In-House or outsourcing skills: How best to manage for innovation?

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Abstract

Innovation is essential for driving business survival, development, and growth. Today managers within firms continuously search for new ways to gain competitive advantage. In many cases this comes from the effective use of intangible assets such as workplace skills and abilities. Despite this, little is known about what types of skills are required for innovation, whether these vary by innovation-type, or whether it matters if these skills are outsourced. This paper addresses these issues using data collected on eight skill types as part of the 2008-2010 Irish Community Innovation Survey. We find that there is substantial heterogeneity in the effectiveness of skills at generating different kinds of innovation. In addition, for some types of innovation it is best to develop the skills in-house (e.g. *Engineering* skills for product innovation) while for others it is best to outsource the skills (e.g. *Multimedia skills* for process and organisational innovation).

Keywords: Skills, Innovation, In-house, Outsource, Multivariate Probit

JEL codes: O15, O31, O32, O33

Introduction

For a firm to prosper and grow it must do more than keep up with its competitors. It must gain a competitive advantage over them whenever possible. While the mechanisms for creating such an advantage are complex, history teaches us that one way to do so is by successfully innovating (Utterback 1996; Patterson, Kerrin, and Gatto-Roissard 2009). Porter (1985) argued that the basic rationale for a firm to innovate is so it can separate itself from its competitors by producing superior goods and services to them. Significant advances in science, information, telecommunications and design technology over the last few decades have benefited many firms and individuals. Innovations change the way we live, learn and communicate. Powerful computer systems have increased the speed with which goods, services and information are designed, produced, and distributed (Misko and Nechvoglod 2011).

Technological developments have changed how we produce, present and exchange information (Paas and Creech 2008), and scientific developments have led to new and improved materials, drugs, medications and medical equipment (Austin 2007). There is little doubt that an organisation's ability to innovate is key to its success (Shipton et al. 2006).The Innovative capabilities of a firm are a function of a firm's human capital, social capital and organisational capital; and these factors act together with people' skills for fostering innovation (Subramaniam & Youndt, 2005). From a knowledge management perspective, social and organisational capital can be referred to as governance mechanisms and knowledge management systems (Foss, 2009) and these systems enable organisational innovation by stimulating knowledge creation and sharing processes. In this paper we focus on the human capital and less developed skills dimension of a firms innovating capability. By skills, we mean the 'abilities' of people (Tether et al., 2005; Green et al., 2012) operating within the firm. It is widely accepted that the knowledge and skills embedded in the abilities of

employees within the firm can be a key determinant of a firm's innovative capability (Romer, 1990; Patterson, Kerrin, and Gatto-Roissard 2009;Doran and Ryan 2014). Curiously, while a considerable literature has accumulated on the subject of innovation and concurs that competitive success is largely built on people skills (Bassett-Jones 2005; Leiponen 2005), little emphasis has been placed on the specific human capital skills required for innovation (Toner 2011; Tether et al. 2005).[1] In addition, we know very little as to whether the impact of specific skill sets on innovation is dependent on whether these skills are available 'in-house' or procured externally.[2]A notable exception is the Doran and Ryan (2014) paper which investigates the importance of different skills-sets for incremental versus radical innovation. All innovating firms must decide whether they should develop the skills they need in-house or whether they should purchase them from other providers.

Firms outsource skills for a number of reasons including to access a greater pool of knowledge than is available in-house (Mata and Woerter 2012), to reduce transaction costs (Stanko and Calantone 2011), to increase the speed and flexibility with which they can access new technologies (Leiponen 2005), to enhance their competitiveness (Gilley and Rasheed 2000) and/ or to allow them to focus on their core competencies (Love and Roper 2009). While the importance of in-house R&D and external networking are well documented (Roper, Du, and Love 2008; Love and Roper 2001, 2002; Cassiman and Veugelers 2006; Love and Mansury 2007; Freel 2003; Cohen and Klepper 1996; Love and Roper 2009) less attention has been given in the literature to the sourcing of other key human capital skills. This paper attempts to fill the gap in the literature by firstly assessing the impact of eight

[1]To date the literature has focused on the employee resources (such as cognition; knowledge; motivation; personality and emotion) and work environment characteristics (such as organisational ambidexterity; social resources [including team working, leader characteristics, feedback, social networks; work design including job characteristics, job demands, physical resources] and organisational resources [including structure, size, climate and culture, resource allocation and incentives]). See Patterson, Kerrin, and Gatto-Roissard (2009) for a thorough literature review.

[2] Previous studies when examining the relationship between outsourcing and innovation tend to focus on a particular skills requirement such as Information Technology (Su, Levina, and Ross 2016; Hoecht and Trott 2006; Miozzo and Grimshaw 2005)).

different skills on the likelihood of a firm engaging in different types of innovations; and secondly investigating the skills-innovation relationship further with respect to 'in-house' or 'outsourced' skills. Hence, this paper will add to the resource based view literature (Penrose, 1995) of the firm by identifying what core competencies (skills) are needed to gain a competitive advantage and it will also add to the literature on transaction cost theory (Williamson, 1979) by identifying what competencies are outsourced.

