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Innovation types and the search for new ideas at the fuzzy front end: Where to look and how often?☆

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ABSTRACT

This study investigates the search for new ideas at the front end of innovation (FEI), exploring how idea search strategies directed beyond and within firm boundaries relate to organizational, managerial, process and marketing innovations (which are overlooked in the product-focused FEI literature), and to innovation performance. Drawing on a cross-industry Australian survey, the study investigates two strategies that direct firms' external idea search: an industry value-chain strategy and a knowledge-economy strategy. Results show that the intensity of idea search strategy across industry value-chains has an effect on the frequency of product and marketing innovations, while the intensity of knowledge-economy idea search strategy has an effect on innovation performance. An interaction effect is observed between external idea search strategies and innovation performance, and internal idea search strategy intensity shows a performance effect. The research importantly extends the analysis of FEI and innovation search to include organizational, managerial, process and marketing innovations.

1. Introduction

Literature on technology diffusion and open innovation has long recognised that knowledge, technologies and innovations produced outside of a firm's boundaries can shape firm innovation strategies and success (Chesbrough, 2005; Freel, 2005; Rogers, 2003; Rosenberg, 1972). The reality for many firms, is that much of their innovation activity relies on adopting knowledge and technology originating from outside sources. This activity is reflected in the industry structures of many developed economies, where novel technology 'producing' firms and high-tech sectors typically account for relatively small shares of firm populations, aggregate employment and output (Trott & Simms, 2017; Robertson, Smith, & Von Tunzelmann, 2009; Von Tunzelmann & Acha, 2005).

Consequently, over the past few decades, innovation scholars have become interested in the processes of external knowledge search as an innovation activity, and a substantial literature is dedicated to 'innovation search'. To date, the search literature has focused predominantly on formal aspects of innovation related search, such as how firms search for and acquire external knowledge, technology and capabilities for innovation projects through collaboration arrangements (with outside organisations), R&D partnerships and other forms of external technology and information acquisition (e.g. via purchased technology licences, patents, human capital or strategic information sourcing) (e.g. Gómez, Salazar, & Vargas, 2016; Moon, Mariadoss, & Johnson, 2017; Czarnitzki, Ebersberger, & Fier, 2007). This research clearly demonstrates the importance of search as an innovation activity supporting new or established projects for product and process innovations. Yet, despite the extensive literature on innovation search, the focus so far has remained on knowledge inputs that are externally sourced for development and implementation stages of innovation, and neglected the external search for new *ideas* in early, fuzzy phases of the innovation process - known as the fuzzy, "front end" of innovation.

This is somewhat surprising, as all innovation invariably begins with new ideas (Boeddrich, 2004), whether they are sourced externally or internally, and regardless of how they evolve, are modified and transformed throughout their development. In the context of innovation, an idea can be defined as "an opportunity to create value for further investment" (Kornish & Ulrich, 2014; p.15). Although a substantial literature is dedicated to Front End Innovation (FEI), most studies of FEI tend to examine idea search and generation processes *within* the firm and at the individual employee or team level, focus only on product innovations and take a qualitative approach (Verworn, 2009).

These patterns underpin several issues identified in the literature on FEI that require further research, and that this study seeks to address.

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First, Ende, Frederiksen, and Prencipe (2014) note a need for further research to explore *how* firms organise their search for new ideas, and how this activity relates to the implementation stages of innovation, while Takey and Carvalho (2016) highlight the lack of studies that examine the organisation and intensity of FEI activity directed beyond firm boundaries. Second, most studies on the ideation aspects of FEI are qualitative in approach and examine idea search at the individual employee or team level (Kock, Heising, & Gemünden, 2015), and most empirical studies of idea search activity focus on very specific industries or particular products. While FEI is acknowledged as important for different types of innovation in processes, business models and marketing (Koen, Ajamian, Burkart, & Clamen, 2001; Ende et al., 2014), the literature on FEI appears to be almost entirely focused on product innovation. Eling and Herstatt (2017) identify a clear need for wider-scale research that both covers multiple industries and that examines how idea search relates to different types of innovation. Finally, Ende et al. (2014) identify a need for research that examines the relationship between external and internal ideas management.

This study makes a valuable contribution to the literature by taking a firm-level, cross-industry approach to investigate idea search activities at the front end of innovation. The paper contends that the idea search aspect of FEI is an antecedent to the more formal aspects of innovation search covered extensively in the traditional search and innovation literature. As such, the approach to investigating FEI search activities is guided by findings from both the FEI literature and broader literature on innovation search. The analysis examines the relationship between the intensity of front end idea search strategies, different innovation types and innovation performance. In particular, the study makes a new contribution by extending the concept of FEI to examine how front end idea search activity relates to organizational, managerial, process and marketing innovations and to innovation performance. The study is motivated by two broad research questions. First, how do firms' idea search activities (external and internal) at the front end impact on different types of innovation? Second, how is innovation performance impacted by the combination of external and internal idea search strategies?

The next section briefly considers relevant conceptual and empirical literature on innovation search and FEI, providing background rationale for the hypotheses tested in the empirical part of this study. The proceeding sections discuss the methodology and results, with a final section offering some discussion and conclusions for future research.

2. Theoretical, conceptual and empirical background and hypothesis development

2.1. Idea search at the fuzzy, front end of innovation

The initial search for new ideas for innovation projects is part of the fuzzy, 'front end' of the innovation process. Front end innovation (FEI) is a term that has been used to describe various concepts related to the early stages of product innovation. Eling and Herstatt (2017, p.864) define FEI as "the very first phase of the NPD process that starts with the discovery of an opportunity or a raw idea for product innovation and ends when the GO decision is made to developing a new product". Ende et al. (2014) describe FEI as the idea-generation phase of innovation, while Frishammar, Dahlskog, Krumlinde, and Yazgan (2016, p. 179) define the front end as the "phase before a project enters formal development". FEI is often described as 'fuzzy', because FEI can often involve informal, unstructured, chaotic, processes by which new ideas are born or sought out. FEI consists of several elements or activities, including opportunity identification, idea search/generation, idea or concept development, evaluation, testing and selection (Florén & Frishammar, 2012; Kim & Wilemon, 2002). Though the term 'Front End Innovation' has been applied to each of these elements, the focus for this paper is the search for new ideas for innovation – which covers idea generation, 'ideation' or opportunity identification aspects of FEI.

Björk and Magnusson (2009) note that in general, literature related to idea generation and identification is extensive, drawing on a broad range of disciplines and theories around creativity, learning, psychology and social networks. However, in FEI specific literature, idea generation is largely neglected (Frishammar et al., 2016; Gurtner & Reinhardt, 2016; Kock et al., 2015), despite its crucial role within FEI and the overall innovation process.

