
Censored/total obs		4,454/7,200	
Wald test of the overall model: chi2(32) = 404.08, Prob > chi2 = 0.0000			
Wald test of independent equations ($\rho = 0$): chi2(1) = 0.84, Prob > chi2 = 0.3600			

Notes: The right-most column shows the marginal effects; p-values in parentheses. Regression equations include industry, year and type of organisation dummies.

Source: Author's estimation based on the econometric methodology detailed in Section 4.3

Table 5.3: Results of the binomial probit with selection model, innovation is the outcome and export status is the selection variable

Explanatory variables	*Dependent variables*		$z = Pr(Inn_{it} = 1 \mid Exp_{it} = 1)$
	$y_j^{outcome} = Inn_{it}$	$y_j^{selection} = Exp_{it}$	*dz/dx*
$multi_{it}$	0.0421 (0.717)	0.0994 (0.177)	0.0308 (0.506)
$home_{it}$	–0.0715 (0.589)	–0.0565 (0.425)	–0.0372 (0.482)
$emp5\text{-}19_{it}$	0.1198 (0.350)	–0.0719 (0.351)	0.0406 (0.447)
$emp20\text{-}199_{it}$	0.0142 (0.918)	–0.1171 (0.210)	–0.0096 (0.871)
$foreign_{it}$		0.6970 (0.000)	0.0890 (0.089)
$franchise_{it}$		–0.2072 (0.165)	–0.0275 (0.318)
$bf\_financial_{it}$		0.1984 (0.011)	0.0263 (0.198)
bf_cost_{it}		–0.1499 (0.039)	–0.0198 (0.147)
$bf\_operational_{it}$	0.0898 (0.395)	–0.0633 (0.319)	0.0291 (0.502)
$bf\_quality_{it}$	0.1372 (0.242)	–0.0069 (0.919)	0.0560 (0.244)
bf_human_{it}	0.2734 (0.011)	0.0425 (0.431)	0.1194 (0.005)
$Colla_{it}$	0.2361 (0.070)	0.2566 (0.000)	0.1334 (0.007)
inc_outs_{it}	0.3439 (0.025)	0.0809 (0.303)	0.1559 (0.013)
inc_emptr_{it}	0.5333 (0.000)	–0.1378 (0.075)	0.2059 (0.001)
inc_IT_{it}	0.4761 (0.000)	0.0243 (0.693)	0.2033 (0.000)
gov_assist_{it}		0.2388 (0.000)	0.0314 (0.155)
$debt_{it}$	0.3300 (0.001)	0.0287 (0.616)	0.1428 (0.001)
mkt_state_{it}	0.1419 (0.147)	0.0296 (0.574)	0.0631 (0.117)
mkt_nation_{it}	0.0144 (0.940)	0.8404 (0.000)	0.1151 (0.012)
$bband_{it}$	0.0936 (0.520)	–0.0060 (0.928)	0.0380 (0.519)
web_pr_{it}	0.1047 (0.473)	0.4100 (0.000)	0.0978 (0.042)
io_place_{it}	0.2385 (0.024)	–0.0077 (0.899)	0.0986 (0.022)
$io\_receive_{it}$	–0.1164 (0.304)	0.2234 (0.000)	–0.0191 (0.671)
Imp_{it}		0.5827 (0.000)	0.0753 (0.112)
constant	0.2880 (0.644)	–2.2888 (0.000)	
All dummies	Yes	Yes	
Censored/total obs		6,099/7,200	
Wald test of the overall model: chi2(32) = 156.33, Prob > chi2 = 0.0000			
Wald test of independent equations ($\rho = 0$): chi2(1) = 4.13, Prob > chi2 = 0.0420			

Notes: The right-most column shows the marginal effects; p-values in parentheses. Regression equations include industry, year and type of organisation dummies.

Source: Author's estimation based on the econometric methodology detailed in Section 4.3

5.3 Sensitivity analysis

In order to check the robustness of the results, presented in Sections 5.1 and 5.2, a number of alternative schemes are implemented. First, both simultaneous equations and selection models are implemented using a proxy variable for innovation. Business focus on (self) innovation performance from a moderate to a major extent when assessing the overall business performance is used as a proxy for actual innovation outcome (Inn_{it}). The results obtained using the

innovation proxy are generally stronger (i.e. coefficient estimates are statistically more significant and larger in magnitude) than those derived using Inn_{it}.