The Irish Community Innovation Survey (CIS) 2008-2010 provides us with a unique dataset. It includes the normal questions on firm-level innovation, but also questions on access to skill sets, specifically (i) graphic arts/ layout/ advertising, (ii) design of objects or services, (iii) multimedia, (iv) web design, (v) software development, (vi) market research, (vii) engineering/ applied sciences, and (viii) mathematics/ statistics/ database management. In addition, it determines if firms employ individuals with these distinct skills or obtain such skills from external sources.[3] Other datasets such as the Business environment and enterprise performance survey (BEEPS) or the Irish innovation panel (IIP) datasets do not provide such information on human capital functions. Since different types of innovation are likely to demand different skill-sets we assess the importance of each skill by innovation type. Following the OECD's *Oslo Manual (2005)* we focus on four innovation types; product, process, organisational and marketing innovation.[4] We estimate four innovation production functions, one for each innovation type, using a multivariate probit model which is a natural extension of the bivariate probit model and allows for more than one equation with correlated error terms (Galia and Legros, 2004; Crowley and McCann, 2015).

[3] Unfortunately, later waves of the Irish CIS did not include specific skills questions.

[4] Product Innovation involves the development of new or significantly improved goods, services, machinery, equipment, components and software within the firm; Process Innovation which relates to the development of new systems or routines of production within the firm; Organisational Innovation which relates to changing management practices or workflow structures; and Marketing Innovation which involves new ways of relating to customers.

This paper makes a number of contributions. Firstly, we add to the limited evidence base in relation to identifying the crucial skill sets for firm-level innovation. Our analysis reveals substantial heterogeneity in the effectiveness of different competencies for different types of innovation. By way of example, software development skills are important for process and organisational innovation, but do not significantly impact product or marketing innovation outcomes. In addition, we find market research skills are important for product, organisational and marketing innovation, but have no impact on process innovations.

Secondly, and perhaps more importantly we assess the relative importance of internal versus external skills providing insights into a less explored area in the literature. Interestingly, we find that some skills when outsourced have a greater impact on innovation than when cultivated in-house. For instance, outsourcing multi-media skills positively influences process and organisational innovation. However, this is not the case across all categories of innovation as the benefit of multi-media skills for marketing innovation is evident whether the skill-set is sourced internally or externally.

We now proceed to the main sections of this paper. Section 2 reviews the relevant literature and develops our hypotheses. Section 3 describes the methodology used, while the data is presented in Section 4. Section 5 discusses the results of our empirical estimation and the final section concludes.

Conceptual Development

The resource-based view (RBV) of the firm provides a theoretical framework that aids in identifying sets of resources that can enhance firms' competitiveness (Penrose, 1995). The RBV focuses managerial attention on the firm's internal resources in an effort to identify those assets, capabilities and competencies with the potential to deliver superior competitive advantages. Employee skills are an important part of a firms' internal resources. In addition,

transaction cost economics theoretically considers the cost incurred in an economic exchange (Williamson 1979), and traditionally has been used to explain 'make' or 'buy' decisions in relation to products (Pascucci, Royer, and Bijman, 2011). Both RBV and transaction cost economics theories inform the conceptual development of this paper, and are discussed in more detail below.

Skills for Innovation

The importance of skills for innovation has long been recognised (Smith 1776; Marx 1909). Yet, the literature does not concur on a definition or classification of such skills. Tether *et al.* (2005; 5) define a 'skill' as "an ability or proficiency at a task that is normally acquired through education, training and/or experience," whilst similarly Green et al. (2012; 7) define skills as "the abilities of people '(including management and leadership abilities, technical, scientific and production abilities, and soft/interpersonal abilities) for which there is a demand within the formal economy." Both definitions here consider skills at the level of the worker, as is the approach of this paper; however it is important to note that skills can be at the level of the worker, the group or the organisation. Stanwick and Beddie (2011) argue that the skills required for innovation are broad and that firms need a mix of various skills for innovation to be successful. This view is shared by Toner (2009) who argues that workers in different occupations are increasingly required to obtain a range of generic skills in addition to specific technical skills.

The specific skills required depend on whether the innovation is product, process, marketing or organisational (Tether et al. 2005). Product innovation involves the development of new goods, equipment and services, and it is the most evident form of innovation from a market-perspective. This type of innovation is critical in changing markets where creating new products is key for firm success, survival and renewal (Eisenhardt and Tabrizi 1995). Firms

are more likely to grow if they can develop existing or new products which satisfy changing consumer tastes and preferences. In this way product development is a source of competitive advantage for a firm. The development of a new product involves two key tasks. The first task is to make the product while the second task is to sell the product. Danneels (2002) argues that the first task is likely to require technological skills (including design and engineering skills, manufacturing, and quality control), while the second involves customer care skills (including the ability to identify consumer tastes and preferences; and to develop purchasing, distribution and sales procedures). Green, Jones, and Miles (2012) identify similar skill needs for product innovation, namely scientific and technological skills, engineering skills, design and packaging skills, market and user research skills. Evidence from a study by Fieger and Rice (2011), using a longitudinal database for Australia, supports these findings and further identifies information technology, marketing, and trades as the top three skills required by those producing new goods and services.

Process innovation involves the development and commercial exploitation of a new way of producing an organisations' products (Europe 2007). It focuses on reaping efficiency gains by means of cost reductions and increased production volumes, reducing development times for products, and improving product quality and reliability. Frishammar et al. (2012) argue that a firm that invests in new process technology will be superior in introducing new products to the market, will sustain lower development risks, and will be protected from would-be imitators. Green, Jones, and Miles (2012) contend that process innovation requires; technical skills, project management skills, organisational and workflow design skills, interaction and relationship skills, and finally management skills. The first two of these skills are required to ensure successful process specification and implementation whilst the latter three are required to ensure successful redesign of workflow processes.

