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Search and Disrupt: The Influence of Strategic Interest Alignment on External Knowledge Search

Anders Ørding Olsen
CBS
Department of Innovation and Organizational Economics
aoo.ino@cbs.dk

Abstract
This paper analyzes how external search is affected by strategic interest alignment among knowledge sources. I focus on misalignment arising from the heterogeneous effects of disruptive technologies by analyzing the influence of incumbents on 2,855 non-incumbents? external knowledge search efforts. The efforts most likely to solve innovation problems obtained funding from the European Commission?s 7th Framework Program (2007-2013). The results show that involving incumbents improves search in complementary technologies, while demoting it when strategic interests are misaligned in disruptive technologies. However, incumbent sources engaged in capability reconfiguration to accommodate disruption improve search efforts in disruptive technologies. The paper concludes that the value of external sources is contingent on more than their knowledge. Specifically, interdependence of sources in search gives rise to influence from individual strategic interests on the outcomes. More generally, this points to the need for understanding the two-way influence of sources, rather than viewing external search as one-way knowledge accessing.

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Introduction

Problem solving as knowledge search(Nelson and Winter 1982) is shown to be an important contributor to firms' innovation and performance (Katila and Ahuja 2002; Laursen and Salter 2006; Leiponen and Helfat 2010) by providing external inputs. Openness towards external sources of knowledge such as universities, suppliers, users and competitors allows firms is shown to provide firms with access to new inputs (Chesbrough 2003; Laursen and Salter 2006; Love et al. 2013) and access to distant knowledge. This improves the innovation efforts of these firms (Rosenkopf and Nerkar 2001) by increasing novelty and reducing inertia in problem solving (Rosenkopf and Almeida 2003). Accessing and using external knowledge involves interacting, contributing and evaluating inputs, as well as selecting and assembling the appropriate pieces of a larger puzzle to eventually form the proposed joint solution to an innovation problem (Love et al. 2013). The extent of these efforts and restrictions from absorptive capacity(Cohen and Levinthal 1990) result in tradeoffs regarding the breadth and depth of external search efforts (Laursen and Salter 2006), and the use of local versus distant knowledge(Rosenkopf and Almeida 2003).

Interestingly, most research on knowledge search has analyzed these efforts from the perspective of a unitary actor, searching for and accessing knowledge(Knudsen and Levinthal 2007). This has overlooked the inherent interdependence in joint efforts and the potential mutual influence of the sources on each other and the outcomes (Knudsen and Srikanth 2014). As such, the mechanisms mainly understood to influence the outcome of external search concern two aspects. Firstly, the internal aspects of the searching firm, such as absorptive capacity(Cohen and Levinthal 1990). Secondly, the characteristics of the external knowledge provided by the sources searched(Katila and Ahuja 2002; Laursen and Salter 2006). The latter assumes that external sources unambiguously provide the searching firm with access to their knowledge. However, recent findings show that firms selectively reveal pieces of knowledge in strategic efforts to attract collaborators(Alexy et al. 2013). This gives rise to concerns as to whether firms may also subsequently be strategic in their contribution to joint efforts. I address this concern by viewing search as interdependent and open to mutual influence between sources(Knudsen and Srikanth 2014). I thereby explore whether and how the individual strategic interests of knowledge sources influence the outcome of external search efforts.

To explore the potential influence of alignment of strategic interests I analyze how incumbent firms affect the outcomes of non-incumbents' external knowledge search related to technological innovation. Firms essentially engage in search efforts to find and develop solutions to problems(Katila and Ahuja 2002; Nelson and Winter 1982). In the context of innovation, doing so results in either complementary or disruptive industry changes, which strongly impact the competitive advantage of incumbent firms (Christensen 1997). The influence on incumbents is a result of the degree to which they continue to posses the capabilities needed to retain or strengthen their competitive advantage. This is the case when innovation within complementary technologies supports the value of existing knowledge, assets and business models in an industry (Henderson and Clark 1990). Contrary to this are the negative effects of innovation within disruptive technologies that undermine incumbents competitive advantage(Afuah and Utterback 1997; Henderson and Clark 1990). However, incumbents that have engaged in a reconfiguration of their capabilities to accommodate disruption may retain their competitive advantage despite these changes (Lavie 2006). To identify strategic interest alignment between sources I dichotomize technologies as complementary or disruptive based on their threat to the competitive advantage of incumbent firms (Adner 2002; Christensen 1997). I predict that alignment of strategic interests result in non-incumbents experiencing positive effects from using incumbent knowledge sources in complementary technologies. However, the effects within disruptive technologies are contingent on the strategic alignment. Misalignment results in negative effects from incumbents, while alignment as a result of their commitment to capability reconfiguration has positive effects.

To test the theoretical predictions I use data on external knowledge search by non-incumbent firms related to complementary or disruptive technologies. Incumbents are either not involved, involved as participants or lead the search efforts, with the latter interpreted as an intention to reconfigure capabilities. The searches result in joint formulation of solutions to specific innovation problems. The most successful are approved by expert reviewers for funding from the European Commission 7th

Framework Program' energy area between 2007 and 2013. Incumbent firms in the energy sector have been engaged in production and distribution of electricity for decades. Their commit into technology specific assets and capabilities make them highly vulnerable to disruption. The emergence of technologies that facilitate small-scale production by individuals or startup firms undermines their investments, profitability, business model and capabilities. This creates a strategic interest for incumbents to retain the dominance of complementary technologies and avoid innovation in disruptive technologies. The exception is the incumbents engaged in reconfiguring their capabilities to accommodate an increase in e.g. home solar systems. Through varying degrees of incumbent involvement in complementary or disruptive technology areas, the data allows observation of strategic interest alignment between sources.

I contribute to extant research by showing how alignment of strategic interests between knowledge sources influence outcomes. Results show that aligned interests result in a positive influence of the outcome external knowledge search, while misalignment has negative effects. This contributes to extant literature by exploring interdependence and mutual influence of knowledge sources in search. I show the influence of incumbent firms at early stages of the innovation process, contributing to the knowledge of their role at later stages (Rothaermel 2001; Teece 1986). Specifically the paper shows how threats to competitive advantage results in misaligned interests that negatively influences the outcomes for firms searching for knowledge among those facing such threats. This emphasizes the need for viewing search efforts and their knowledge sources as interdependent. The findings indicate that collaboration and openness may serve as a strategy to influence other firms and pre-emptively protect competitive advantage. This supplements recent findings on the strategic use of selective revealing of knowledge (Alexy et al. 2013).

Theory and Hypotheses

Innovation is essential for firms to continuously introduce new products, services and technologies, and survive and prosper in an increasingly competitive global business environment. Problem solving is an integral part of these innovation efforts and often involves external sources of knowledge (Katila and Ahuja 2002). The theoretical background of the paper rests on the conceptualization of external knowledge search as efforts to solve technologically related innovation problems (Dougherty and Hardy 1996; Katila and Ahuja 2002; Nelson and Winter 1982). These efforts benefit from distant knowledge since this provides firms with novel perspectives and solutions to the problems faced (Afuah and Tucci 2012; Rosenkopf and Almeida 2003). External search thereby helps firms overcome the path-dependency of reapplying local knowledge and familiar solutions by combining a variety of knowledge sources and domains (Laursen and Salter 2006; Rosenkopf and Nerkar 2001). These efforts entail a process of coordination, communication and combination of knowledge, resources and capabilities between knowledge sources for the purpose of joint learning and solution development(Love et al. 2013). Inherently, firms are susceptible to influence from their sources(Cronin et al. 2011), although this has remained unexplored in the literature(Knudsen and Srikanth 2014).