From a theoretical perspective, idea generation is commonly explained with linear models of product innovation such as the Stage Gate Model (Takey & Carvalho, 2016; Cooper & Kleinschmidt, 1993). Linear models focus on idea generation as the crucial beginning or pre-phase of new product development (NPD) (Stevens, 2014) in which the seeds of novelty are planted. On the other hand, iterative approaches such as the New Concept Development (NCD) model (Koen et al., 2001) recognise idea generation as iterative and unstructured (Pereira, Ferreira, & Lopes, 2017). The literature extends on iterative views by recognising the value of social networks for supporting the inward flow of ideas from outside of the firm, with both 'weak' and 'strong' social ties viewed as important for idea generation (Ende et al., 2014; Gupta & Maltz, 2015). Taken together, these perspectives emphasise that idea search is both crucial for initiating product innovation projects and important for their implementation.

Several findings from the FEI literature that reflect these themes provide motivation for this research. Early work showed that FEI stages were crucial for innovation success (Cooper & Kleinschmidt, 1987; Cooper, 1988) and later studies reiterate that the effectiveness at early stages of FEI can significantly influence the likelihood of later success for innovation projects (Backman, Börjesson, & Setterberg, 2007; Khurana & Rosenthal, 1997). Research suggests that as much as 50% of total innovation development time is attributable to FEI (Jensen, 2017). Despite recognised tension between the need for quantity and quality in the search for new ideas (Gama & Parida, 2017), studies in the FEI literature consistently find that maintaining a high intensity of new ideas flowing into the firm from outside, is crucial for innovation (Gilson & Litchfield, 2017). These theoretical and empirical insights around FEI, combined with those from the broader literature on innovation search (discussed in Section 2.2 below) underpin the development of specific hypotheses in this study.

2.2. Literature on innovation search

2.2.1. Theoretical background

Over the past two decades, an increasing number of empirical studies have examined 'innovation search', defined here as processes by which firms search their external environment for new information and knowledge to support their innovation projects. Various theoretical approaches underpin this work. Transaction cost theory can explain a firm's motivation for innovation search based on the cost and efficiency advantages achieved from importing external knowledge for innovation (compared to investments in internal development) (Williamson, 1985, 1987). The dynamic capabilities tradition views innovation search as an essential activity for maintaining innovation based competitiveness: search is a process by which firms seek out and respond to new information from ever changing external environments (Teece & Pisano, 1994; Teece, 2009). Similarly, absorptive capacity approaches view the effectiveness of external innovation search as tempered by a firms internal capabilities; which enable firms to more effectively locate and integrate new knowledge and technology for innovation projects (Cohen & Levinthal, 1990). Many recent studies are framed by open innovation theory (West & Bogers, 2014), which recognises that firms will typically search their external environments for knowledge and innovations to adopt before investing in developing innovations in-house.

2.2.2. Search activities and innovation

Drawing largely from these related theories, the empirical literature

reveals several aspects of knowledge search across large firm populations that frame the hypotheses development in this study. First, a consistent finding across many studies is that external knowledge sourcing has a positive effect on the likelihood of implementing innovations and on innovation performance (Love, Roper, & Vahter, 2014; Ren, Eisingerich, & Tsai, 2015). For example, in a study of 1353 manufacturing firms in Korea, Kang and Kang (2009) find that external search has a positive effect on the likelihood of product innovation, while Kang and Kang (2014) find a positive relationship between external information acquisition and the likelihood of service innovations in a sample of 454 Korean services firms.

In their seminal study of 2707 manufacturing firms in the U.K., Laursen and Salter (2006) developed firm level measures of external search activity using breadth and depth indicators. Search *breath* is measured as a count variable which sums the total number of different external knowledge sources reported (e.g. suppliers, customers, universities), while search *depth* is an intensity measure, calculated by adding the importance ratings given to each information source. Laursen and Salter (2006) find a curvilinear relationship between search breadth and innovation performance, suggesting that search is beneficial only up to a point – a finding that is replicated in subsequent studies of search and collaboration processes (e.g. Díaz-Díaz & de Saá Pérez, 2014; Garriga, Von Krogh, & Spaeth, 2013; Leiponen & Helfat, 2010).

2.2.3. Search strategies, types and performance

Though useful, breadth and depth measures fail to capture the *direction* of search (Köhler, Sofka, & Grimpe, 2012). Search direction is defined by the different combinations of external knowledge source used by a firm (e.g. universities versus suppliers or customers), and direction represents the specific, targeted search strategies pursued by the firm. The use of particular search strategies typically varies according to the type of innovation introduced (Gómez et al., 2016). For example, Köhler et al. (2012) study 4933 manufacturing and services firms in five European countries and find that knowledge search across the science sector (universities and research providers) is associated with a greater likelihood of novel product innovation, while knowledge search across supplier networks is associated with imitated product innovations. Empirical studies of innovation search tend to link the external sourcing of knowledge from what can be labelled "knowledge-economy" sources (which include universities, research labs, scientific publications/patents and consultants) with novel product innovations (e.g. Köhler et al., 2012; González-Pernía, Parrilli, & Peña-Legazkue, 2015; Tödtling & Grillitsch, 2015; Tödtling, Lehner, & Kaufmann, 2009), while external knowledge sourced from learning across "industry value-chains" (consisting of suppliers, customers and competitors) is commonly associated with operational process innovations (Grimpe & Sofka, 2009; Hirsch-Kreinsen, 2015). The former pattern has theoretical roots in the traditional, linear view of innovation as a process beginning with scientific and technical knowledge inputs (Godin, 2006). The latter pattern stems from systemic views of innovation as an interactive process, that depends on a comparatively wider array of knowledge inputs from industry, institutional and science based actors (Lundvall, 1992). However, the relationship between these two external knowledge sourcing strategies (knowledge-economy and industry value-chain) and product and process innovation is not always obvious from the empirical literature, as each category of knowledge source has also been linked with both product and process innovations and with innovation performance (e.g. Tödtling & Grillitsch, 2014; Vega-Jurado, Gutiérrez-Gracia, & Fernández-de-Lucio, 2009).

Extending these themes around search, innovation types and performance to the search for new ideas at the front end of innovation - where an incoming, high intensity flow of ideas is viewed as positive – the following set of hypotheses are proposed:

H1a. The intensity of front end, idea search strategy across *industry value-chains* has a positive effect on product innovation.
H1b. The intensity of front end, idea search strategy across *industry value-chains* has a positive effect on process innovation.
H1c. The intensity of front end, idea search strategy across *industry value-chains* has a positive effect on innovation performance.
H2a. The intensity of front end, idea search strategy across *knowledge-economy* sources has a positive effect on product innovation.
H2b. The intensity of front end, idea search strategy across *knowledge-economy* sources has a positive effect on process innovation.
H2c. The intensity of front end, idea search strategy across *knowledge-economy* sources has a positive effect on innovation performance.