Different considerations apply to organisational innovation. Firms that are consistently successful at organisational innovation improvements outperform their peers in terms of growth and finance performance (Tidd and Bessant 2011). Organisational innovation involves changes in management practices, organisational structures, and work practices and routines (Europe 2007). It is commonly targeted at securing increased efficiency and effectiveness. Organisational innovation has become increasingly important for firms with many firms implementing work practices such as brainstorming sessions, multidisciplinary and cross-functional work teams, multi-tasking and job rotation. Tidd and Bessant (2011) contend that this type of innovation is driven by the ability to see connections, to spot opportunities and to take advantage of them, while Green et al. (2002) find that it depends on four key skills; opportunity recognition, systems design skills, leadership skills and communication.

Many authors argue that marketing innovation is indispensable (Hoffman, Kopalle, and Novak 2010; Gupta, Raj, and Wilemon 1986). Customers cannot purchase products if they are not aware of what firms have to offer. Successful businesses position themselves in the minds of their customers and offer the best solution to their needs. Marketing innovation involves improvements in product design, placement, promotion and pricing. Smith and Jonathan (2004) argue that the world of marketing has changed dramatically over the last two decades. Advertising is no longer the only way to promote and market a business. Internet and e-marketing have had a dramatic impact on the world of marketing communications. A study of 298 marketing alumni, conducted by Davis, Misra, and Van Auken (2002), found that oral communication is the most important skill needed for successful marketing. This is followed closely by written communications, and the ability to use spreadsheets, statistical packages and database packages in a marketing context. Evidence by Green, Jones, and Miles (2012) supports these findings and they note that marketing innovation requires four

skills; ICT & systems development skills, web design and content development skills, data analysis skills, and language and communication skills.

In recognising the importance of different skills for innovation, we further acknowledge that differences are likely to exist as to which skills will benefit different types of innovation (i.e. product, process, organisational and marketing). Given the eight skills included in the 2008-2010 Irish Community Innovation Survey, we hypothesise the category of skills that are important for each innovation type. We expect that the design of objects or services, market research, and engineering/ applied sciences skills will be important for product innovation; software development skills and mathematics/ statistics/ database management skills will be important for process innovation; software development, market research, and mathematics/ statistics/ database management skills will be important for organisational innovation; and finally graphic arts/ layout/ advertising, the design of objects or services, multimedia, web design, market research, and mathematics/ statistics/ database management skills will be important for marketing innovation.

Internal Versus External Skill Sourcing

The reality for most firms, large or small, regardless of industrial sector, is the need to keep costs down. Today's firms are working hard to control and reduce their costs. As they try to contain their costs they must decide whether to develop the skills and capabilities they need internally or whether to outsource them. Innovative firms in industries as diverse as software, automotive and aerospace, as well as less high-tech industries such as consumer packaging, currently choose to outsource innovation efforts (Stanko and Calantone 2011). Many firms have outsourced non-core functions such as IT, cleaning, security and transport, as specialisation and economies of scale allow the outsourced firm to provide a better quality and cheaper service.

There are many advantages and disadvantages to outsourcing. On the positive side it helps firms to overcome small in-house research and development budgets, it allows them access to the economies of scale and scope available to specialised firms and it allows them access the expertise of specialists (Love and Roper 2009). On the negative side firms may lose internal innovation opportunities, firms may not have the appropriate in-house skills to evaluate the quality of the outsourced product, and firms may have difficulties assigning intellectual property rights (Pascucci, Royer, and Bijman 2011). Misko and Nechvoglod (2011) argue that intellectual property issues are especially of concern to companies which design, manufacture and distribute or retail their products in world markets. These firms have to work hard to keep cheap imitation copies from the market and are more likely to innovate in-house.

Two primary reasons for outsourcing have been put forward in the literature, the first is based on transaction cost economics (Williamson 1979), while the second is based on the resource based view of the firm (Penrose 1995). Transaction cost economics refers to the cost incurred in an economic exchange (Williamson 1979). The costs most commonly associated with innovation are asset specificity, environmental uncertainty and behavioural uncertainty. Asset specificity refers to the transferability of knowledge and assets between projects (Stanko and Calantone 2011). If the project being outsourced is very specific in nature, and the provider must purchase specialised equipment or develop specialised knowledge, then the provider firm may charge an additional fee due to the increased market risk. If this fee is large then the firm may choose to keep the innovation activity in-house. Likewise, if there is a chance the provider will act opportunistically after being awarded the contract then the firm may choose to keep the innovation activity in-house (known as a safegaurding cost see Pisano (1990)). The second cost, environmental uncertainty takes two forms, market uncertainty and technological uncertainty (Rindfleisch and Heide 1997).

Market uncertainty results from unpredictable changes in consumer needs and wants and can lead to the renegotiation or cancelation of innovation contracts. If the penalties for such actions are high then internalisation is preferred (Stanko and Calantone 2011; Love and Roper 2002). Technological uncertainty, on the other hand, refers to the inability of a firm to forecast technical requirements. In most technologically uncertain environments outsourcing is favoured as it allows firms the flexibility to end relationships when technical requirements shift (Balakrishnan and Wernerfelt 1986). Contracting with a new partner is generally faster than developing new technology and expertise in-house (Ulset 1996; Geyskens, Steenkamp, and Kumar 2006). The final transaction cost is due to behavioural uncertainty. This cost includes all expenses associated with confirming that contracts have been fulfilled to the specification and quality required. Similar to asset specificity and market uncertainty when this cost is high then internalisation will be favoured.