The successful use of external knowledge rests on the ability to identify, access and integrate knowledge (Cohen and Levinthal 1990; Lewin et al. 2011). Search efforts therefore rely on the provision of relevant knowledge and resources by the parties (Love et al. 2013), as well as effective and productive interaction (Cronin et al. 2011). Inherently this makes the sources involved subject to an interdependence and mutual influence not explored in extant research. However, traditional models of search (Nelson and Winter 1982) and related empirical work has largely viewed searching firms as unitary actors(Knudsen and Srikanth 2014). The conceptualized process has thus been once of a problem-solving firm identifying and obtaining an external source through various arrangements(Ahuja and Katila 2001; Katila and Ahuja 2002; Laursen and Salter 2006; Rosenkopf and Nerkar 2001). This assumes that once in place, an unambiguous provision of knowledge occurs. However, this underestimates the interdependent nature of joint efforts (Cronin et al. 2011; Knudsen and Srikanth 2014). As a result of the current conceptualization of external knowledge search, a significant research gap remains in understanding how strategic interest alignment between sources may influence external knowledge search.

Misaligned interests are a result of the impacts of technological innovation. While innovation is fundamental for firms to establish and maintain competitive advantage, it can similarly undermine their existence if their capabilities are undermined as a result (Henderson and Clark 1990; Tripsas 1997). The fundamental strategic interest of firms is to maintain or achieve competitive advantage in their industry. As such, strategic interests and technological innovation are closely connected, as competitive advantage is created or destroyed by the effects of the development of new or improved technologies(Suárez and Utterback 1995; Teece 1996). Incumbent firms have built their competitive advantage from and around technologies that gradually have manifested as dominant in their industry(Anderson and Tushman 1990). Incumbents and non-incumbent developers of complementary technologies can both benefit from innovations within these technologies. Conversely, innovation within disruptive technologies affords opportunities for non-incumbents and new entrants, while threatening the incumbents(Christensen 1997). However, incumbents may engage in a reconfiguration of their capabilities to accommodate disruption and thereby retain their competitive advantage after disruption (Lavie 2006). Unless incumbents have made such strategic commitments to disruption, a misalignment of their and non-incumbents' strategic interest is likely.

Strategic interest alignment is likely to influence the degree of knowledge provision and interaction between knowledge sources. Firms have been found to selectively make certain knowledge publicly available for strategic purposes(Alexy et al. 2013; Henkel 2006). Accordingly, firms may vary the knowledge provided to other firms in joint problem solving contingent on the alignment of their strategic interests. Most firms face some degree of resource constraints and are subject to limited absorptive capacity(Cohen and Levinthal 1990). As result, they prioritize the allocation of resources to external knowledge search, which influences their outcome (Garriga et al. 2013). This unitary view does not consider the effects of such allocation on the knowledge sources taking part in the search process. However, it shows that firms vary in their allocation of resources to external knowledge search. Strategic misalignment between sources is likely to reduce prioritization of a joint problem solving effort. In sum, aligned strategic interests increase the incentive to fully disclose knowledge and dedicate time and effort into productive interaction, while misalignment will likely result in reservations. In the following sections I develop testable hypotheses regarding the influence of strategic interest alignment.

Aligned Strategic Interests

To explore the effects of strategic interest alignment I define technologies from the point of view of the incumbents that non-incumbent firms potentially use in their external knowledge search to solve innovation problems. Complementary technologies are defined as those where problem-solving contributes to maintaining or reinforcing the competitive advantage of the incumbents. Innovations within these technologies are often provide minor improvements to the existing technologies, products or services (Henderson and Clark 1990). The implications are often limited impact the industry structures and business models (Christensen 1997; Henderson and Clark 1990). Solving problems related to these technologies maintains or improves the competitive advantage of incumbents by protecting the assets, capabilities and technologies they have based their competitiveness on (Afuah and Utterback 1997; Anderson and Tushman 1990). For example, the improvement of manufacturing processes in existing technologies has the advantage of reduced cost or time of production, benefitting the profitability of incumbents. Alternatively, advances in complementary technologies can provide opportunities to integrate related technology, components or similar into the existing production facilities or business models. Indeed, incumbents tend to favor innovation related to complementary technologies because of their enhancement of the value of existing capabilities and lack of threat to competitive advantage (Henderson and Clark 1990; Tushman and Anderson 1986).

For non-incumbent firms the opportunity to collaborate with incumbents to innovate in complementary technologies is attractive for several reasons. First, the incumbents are likely to have significant experience with the problem from several years of activities within the technology following the emergence of a dominant design (Anderson and Tushman 1990; Suárez and Utterback 1995). This enables them to provide in-depth knowledge regarding the particular problem, which is likely to increase the likelihood of finding a solution with their inputs. Second, incumbents are among the users of the resultant innovations. Involvement of users has been show to increase the value of solutions (Franke et al. 2013; Jeppesen and Lakhani 2010), which would benefit of the non-incumbent collaborators. Third, incumbents have significant resources, as well as knowledge of and central positions in the industry. This can among others include financial, knowledge and relational resources in the industry (Rothaermel 2001; Teece 1986). These complementary assets are valuable for non-incumbents that engage in innovation efforts with incumbents (Chesbrough 2003; Teece 1986).

I predict strategic interests to be aligned between non-incumbents and the incumbent knowledge sources they use in complementary technologies. The incumbents are the main problem owners, since they are the largest users of the complementary technologies. As such, they would be the main benefactors of solving the problems due to resultant cost or time savings, integration of technology that complements, benefits and sustains their competitive advantage. Finally, improvements in complementary technologies are likely to raise the expectations for what benefits disruptive technologies should provide to convince customers to incur switching costs. This lowers the threat of disruptive technologies. Incentivized by these benefits, incumbents' strategic interests are aligned with the non-incumbents searching for solutions in the complementary technologies. As a result, the incumbents are likely to readily contribute the knowledge and expertise sought by non-incumbents, and allocate resources to the search effort. Both these aspects are shown to be important to such efforts from a unitary perspective of search (Garriga et al. 2013; Love et al. 2013). Viewing search as interdependent entails an expectation of sources mutually influencing each other (Knudsen and Srikanth 2014). As such, incumbents' willingness to share knowledge and allocate resources based on strategic interests in problem solving should positively influence the non-incumbents seeking to access their knowledge. As such, the first hypothesis predicts that the aligned strategic interests in complementary technologies results in a positive effect on non-incumbents external knowledge search when using incumbent sources.