2.2.4. Innovation search and organisational, managerial and marketing innovations

New or improved marketing methods, organisational and managerial processes are now recognised as constituting important innovations that also draw from external knowledge across industry value-chains and knowledge-economy sources (Camisón and Villar-López, 2014; Tödtling & Grillitsch, 2014; Damanpour & Aravind, 2012). For example, Varis and Littunen (2010) find a positive correlation between external information sourcing and the introduction of novel marketing innovations in a study of 264 SMEs in Finland. Similarly, in a study of 466 firms in seven European countries, Tödtling and Grillitsch (2014) find a positive effect on organisational and strategic innovation from both industry value-chain and knowledge-economy sources. Drawing on this work and the FEI literature finding that a high intensity inflow of ideas is crucial for innovation, we can reason that the intensity of idea search strategy is also linked to organisational, managerial and marketing innovation, leading to the following hypotheses:

H3a. The intensity of front end, idea search strategy across *industry value-chains* has a positive effect on organisational/managerial innovation.
H3b. The intensity of front end, idea search strategy across *industry value-chains* has a positive effect on marketing innovation.
H4a. The intensity of front end, idea search strategy across *knowledge-economy* sources has a positive effect on organisational/managerial innovation.
H4b. The intensity of front end, idea search strategy across *knowledge-economy* sources has a positive effect on marketing innovation.

2.2.5. Internal search strategies, innovation types and performance

Opportunities for innovation are often discovered through experience, from learning by doing, using or interacting. Consequently, many potential ideas for innovation are embedded in the experience and tacit knowledge of firm employees (Lundvall & Johnson, 1994; Nelson & Winter, 1982), and the search for new ideas from within the firm requires active strategies to tap into the ideas of employees (Mascitelli, 2000). Over the past two decades, the innovation literature has progressively recognised the link between firm processes to actively search for new ideas internally, and a wide range of innovation types and outcomes (e.g. Laursen & Foss, 2003; Foss, Laursen, & Pedersen, 2011), while the FEI literature has clearly demonstrated the link between internal idea search activities and product innovations. Therefore, the following hypotheses are proposed:

H5a. The intensity of front end, *internal* idea search strategy has a positive effect on product innovation.
H5b. The intensity of front end, *internal* idea search strategy has a positive effect on process innovation.
H5c. The intensity of front end, *internal* idea search strategy has a positive effect on organisational/managerial innovation.
H5d. The intensity of front end, *internal* idea search strategy has a positive effect on marketing innovation.
H5e. The intensity of front end, *internal* idea search strategy has a

positive effect on innovation performance.

2.2.6. External search strategy interactions and innovation performance

Recent theoretical and empirical literature has shifted away from viewing innovation as a dichotomous process driven by either science-based knowledge *or* industry-based knowledge (Fitjar and Rodriguez-Pose, 2013), towards recognising that innovation can fluctuate between these modes or combine both (Apanasovich, Heras, & Parrilli, 2016). This trend reflects the view within contemporary innovation theories (e.g. Chesbrough, 2005; Rogers, 2003; Lundvall, 1992) that innovation is often dependent on multiple knowledge domains dispersed across multiple sources outside of the firm. Interpreted from this theoretical background, high-level innovation performance typically rests on externally sourced scientific knowledge matched with tacit, industry or experience based knowledge and vice versa. Jensen, Johnson, Lorenz, and Lundvall (2007; p. 683) for example, note that scientists working at the frontier of their fields in R&D departments, often depend on industry based know-how – gained from practical problems previously encountered and solved – when making experiments and producing results in pursuit of innovation. This idea finds support in recent empirical research showing that in terms of the external knowledge inputs underpinning innovation implementation, firms that deploy mixed innovation modes (e.g. drawing on both science-based knowledge and experience-based knowledge from doing, using, and interacting across industry value-chains) tend to show better innovation performance than those with singular strategies (Caloghirou, Kastelli, & Tsakanikas, 2004; Evangelista & Vezzani, 2010; Jensen et al., 2007; Marzucchi & Montresor, 2017; Parrilli & Heras, 2016). In the context of this theoretical and empirical background, we can reason that firms that source knowledge from both industry value-chain and knowledge-economy sources will tend to have superior innovation performance. Further extending this theoretical logic to the front end of innovation, this paper proposes that firms that maintain high intensity industry value-chain *and* knowledge-economy idea search strategies will have superior innovation performance, because like knowledge, ideas from different sources fuse, interact, combine, cumulate and evolve to create better ideas and innovations throughout the process of innovating, and because maintaining a high intensity inflow of ideas from outside of the firm, increases the probability of finding winning ideas that lead to successful innovation (Gilson & Litchfield, 2017). Ideas for novel technological innovations sourced from consultants or research publications for example (sourced through a knowledge-economy strategy), will require fresh ideas from clients and suppliers (industry value-chain strategy) on how to achieve customer and market acceptance, and vice versa. Therefore, this paper proposes the following hypothesis:

H6. A positive interaction effect occurs between the intensities of front end, external *industry value-chain* and *knowledge-economy* idea search strategies, as related to their effect on innovation performance.

2.2.7. The moderating effect of internal search strategy on external search strategy and innovation performance

Cohen and Levinthal (1990, p. 128) define absorptive capacity as a firm's *"ability to recognise the value of new information, assimilate it, and apply it to commercial ends"*. From the perspective of absorptive capacity theory, external knowledge search alone, will not provide the same benefits to all firms in terms of innovation performance (Cohen & Levinthal, 1990; Fabrizio, 2009), as the depth of a firm's stock of internally developed knowledge and capability will enhance the positive effect of its external knowledge sourcing on performance. Firms lacking sufficient internal knowledge capability may not know where to search for the right types of knowledge, or may not be equipped with the internal knowledge required to effectively put externally sourced knowledge to use (Fabrizio, 2009). Due to the cumulative properties of knowledge, the successful integration of new external knowledge is a function of the depth of the internal knowledge base that has accumulated through intensive knowledge development activities, experience and time (Cohen & Levinthal, 1990). Without knowledge of prior failed efforts to adopt a particular external technology for example, a firm may unwittingly encounter the same problems when acquiring new related technology, and fail to achieve improved innovation performance through technology acquisition. As key aspects of absorptive capacity, the depth of internal knowledge, and the intensity of internal knowledge search and development activities (that determine the rate at which internal knowledge accumulates) therefore play a determining role for innovation performance (Escribano, Fosfuri, & Tribó, 2009). This theme has found frequent empirical support. Studies that use internal R&D based measures of internal knowledge capability typically find that such internal capability moderates the effect of external knowledge sourcing on innovation performance (e.g. Berchicci, 2013). Similarly, Segarra-Ciprés, Roca-Puig, and Bou-Llusar (2014) find that internal knowledge transfer activities intensify the influence of external knowledge acquisition on innovation output in a cross-sectoral study of 916 Spanish firms. This paper extends the logic of absorptive capacity theory to the process of searching for new ideas at the front end of innovation, and suggests that firms will be more likely to improve innovation performance from an intensive external search for ideas if they intensively search for new ideas internally, as a higher intensity of internal idea search will increase the rate at which the internal stock of ideas accumulates, and because ideas – like knowledge – will cumulate and combine to achieve better ideas and innovation performance. Consequently, the following hypotheses are proposed:

H7a. The intensity of front end, *internal* idea search strategy, positively moderates the effect of the intensity of *industry value-chain* idea search strategy on innovation performance, such that, at high levels of intensity of front end, *internal* idea search strategy, the effect of the intensity of *industry value-chain* idea search strategy on innovation performance will be greater.