Pascucci, Royer, and Bijman (2011) argue that while transaction cost theory is successful in explaining general 'make' or 'buy' decisions for products, it does not help much when explaining innovation decisions. They argue that the latter is motivated more by strategic or resource considerations rather than by cost considerations. The resource based view of the firm focuses on the strategic priorities of the firm and the desire to develop "core" competencies and to outsource "non-core" competencies (Love and Roper 2009). Since it is expensive to develop and maintain resources firms often outsource activities that are not central to their resources, while protecting resources critical to their competitive advantage. In some cases firms outsource in order to access unique resources, expertise, and capabilities possessed by other firms (Edvardsson 2011). Where there is no opportunity to develop sustainable advantage, firms will favour outsourcing over internalization. The outsourced firm can gain scale efficiencies not available in-house, they can benefit from experience learning and they are motivated to develop processes in order to keep up with demand

(Mudambi and Tallman 2010). Consequently, where firms' competencies can easily be appropriated by competitors, firms normally opt to outsource.

Fill and Visser (2000) point out that some functions are better suited for outsourcing than others. Edvardsson (2011) suggests that simple, detached and structured functions are most suitable for outsourcing. Kremic, Tukel, and Rom (2006) argue that outsourcing is more likely when there is less asset specificity and Quinn (1999) argues that functions with little competitive edge are most suitable for outsourcing. Love and Roper (2001) argue that firms in high-concentration markets are more likely to innovate in-house as they are keen to prevent or delay imitation by rivals, while Hertog and Thurik (1993) highlight by innovating in-house firms in these concentrated markets can gain a valuable lead-time. In a similar vein, Mithas and Whitaker (2007) conclude that jobs with high information intensity are best suited for outsourcing as these jobs can easily be codified, standardised, and modularised, whilst highly tacit processes and jobs such as those requiring physical presence are not suited for outsourcing. However, a study of knowledge-intensive business services reveals that IT outsourcing is frequently accompanied by wider transformations in clients' production technologies and can exacerbate the conflicts between clients and suppliers, which may present obstacles to innovation (Miozzo and Grimshaw, 2005). In addition, when outsourcing moves from traditional outsourcing with one or a small number of key partners and long-term contracts to strategic outsourcing with multiple partners and short-term contracts the risks to innovation increase (Hoecht and Trott, 2006). Furthermore, guidelines related to good contract management often deter innovative behaviour (Aubert, Kishore, and Iriyama 2015).[5] It is important to note that studies which have identified negative innovation consequences from outsourcing have generally focused on one particular skill-set, largely information technology skills. A previous study which examined a much broader range of outsourced

[5] Aubert et al. (2015) refer to this as the 'innovation through outsourcing' paradox.

skills reported considerable benefits to both radical and incremental innovation and outsourcing web-design, market research and design benefited innovation activity within firms (Doran and Ryan, 2014).

Firms outsource skills for various strategic reasons: to access knowledge external to the organisation, to reduce transaction costs, to access new technologies; to enhance their competitiveness; and/ or to allow them to focus on their core competencies. We expect that in enhancing human capital through out-sourcing, firms innovation activities will benefit from the externally procured skills and expertise. The impact of outsourcing skills is likely to differ given the innovation activity under investigation. However, when firms strategically identify and externally access crucial skills, we expect that, under these circumstances and in general, outsourcing activity will benefit innovation. We hypothesise that firms will outsource costly, reproducible skills, particularly those not associated with their core competence.

Methodology

When considering the impact of innovation inputs on innovation outputs the standard approach in the literature is to use an innovation production function (Bourke and Crowley, 2015; Crowley and Bourke, 2017; Crowley, 2017; Crowley and Jordan, 2017; Doran and O'Leary 2011; Roper, Du, and Love 2008; Freel 2003; Love and Mansury 2007). We specify our innovation production function in equation (1).

$$IO_i = \alpha_0 + IS_i\alpha_1 + ES_i\alpha_2 + R\&D_i\beta + N_i\chi + Z_i\lambda + \varepsilon_i \quad (1)$$

Where IO_i is a binary indicator of whether firm *i* innovated, where *i*=1,…*N*. As explained above we consider four types of innovation; (i) product, (ii) process, (iii) organisational and (iv) marketing. α_0 is a constant term, IS_i is a N*eight matrix of variables indicating the type

of internal skills utilised by firm *i* to produce innovation output. ES_i is a N*eight matrix of variables indicating the type of external skills utilised by firm *i*. The eight skills considered are (i) graphic arts/ layout/ advertising, (ii) design of objects or services, (iii) multimedia, (iv) web design, (v) software development, (vi) market research, (vii) engineering / applied sciences, and (viii) mathematics/ statistics/ database management. α_1 and α_2 are one*eight vectors of coefficients showing the impact of these factors on the likelihood of a firm innovating.

We are interested in the coefficients contained within the vectors α_1 and α_2. Specifically we are interested in two questions. Firstly, which skills are important for each type of innovation and, secondly, whether it is better to possess these internally or to source them externally. We anticipate that, if significant, the effects will be positive, with these skills facilitating innovation. Existing literature also suggests that if there is a cogitative disconnect between firm *i* and the external agent providing the desired skills, firm *i* may not be able to assimilate the information provided (Boschma 2005). We cannot measure the cogitative proximity of the firms, however, we can assess based on the significance of the coefficients and their relative magnitude, whether external skills are important for innovation.