Moreover, alternative indicators of exporting status can be used since the survey on which the data is based has a number of alternative questions that attempt to pick up firm exporting status. For example, in one question, businesses are asked if they received any income from the export of goods or services.[22] In another question, businesses are asked if, compared to the previous year, export markets targeted decreased, stayed the same or increased. In yet another question, businesses are asked if it operated in overseas markets. The responses to these questions are coded to indicate firm exporting status. Finally, the database includes the numeric indicators of export sales in ranges sourced from the Customs as well as the nominal values of exports sourced from the ATO's Business Activity Statement. These latter variables can also be used to distinguish exporters from non-exporters. The aforementioned indicators of exporting are used alternately in the suite of regression equations, but the patterns of the core results remain broadly unchanged.

Second, the default standard errors are adjusted to account for unknown forms of heteroskedasticity and some kinds of model misspecification as well as intragroup (i.e. intrafirm) correlation (clustering).[23] Allowing for clustering of errors around groups (firms) is an alternative approach to deal with firm unobserved heterogeneity since it accounts for the fact that observations for the same firm are related over time (Greenaway et al. 2007). Robust and clustered standard errors are larger than unadjusted errors, and hence fewer variables are statistically significant when standard errors are adjusted.

Third, in order to confirm the results obtained from the nonlinear seemingly unrelated regressions, the same equations are re-estimated using the seemingly unrelated bivariate probit models.[24] The sign and the statistical significance of the coefficients remain broadly similar across the two estimators, although the magnitude of the marginal effects differ slightly for most explanatory variables.

Fourth, equations (1′) and (2′) are estimated separately (i.e. not as simultaneous equations) using random-effects probit models, which is a standard technique for estimating binary choice models with unobserved firm heterogeneity (Roberts & Tybout 1997). Results from estimating the two equations independently concur with those obtained from estimating them interdependently. Both innovation and exporting are statistically significant determinants of, respectively, exporting and innovation. In addition, similar firm characteristics turn out to be statistically significant in exporting/innovation equations in both standalone probit and simultaneous equations models. However, marginal effects resulting from independent probit equations are larger in magnitude than those obtained from simultaneous equations. This is not unexpected, since the use of the random effects probit results in biased estimates if the firm-specific component of the error term is correlated with the regressors. It is plausible that unobserved firm-specific characteristics (e.g. management capability) may be correlated with certain regressors (e.g. collaboration, investment in skills and IT,

[22] This is the preferred measure of exporting status used in this paper.
[23] The former type that correct the default standard errors for heteroscedasticity and model misspecification are known as robust standard errors, while the latter type is known as clustered standard errors.
[24] Results not presented here, but may be obtained from author.

business focus on human resources, etc.), and thereby biasing the random-effects probit results. The probit models, nevertheless, remain attractive for the purpose of preliminary analysis.

Fifth, marginal effects remain unaffected by the removal of time dummies (year-specific common effects on all firms) that control for macro effects, such as aggregate exchange rate effects in the data as well as any other macroeconomic shifts. This is expected, given that none of the four year dummies is statistically significant in any equation. Finally, only one or two of the dummies included for ANZSIC industry divisions appear highly significant.[25] For example, firms of *Agriculture, forestry & fishing* and *Manufacturing* industry divisions are, respectively, 8 and 7 per cent more likely to be exporters; while firms from *Mining* industry division are 16 per cent less likely to be innovators.[26] These results are statistically significant at 1 per cent or below. As such, marginal effects of firm characteristics on firm innovation outcome and exporting status do not change due to the exclusion/inclusion of industry dummies into regression equations.

Sixth, the marginal effects of the main regressors of interest (i.e. innovation in exporting equation and exporting in innovation equation) remain positive and statistically significant even when lagged regressors as well as lagged dependent variables are controlled for. For example, firm innovation outcome (Inn_{it}) remains a positive and significant predictor of firm exporting status (Exp_{it}) in the presence of past innovation outcome (Inn_{it-1}) as well as past exporting status (Exp_{it-1}) as regressors. Similar results are obtained for the innovation equations. Although some studies (e.g. Salomon & Shaver 2005; Caldera 2010) use the lagged dependent variable as a regressor, this paper is less inclined to do so.