H7b. The intensity of front end, *internal* idea search strategy, positively moderates the effect of the intensity of *knowledge-economy* idea search strategy on innovation performance, such that, at high levels of intensity of front end, *internal* idea search strategy, the effect of the intensity of *knowledge-economy* idea search strategy on innovation performance will be greater.

3. Methodology

3.1. Data

The empirical part of this paper is based on cross-sectional data from a 2015 survey of 1600 Australian businesses, randomly selected from a national business register. The survey was part of a research project undertaken for the Australian Department of Innovation, Industry and Science (http://industry.gov.au). The survey questionnaire was designed to collect new types of data on firms' innovation search activities, investments and performance. The questionnaire was subject to an extensive cognitive testing process to optimise quality, validity, and reliability (e.g. see Collins, 2003; Hughes, 2004; and Presser, Rothgeb, & Couper, 2004). Cognitive testing involved 33 interviews with respondents across a diverse set of industries and firm sizes. The final survey was administered using both mailed and online questionnaires. Of 1600 selected businesses, 359 responded, giving a response rate of 22.4%. Non-response analysis found no evidence of bias between the responding and non-responding samples, suggesting that results are representative of the broader population of Australian businesses (further details are included in Appendix A). The survey design was based on guidelines provided by the OECD (OECD, 2005), and the survey period covers activities in the 2014 calendar year. Of all respondent firms, 15% are in primary resources, 7% are in manufacturing, 23% are in knowledge intensive business services and 55%

are in general services. Of all respondents, 65% have less than 200 employees (including 16.7% with 0–4 employees) and 35% have 200 or more employees.

3.2. Variables and measures - independent variables

3.2.1. Measures of front end, external idea search strategy intensity

The approach to measuring firms external idea search activity at the front end follows prior studies in the innovation search tradition (e.g. Laursen & Salter, 2006; Köhler et al., 2012; Grimpe & Sofka, 2009; Sofka & Grimpe, 2010). Adopting the measurement approach used by Katila and Ahuja (2002), the survey uses a categorical variable to measure the frequency of idea search activity (not at all, less than once a month, approximately once a month, more than once a month) across a range of external idea sources. Firms are asked to report how often they searched for ideas for innovations from ten different external sources of ideas:

1.) websites or social media; 2.) clients, customers or buyers; 3.) suppliers; 4.) competitors; 5.) industry associations; 6.) consultants or private research institutes; 7.) universities or other higher education institutions; 8.) government agencies; 9.) journals, research papers or publications; 10.) professional conferences, seminars, meetings or trade shows.

The question applies to idea search activity for organizational and managerial process innovations, marketing innovations, operational process and product (good or service) innovations.

The ten variables that measure separate external idea sources are grouped into exclusive categories which correspond to industry value-chain and knowledge-economy idea search strategies. The industry value-chain strategy covers the search for ideas across clients, competitors, industry associations, suppliers, websites and social media and industry associations. The knowledge-economy search strategy covers the search for ideas from universities or other higher education institutes, government agencies, providers of consultancy and research services, journals and research publications and professional knowledge dissemination events such as conferences and seminars. These groupings reflect strategies found in studies of external knowledge search for innovation (e.g. Vega-Jurado et al., 2009), and following Sofka and Grimpe (2010) and Köhler et al. (2012), are validated by an exploratory principal-components factor analysis of external idea source variables (factor analysis and observed correlations across variables are included in Appendix B).

To measure the intensity of external idea search strategy, depth variables are created for both the industry value-chain strategy and the knowledge-economy strategy. Depth for each strategy is calculated by summing the frequency of idea search activity across idea sources that correspond to each strategy. In the study questionnaire, search activity frequency is measured for each external idea source as: not at all = 0, less than once a month = 1, approximately once a month = 2, more than once a month = 3. This gives a maximum possible depth score of 15 for each external idea search strategy. The regression analysis includes a variable for external idea search strategy intensity, which is measured as the normalised depth score for each strategy. This is calculated as the depth score expressed as a percentage share of the maximum possible depth score for each strategy. External idea search strategy intensity is a percentage variable ranging from 0 to 1.

3.2.2. Measure of front end, internal idea search intensity

In this study, the intensity of internal idea search strategy is measured based on the number of employee types that firms identify as providing ideas for innovations. Firms were asked to identify whether they sourced ideas for innovation from six categories of employee via a binary response variable (yes/no). The employee categories include:

1.) owners; 2.) senior or middle managers; 3.) professional employees (engineers, scientists, IT specialists, lawyers); 4.) clerical, sales or service employees; 5.) production, transport or trade employees; or 6.) other types of employees.

As with external idea search, the question applies to organizational and managerial process innovations, marketing innovations, operational process and product (good or service) innovations. For each firm, a single variable to measure the depth of internal idea search strategy was calculated as the count of all internal idea sources used (ranging from 0 to 6). This approach was validated by principal components analysis which showed unidimensionality across all internal idea sources. The regression analysis includes a variable for internal idea search strategy intensity, which is calculated as the depth score expressed as a percentage of the maximum possible depth count (n = 6), and ranges from 0 to 1.

3.2.3. Interaction/moderation variables for the intensity of external and internal idea search strategies

Following the theoretical and empirical reasoning for Hypotheses H6, H7a and H7b discussed in Sections 2.2.6 and 2.2.7, interaction variables are included to test for an interaction effect between the intensity of the two *external* idea search strategies, as related to their effect on innovation performance (H6), and to test for a positive moderation effect between *internal* idea search strategy intensity, as related to its effect on the relationship between the intensity of knowledge-economy and industry value-chain search strategies and innovation performance (H7a and H7b). This approach addresses the research question regarding innovation performance and the interaction between external and internal idea search activities at the front end. Following Aiken and West (1991), to address the potential issue of multicollinearity impacting the analysis, both the predictor and moderator/interaction variables were mean-centred prior to creating interaction variables. As an additional test, following Vaccaro, Jansen, Van Den Bosch, and Volberda (2012) variance inflation factors (VIF) were computed to test for multicollinearity. All computed values were below the cut-off value of 10 (with the highest VIF 1.54) (Netter, Wasserman, & Kutner, 1990), suggesting that multicollinearity is not an issue for the analysis.

3.3. Variables and measures - control variables

Four control variables are included in the study: firm size, firm industry, firm age, and internal innovation investment intensity. A wide body of empirical literature shows that the probability of innovation is positively influenced by firm size, as size determines the array and volume of resources available to a firm for innovation projects (Cohen, 1995; Evangelista & Mastrostefano, 2006). Consequently, a categorical control variable for firm size is included with categories for 0–4, 5–19, 20–199 and 200 + employees (the base category). Secondly, different industries are underpinned by different markets, knowledge bases, appropriability conditions and technological opportunities (Klevorick, Levin, Nelson, & Winter, 1995; Malerba, 2002). Thus opportunities and propensities for innovation differ by industry. Consequently, a categorical control variable is added with industry categories for primary resources, manufacturing, knowledge intensive business services (KIBS) and general services sectors (the base category).