It is generally accepted that R&D is an important driver of innovation activity (Love and Mansury 2007; Mansury and Love 2008; Feldman 1999; Crowley and McCann, 2018). Therefore, we include $R\&D_i$ which is a N*two matrix of variables representing the R&D effort of the firm which includes intramural and extramural R&D performance. β is a vector of associated coefficients. N_i is an N*four matrix of binary variables which indicate whether firm *i* engages in backwards, forwards, horizontal or public networking. Freel (2000, 2003) notes that external networking may assist firms in accessing knowledge pertinent to innovation. χ is the one*four vector of associated parameters.

Z_i represents firm specific factors which might explain heterogeneity in their innovation performance while λ is the vector of associated coefficients. Z_i contains information on firm size (no of employees), whether the firm is Irish owned or not and the sector in which firm *i* operates in. These have all been previously shown to have an impact on the innovative performance of firms (Pavitt 1984; Cohen and Klepper 1996; Cohen, Levin, and Mowery 1987; Roper 2001).

As noted previously we consider four distinct types of innovation. The standard practice in the literature would be to estimate four distinct probit models (Roper, Du, and Love 2008; Doran and O'Leary 2011). However, it is likely that individual heterogeneity not captured by the independent variables could impact on the likelihood of firms engaging in numerous forms of innovation simultaneously. This upward bias (or indeed downward bias if the firm possesses unobserved characteristics which impede innovation performance) in innovation likelihood will manifest in the error terms (ε_i), being correlated across the four regression equations. This may result in biased estimates of our coefficients. Therefore, in order to take account of this potential bias we estimate a multivariate probit model, which estimates the four equations taking account of potential correlation across the error terms (Cappellari and Jenkins 2003, 2006; Greene, 2003; Crowley and McCann, 2015).

Data

The data used in this paper is derived from the Irish Community Innovation Survey 2008-2010. This survey was conducted jointly by Forfás (Ireland's national policy advisory body) and the Central Statistics Office in Ireland. The survey is directed to companies employing more than 10 persons engaged in a range of sectors. Consistent with the OECD's Oslo manual, the survey includes a reference period, which in this case is 2008 to 2010, for innovation inputs and outputs (OECD 2005). The target for the Irish CIS are the complete

range of manufacturing sectors, with selected service sectors (CSO 2010) and the sample size for the analysis is 3,245 firms. The motivation for the CIS survey is to provide a comprehensive survey of the innovation performance of Irish firms. The survey is conducted as part of the European wide Community Innovation Survey project and is completed every two years (CSO 2010).

The unique element of the Irish CIS 2008-2010, which facilitates this research paper, is based around whether the firm employed individuals in-house with distinct skills, or obtained these skills from external sources during the period 2008 to 2010. Specifically eight skills were identified by the Irish CIS. Firms were asked whether they used: (i) graphic arts/ layout/ advertising, (ii) design of objects or services, (iii) multimedia, (iv) web design, (v) software development, (vi) market research, (vii) engineering/ applied sciences, and/or (viii) mathematics/ statistics/ database management skills. They were also asked to indicate whether they accessed these skills internally within the firm or externally from outside the firm[6]. Descriptive statistics for each of these factors and an abbreviated name for each factor are displayed in Table 1.

Table 1: Descriptive Statistics of Skills Variables

Skills	Sourced internally	Sourced externally	Sourced internally and externally
Graphic arts/layout/advertising	19.20%	34.51%	4.49%
Design of objects or services	23.76%	20.77%	4.01%
Multimedia	13.90%	23.11%	3.32%
Web design	18.67%	43.33%	4.62%
Software development	18.95%	35.10%	5.23%
Market research	19.82%	23.14%	4.22%
Engineering / applied sciences	21.73%	10.94%	3.85%

[6] Specifically, the CIS asked the question: 'during the three years 2008 to 2010, did your enterprise employ individuals in-house with the following skills, or obtain these skills from external sources?' Respondents were told to 'tick both "Employed-in-house" and "obtained from external sources" if applicable.' It is important to acknowledge that the survey question specifically asks which skills are obtained externally rather than asking if particular functions within the organisation are outsourced.

Mathematics/statistics/database management	19.45%	10.26%	3.02%

Data Source: Irish Community Innovation Survey 2008-2010

We note that there is no clear indication that firms made use of internal skills more than external skills. The utilisation of internal versus external varies depending on the type of skill considered. For instance, 35% of firms use external skills for graphic arts/ layout/ advertising while only 19% of firms use in-house skills. However, 22% of firms use in-house skills in engineering/applied sciences while only 11% of firms get this skill externally. The most popular skill sourced internally is the *design of objects or services* skill (24% of firms), while the least popular is the *multimedia* skill (14% of firms). The most popular skill sourced externally is *web design* (43% of firms) while the least popular skill is the *mathematics/ statistics/ database management* skill (10% of firms). These statistics correspond with the findings of Edvardsson (2011), Kremic, Tukel, and Rom (2006), and Mithas and Whitaker (2007) who suggest that functions which can be replicated easily are most suited to outsourcing while those which help build a competitive edge or which require specialised knowledge are best kept in-house. In addition, few firms source the same skill both internally and externally.