H1: *The outcome of non-incumbents' external knowledge search is positively influenced by strategically aligned incumbent knowledge sources in complementary technologies*

Misaligned Interests from Threats to Competitive Advantage

The characteristics of disruptive technologies often include radically new features, increased costumer benefits and novel applications. These characteristics carry the potential for dramatic changes in established industry structures and business models (Adner 2002; Christensen 1997). Solving innovation related problems within these technologies is thereby likely to result in innovations that radically overturn the competitive advantages of incumbents (Christensen 1997; Tushman and Anderson 1986). As these firms survive and grow into incumbency, their capabilities, assets and business models are increasingly based on the dominant technologies (Henderson and Clark 1990; Lavie 2006). These commitments increase as their competitive advantage is established, creating a reinforcing path-dependency (Arthur 1989). The economies of scale, price advantages and barriers to entry for competitors created through their investments suffer from the improvement of disruptive technologies (Adner 2002; Christensen 1997). As new technologies capture market shares and reduce the potential to utilize the full capacity of existing production facilities, incumbents' profitability and payback times suffer (Panzar and Willig 1977). The sunk costs incurred during decades of establishing competitive advantages based on existing technologies are potentially lost. In addition to these financial losses, the future profitability of incumbents is threatened by their lack of capabilities needed to compete following disruption (Adner and Zemsky 2005; Tripsas 1997). Finally, the business models that complement the investments and capabilities of incumbents may be undermined by technologies that enable significantly different modes of value creation and capture (Chesbrough 2010). The consequence is an immediate strategic interest of incumbents to avoid occurrence of these effects as a result of innovation in disruptive technologies.

Incumbent firms are poorly positioned to compete and risk losing their competitive advantage following improvements in disruptive technologies (Adner and Zemsky 2005; Christensen 1997). However, the *"disastrous effects on industry incumbents"* (Henderson and Clark 1990, pp.1) are caused by and result in entrepreneurial activity. As such, just as the incumbents are incentivized to avoid disruption, other firms come into existence and base future rise to incumbency as a result thereof

(Anderson and Tushman 1990). The existence of these non-incumbents relies on the successful problem solving in disruptive technologies. For non-incumbents the attraction of involving incumbents in external knowledge search includes access to complementary assets and valuable industry expertise and networks (Spithoven et al. 2013; Teece 1986; Van de Vrande et al. 2009). However, the focus of such findings has largely been on complementary technologies where an alignment of interests is present. Alternatively, the focus has been on disruptive technologies through the perspective of incumbents, and stages of maturity where they have already engaged in adoption of these technologies (Rothaermel and Boeker 2008; Rothaermel and Hill 2005). As such, the question of whether non-incumbents' use of incumbent knowledge sources for problem-solving at early stages of the innovation process remains unexplored. This is consistent with the argued limitations of the current conceptualization of search as unitary and without mutual interdependence of sources (Knudsen and Srikanth 2014). Further, it seems highly likely that strategic interests are misaligned in this context, although non-incumbents may nonetheless engage use incumbent knowledge sources due to the above outlined advantages.

Non-incumbents are inherently interested in solving innovation problems and advance the disruptive technologies they are dependent on for survival. However, incumbents are likely to have the opposite interest, unless they have identified an opportunity from disruption and are actively engaged in a reconfiguration of their capabilities (Lavie 2006). Such instances are explored in the following section. For incumbents committed to the status quo, avoiding or delaying problem solving in disruptive technologies can reduce the threat to their competitive advantage. Their strategic interest is to retain their competitive advantage by innovation problems remain unsolved, being solved slowly or in a less efficient manner, allowing them to reconfigure capabilities (Lavie 2006; Smink et al. 2013). This presents a misalignment with the strategic interests of non-incumbents in disruptive technologies. Their external search uses incumbent sources to access knowledge that intents to solve problems efficiently to rapidly develop these technologies. Viewing knowledge search as interdependent and a process where actors mutually influence each other reveals a dilemma of asymmetry in the interdependence between these actors (Puranam et al. 2012). The asymmetry between the strategic interests of the actors may have important implication for the knowledge search. Incumbents are likely to be selective in what knowledge is revealed, a strategic behavior observed in other contexts (Alexy et al. 2013; Henkel 2006). Furthermore, it is unlikely that they will prioritize the allocation of resources to these efforts, which has been shown to influence the outcome for searching firms (Garriga et al. 2013). Central aspects of search such as coordination, and mutual contribution and sharing of knowledge (Love et al. 2013) are thereby likely to suffer as a result of misaligned strategic interests. As such, the second hypothesis of this paper predicts that:

H2: *The outcome of non-incumbents' external knowledge search is negatively influenced by strategically misaligned incumbent knowledge sources in disruptive technologies*

Aligned Strategic Interests for Disruption

Extant research has shown the ability of some incumbents to retain their competitive advantage despite the emergence of disruptive technologies (Hill and Rothaermel 2003; Jiang et al. 2011). The use of external knowledge sources is shown as a fruitful strategy for incumbents to survive and potentially thrive following disruption (Rothaermel and Boeker 2008; Rothaermel and Hill 2005). Use of external knowledge sources enables incumbents to overcome the path-dependency and inertia created by an exclusive focus on existing internal knowledge (Henderson 1993; Rosenkopf and Nerkar 2001). Furthermore, it increases their ability to identify, develop and commercialize novel solutions from new technologies (Chesbrough 2010; Sydow et al. 2009). The prerequisite of obtaining these advantages is an initial strategic commitment by the incumbent to a reconfiguration of capabilities (Lavie 2006). Through a reconfiguration of certain capabilities and use of external sources, incumbents can leverage their existing complementary assets to remain at a competitive advantage after technological disruption(Rothaermel and Hill 2005). As such, incumbents may respond to disruptive technological change and potential capability destruction beyond reactive avoidance behavior. This can either be through continuous development and adaption of existing capabilities, or complete substitution of these with capabilities to retain competitive advantage profit after the breakthrough of disruptive technologies (Lavie 2006). Either strategy is inherently dependent on an initial identification of incentives from disruption and a strategic commitment to the pursuit of these (Chandy and Tellis 2000).

Incumbents that have committed to reconfiguring their capabilities to accommodate disruption are likely to be valuable sources for non-incumbents external knowledge search. The non-incumbents' efforts can benefit from the knowledge, expertise and complementary assets of the incumbents (Spithoven et al. 2013; Teece 1986). Inherently however, these benefits are contingent on the alignment of strategic interests between the actors. The provision of these incumbents' resources that positively impact non-incumbents require their identification of opportunities to remain at a competitive advantage subsequently. If this is the case, the incumbents will likely commit the resources for them to benefit (Garriga et al. 2013), subsequently benefitting the non-incumbents based on an interdependent rather than unitary view of search (Knudsen and Srikanth 2014). This realignment of the symmetry of the actors in an interdependent relationship compared to the above is likely to be valuable to the outcome (Puranam et al. 2012). Incumbents committed to developing disruptive technologies can contribute valuable knowledge regarding the industry, business model and the limitations of existing technologies that are to be displaced. While such knowledge may be strategically revealed or withheld by firms (Alexy et al. 2013; Henkel 2006), the alignment of strategic interests in developing disruptive technologies likely ensures full disclosure. The non-incumbents that are involved in external knowledge search with incumbent sources within disruptive technologies are thereby predicted to have an increased likelihood of solving innovation problems.