Firm age plays a role in firm propensity for innovation, though the empirical results are mixed regarding the nature of the relationship. Start-ups can be more innovative than incumbents in turbulent industries (Christensen, 2013), though large firms can have innovation advantages when new technologies are complex and require large resource commitments and sustained R&D (in the aerospace sector for example). To control for firm age differences a categorical variable is included with categories for 0 to less than 7 years, 7 years to less than 15 years, 15 years to less than 25 years and 25 years or greater (the base category).

Based on absorptive capacity theory, the benefits to innovation from external knowledge search are enhanced by a firm's internal research and development capability (Cohen & Levinthal, 1990). Consequently,

a control variable is included for internal innovation investment intensity. This is calculated as the ratio of internal innovation investment to annual sales turnover. In this study, internal innovation investment covers internal R&D expenditure and other innovation development expenditures (such as staff training) linked to absorptive capability. Investment intensity is measured as an ordinal categorical variable including three categories: high internal investment intensity (> = 2.5% internal innovation investment intensity), low internal investment intensity (0–2.5%) (the base category) and zero internal investment intensity. Low investment intensity is selected as the base category to detect any differences between the effect of high and low investment intensities on dependent variables.

3.4. Variables and measures - dependent variables

3.4.1. Different types of innovation

Given that all types of innovation can generate firm-level benefits and are widespread across typical firm populations, four types of innovation are measured in this study in alignment with definitions provided in the OECD Oslo manual guidelines (OECD, 2005). Specifically, the frequency of four different types of innovation introduced by firms over the study period provide outcome variables in the analysis: new products (goods or services), new operational processes, new organizational/managerial processes and new marketing methods. All are ordinal categorical variables (0, 1, 2, 3 to 4, 5 or more innovations introduced over the survey period).

3.4.2. Innovation performance

Several innovation performance measures feature in empirical research at the firm level (see OECD (2005) for a summary). Two of the most common types include a binary measure which is positive if the firm introduced a technological (product or process) innovation in the period of study, and the proportion of annual sales attributable to new or significantly improved products (usually measured as an interval or categorical variable). Though both are widely used outcome measures, they are biased towards technological innovation (O'Brien, 2016; Som et al., 2012), neglecting organizational and marketing innovations.

For this study, innovation performance is measured as the complexity of the firms most important innovation reported over the survey period. Following the 'object' approach to measuring innovation - which focuses on a single innovation as the unit of analysis (OECD, 2005) - in this study, firms are asked to identify their *single most important innovation* (in terms of having the greatest benefit for the financial position of the business) implemented over the survey period. A follow up question asks firms about the time required to develop that innovation in person-months (equal to the share in months of one full time employee's time working on innovation development). Person-months is measured as a categorical ordinal variable (less than 1 month, 1 to less than 6 months, 6 to less than 12 months, 12 to less than 24 months, 24 months or more). Innovation complexity is proxied by the time required to develop the firm's single most important innovation, which signals both complexity and the level of innovativeness based on the degree of development difficulty (Rogers, 2003). Since all of the dependent variables in this study are ordinal, an ordinal logistic regression approach is used to test the effect of the independent variables on innovation outcomes.

3.5. Common method bias assessment

Since all independent and dependent variables were derived from a single survey instrument and point in time, common method bias (CMB) may potentially influence the findings and present problems for the analysis (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Following Bharadwaj and Menon (2000) and Scott and Bruce (1994), Harman's one-factor test was applied to test for CMB. Under this approach, if CMB were a problem for the study, a single factor would account for the majority of variance across all study variables (Bharadwaj & Menon, 2000). Using SPSS Statistics 24, a principal components factor analysis was applied to all variables included in the analysis, yielding four factors with eigenvalues greater than one that accounted for 60% of the cumulative variance. Since no single factor emerged from the factor analysis, the results suggest that common method bias is not an issue for the study.

Table 1
Descriptive statistics.

Variable	N	Mean	S.D.
Product innovation	178	1.43	1.54
Operational processes innovation	193	1.86	1.42
Organizational/managerial process innovation	185	1.77	1.32
Marketing method innovation	181	1.40	1.23
Innovation performance	207	2.26	1.15
Primary industries	225	0.15	0.35
Manufacturing	225	0.07	0.26
KIBS	225	0.23	0.42
General services	225	0.55	0.50
0–4 employees	28	0.12	0.33
5–19 employees	45	0.20	0.40
20–199 employees	66	0.29	0.46
200+ employees	86	0.38	0.49
0–6 years	61	0.27	0.45
7–14 years	57	0.25	0.44
15–24 years	51	0.23	0.42
25+ years	47	0.21	0.41
Internal_Inv_Int(high)	37	0.16	0.37
Internal_Inv_Int(low)	20	0.56	0.50
Internal_Inv_Int(zero)	125	0.09	0.29
IndValChain_Int	225	0.47	0.27
Know_Econ_Int	216	0.22	0.20
Internal_Int	216	0.29	0.21

3.6. Conceptual framework: Variables and relationships

A conceptual framework showing all independent and dependent variables in the study (excluding control variables), and hypothesised relationships between variables is presented in Appendix C.

4. Results

Table 1 presents descriptive statistics for variables and measures included in the analysis. Operational process innovations exhibit the highest average implementation frequencies, and both types of process innovation are the most common innovation types reported by firms in the study sample (see Appendix D). The industry structure of the sample (and broader Australian economy) is characterised by a small share of firms in manufacturing (7% of respondents) compared to primary industries (15%), general services (55%) and knowledge intensive business services (23%). As in most similar developed economies, most responding firms (62%) are small with less than 200 employees, while 78% are less than 25 years old. Of the respondent firms, 56% have a low internal innovation investment intensity compared to 16% with high internal investment intensity and 9% with no internal investment over the study period. The average external search strategy intensity score is higher for industry value-chain search (47%) than knowledge-economy search (22%), while the average score for internal idea search strategy intensity is 29%.

The results in Table 2 show the effect of front end, idea search strategy intensity on the frequency of different innovation types. Results are presented for four models that correspond to four different types of innovation: new products, new operational processes, new organizational/managerial processes and new marketing methods.

Focusing on the first model for product innovation frequency, the intensity of idea search strategy across industry value-chains (*IndValChain_Int*) shows a positive significant effect on the frequency of

Table 2
Results from ordered logit regressions, innovation frequencies of different innovation types.