Table 2: Descriptive Statistics of Dependent & Independent Variables

Variable	Mean	sd
Innovation		
Product (%)	31	na
Process (%)	36	na
Organisational (%)	39	na
Marketing (%)	32	na
Firm Specific Factors		
Irish Owned (%)	73	na
Firm Size (No of employees) (mean)	96	382
Networking		
Backwards (%)	12	na
Forwards (%)	9	na
Horizontal (%)	3	na
Public (%)	8	na

R&D		
Intramural R&D (mean in millions of €)	€2236	11308
Extramural R&D (mean in millions of €)	€530	5420

Data Source: Irish Community Innovation Survey 2008-2010

Turning to the other descriptive statistics displayed in Table 2 we see the average firm size in our sample is 96 employees with a standard deviation of 381. Approximately 73% of the firms surveyed are Irish owned. Following Roper et al (2008) we define four types of external networking. We note that backward linkages to suppliers are the most common form of networking (9%). This is followed by forward linkages to customers (9%) and public interaction with universities or public research institutes (8%). The lowest level of networking is horizontal linkages to competitors and consultants (3%). Regarding research and development activity we control for both intramural and extramural R&D. Intramural R&D is defined as creative work undertaken within the firm to increase the stock of knowledge for developing new and improved products and processes while extramural R&D is defined as the same set of activities as above, but performed by other enterprises. We also include sectorial controls for broad NACE sectors.

Empirical Results

The results of our estimation are presented in Table 3. Regarding internal skills we note that out of thirty-two coefficients, fifteen are significant. Likewise, for external skills out of a possible thirty-two relationships, eighteen are significant. This suggests that there is no clear pattern that internal or external skills are better. There is also substantial heterogeneity in the importance of the various types of competencies. These are discussed in more detail below.

Regarding our R&D variables we note that intramural R&D is significant and positive across all innovation types while extramural R&D is significant and positive for product and organisational innovation. The results on intramural R&D are not particularly surprising. One

would expect that investment in creative work that increases the stock of knowledge is likely have a positive influence on all types of innovative activities within the firm. These results are broadly consistent with the international literature (Crépon, Duguest, and Mairesse 1998; Love and Mansury 2007; Hall, Lotti, and Mairesse 2009) and the literature using Irish data (Roper, Du, and Love 2008; Doran and O'Leary 2011; Doran and Ryan 2012; Crowley and McCann, 2015). It is more difficult to assess why extramural R&D is only significant for product and organisational innovation. Perhaps, it is due to knowledge difficulties associated with process and marketing innovations where the knowledge capabilities gleaned internally for these innovation types are less likely to be appropriated through extramural R&D processes. Clearly, it appears intramural R&D spend expands the knowledge resource base of the firm that positively effects the production of all innovation outputs. But, extramural R&D will not achieve the same outcomes as intramural R&D in the extent of its broader impact across the wider performances of the firm.

Regarding external networking we note that backward networking with suppliers and forward networking with customers have positive effects on all forms of innovation. This is consistent with Freel (2003) and Roper et al. (2008) who emphasise the importance of external knowledge sourcing for innovation. Hence, external knowledge sourcing improves a firm's knowledge base resulting in an improved firm resource base competitive capacity (Zahra & George, 2002).However, horizontal and public networks are found to have no significant effect on the likelihood of innovation. We also find that larger firms are more likely to engage in all forms of innovation. This is not surprising as Schumpeter (1942) argued that larger firms have the resources to invest in R&D and take on the uncertainty inherent in R&D activity. Additionally, Irish owned firms are less likely to product or organisationally innovate. Previous research by Roper, Du and Love (2008) in the Irish

context suggested that larger firms are more likely to innovate and that the nationality of a firm may affect its probability of innovating.

Table 3: Results of Empirical Estimation

	Product	**Process**	**Organisational**	**Marketing**
Constant	-2.1010	-1.4300	-1.3289	-1.6526
	(0.3798)	(0.2924)	(0.2857)	(0.3294)
R&D				
Intramural R&D	0.1395***	0.0742***	0.0491***	0.0581***
	(0.0097)	(0.0092)	(0.0092)	(0.0094)
Extramural R&D	0.0612***	0.0202	0.0240***	0.0133
	(0.0145)	(0.0130)	(0.0134)	(0.0130)
Networking				
Backwards	0.2363***	0.1785***	0.1561***	0.0730***
	(0.0554)	(0.0474)	(0.0492)	(0.0428)
Forwards	0.1896***	0.1689***	0.1005*	0.0957*
	(0.0641)	(0.0607)	(0.0612)	(0.0544)
Horizontal	0.1124	0.0712	0.0464	0.0128
	(0.1170)	(0.1083)	(0.1081)	(0.0941)
Public	-0.0460	-0.0869	0.0834	0.0085
	(0.0738)	(0.0619)	(0.0695)	(0.0584)
Firm Specific Factors				
Firm-Size (No of employees)	0.0749***	0.0988***	0.0924***	0.0491*
	(0.0278)	(0.0256)	(0.0254)	(0.0265)
Irish Owned	-0.1274*	-0.0698	-0.1976***	-0.0903
	(0.0680)	(0.0628)	(0.0612)	(0.0655)
Internal Skills				
Graphic arts/layout/advertising	-0.0439	0.0019	0.0616	0.4300***
	(0.0928)	(0.0843)	(0.0829)	(0.0830)
Design of objects or services	0.2097***	0.1231*	0.1063	0.1721**
	(0.0771)	(0.0713)	(0.0708)	(0.0710)
Multimedia	-0.0161	0.0391	-0.0187	0.1439**
	(0.0955)	(0.0875)	(0.0867)	(0.0864)
Web design	0.0297	-0.0269	0.1197	0.1588*
	(0.0910)	(0.0828)	(0.0813)	(0.0838)
Software development	0.1257	0.2464***	0.3354***	-0.0236
	(0.0842)	(0.0783)	(0.0772)	(0.0798)
Market research	0.1663**	0.1001	0.1277*	0.4216***
	(0.0762)	(0.0698)	(0.0693)	(0.0695)
Engineering / applied sciences	0.1692**	-0.0017	0.0132	-0.1581**
	(0.0777)	(0.0718)	(0.0709)	(0.0742)
Mathematics/statistics/database management	0.0209	0.2606***	0.2457**	0.1539**
	(0.0797)	(0.0730)	(0.0723)	(0.0738)