H3: *The outcome of non-incumbents' external knowledge search is positively influenced by strategically aligned incumbent knowledge sources in disruptive technologies*

Data and Method

Empirical Setting

The paper tests the theoretical predictions through an analysis of non-incumbent firms use of incumbents as knowledge sources in their external knowledge searches. These searches consist of joint efforts to develop solutions to innovation problems within complementary and disruptive technologies. The solutions are formulated as grant applications for innovation projects submitted to the European Commission as part of the 7th Framework Program running from 2007 to 2013. Independent experts approve those with highest likelihood of solving problems for funding. The analysis focuses on the energy theme of the collaboration branch of the framework to disentangle complementary and disruptive technologies and create a clear identification of incumbent firms and their strategic interests. Technologies are defined from the perspective of incumbent firms to analyze the influence strategic interest alignment between them and non-incumbents. The end product in the energy sector is the fully commoditized, homogeneous good of electricity, which functions equally well independent of its technological origin. This minimizes gains in competitive advantage through quality based on technological differentiation and enables direct substitution of incumbent technologies by disruptive alternatives. The high homogeneity of the end product and substitutability for electricity customers creates an important heterogeneity in terms of the complementary or disruptive impacts that these technologies have on incumbents. Improvements in disruptive technologies as a result of solving innovation problems will increasingly enable and encourage customers to decouple from incumbent firms' supply, exclude these from the value chain and undermine their business model. This provides a suitable setting to analyze the influence of resultant misalignment of strategic interests.

A total 2.35 billion Euros was allotted to solving energy related problems through the solutions proposed. These target the development of commercial technologies, creation of growth and development of global business opportunities[1]. The joint solution proposals are submitted to specific calls, each within certain technological areas that are defined as complementary or disruptive as

[1] Additional details are available through the website of the European Commission's Seventh Framework Program: www.ec.europa.eu/research/fp7

described above. Allocation of funds was based on the evaluation of external experts, hired by the European Commission based on their expertise within each of the 38 particular problem areas. These problem areas are represented by calls formulated by the European Commission and considered central to the advancement of the particular technology. The rewards of developing solutions that are approved for funding are substantial, with individual grants amounting to several million Euros. This creates a setting in which significant effort and reward is connected to the formulation of solutions to the innovation problems.

Classifying Incumbents and Technologies

Incumbents are defined as large actors with large sunk costs in and capabilities tied to, the existing technologies and business models (Christensen 1997). This results in strong interests in and incentives to retain the status quo rather than face the consequences of disruptive technologies. The empirical setting provides clear identification of incumbent firms through the industry classification code 40.1 covering "*Production and distribution of electricity*". Problem solving in disruptive technologies and resulting increases in distributed energy production lead to the loss of decades of investments in and capabilities related to large-scale centralized facilities, related technologies and the capabilities to produce and distribute energy for these incumbent firms (The Economist 2013; Watson 2004). Manual revision of the identified incumbents removed those solely involved in energy production from disruptive technologies. The units of analysis are the external knowledge searches of non-incumbent firm that either within or without the joint effort of incumbents attempts to develop a solution to innovation problems. Non-incumbents are defined as private firms that neither produce nor distribute electricity but participate in problem solving related to the development of technologies to do so. The data on the non-incumbents' external knowledge searches is supplemented by firm-level data from Bureau van Dijk's Orbis database, which provides the turnover, size, industry and patent portfolios. Firms that are not identified in the Orbis database are dropped, which results in a final sample of 2,855 non-incumbent firms. 1,650 of these participate in problem solving within complementary technologies and 1,205 within disruptive technologies.

Since incumbents are expected to be motivated by the perseverance of their profitability, business model, assets and capabilities, disruptive technologies are defined as those which undermine these (Christensen 1997). Disruptive technologies are defined in the data as "*future technologies and novel materials*", fuel cells and hydrogen, electro-chemical storage as well as photovoltaic solar energy. Solving innovation problems within these will result in disruption of incumbents existing capabilities and profitability due to increasing decentralization of energy production (The Economist 2013; Watson 2004). The result of innovation in this area in recent years has been a radical reduction in the value of energy incumbents' assets and their future earning potential. Business models have emerged in which large customer segments are increasingly producing their own energy by purchasing or leasing solar panels from 3rd parties. This has excluded incumbent energy producers and distributers from the value chain and damaged their earnings, resulting in losses of more than $550 billion during recent years in Europe alone (The Economist 2013). Finally, the disruptive definition covers problems related to *energy savings* since significant reductions in the electricity usage of consumers would be disruptive to the incumbents' core business of selling kilowatt-hours of electricity.

Conversely, technologies within which problem solving preserves or improves the incumbents' competitive advantage are defined as complementary. Complementary technologies are defined in the analysis as wind, biomass, geothermal, concentrated solar power, ocean power, hydro power, biofuels, smart energy networks, co2 capture and storage technology, and clean coal technologies. These technologies are either integrated into or complement the business models of incumbents, require traditional capabilities related to large-scale centralized production or improve the profitability or environmental impact of existing technologies.

Variables

Dependent Variable

The data applied to test the paper's theoretical predictions differs from the data traditionally applied in research on external knowledge search partly by focusing on individual knowledge search efforts to solve problems, rather than aggregate firm-level measurements. Furthermore, it differs somewhat through the use of an ex-ante outcome measure that captures expert decisions on whether to allocate funding to the execution of a proposed solution. Extant research has mainly applied data from innovation surveys such as CIS data (Laursen and Salter 2006), data on patenting behavior and patterns (Katila and Ahuja 2002) or data on firm's alliance portfolios (Rothaermel and Boeker 2008). An important commonality of these data sources is the exclusive focus on realized outcomes at firm level. This assumes that execution of a solution is immune to exogenous factors at both firm, industry and policy levels, despite the likelihood that exogenous changes cause discrepancies between search strategies and resultant outcomes. Furthermore, firms are assumed to find what they are looking for. That is, it is expected that the solutions or innovations that result from external search were fully intended at the onset of the search process. The unique dataset used in this paper provides ex-ante evaluations of individual external knowledge search efforts developing solutions to innovation problems. This characteristic overcomes these assumptions in extant research.

The ex-ante decision to grant funding to proposed solutions is based on three to five independent experts appointed by the European Commission. Each carries out an individual evaluation before they reach a consensual decision in Brussels under the guidance of a representative of the European Commission and additional expert to ensure an unbiased process that includes input from each expert. The dependent variable used in this paper is in line with an increasing trend to use ex-ante measures based on expert evaluations in related literature. This includes analyses of the quality of within-firm ideation (Salter et al. 2014), the novelty and potential of proposed innovation projects (Salge et al. 2013), as well as the value proposed solutions generated by individuals (Poetz and Schreier 2012). The use of an ex-ante measure of the likelihood of jointly solving problems based on an individual knowledge search effort is beneficial because exogenous factors are likely to influence eventual outcomes (Ring and Van de Ven, Andrew H. 1994). The disentanglement of unobserved exogenous and observed explanatory factors thereby remains a significant challenge in the use of ex-post measurements. Similarly, the process of executing solutions before measuring ex-post outcomes is vulnerable to changing group and individual firm dynamics and conditions. An ex-ante dependent variable overcomes the measurement challenges caused by potential changes in competitive dynamics or other within-group factors during execution (Cronin et al. 2011). These may include shifts in strategies, resource allocations, departure of key employees and similar in individual participants or the group during execution.