	Products		Operational processes		Organizational/managerial processes		Marketing methods	
	B	S.E.	B	S.E.	B	S.E.	B	S.E.
Primary industries	0.050	0.488	0.502	0.445	−0.171	0.466	−0.445	0.492
Manufacturing	1.576***	0.606	1.051*	0.572	−0.013	0.591	0.688	0.592
KIBS	−0.037	0.407	−0.097	0.387	−0.121	0.394	−0.376	0.403
0–4 employees	0.379	0.567	−1.220**	0.538	−0.740	0.588	−0.164	0.559
5–19 employees	0.291	0.486	−0.718	0.471	−0.690	0.468	0.110	0.472
20–199 employees	0.152	0.393	0.011	0.362	0.036	0.368	0.362	0.377
0 to 7 years	−0.138	0.499	0.256	0.473	−0.464	0.484	0.011	0.476
7 to 15 years	0.142	0.500	−0.022	0.471	0.016	0.475	0.304	0.480
15 to 25 years	−0.307	0.512	−0.612	0.500	−0.440	0.491	−0.318	0.486
Internal_Inv_Int(high)	0.179	0.456	621	0.425	0.775*	0.454	0.130	0.448
Internal_Inv_Int(zero)	−0.386	0.564	−1.346**	0.547	−0.836	0.555	−1.118**	0.547
IndValChain_Int	2.263***	0.699	−0.266	0.704	0.740	0.697	1.446**	0.681
Know_Econ_Int	0.450	0.945	1.743*	0.974	0.769	0.968	0.754	0.932
Internal_Int	0.284	0.841	0.668	0.814	0.181	0.821	−0.699	0.818
N (Observations)	225		225		225		*225*	
−2 Log likelihood	451.990		432.455		418.667		400.729	
Model X^2 (df)	35.151		37.390		22.900		21.367	
Pseudo R^2 (Cox and Snell)	0.192		0.217		0.144		0.135	

*p < 0.1, **p < 0.05, ***p < 0.01, ****p < 0.001.
Industry: base category = general services, firm size, base category = 200 + employees, firm age, base category = 25 years or older.

product innovation (p < 0.01), providing support for Hypothesis H1a. No effects are observed for the intensity of knowledge-economy idea search strategy (*Know_Econ_Int/H2a*) or internal idea search strategy intensity (*Internal_Int, H5a*). For the control variables, a positive significant effect is observed for industry, with firms operating in the manufacturing sector more likely to implement a greater number of product innovations (*p < 0.01)* compared to firms in general services (the base category).

For the second model, knowledge-economy idea search strategy intensity shows a positive significant effect on the frequency of operational process innovations (*H2b*) - though the effect is only marginally significant (p < 0.1) - while no effect is observed for industry value-chain idea search strategy intensity (*H1b*) or for internal idea search strategy intensity (*H5b*). A positive and marginally significant industry effect is observed for manufacturing firms (compared to firms in general services) (*p < 0.1*). The results also suggest that internal innovation investment intensity (*Internal_inv_int*) matters for the frequency of operational process innovation. A significant negative effect is observed for firms with zero investment compared to firms with low internal investment intensity (*p < 0.05*), though compared to low investment intensity, a high investment intensity does not impact on the likelihood of a higher frequency of operational process innovation.

For the organizational and managerial process innovation model, no significant effects are observed for external or internal idea search strategy intensities (*H3a, H4a, H5c*). This suggests that the frequency of innovation in organizational and managerial processes is not correlated with the intensity of particular external idea search strategies, or with the intensity of internal idea search from employees. One explanation is that organizational and managerial innovations are commonplace, ongoing and driven internally by regular management and leadership initiatives rather than strategic (external and internal) idea search activity. This explanation finds some support in the descriptive survey results (Appendix D), which show that organizational and managerial innovations are the most frequently reported type of innovation, cited by 49.3% of respondent firms compared to 30.9% citing product innovations. Of the control variables, only internal innovation investment intensity shows a positive, marginally significant effect (*p < 0.1*), with high internal investment intensity correlated with a higher frequency of organizational and process innovation compared to low internal investment (the base category).

For the fourth model in Table 2, idea search intensity across industry value-chains has a positive and significant effect on the frequency of marketing method innovations (*p < 0.05)*, though no effect is observed for knowledge-economy search strategy intensity (*H4b*) or for internal search strategy intensity (*H5d)*. This result provides support for Hypothesis *H3b*, suggesting that open innovation orientation is not only important for product and process innovations but also for marketing innovations, highlighting the importance of keeping abreast of activity across customer, supplier, industry and competitor networks in order to capture new ideas for marketing innovations. A significant effect is observed for internal innovation investment intensity, with a lack of internal investment showing a negative effect (*p < 0.05*).

Table 3 shows the effect of the intensity of front end idea search

Table 3
Results of ordered logit regressions, innovation performance.

Innovation performance				
	B	S.E.	B	S.E.
Primary industries	−0.342	0.463	−0.334	0.466
Manufacturing	0.907	0.555	0.838	0.561
KIBS	0.211	0.370	0.303	0.375
0–4 employees	−0.975*	0.548	−0.786	0.556
5–19 employees	−1.215***	0.463	−1.179**	0.462
20–199 employees	−0.730**	0.360	−0.615*	0.365
0–7 years	−0.696	0.480	−0.862*	0.487
7–15 years	−0.875*	0.474	−1.133**	0.490
15–25 years	−1.148**	0.491	−1.341***	0.500
Internal_Inv_Int(high)	−0.608	0.419	−0.597*	0.421
Internal_Inv_Int(zero)	−1.534***	0.552	−1.709***	0.557
IndValChain_Int	−0.456	0.658	−0.173	1.680
Know_Econ_Int	3.044***	0.938	2.043*	1.095
Internal_Int	1.809**	0.797	1.192**	0.832
IndValChain_Int*Internal_Int			2.563	3.580
Know_Econ_Int*Internal_Int			−3.083	4.301
IndValChain_Int*Know_Econ_Int			7.014**	3.251
N (Observations)	225		225	
−2 Log likelihood	414.507		408.402	
Model X^2 (df)	65.030		71.134	
Pseudo R^2 (Cox and Snell)	0.318		0.342	

*p < 0.1, **p < 0.05, ***p < 0.01, ****p < 0.001.
Industry: base category = general services, firm size, base category = 200 + employees, firm age, base category = 25 years or older.

strategies on innovation innovation performance. The results for two models are presented. The first model presents the main effects. The second model includes interaction effects. The second model tests for an interaction effect between the intensity of the two *external* idea search strategies, as related to their effect on innovation performance (*H6*), and whether internal idea search strategy intensity moderates the relationship between external idea search strategy intensity and innovation performance (*H7a* and *H7b*). As noted by Baron and Kenny (1986), observed effects for model 1 are not directly relevant conceptually to testing the moderation/interaction effects for model 2.

In the first model (no interaction effects), knowledge-economy idea search strategy intensity shows a positive significant effect on innovation performance ($p < 0.01$), providing support for Hypothesis *H2c*, though no effect is observed for idea search strategy intensity across industry value-chains (*H1c*). This result highlights the importance of frequently searching for ideas across networks of specialised knowledge providers (such as universities, consultants and specialist service providers) for innovation performance. Internal idea search strategy intensity also shows a positive and significant effect ($p < 0.05$), providing support for Hypothesis *H5e* and indicating that search activities to capture ideas from employees across multiple functions and levels of responsibility are also important for innovation performance.

The results from the second innovation performance model add weight to these findings and provide support for Hypothesis H6, though no moderating effect is observed to support Hypothesis *H7a* or *H7b*. A significant positive interaction effect is observed for the two types of *external* idea search strategy ($p < 0.05$). Knowledge-economy idea search strategy intensity enhances the effect of industry value-chain idea search strategy intensity on innovation performance. Again, this result emphasises that the most important innovations with a high level of complexity (based on the required development time/resources) draw on ideas from a diverse set of external actors and institutions. This finding resonates with the view of FEI as a chaotic, unstructured process that seeks out many ideas from many different places.