External Skills				
Graphic arts/layout/advertising	0.1527**	0.2027***	0.1452**	0.4116***
	(0.0790)	(0.0709)	(0.0697)	(0.0712)
Design of objects or services	0.1962***	0.1144	0.1830**	0.3392***
	(0.0807)	(0.0741)	(0.0734)	(0.0738)
Multimedia	0.0727	0.1446***	0.1199*	0.3070***
	(0.0798)	(0.0735)	(0.0728)	(0.0720)
Web design	0.1544**	0.0458	0.0764	0.2988***
	(0.0747)	(0.0668)	(0.0656)	(0.0687)
Software development	-0.0020	0.2961***	0.2984***	0.0134
	(0.0660)	(0.0596)	(0.0583)	(0.0613)
Market research	0.2857***	0.0724	0.1465**	0.3450***
	(0.0729)	(0.0682)	(0.0667)	(0.0670)
Engineering / applied sciences	0.0411	0.0448	-0.1180	-0.1234
	(0.0922)	(0.0853)	(0.0855)	(0.0864)
Mathematics/statistics/database management	-0.0854	0.1045	0.2549***	-0.2036**
	(0.0921)	(0.0846)	(0.0852)	(0.0876)
No. Of Obs				3245
chi2				2357.28
Prob>Chi2				0.0000
Log likelihood				-5994.93

Note 1: ***, ** and * indicate significance at the 99, 95 and 90 percentage level.
2: Sectoral controls are included in the regression but not presented to save space.
3: Standard errors are in parentheses.

Internal and External Skills

Overall, we find support for our first hypothesis. As expected we find that the design of objects or services, market research, and engineering/ applied sciences skills are important for product innovation; software development skills and mathematics/ statistics/ database management skills are important for process innovation; software development, market research, and mathematics/ statistics/ database management skills are important for organisational innovation; and graphic arts/ layout/ advertising, the design of objects or services, multimedia, web design, market research, and mathematics/ statistics/ database management (internally sourced only) skills are important for marketing innovation. In addition to these we find the following externally sourced skills increase innovation outputs:

externally sourced *Graphic arts/layout/advertising* and *Web design* skills increase product innovation, externally sourced *Graphic arts/layout/advertising* and *Multimedia* skills increase process innovation, and externally sourced *Graphic arts/layout/advertising*, and *Design of objects or services* skills increase organisational innovation.

Table 4 presents a summary of the significance of the internal and external skills a firm employs for innovation. The summary is based on the estimates of Table 3. Firstly we note three of the skills, specifically *Graphic arts/ layout/ advertising*, *Multimedia* and *Web design*, have a positive effect on marketing innovation when sourced internally. However, these three skills, when sourced internally, have no effect on process, product or organisational innovation. This result is not surprising since the literature argues that firms are likely to develop the skills in-house if it relates to their core competence or if there are excessive costs associated with outsourcing. Consequently it is natural that firms engaged in marketing innovation would develop these skills, or at least some of these skills, in-house.

All four types of innovation gain from sourcing the *Graphic arts /layout/ advertising* skill externally. These results are supported by Quinn (1999) who argues that functions with little competitive edge are most suitable for outsourcing. Likewise, Love and Roper (2009) argue that firms are likely to outsource functions where specialised firms have a greater ability to access economies of scale and scope. This reinforces our principle conclusion that there is no clear pattern that internal or external skills are better but it does highlight that outsourcing functions in this case resulted in a better performance from external sourcing relative to internal sourcing. However, there is also a likely complementary relationship between internal and external skill sourcing which we elaborate upon later.

Process, organisational, and marketing innovation gain from obtaining *Multimedia* skills externally. This result coincides with Green, Jones, and Miles (2012) who argue that technological skills are particularly important for these types of innovation. Moreover, Gassmann (2006) argue that multimedia skills are growing in importance as they allow firms to build alliances across diverse sectors and to pool their complementary competencies.

Product and marketing innovation both gain from obtaining external *Web design* skills. Since a product is of little value unless consumers are made aware of it, it is not surprising that those firms producing new products require multimedia skills. Since it is not their core competence it is natural that they would outsource this skill.

Table 4: Summary of Internal and External Skills

	Product		**Process**		**Organisational**		**Marketing**	
	Internal	**External**	**Internal**	**External**	**Internal**	**External**	**Internal**	**External**
Graphic Design	**ns**	**+**	**ns**	**+**	**ns**	**+**	**+**	**+**
Design	**+**	**+**	**+**	**ns**	**ns**	**+**	**+**	**+**
Multi-media	**ns**	**ns**	**ns**	**+**	**ns**	**+**	**+**	**+**
Web-design	**ns**	**+**	**ns**	**ns**	**ns**	**ns**	**+**	**+**
Software Dev	**ns**	**ns**	**+**	**+**	**+**	**+**	**ns**	**ns**
Mkt research	**+**	**+**	**ns**	**ns**	**+**	**+**	**+**	**+**
Engineering	**+**	**ns**	**ns**	**ns**	**ns**	**ns**	**-**	**ns**
Database Mgt.	**ns**	**ns**	**+**	**ns**	**+**	**+**	**+**	**-**

Note: (1) + indicates a significant positive relationship, - indicates a significantly negative relationship and ns indicates not significant

(2) This table is based on the estimates in Table 3

Marketing innovation is the only innovation type to gain from having both in-house and externally sourced skills in *Graphic arts/layout/advertising, Multi-media* and *Web*

design. This concurs with previous research, see for example Cusmano, Mancusi, and Morrison (2010), who argue that complementary relationships exist between in-house departments and specialized suppliers when knowledge-intensive or strategic activities are involved. In the case of *Design of objects or service, software development and Market research,* utilising this skill internally is positively associated with product, process and marketing innovation. When *Design of objects or service, software development and Market research* is utilised externally, this positively influences organisational innovation. When *Design of objects or service, software development and Market research* is used internally or externally, this skill increases the likelihood of product, organisational and marketing innovation.