Further supporting the use of ex-ante measures if the likelihood that industry or policy level event create higher or lower pressures on firms to solve particular problems during execution (Arino and De La Torre 1998). Such unobserved exogenous influence is likely to have significant influence on the ex-post outcome. An additional benefit of the ex-ante expert evaluations is the opportunity to avoid the selection bias resulting from studying outcomes of executed problem solving efforts. This would inherently exclude a large amount of non-realized efforts, which potentially differ from those that are realized. Both approved and rejected proposals should be analyzed to avoid an under-estimation of the factors resulting in rejection, which would create unobserved sample and selection bias (Heckman 1979). It is therefore beneficial to capture the full variation in problem solving efforts irrespective of their eventual execution through use of ex-ante measures. Finally, the dependent variable provides the opportunity to address the increasing interest in understanding the front-end of innovation processes (Kijkuit and van den Ende 2010; Salter et al. 2014), in particular the early stage of developing solutions to innovation related problems.

Explanatory Variables

The explanatory variables in the analysis capture whether the observed external knowledge search effort of a non-incumbent firm involves an incumbent. This involvement of incumbent knowledge sources may occur in two different ways. Incumbent firms may be participants, or initiate and lead the search. The dummy variable *Incumbent Participant* takes the value 1 for non-incumbent knowledge search that include an incumbent participant and 0 otherwise. The dummy variable *Incumbent Leader* captures the influence on non-incumbents' search from incumbent sources that initiate and lead these efforts. This is interpreted as a reflection of strategic intention from the incumbent, as this shows a commitment to, and identification of incentives from, solving the innovation problem. The value 1 in

Incumbent Leader thereby reflects efforts in which incumbents are strategically committed to a reconfiguration of their capabilities according to the changes resulting from solving the specific problem. This is used to differentiate the strategic misalignment and alignment of incumbents and non-incumbents in disruptive technologies, and test hypothesis 3 separately from hypothesis 2.

Control Variables

Experience with similar problem solving and related interactions, coordination and knowledge sharing is likely to influence the ability of firms to develop appropriate solutions (Love et al. 2013). The analysis therefore controls for whether experience and routines of collaborators drives the outcomes. *Accumulated Experience* captures the amount of previous experience within the 7th Framework Program accumulated by the knowledge sources prior to the observed search effort. Knowledge intense firms may be more likely to solve problems due to a wider range of knowledge and higher absorptive capacity that facilitate the use of external knowledge (Cohen and Levinthal 1990). Following extant literature the variable *Firm Patentstock* captures knowledge through a count of patents assigned by the European Patent Office to firms involved in problem solving (Katila and Ahuja 2002; Rosenkopf and Nerkar 2001). The patents are discounted at an annual rate of 15% to account for whether the knowledge is likely to still remain active and readily available within the firms in the year of the observed efforts (Aerts and Schmidt 2008).

Variables are included for the number of employees and size of turnover for individual firms to control for the benefits of available resources. Firms with a large number of employees may commit more of this resource to the problem solving efforts' coordination and knowledge sharing requirements. Furthermore, a larger number or diversity of employees may also increase absorptive capacity (Cohen and Levinthal 1990), increasing the ability to develop solutions. Similarly, firms with high turnover may benefit from the ability to commit larger amounts of financial resources to the effort of developing solutions. The variation in the number of employees and turnovers of the observed firms causes skewedness in both measures. Accordingly, the natural logarithms *Turnover* and *Employees* are included to control for firms' turnover and number of employees in the year of the observed effort.

Science-based sources can increase innovation by involving novel knowledge from universities (Köhler et al. 2012). This is particularly observed in immature technologies where the non-commercial targets of universities, focus on basic research and sharing of the knowledge proves valuable (Cohen et al. 2002; Link and Scott 2005). Consequently, the analysis controls for the influence of universities and research organizations in problem solving through the variable *Science Source*. The variation of knowledge types influences outcomes positively by increasing the breadth of knowledge inputs. However, this eventually creates negative returns as absorptive capacity limits constraint the effective transformation of knowledge into value (Laursen and Salter 2006). The variable *Breadth* controls for the number of different sources of knowledge involved in each effort. To control for the size of the problem solving efforts *Participant Count* captures the number of participants. The variable *Funding Requested* reflects the amount of funding requested by each individual participant to cover potential effects from large or small funding requests.

Finally, I control for geographical and industry specific factors. Regional differences are captured by dummy variables that capture the location of each firm. The regions are defined as *Northern, Eastern, Western, Southern Europe* or *Non-European*, with *Northern Europe* functioning as the reference category. Industry dummies are included to account for industry specific effects (Grimpe and Sofka 2009). The analysis controls for whether observed firms belong to the *High-Medium Tech Manufacturing*, *Medium-Low Tech Manufacturing*, *Knowledge Intense Services*, *Less Knowledge Intense Services* or *Other* categories. The latter serves as reference group in the analysis These are based on NACE industry classifications and aggregated in accordance with Eurostat's definition of sectors according to knowledge intensity. A further aggregation combines high-tech and medium to high tech sectors in one category, and medium-low tech and low tech manufacturing into one.

Statistical Method

To test the theoretical predictions the paper I apply a logistic regression model to analyze the binary dependent variable capturing expert approval of funding. Two-way clustering is applied to account for clusters at the level of individual firms and the problem solving efforts simultaneously (Cameron and

Miller 2010; Cameron et al. 2011). This is required due to the correlations caused by firms participating in multiple problem solving efforts in the dataset and the analysis of multiple firms per problem solving effort. The latter clustering accounts for the potential over or under prediction of the explanatory variables on problem solving likelihood caused by multiple observations of the same effort for each of participant (Cameron and Miller 2013). Accounting for this by one-way clustering at the level of the efforts would meanwhile remove the ability to include controls at the firm level. To include firm level variation and controls the analysis observes each participant in each effort. Clustering is performed at the effort level as described, while simultaneously clustering on a second dimension at the firm level. This enables analysis of the influence of firm level characteristics concerning size, employees, industry, geography and patents, as well as the effort level characteristics such as individual funding requests of each participant, the size of efforts, the search breadth and involvement of science sources.

The data sample is split into complementary and disruptive technologies to capture the effects of strategic interest alignment between non-incumbents and their incumbent knowledge sources. The sample is restricted to private firms as their search strategies for problem solving are central to the theoretical logic applied in the paper. Furthermore, the incentives and interests of private firms, public agencies, universities and others might differ significantly. Consistency checks are performed as described after the presentation of the results in the following section.

Results

Descriptive Results

Table 1 presents the summary statistics for the full sample. The mean of *Incumbent Leader* shows a low propensity for non-incumbents to be involved in external knowledge search led by incumbents. The variable *Incumbent Participant* shows a higher frequency of non-incumbents simply accessing incumbent sources as non-leaders. The use of science sources is very high in the sample, which is expected given the nature of the knowledge search taking place at early stages of knowledge development and innovation. As such, these efforts are likely to benefit from and involve basic and science based knowledge (Köhler et al. 2012; Link and Scott 2005). While the mean size of the problem solving efforts is 12 collaborators, this ranges broadly from 2 to 40. The majority of participants are based in Northern and Western European countries and represented within knowledge intense services.

