Governance Considerations for Seeker-Solver Relationships: A Knowledge-Based Perspective in Crowdsourcing for Innovation Contests

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ABSTRACT

The need to solve innovation problems and insource knowledge has led to an increasing number of organizations engaging in crowdsourcing activities and subsequently establishing working relationships with winning solution providers. Using a knowledge-based view and the problem-solving perspective, we develop a theoretical framework suggesting how specific innovation problem attributes, i.e., the decomposability, formulation and search space of the problem, influence the governance decision (unilateral vs. bilateral) of seekers to manage the relationship with winning solvers. We empirically analyze the framework using 582 challenges broadcast on the NineSigma crowdsourcing platform. Our results indicate that problem attributes – the formulation and search space of problem – have a positive effect on seekers' preference toward unilateral governance structures. However, we did not find empirical confirmation of the effect that the decomposability of the innovation problem has on seekers' preference toward unilateral governance structures. This study offers several contributions to the crowdsourcing literature, and it also has important implications for managers of organizations aiming at insourcing knowledge through crowdsourcing for innovation contests.

INTRODUCTION

As more organizations access external knowledge, open up their boundaries and engage in crowdsourcing for innovation contests, determining how to govern the working relationships with external solution providers has increasingly become strategically important (Majchrzak and Malhotra, 2013; Lüttgens et al., 2014). For example, if organizations perform poorly in choosing the structure of the working relationship, it may result in missed opportunities and wasted resources due to delays in the new product development process and a decrease in innovation outcome rates (Sampson, 2004; Stanko and Calantone, 2011). Further, choosing inappropriate governance structures may also lower the revenues of future contests, since an unfair and poorly designed crowdsourcing contest may damage the company's reputation (de Beer et al., 2017). Accordingly, deepening the understanding of the governance structure of the working relationship between organizations and solution providers is vital for organizations looking for appropriate relationships that may increase the value of their crowdsourcing initiatives.

Organizations (i.e., seekers) that wish to solve a given innovation problem are searching for external providers (i.e., solvers) that possess particular know-how to join in a working relationship (i.e., governance structure decision) and implement the best solutions (Lüttgens et al., 2014). When crowdsourcing innovation problems, the seeker must still take several decisions such as whether to proceed with an external crowdsourcing platform instead of an internal one, and how to organize the knowledge sharing and transfer of intellectual property related to the winning solution (de Beer et al., 2017; Schenk et al., 2017). To date, how seekers can insource new knowledge from winning solvers by establishing an appropriate working relationship remains a neglected area of research. This relationship ranges from unilateral (e.g., licensing arrangements and research contracts) to bilateral relationships (e.g., technology partnerships, cross-licensing agreements, and joint ventures) (Hagedoorn, 1990; Leonard-

Barton, 1995). In particular, a related question has been overlooked: what influences seekers in deciding the governance structure of the working relationship they will establish with the winning solver?

As previous scholars have empirically shown, the attributes of the problems may attract or inhibit potential solvers to participate in the innovation contests, thereby influencing the overall performance of the challenge (Terwiesch and Xu, 2008; Jeppesen and Lakhani, 2010; Boudreau et al., 2011; Franke et al., 2013). These attributes, which are more complex than technical indications favoring the use of new ideas or solutions to innovation problems, depend on the nature of the problem and the knowledge requirements of the solver. The seeker-preferred governance structure is then pushed forward when the combination of these attributes yields solutions that exceed the expectations generated by the solver's experiences. The challenge attributes, therefore, play a critical role, not only in gaining new knowledge from outsiders and attracting solvers but also in defining governance structures. Thus, the aim of the paper is to fill the previous gap and answer the research question by investigating whether and how the problem attributes affect the seeker's governance preferences under alternative governance structures, both unilateral and bilateral (Afuah and Tucci, 2012; Lüttgens et al., 2014; Nickerson et al., 2017).

An organization's level of knowledge access is a key driver of competitive advantage and organizational capacity (Easterby-Smith and Prieto, 2008); the knowledge-based view of the firm examines the ways in which organizations can increase this level (Grant, 1996; Kogut and Zander, 1992). Within the framework of the knowledge-based view of the firm, research has explored how knowledge considerations impact the type of alliance chosen (e.g., Gulati and Singh, 1998), the management of partners (e.g. Dimitratos et al., 2010), the integration of knowledge in the crowd context (e.g., Malhotra and Majchrzak, 2014) and the connection between the type of governance chosen and the problem-solving context (e.g., Felin and Zenger,