As expected the *Engineering / applied sciences* skill has a positive impact on product innovation when sourced internally. This skill is essential for product development and as explained previously, firms are unlikely to outsource anything that helps them build their core competence. The literature review suggested that in cases where it is difficult to establish intellectual property rights, in cases where imitation is possible and where it is necessary to develop products quickly then the firm in likely to keep the skill in-house. This is borne out by the fact that this skill has no positive impact on innovation when out-sourced. This skill has a negative impact on marketing innovation. Internal skills in *Mathematics/ statistics/ database management* have a positive effect on process, organisational and marketing innovation while external acquisition of this skill has a positive effect on organisational innovation and a negative effect on marketing innovation.

These results suggest that certain types of skills are particularly suited to different types of innovation and that sourcing them in-house or externally could impact on the effectiveness of the skill to produce innovation output. For instance the external sourcing of expertise in *Graphic arts/layout/advertising* will have a positive effect on all types of

innovation within a firm. However, if this skill is developed and sourced in-house it will only be effective at stimulating marketing innovation, with no significant effect on any other form of innovation. Or looking at this from the perspective of a firm wishing to product innovate it should use internal skills in the *Design of objects or services*, *Market research*, and *Engineering/applied science* while using externally sourced skills in *Graphic arts/layout/advertising*, *Web design*, and *Market research*.

While most forms of innovation have roughly the same number of significant internal and external skills (but obviously not the same specific skills) organisation innovation is different. Three forms of internal skills have a significant effect while six different external skills have an effect. This may be due to organisational rigidities relating to change. As organisation innovation involves changing the structure of the organisation, the effectiveness of internal skills may be restricted due to immunity to change (Kegan and Lahey 2001), whereas external skills will not be constricted by this immunity.

Finally, it is also notable that of all the significant coefficients - two possess negative signs. The internal sourcing of *Engineering/ applied science* and the external sourcing of *Mathematics/ statistics/ database management* have a negative effect on the likelihood of marketing innovation. These negative relationships may be manifest of the fact that marketing innovation is inherently a non-technological innovation while *Engineering/applied science* and *Mathematics/statistics/database management* are technical competencies and therefore may be less suited to this type of innovation. Furthermore, firms with strong knowledge competencies in *engineering/applied sciences* and *Mathematics/ statistics/ database management* may result in a firm level knowledge deficiency or imbalance when it comes to producing other innovation outputs, which in the Irish firm case happens between the *engineering/applied science*, *Mathematics/ statistics/ database management* and

marketing innovation nexus. Consequently firms with significant skills in these areas should be wary that this may result in a negative spill over effect to marketing innovation outcomes.

Conclusion

This paper analyses the impact of eight distinct skills, sourced both internally and externally to the firm, on the likelihood of firms engaging in four types of innovation. This is facilitated through the use of a special module on the Irish CIS 2008-2010. We estimate an innovation production function, using a multivariate probit model, augmented to include our eight skills. This allows us to assess the impact of each of the competencies on the likelihood of firms engaging in product, process, organisational and marketing innovation.

The results of our estimates suggest that there is substantial heterogeneity in the effectiveness of competencies at generating different kinds of innovation output. It also appears that for different types of innovation and skills it may be best for firms to develop them in-house or source them from outside the business. For instance sourcing *Graphic arts/ layout/ advertising* skills from outside the firm increases the likelihood of all types of innovation while developing in-house skills in *Design of objects or services* increases the likelihood of product, organisational and marketing innovation.

From a management perspective it appears that a blanket development of skills in-house or a total outsourcing of skills may be counterproductive. Our results suggest that specific skills are better suited to different types of innovation and others are more conducive to being outsourced. This implies that management within firms should focus on developing skills which best suit their innovation needs while also cultivating links with external specialists which can provide the skills not available/suited to in-house development.

A key limitation of our study is its cross-sectional nature limiting inference to correlation rather than causality. However, the Irish CIS data did not include questions on

internal and externally procured skills-sets in later waves. Our results are also limited in that they only consider firms operating in Ireland. Replication in different national contexts would therefore be a useful robustness check.

Clearly, this research is important when deciding on how best to manage the skills needed for innovation. Previous research has also examined the influence of the manager and the role of resource management practices as determinants of firm innovation outcomes (Bourke and Roper, 2015; Bourke and Roper, 2016; Bourke and Crowley, 2016; Crowley and Bourke, 2018; Terziovski and Guerrero, 2014; Zeng et al., 2015). Given the limited evidence on the importance of skills for innovation as a predetermining motivation for this paper – it is also further likely that the manager would play a key role in influencing this decision. Therefore, the influence of the manager and the propensity of human resource management practices will also be a factor in explaining the acquisition of internal and external skills by the firm. Future studies should attempt to address the interaction between the manager, human resource practices and in-house and outsourcing of skills.

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