----INSERT TABLE 1 AROUND HERE----

The knowledge sources and firms have large variation in terms of their experience throughout the 7th Framework Program as well as in their patentstock, representing knowledge intensity. This variation supports the benefits of applying multi-way clustering to enable inclusion of the full variety as controls and identify the influence of incumbents on problem solving. Table 2 shows the pairwise correlation of the variables. No high correlations are detected among the variables and a mean variance inflation factor of 2.17 supports the suggestion that the data does not suffer from multicollinearity (Belsley et al. 2005).

----INSERT TABLE 2 AROUND HERE----

Regression Results

Tables 3 presents the regression results from the estimation model with a step-wise introduction of the variables and the sample of complementary technologies represented in left-hand columns and disruptive technologies in the right-hand columns under each step-wise model, denoted by *(C)* and *(D)* respectively. Models one and two are baseline models including firm-level controls and controls at both the level of the firm and seach effort respectively. Model three includes the first of two explanatory variables *Incumbent Participant*, which takes the value 1 for problem solving efforts with an incumbent participant and 0 otherwise. Model four in table 3 provides the full estimation including both dummies for incumbent knowledge sources within complementary and disruptive technologies. The effects of remain significant in the full model, supporting the significance of both variables. This is further supported by a test for statistical difference between the two variables, which is significant at the 1% level, leading to a rejection of the null-hypothesis that the effects of the two variables are identical. The significant and positive effect of both explanatory variables in the complementary technology sample in model three provides support for hypothesis one. This predicted that non-incumbent firms experience a positive effect on problem solving from accessing incumbent knowledge sources in their external search. The positive effect was hypothesized to be contingent of the alignment of strategic interests among the sources, which is established by confirmation of hypothesis two. The significant and negative effect of *Incumbent Participant* in model three's disruptive sample provides support for hypothesis two. I predicted that non-incumbents that search incumbent knowledge sources within disruptive technologies experience a reduced likelihood of solving problems. This reduced likelihood was argued to be cause by a lack of strategic interest alignment, which is confirmed by the difference in effects found in hypotheses one and two. The interpretation of the different coefficient shown in complementary and disruptive technologies, as a sign of the importance of aligned strategic interests between knowledge sources is further supported by the confirmation of hypothesis 3.

----INSERT TABLE 3 AROUND HERE----

Hypothesis three predicted that a realignment of strategic interests between non-incumbents and their incumbent knowledge sources in disruptive technologies would reverse the negative effects predicted in hypothesis two. As incumbents engage in a reconfiguration of their capabilities to accommodate disruption (Lavie 2006), it was predicted that non-incumbents would benefit from access to their knowledge and resources in the development of solutions. The indicator of such commitment by incumbents is argued to be the initiation and leadership of problem solving in disruptive technologies. As such, variable *Incumbent Leader* in model 4's right-hand column captures instances of non-incumbent knowledge search in disruptive technologies, which involve incumbent knowledge sources with strategic interest alignment. The predicted positive influence of this alignment on search is confirmed by the significant and positive effect of the variable *Incumbent Leader* in model 4's right-hand column. No hypothesis was developed for the effects on non-incumbents search from incumbent leadership in complementary technologies. However, it could be expected to align with the effects in hypothesis one, as this would similarly constitute instances of aligned strategic interest with the observed non-incumbents' search. This expectation is supported by the positive and significant effect of incumbent leadership in complementary technologies.

The control variables in the estimation model show positive effects of increasing experience among the collaborators. This was expected based on the value of knowledge sharing routines, effective communication and coordination in external knowledge search (Love et al. 2013). The use of science sources does not show the expected positive and significant influence (Köhler et al. 2012), which may be caused by the proliferation of this source among the efforts as shown in table 1. While the number of participants has a positive impact within disruptive technologies, the breadth of sources is insignificant. The significance of the number of participants is potentially a reflection of the value of knowledge and input from multiple sources at the early stages of innovation in immature technologies. The insignificance of *Breadth* may be a reflection of the differences between this measure and that of e.g. Laursen and Salter (Laursen and Salter 2006). The authors employ a more detailed measure of the variety of knowledge provided than that afforded by the data in this paper. The weighted patentstock of individual firms has a small but significant influence in complementary technologies, while being insignificant in disruptive technologies. This may reflect the limited benefit of prior knowledge in immature technology areas due to the high degree of uncertainty involved at this stage. As such, prior knowledge may potentially be less relatable to problems in immature, disruptive technologies compared to mature technologies. In mature technologies prior related knowledge to similar problems is more likely support the development of a solution.

Consistency Checks

A number of consistency checks are performed to confirm the stability and validity of the findings and discount alternative explanations. All estimation results of the consistency check are available from the author upon request. In addition to the models in table 4, consistency check are performed using one-way clustering at the firm and effort level respectively, as well as clustering on the call identifiers to account for potential within-problem correlations. In line with related research where individual firms are observed multiple times across the data a consistency check is performed using the Generalized Estimating Equations (GEE) model to account for potential autocorrelation (Katila and Ahuja 2002; Katila et al. 2008). The results reported in table 3 all remain consistent to these consistency checks. Model five in table 4 shows the results an estimation model that accounts for potential selection bias related to search efforts initiated by incumbent. The concern is that incumbents have large resources and central position in the industry, as well as large pools of resources and influence. This may enable them to attract the best non-incumbents and other sources for their problem solving, thereby driving the positive results of incumbent led search efforts. To address this concern a probit model is used to estimates the likelihood of any of the participants on projects within complementary or disruptive technologies in the dataset being part of an incumbent led effort. This likelihood is estimated based on the explanatory variables in the main model. The Inverse Mills Ration is calculated and subsequently included in the analysis to account for the influence of any selection bias on the estimation outcomes (Heckman 1979). Table 4, model five shows consistent significance and effects for the explanatory variables after inclusion of the Inverse Mills Ration to control for the influence of such selection bias on the result.

----INSERT TABLE 4 AROUND HERE----

A consistency check if performed in model six to address concerns of abilities of search leaders as the driver of the paper's findings. The variable *Average Score of Leader* capture the average score of the leader on search efforts covered in the dataset. The consistency of the findings in the right-hand column of model six in table 5 indicates the validity of strategic interest alignment as driver of search outcomes, rather than individual ability of leaders. In sum, the consistency checks described above indicate that the empirical analysis of the hypothesis is not sensitive to alternative specifications of the models or any of the above reported concerns.

Discussion and Conclusions

With firms' increasing use of external sources of knowledge to increase problem solving and thereby innovation performance, research in the area has increased within open innovation (Chesbrough 2003). Specifically external knowledge search has attracted attention from innovation scholars (Katila and Ahuja 2002). This has particularly focused on the use of local or distant sources and knowledge domains (Laursen 2012; Rosenkopf and Nerkar 2001; Rosenkopf and Almeida 2003).