2014; Nickerson et al., 2017). We grounded the development of our model in the knowledge-based view of the firm (Grant, 1996; Kogut and Zander, 1992) positing that the seeker's knowledge-based objective is to insource valuable new knowledge from the crowd. The seeker, however, cannot simply choose a problem and ask for the new knowledge to be acquired because the desired knowledge is frequently hard to communicate or has not been developed yet (Nickerson and Zenger, 2004). Instead, seekers must define valuable problems that, through their attributes, formalize the knowledge required. Such problem attributes, i.e., decomposability, formulation and search space of the problem (Afuah and Tucci, 2012; Natalicchio et al., 2017), are the means through which a seeker can solicit knowledge from the crowd. Thus, when deciding about the governance structure of the working relationship, seekers adopt a problem-solving perspective (Nickerson and Zenger, 2004). They rely on the attributes of the problem they would like to solve and match these attributes with governance modes that allow them to better acquire the related knowledge from the crowd (Nickerson et al., 2017). As such, we integrate the problem-solving perspective and the knowledge-based view of the firm (Kogut and Zander, 1992; Grant, 1996; Nickerson and Zenger, 2004; Nickerson et al., 2017) and provide matching arguments between problems, which vary according to their attributes, and crowdsourcing relationships, which vary according to their governance structures.

To empirically investigate the effect that innovation problem attributes have on seeker preferences in governance structures, we chose the NineSigma crowdsourcing platform. Collecting a distinctive dataset of 582 challenges broadcast from 2010 to 2014, we tested the hypotheses related to the seeker knowledge-based governance considerations. Moreover, since our empirical setting presents some specificities, we conducted exploratory interviews to deepen our understanding of the crowdsourcing for innovation process on the NineSigma platform.

CROWDSOURCING FOR INNOVATION IN THE NINESIGMA PLATFORM

In this paper, we particularly refer to the NineSigma platform since, in contrast to other crowdsourcing platforms in which winning solvers receive a monetary prize for selling their IP outright (e.g., InnoCentive), NineSigma allows seekers and solvers to engage in a working relationship, e.g., licensing and co-development (Katzy et al., 2013; Lopez-Vega et al., 2016). Given the specificities of the empirical setting, we deepen our understanding of the crowdsourcing for innovation context by conducting exploratory interviews in December 2016. One of the author conducted interviews with two multinational companies, located in Scotland here named for reasons of confidentiality FirmA and FirmB that engaged in crowdsourcing activities through the NineSigma platform. The interviews were concerned with an in-depth comprehension of the governance considerations related to the relationship with the solvers, the support offered by the platform during the contest, and the role played by the attributes of the problem in this context. Moreover, we also interviewed a NineSigma program manager, whose role is to support seeker companies during the crowdsourcing process.

On the NineSigma platform, the challenges are broadcast through a problem statement called a *Request for Proposal* (RFP) (Lüttgens et al., 2014). In the RFP seekers describe the attributes of the innovation problem to be solved and inform potential solvers of the governance structures that will regulate the working relationship between the seeker and the winning solver (Franke et al., 2013; Lopez-Vega et al., 2016; de Beer et al., 2017). FirmA stressed the importance of declaring the preferred governance structure in the RFP:

> […] We feel we need to be prepared for that because the last thing we want is to have an amazing proposal and then we say "sorry, you could probably solve our challenge but the contract that we want to put in place is different to what you want." So, we need to be very careful about that.

The seeker-solver working relationship can be managed through different forms of governance structures. Specifically, governance forms to manage the working relationships can range from unilateral (e.g., a licensing agreement) to bilateral (e.g., a joint development agreement) governance structures. This was confirmed by the interviews with FirmA manager:

> […] Sometimes we're looking for a readymade solution in which case we are just looking for a supply agreement. If there's a challenge that we know there must be a solution to, maybe it's a material challenge and we're just looking for a hard material we'll just say "you can supply us; we'll pay you…" and we'll make an agreement of how much we're going to pay for the bulk material or doing the process.
>
> […] If it's something a bit more out there and we're looking for something that's a bit maybe not developed and we're looking for ideas, then we'll have two or three options about how we work on it. One is that we support the research, so we'll give them some laboratory space or field testing or some engineering time to help them out, or we'll go onto a joint development agreement where we'll pay a lot of it but we expect then a portion of the IP.

The formulation of the RFP is an important step for firms engaging in crowdsourcing activities in order to find valuable knowledge since it may affect the output of the contest (Sieg et al., 2010). Thus, NineSigma managers offer their support and work closely with their seeker clients to help them write the RFPs (Lopez-Vega et al., 2016; Natalicchio et al., 2017). The following quote from the NineSigma program manager nicely captures the role of the platform in supporting the seeker writing the RFP:

> […] we try to write technology searches in such a way that our external community can understand the problem. […] It's about what is the actual technology problem, what is it you're looking for and that is a really difficult technique to do and most clients don't do it very well.