In the case of a fairly long time series, a lagged dependent variable can help to counteract the serial correlation the residual usually suffers from. However, the panel data set used for the purpose of this research has only five years of data. Therefore, residual correlation over time is not a major concern. Moreover, it is hard to argue against potential endogeneity when the lagged dependent variable is a regressor. Hence, it is argued that the cost of using the lagged dependent variable as a regressor outweighs the benefits of doing so.

5.4 Limitations

While trade and growth theories predict mutual causation of innovation and exports, this paper does not attempt to establish causality between exporting and innovation. Some researchers use lagged indicators of innovation (e.g. Caldera 2010) or exporting (e.g. Salomon & Shaver 2005) as instrumental variables to infer their causal influence on, respectively, firm exporting status or innovation outcome. While lagging potentially endogenous regressors resolves one form of endogeneity (simultaneity), it remains inadequate in addressing more entrenched forms of endogeneity. For instance, if past exporting status is a significant determinant of the current exporting status (i.e. persistence in export behaviour, as is widely documented in the extant literature on internationally

[25] The dummies are meant to control for differences across industry divisions in terms of product markets, technology, demand characteristics and common industry-specific effects.
[26] These probabilities are relative to a typical firm of *Personal & Other Services* industry division.

trading firms) and if innovation and exporting are contemporaneously correlated, then past exporting will be correlated with past innovation outcome. In such cases, the using of the lagged innovation indicator as a regressor to explain the variation in firm exporting status does not appear to 'cure' the dependence of innovation on exporting.

For reasons discussed above, neither lagged firm behaviour nor a lagged dependent variable is used as regressors for the main equations. Such choice of specification limits this paper from exploring the dynamics and evolution of the potential interrelationships between the decisions to innovate and export. Moreover, the empirical analysis does not take into account the persistence of exporting or innovation. Therefore, results of this paper cannot be used to comment on the path-dependence (i.e. the effect of past behaviour on the current outcome) of the processes of innovation or foreign market participation. In addition, although the analysis controls for unobserved firm heterogeneity, it is not possible to rule out the possibility that the results may still suffer from omitted variable bias.

Most regressions discussed in this paper use categorical data items only. This particular characteristic of the data set limits the range of econometric techniques that can be applied to examine the key relationships of interest. Moreover, controlling for endogeneity is less straightforward when the endogenous regressors, besides the dependent variable, are also categorical variables (Carrasco 2001). Nevertheless, fitted values of the endogenous regressors (e.g. Exp_{it} when Inn_{it} is the dependent variable, and vice versa), generated by instrumenting them appropriately, are used in a seemingly unrelated bivariate probit model (as mentioned in Section 5.3) in order to check the robustness of the coefficient estimates obtained using the nonlinear seemingly unrelated regression model.

Several researchers (e.g. Basile 2001, Roper & Love 2002) examine if innovation increases export propensity (i.e. export sales as a share of total sales), since it is argued that innovation, through its direct impact on firm competitiveness, can help to increase the foreign market share enjoyed by exporters. However, the relationship between innovation and export propensity is outside the scope of this paper.[27]

Even though the results of the binomial probit models of exporting and innovation with selection are consistent with the learning-by-exporting hypothesis, the presence of some common processes impacting both exporting and innovation simultaneously could undermine this finding. For instance, if an omitted variable such as market growth induces firms both to export and innovate, then the correlation between exporting and innovation could be deemed spurious.

Likewise, if domestic spillovers are more prevalent than international spillovers for this set of firms, and the former increase concurrently with export activity, then there is a risk of misinterpreting increased innovation as evidence of

[27] Exporting entails two decisions—whether to export and, if so, then how much to export. The primary focus of this paper is on modelling the first of these two decisions. This is because, for small and medium businesses, breaking into foreign markets (by incurring the sunk cost associated with it) is presumed to be more difficult than increasing the amount exported relative to total output. Moreover, arguably, it is the SMEs that need government assistance for their initial penetration of foreign markets. Hence, the former decision is of greater policy interest.

learning from foreign markets rather than a result of domestic spillovers (Salomon & Shaver 2005). Yet again, if competitive pressures associated with foreign market participation induce investment in absorptive capacity (in order to better exploit foreign knowledge), then innovation outcome would be more directly impacted by such investments rather than exporting per se.