The growing research in the field has established the benefits of accessing external knowledge from sources such as universities, suppliers and user (Köhler et al. 2012; Laursen and Salter 2006; von Hippel 2005). These sources of knowledge are shown influence the innovation efforts in firms through improved problem solving. Furthermore, coordination and development of efficient knowledge sharing routines is increasingly shown to influence the ability to benefit from external knowledge search and collaborative problem solving (Love et al. 2013). However, extant research has largely conceptualized the process of accessing external knowledge as one involving a unitary actor, the searching firm (Knudsen and Srikanth 2014). This has overlooked the inherent interdependence of knowledge sources that jointly develop solutions, due to the their mutual influence on each other through actions and knowledge (Puranam et al. 2012). Extant research's unitary view on search has overlooked the potential for the inherent interdependence to create important contingencies in knowledge search. As such, a significant research gap exists in understanding how knowledge sources mutually influence each other in joint problem solving efforts. I address this gap in the current paper by exploring the importance of strategic interest alignment, the degree to which individual knowledge sources share incentives for solving the problem at hand.

The paper contributes to the extant literature by showing the influence of homo- or heterogeneous strategic interests among knowledge sources. Extant research has implicitly assumed a shared strategic interests in unambiguously sharing knowledge and committing resources to problem solving once engaged in an effort to do so (Katila and Ahuja 2002; Laursen and Salter 2006; Rosenkopf and Almeida 2003). However, I show that the varying degrees of impact from problem solving on firms results in potential heterogeneity in and misalignment of strategic interests, which significantly influence the outcomes of external knowledge search. More generally this supports the notion that knowledge search should be viewed as an interdependent process, rather than from a unitary perspective (Knudsen and Srikanth 2014). In doing so, I also contribute by exploring the role of a central actor in the innovation activities and technology development in many industries, incumbent firms. Similarly to the strategic revealing of knowledge to attract collaborators (Alexy et al. 2013) or protect other piece of knowledge (Henkel 2006), I argue that knowledge may be strategically leveraged according to underlying incentives. As strategic interests are misaligned, collaborating knowledge sources are expected to be less likely to fully engage in unambiguous sharing and revealing of knowledge. This results in findings of a reduced likelihood of solving problems using external knowledge sources when these have misaligned strategic interests.

Research on incumbents and external knowledge has been restricted to their perspective. Innovation and strategy scholars have explored how incumbents are able to retain competitive advantage despite technological disruption (Hill and Rothaermel 2003; Lavie 2006). This research has emphasized the use of external sources to access novel knowledge as a fruitful strategy for incumbents to survive disruption (Rothaermel and Boeker 2008; Rosenkopf and Nerkar 2001). A central limitation in the findings on incumbents and disruptive innovation has been the predominant focus on the incumbent perspective. As such, finding successful outcomes for incumbents from collaborative efforts does not necessarily equate to beneficial outcomes for non-incumbents. However, the effects on the non-incumbent firms have remained unexplored. This is interesting given to the potential effects on incumbents' competitive advantage from innovation in disruptive technologies (Christensen 1997). These effects can create a misalignment of interests between the incumbents and non-incumbents, and negatively impact the joint effort. I show this to be the case when non-incumbent engaged incumbent knowledge sources to solve problem, which may have negative consequence for their competitive advantage. However, with an alignment of interests in complementary or though incumbent commitment to disruption, the effects are opposite. These findings contribute to an understanding of the role of incumbents in external knowledge search and innovation. It improves the understanding of an important knowledge source, and directs attention to the importance of strategic interest alignment. Finally, it provides nuance to the findings regarding benefits of incumbent openness to innovation and engage in disruption by exploring the potential negative effects for non-incumbents.

The paper contributes by introducing and determining the important influence of strategic interest alignment in external knowledge search. The process of joint problem solving involves interaction and sharing of knowledge and resources (Love et al. 2013). The resultant interdependence has been underexplored in the search literature (Knudsen and Srikanth 2014), which is critical given the outlined difference in strategic interests. Such alignment might be particularly critical in the early stages of the innovation process, where uncertainty is high about appropriate solutions. This uncertainty might leave the outcomes vulnerable to selective revealing or withholding of knowledge observed in other contexts (Alexy et al. 2013; Henkel 2006). Similarly, the resources required to innovate during high uncertainty could leave efforts vulnerable to resource allocations, previously found to influence external search from a unitary view (Garriga et al. 2013). As such, an important contribution of the paper lies in understanding the impact of misaligned interests at the early stages of the innovation process. This contributes to an increasing focus on this stage, argued to involve different dynamics than later commercialization (Kijkuit and van den Ende 2010; Salter et al. 2014) by showing the vulnerability to misaligned interests at this stage.

The finding supports the importance of strategic interests by emphasizing that lack of ability does not seem to drive incumbents' suppression of non-incumbents problem solving within disruptive technology efforts. Rather, the central explanation seems to be found in their strategic interests and commitments. This contributes to the debate of incumbents' ability and influence on innovation in disruptive technologies (Jiang et al. 2011), by supporting the idea that incumbents are capable thereof if strategically committed (Hill and Rothaermel 2003; Lavie 2006; Rothaermel and Hill 2005). More specifically, this has implications for the debate of whether start-ups should be vary of incumbent firms in their early stage innovation efforts (Diestre and Rajagopalan 2012; Katila et al. 2008; Marx et al. 2014). My findings indicate, that rather than incompetency concerns, non-incumbents should be attentive of the risks involved in incumbent collaboration due to misalignment of strategic interests as incumbents seek to maintain their competitive advantage. This is supported by previous research in a similar empirical setting that observed a heterogeneous willingness of incumbents to reconfigure their capabilities during disruptive regulatory changes (Delmas and Toffel 2008). This importance is underlined by the finding that incumbents are seemingly unwilling rather than unable to productively collaborate with non-incumbents within disruptive technologies.

These findings contribute both to the literature on external knowledge search by suggesting that aspects found to be important in a unitary view of knowledge search such as selective revealing of knowledge (Alexy et al. 2013; Henkel 2006), restriction of resources to particular external search efforts (Garriga et al. 2013), are similarly important in an interdependent view. These, or other strategies, might be employed to cater to the interests of individual knowledge source rather than that of the collective and joint outcome. This contributes both to the knowledge search, open innovation and strategic alliance literature by showing the importance of alignment of interests. While this is intuitively important to the well-functioning of joint efforts, empirical exploration regarding the consequences of strategic interest alignment has been neglected. With external sources of innovation being increasingly researched and used by practitioners, the elaborated insight into these and other potential threats and contingencies provides a significant contribution.

Limitations and Further Research

While the paper benefits from detailed data on the nuances of individual problem solving efforts and the effects on heterogeneous strategic interests of collaborators, the data has the drawback of not observing the long-term performance or outcomes of the collaborations. Linking specific external knowledge search and problem solving efforts with long-term performance may suffer from unobservable influences. However, it may nevertheless add to the insights in this paper regarding the influence of strategic interests and incumbents on collaborations. Future research may increase the understanding of the influence of strategic interest alignment and incumbents on innovation activities and on the long-term effects of incumbent collaborations. It may be fruitful to investigate new firms' survival rates and performance, since the problem solving in new firms is decisive to survival. These firms may be particularly susceptible to incumbent influences due to limited resources.