5. Conclusion and discussion

This study investigated the search for new ideas at the front end of innovation, uniquely contributing to the FEI literature by extending the concept of FEI to organizational, managerial, process and marketing innovations. This contribution is significant because as many authors note, these types of innovation have been generally under-researched in economy-wide empirical innovation research (Som et al., 2012; Sapprasert & Clausen, 2012; Damanpour & Aravind, 2012). At the same time, these innovation types are clearly important for the innovation strategies and success of a large proportion of firms in most economies (Armbruster, Bikfalvi, Kinkel, & Lay, 2008; Camisón & Villar-López, 2014; Mol & Birkinshaw, 2009; Hervas-Oliver and Sempere-Ripoll, 2015), particularly for firms in services sectors (which make up over 70% of firm populations in most advanced economies (OECD, 2013)), low-tech industries and smaller sized firms (Laforet, 2013; Sundbo, 1997; Tether & Tajar, 2008; Trigo, 2013). By controlling for industry differences, the findings of this study address an identified need in the FEI literature for new, cross-industry evidence that shows how firms organise their idea search activity; also demonstrating that search depth and direction concepts found in the broader innovation search literature can be applied to study and analyse FEI processes. The study also adds to the broader innovation search literature, which is principally concerned with product and process innovations in development and implementation stages and neglects search at the front end.

Concerning idea search strategy at the front end and innovation, the results show that the direction and intensity of idea search strategy matter for both the frequency of different types of innovation introduced and for innovation performance. As a general observation, the results overall are consistent with FEI studies suggesting that sustaining a high number of incoming ideas into the firm is important for stimulating product innovation. The results add to this FEI literature by linking the intensity of external idea search strategy at the front end, with a greater probability of implementation success for marketing and operational process innovations. In particular, the findings extend on prior FEI studies by showing that the effect of the direction of external idea search, defined by specific strategies, varies for different types of innovations.

Prior innovation search literature tends to link external knowledge inputs sourced from knowledge-economy actors with novel products (e.g. Köhler et al., 2012; González-Pernía et al., 2015; Tödtling & Grillitsch, 2015), associating knowledge inputs sourced from learning-by-doing across industry-value chains with operational process innovations (Grimpe & Sofka, 2009; Hirsch-Kreinsen, 2015). In this study, the results for idea search intensity at the front end display an inverse pattern: idea search intensity from knowledge-economy providers is positively correlated with the frequency of operational process innovation, while idea search intensity across industry value-chains is positively correlated with product innovation frequency. This pattern indicates that for product and process innovations, the types of strategies (or combination of external actors) important for sourcing ideas at the front end are different from those that are important for sourcing knowledge at implementation stages.

The absence of any observed effects between front end, external idea search strategy intensity and organizational and managerial innovation stands out, given that organizational and managerial innovation is the most common innovation type in the study sample (cited by 49.3% of firms in the study). One explanation for this result, is that inspiration for organizational and managerial innovation is more likely to originate from inside of the firm. Subsequently, the fact that internal idea search strategy intensity also showed no effect in the results for organizational and managerial innovation implies that internal organizational factors not included in the analysis (e.g. management capability, management turnover, leadership culture) are more important drivers of this type of innovation than front end, idea search strategy intensity.

The results for the innovation performance model showed that the intensity of idea search strategy both inside the firm and across knowledge-economy sources had an effect on performance, while an interaction effect between the two different *external* idea search strategy intensities also showed an effect. These findings can be related to prior theoretical and empirical literature that associates diverse knowledge input combinations (codified and tacit) with higher levels of innovativeness at the firm level (Jensen et al., 2007; Parrilli & Heras, 2016; Tödtling & Grillitsch, 2014). The performance model results extend this theme to the front end of innovation, demonstrating that for complex innovations with impact, inspiration is more likely to be drawn from an intensive search for new ideas across a diverse set of actors inside and outside of the firm.

This study yields several implications for firm managers. First, echoing Drucker (1985), results strongly suggest that regardless of industry, idea search activity at the front end of innovation should be both frequent, and decisive in terms of the different types of external actors sought out for inspiration. The front end, search for new ideas should be a planned, coordinated, strategic activity for firms. Second, idea search strategies should be sensitive to particular innovation strategies in place, or the particular innovation types being pursued by the firm (in the absence of clearly defined strategy). As the results show, no one size fits all: different strategies suit different innovation types.

The contrast between some results and themes in the broader innovation literature serve as a reminder to firm managers, that idea search processes at the front end are distinct from implementation phases and should be managed differently. While clear strategies for regular, targeted search for new ideas outside of the firm should be pivotal for stimulating innovation activity, they are only part of the overall innovation process and will not alone guarantee success; equally strategic external knowledge search activity is necessary to accumulate

the right knowledge for innovation development and implementation.

Finally, the study results suggest that for complex innovation projects - and to achieve any aspirations towards a higher level of innovativeness - firm managers should be prepared to be open and flexible in their quest for new ideas. Managers should be prepared to both look inside and cast the net far and wide to capture the next great new idea, as the results suggest that multiple ideas, sourced from multiple, diverse sources inside and outside of the firm are important for the most significant and complex innovation projects.

5.1. Limitations and future research

Some limitations of this study should be considered when interpreting the results. Of note, the cross-sectional nature of the study limits the analysis to correlation over causation, and the study has a single country focus. Future research should span multiple countries, and panel or longitudinal studies can help with understanding the dynamics and effects of idea search strategies over time.

Within the analysis, a key outcome variable is the frequency of different types of innovation implemented, which does not take into account innovation novelty or impact. Future research is needed to examine the relationship between idea search strategy and the novelty and impact of different innovation types. This requires work to define new outcome measures for different types of innovation. Using a firm-level approach, this could benefit from an 'object' based research perspective, that first asks firms to identify particular innovations with significant impacts for the firm, then investigates how firms source ideas underpinning those specific innovations. Alternatively, qualitative research on the various sub-types of organizational, marketing and managerial innovations and their effects can help to develop better outcome measures for use in large scale, firm level survey research.

Finally, the study results highlight a need for more in depth, firm-level research to investigate the mechanisms by which firms search for ideas at the front end (within and outside) for organizational and managerial innovations. Such research should examine how internal specific factors, such as key manager capabilities, manager turnover, and organizational culture influence front end, idea search strategies linked to organizational and managerial innovations.

Appendix A. Non-response analysis

The non-response analysis tested for non-response bias using Armstrong and Overton (1977) time-trend extrapolation approach, which maintains that non-respondents resemble late respondents. Late respondents were identified as those that responded after the final (third) follow up reminder, while early respondents were classified as all respondents that participated prior to this reminder. This led to 10.6% (38) of all respondents being classified as late responders and 89.4% (321) classified as early responders. No statistically significant differences are observed between the two response groups in terms of the proportion of innovators or the proportion of different types of innovation (product, operational process, organizational or managerial process, marketing methods). These results, combined with a close match in the industry distribution between the target population sample and the response sample, suggest that the results are unlikely to be impacted by non-response bias.