Although the existence of an underlying latent variable as an alternative explanation cannot be dismissed, steps are taken to mitigate the potential for this type of spurious relation by controlling for unobserved firm heterogeneity, by considering the effect of different lagged values of the focal independent variable, and by employing an estimator that can accommodate predetermined regressors.

6. Conclusion

Economic theories of international trade and economic growth predict a two-way relationship between innovation and exports. Several researchers, however, have only studied the effect of innovation on export activity. This is perhaps due to a relative scarcity of evidence in favour of the learning-by-exporting hypothesis. Nevertheless, some recent papers attempt to examine how international trade may affect firm innovation behaviour, and find that exports have a positive and statistically significant effect on innovation. This is taken as the evidence of learning feedback flowing from export destinations to exporters, although competitive pressures associated with trade should also force firms to be more innovative. It is argued in these two strands of literature that while innovation-driven productivity growth leads the decision to export, knowledge and competition effects of foreign market participation in turn reinforce the observed pattern of heterogeneity in firm attributes (productivity) and firm behaviour.

While both innovation and export performance of firms are at the forefront of policy interest, few studies have examined the existence of potential simultaneity in their relationship using firm-level data. Allowing for the joint determination of firm innovation outcome and export status, this research aims to quantify the impact of innovation on the probability of exporting, and vice versa. In doing so, a wide range of firm characteristics, including firm investment in outsourcing, employee training and information technology (IT), are controlled for. Other novelties of the paper include explicitly accounting for firm strategy aimed at improving firm performance as well as their e-commerce profile. This paper also explores if the innovation–exporting relationship varies by type of innovation (product vs. process).

Results of the econometric analysis show that the decisions to innovate and export are interrelated: innovative firms are 4–8 per cent more likely to be exporters, while exporting increases the probability of introducing new or significantly improved products/processes by 7–10 per cent. The impact of product innovation is larger in magnitude than other types of innovation. Larger and collaborating firms with web presence are more likely to both innovate and export. Business focus on the improvement of product quality and human resources positively affects firm innovation outcome. Investment in outsourcing,

worker training and IT capital are significant determinants of the probability to innovate. Firms that are partly owned by foreigners, that receive government assistance, that receive orders over the Internet, and that import are more likely to be exporters. In addition, firms seeking external finance are statistically more likely to be innovators — suggesting small and medium businesses lack own financial resources required to invest in innovative activity. These findings are robust to a number of alternative specifications as well as alternative indicators of innovative and exporting activities.

The majority of the existing empirical research do not account for the endogeneity of both innovation and exporting at the same time, and ignore the possibility that firms may self-select, owing to prior decisions and characteristics, into one activity or the other. This paper, however, reveals the presence of a selection mechanism whereby exporting firms deliberately strategise to improve their human resources profile, collaborate and commit to efficiency improvement through investment in worker training and IT capital — all of which then increase the likelihood of innovation. This suggests competition and learning associated with foreign market participation are key drivers of firm innovation behaviour. The selection effect of exporting on innovation is strongest for process innovation; this finding supports the argument that exporting firms are forced to reduce cost through process innovation in order to remain competitive. Finally, this paper finds no evidence to suggest that innovative firms select into exporting.

While direct government assistance is conducive to export market participation, any policy that would help to increase business investment in worker training and IT capital as well as facilitate collaboration and foreign ownership may boost firm innovation performance. Moreover, since the limited appropriability of human capital — in the form of skills acquired by workers through employer-provided training — is a disincentive for firm investment in worker training, policy focus towards addressing this market failure would be desirable.

Since exporting leads to innovation, reorienting policy attention towards export promotion may generate potential savings in terms of policy resources. In addition, because firms use imported inputs for export production, alleviating trade barriers would not only boost exports, but also improve overall efficiency by forcing import-competing firms to be more innovative. Finally, the importance of e-commerce for the 21st-century marketplace cannot be overemphasised. Policy assistance to help firms embrace e-commerce technology, and public investment in the infrastructure required for its adoption would likely positively affect firm innovation and export performance.

Future research may attempt to reveal the potential causality in the relationship between firm innovation and export behaviour. This may be done by instrumenting innovation using the information on barriers to innovation, as identified by surveyed firms. In addition, further research may also attempt to shed light on the persistence of innovative and exporting activities among some firms by incorporating dynamics into the analytical framework.

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