The findings are based on data on firms choosing to engage in collaborative efforts in application of funding, which is not uncommon for innovative firms. However, a limitation might lie in the choice of firms to refrain from application, remain closed, or open in different ways. Future research might explore different settings or compare effects across settings. The findings draw on data from the energy sector. This is valuable to distinguish technologies and identify incumbents, but may involve dynamics that different from other industries. The importance strategic interest alignment might vary across sectors due to different competitive dynamics, entry barriers or historical contexts.

Tables

Table 1: Summary Statistics

Variable	Mean	S.D.	Min	Max
Approved	.37	.48	0	1
Incumbent-Leader	.04	.20	0	1
Incumbent-Participant	.34	.47	0	1
Science Source	.97	.16	0	1
Breadth	2.94	.75	1	5
Participant Count	11.96	5.90	2	40
Accumulated Experience	3.40	5.93	0	86
Turnover	16.69	3.37	5.11	25.98
Employees	4.23	2.66	0	12.86
Firm Patentstock	6.29	102.35	0	3,691
Funding Requested	487,185	1,488,605	0	5,400,307
Eastern-Europe	.18	.31	0	1
Non-European	.01	.10	0	1
Southern-Europe	.33	.47	0	1
Northern-Europe	.10	.30	0	1
Western-Europe	.45	.50	0	1
High-Medium Tech Manufactoring	.19	.39	0	1
Knowledge Intense Services	.45	.50	0	1
Less Knowledge Intense Services	.04	.20	0	1
Med-Low Tech Manufactoring	.13	.34	0	1
Other Sectors	.19	.39	0	1

Table 2: Pairwise Correlations

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
(1) Approved	1																			
(2) Incumbent-Leader	.09	1																		
(3) Incumbent-Participant	.12	.12	1																	
(4) Science Source	.04	.01	.03	1																
(5) Breadth	.13	.04	.17	.39	1															
(6) Participant Count	.22	.13	.39	.17	.48	1														
(7) Accumulated Experience	.26	.06	.11	.09	.11	.34	1													
(8) Turnover	.13	.09	.14	.01	.01	.09	.09	1												
(9) Employees	.10	.07	.11	.01	.02	.07	.07	.92	1											
(10) Firm Patentstock	.04	-.00	.02	.00	.01	.02	-.01	.18	.20	1										
(11) Funding Requested	.05	.01	-.01	-.06	-.04	-.05	.04	.02	.01	-.00	1									
(12) Eastern-Europe	-.05	.04	-.05	.04	.01	-.02	-.02	-.10	-.02	-.03	.04	1								
(13) Non-European	.07	-.01	.03	-.02	-.01	-.00	.08	.20	.02	.04	-.02	-.60	1							
(14) Southern-Europe	.05	-.00	.05	.01	.01	.04	-.03	-.02	.04	-.00	.02	-.20	-.37	1						
(15) Western-Europe	-.09	-.04	-.01	-.02	.00	.00	-.08	-.16	-.05	-.02	-.05	-.19	-.35	-.11	1					
(16) High-Medium Tech Manufactoring	-.02	-.01	-.03	-.01	-.10	-.10	-.04	.11	.08	.02	.03	-.04	.05	.02	-.04	1				
(17) Knowledge Intense Services	-.03	-.02	.01	.01	.10	.05	-.02	-.26	-.22	-.03	-.04	.04	-.06	-.02	.06	-.44	1			
(18) Less Knowledge Intense Services	-.00	-.01	-.01	.01	.01	.03	-.01	.08	.09	-.01	.04	.08	-.08	.02	.00	-.10	-.19	1		
(19) Med-Low Tech Manufactoring	.01	.00	-.05	.02	-.04	-.05	-.01	.14	.12	.05	-.02	-.02	.04	-.01	-.02	-.19	-.36	-.08	1	
(20) Other Sectors	.05	.03	.06	-.02	.00	.06	.09	.04	.04	-.02	.02	-.03	.03	.01	-.02	-.23	-.43	-.10	-.19	1
Mean Variance Inflation Factor	2.17																			

Table 3: Multiway Culstered Logistic Estimations for Problem Solving Likelihood. Outcome: Approval

	(i)		(ii)		(iii)		(iv)	
Variables	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)
Incumbent-Leader							0.63*	1.81**
							(0.37)	(0.76)
Incumbent-Participant					0.56***	-0.63**	0.54**	-0.64**
					(0.21)	(0.32)	(0.21)	(0.32)
Science Source			-0.57	1.52	-0.49	1.50	-0.47	1.49
			(0.60)	(1.11)	(0.63)	(1.11)	(0.62)	(1.11)
Breadth			0.13	0.08	0.15	0.09	0.15	0.10
			(0.16)	(0.20)	(0.16)	(0.20)	(0.16)	(0.20)
Participant Count			0.03	0.07**	0.01	0.09***	0.01	0.09***
			(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)
Accumulated Experience			0.13***	0.06**	0.12***	0.06**	0.12***	0.06**
			(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Turnover	0.07	0.04	0.05	0.03	0.04	0.04	0.04	0.04
	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Employees	0.01	0.03	0.01	0.03	0.01	0.02	0.01	0.02
	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Firm Patentstock	0.00*	-0.00	0.00**	-0.00	0.00**	-0.00	0.00**	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Funding Requested	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-1.41	-0.80	-2.13*	-3.35*	-2.13	-3.78*	-1.99	-3.76*
	(1.25)	(1.43)	(1.27)	(1.96)	(1.36)	(1.99)	(1.33)	(1.99)
Geographical-Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Sector-Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1,650	1,205	1,650	1,205	1,650	1,205	1,650	1,205

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
C: Complementary technologies
D: Disruptive technologies

Table 4: Consistency Checks

Variables	(v) (C)	(D)	(vi) (C)	(D)
Incumbent-Leader	0.63*	1.82**	0.57	1.89**
	(0.37)	(0.76)	(0.37)	(0.76)
Incumbent-Participant	0.54**	-0.65**	0.49**	-0.71**
	(0.21)	(0.32)	(0.22)	(0.33)
Science Source	-0.47	1.50	-0.35	1.07
	(0.62)	(1.11)	(0.65)	(1.14)
Breadth	0.15	0.09	0.10	0.17
	(0.16)	(0.20)	(0.17)	(0.21)
Participant Count	0.01	0.09***	0.01	0.10***
	(0.02)	(0.03)	(0.02)	(0.03)
Accumulated Experience	0.12***	0.06**	0.12***	0.06*
	(0.03)	(0.03)	(0.03)	(0.03)
Turnover	0.00	0.03	0.06	0.01
	(0.06)	(0.06)	(0.06)	(0.06)
Employees	0.03	0.02	-0.01	0.04
	(0.07)	(0.07)	(0.06)	(0.07)
Firm Patentstock	0.00***	-0.00	0.00**	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Funding Requested	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Inverse Mills Ration	-0.91	-0.57*		
	(0.72)	(0.31)		
Average Score of Leader			-0.00	0.01**
			(0.01)	(0.01)
Constant	4.00	0.15	-2.32*	-2.76
	(5.27)	(1.40)	(1.33)	(2.24)
Geographical-Dummies	Y	Y	Y	Y
Sector-Dummies	Y	Y	Y	Y
Observations	1,650	1,204	1,519	1,107

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

C: Complementary technologies

D: Disruptive technologies

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