See Table A1.

Table A1
Non-response analysis.

	Early responders	Late responders
Innovative firms (any innovation in the study period)	62.6%	63.2%
Product innovators	31.8%	23.7%
Operational process innovators	44.5%	47.4%
Organizational and managerial process innovators	48.6%	55.3%
Marketing innovators	38.9%	36.8%

Note: Pearson Chi-Square test showed no significant differences between response status group.

Appendix B. Correlation matrix and factor analysis validation of external idea source variables

Observed correlations between the search frequencies reported across separate external idea sources (Table B1) suggest the presence of underlying search direction and particular strategies (all correlations in B1 are significant at $p < 0.01$). Following the approach of Sofka and Grimpe (2010) and Köhler et al. (2012), an exploratory principal-components factor analysis is undertaken to verify the grouping of external idea source variables into strategy categories. Table B2 shows the rotated factor loadings of the idea search channels. The two factors with an eigenvalue greater than one identified support the variable groupings that measure industry value-chain sources (Factor 1) and knowledge economy sources (Factor 2). The keyser-meyer-olkin sampling adequacy measure of 0.867 is satisfactory, while the factor loadings are all over 0.5.

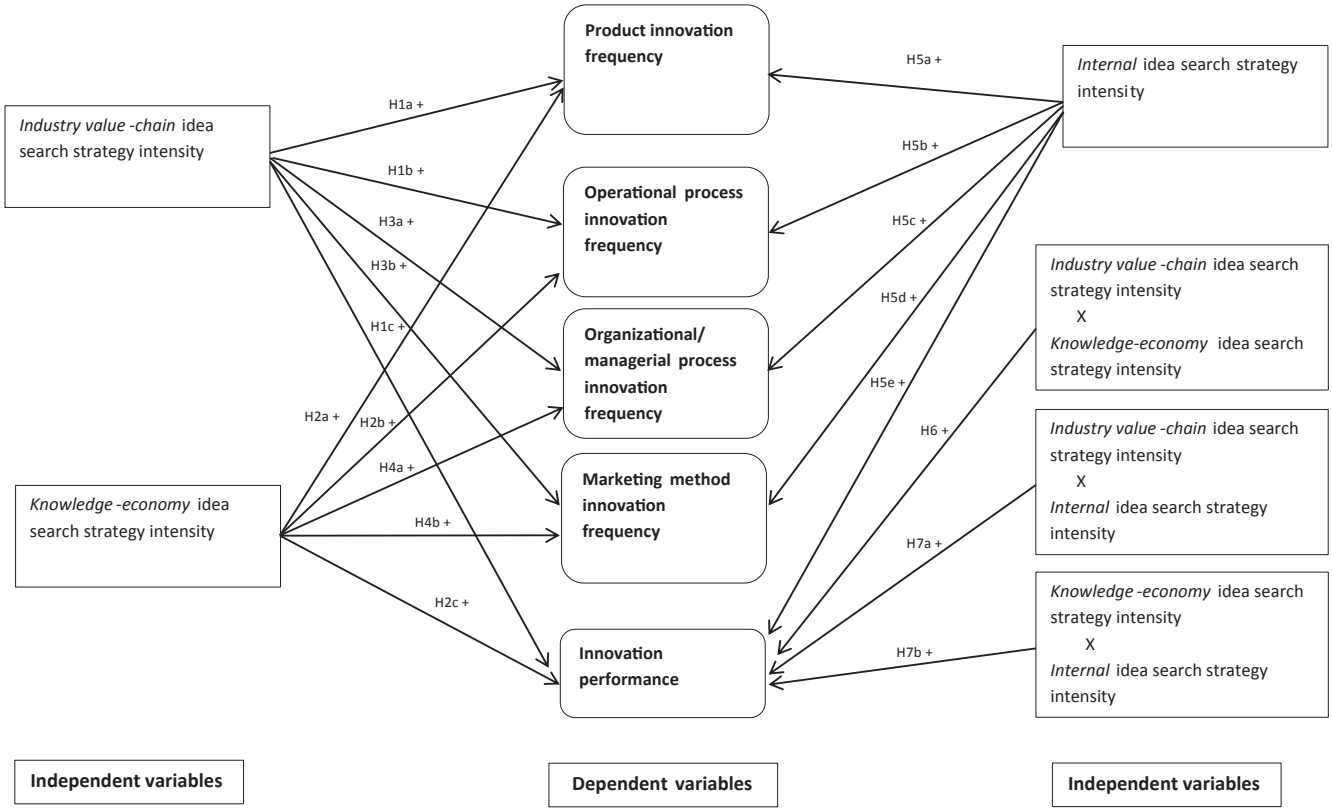
Table B1
Correlation matrix – intensity of external idea search by source.

	Web	Clients	Suppliers	Competitors	Industry	Consultants	Universities	Government	Journals	Conferences
Web	1.000	0.505	0.521	0.453	0.409	0.242	0.253	0.296	0.325	0.392
Clients	0.505	1.000	0.523	0.574	0.411	0.167	0.204	0.206	0.375	0.414
Suppliers	0.521	0.523	1.000	0.598	0.427	0.294	0.237	0.345	0.266	0.357
Competitors	0.453	0.574	0.598	1.000	0.549	0.339	0.258	0.205	0.300	0.396
Industry	0.409	0.411	0.427	0.549	1.000	0.382	0.391	0.314	0.389	0.557
Consultants	0.242	0.167	0.294	0.339	0.382	1.000	0.431	0.351	0.323	0.337
Universities	0.253	0.204	0.237	0.258	0.391	0.431	1.000	0.534	0.414	0.398
Government	0.296	0.206	0.345	0.205	0.314	0.351	0.534	1.000	0.393	0.393
Journals	0.325	0.375	0.266	0.300	0.389	0.323	0.414	0.393	1.000	0.508
Conferences	0.392	0.414	0.357	0.396	0.557	0.337	0.398	0.393	0.508	1.00

Table B2
Results of principle components factor analysis: factor loadings after varimax rotation.

Informal external knowledge source	Factor 1	Factor 2
Websites or social media	**0.704**	*0.218*
Clients, customers or buyers	**0.807**	*0.107*
Suppliers	**0.767**	*0.191*
Competitors or other businesses from the same industry	**0.805**	*0.180*
Industry associations	**0.573**	0.471
Consultants or private research institutes	*0.179*	**0.644**
Universities or other higher education institutions	*0.079*	**0.814**
Government agencies	*0.118*	**0.751**
Journals, research papers or publications	*0.298*	**0.628**
Professional conferences, seminars, meetings or trade shows	0.452	**0.580**

Appendix C. Conceptual framework: Variables and relationships



Appendix D. Distribution of respondents by innovation status

Innovation status	N	Proportion of respondents (N = 359) %
Innovator	225	62.7
Product innovator	111	30.9
Operational process innovator	161	44.8
Organizational/managerial process innovator	177	49.3
Marketing innovator	139	38.7

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