The support offered by NineSigma to seekers in managing every stage of the challenge, from the design of the RFP to the contracting of the working relationship, is also highlighted by FirmB:

> […] They will also provide support in terms of if we need to set up the challenge then we can get their support to define what we really want, how we're going to get that, how we are going to find that and then how we're going to manage it when it comes back to us.

Finally, when the firms were asked about what they consider valuable in thinking about the governance form of the working relationship to establish with the winning solver, the director of innovation for FirmA clearly said:

> […] Arrangements depend on where the challenges come from and the characteristics of problems.

Thus, the importance of the innovation problem's attributes emerged as a significant factor in considering the governance structure of crowdsourcing in order to insource the knowledge related to the solutions. We, thus, start from these evidences to investigate the role played by

problem attributes in affecting a seeker's governance preferences under alternative governance structures, both unilateral and bilateral.

HYPOTHESES DEVELOPMENT

Adopting a problem-solving perspective, we focus on the problem as our central unit of analysis and hypothesize that problem attributes related to the desirable knowledge guide the seeker in crowdsourcing relationship governance considerations (Nickerson and Zenger, 2004; Nickerson et al., 2017). As showed in Figure 1, our effort is to match problem attributes with governance forms that differently support knowledge insourcing. To enable this matching, and consistent with prior work, we argue that three key characteristics of problems influence seekers' knowledge-based governance considerations: the decomposability, the formulation, and the search space of the problem broadcast (Afuah and Tucci, 2012; Felin and Zenger, 2014; Natalicchio et al., 2017).

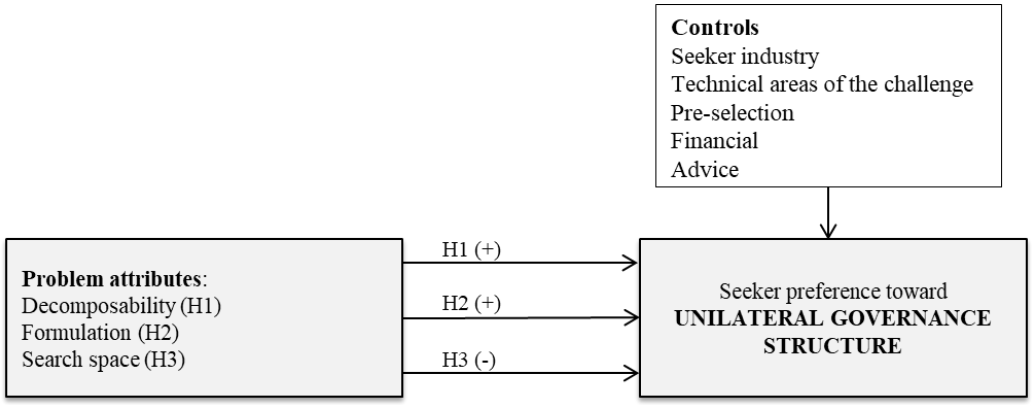

Figure 1. Conceptual framework

Decomposability of the problem

The decomposability of the problem is defined as the number of knowledge elements that compose the innovation problem and the number of interdependencies among them (Casciaro, 2003; Afuah and Tucci, 2012; Kosonen and Henttonen, 2014). Problems could range

from being high-decomposable (i.e., suitable modularity, known knowledge elements, or explicit knowledge required with less interaction with partners) to low-decomposable (i.e., less modularity, unknown knowledge elements, or requiring a high level of interactions) (Nickerson and Zenger, 2004; Jeppesen and Lakhani, 2010). The level to which a problem can be decomposed into smaller knowledge components (i.e., the structure of the problem) allows solvers to utilize their expertise to independently solve subsets of the larger problem (Jeppesen and Lakhani, 2010). Thus, unlike high-decomposable problems, low-decomposable problems are prone to unexpected or unknown interactions among knowledge sets potentially required to formulate a solution.

The degree of problem decomposability is the consideration that Nickerson and Zenger (2014) employ to match problem types to governance forms. They suggest that a problem that is high-decomposable is more amenable to a market-based problem-solving approach (i.e., unilateral governance structures) because it requires a more clear process to formulate the solution and an extensive knowledge sharing is not needed. In such a case, the resolution of high-decomposable problems requires solvers to perform a sequential choices process that has to deal with clear and simple information processing coming from few or even a unique knowledge element and that seekers can easier assess (Afuah and Tucci, 2012; Natalicchio et al., 2017). Moreover, since the knowledge related to high-decomposable problems can be easily embedded into a product or a service, seekers can more easily assess the resolution process by evaluating the quality and efficacy of a product or service (Gulati and Singh, 1998; Casciaro, 2003). Assessing and understanding the resolution process of high-decomposable problems, thus, do not require seekers to strictly work with the winning solvers (Felin and Zenger, 2014). Then, seeker can economize the knowledge transfer, building a seeker-solver relationship with a unilateral governance structure requiring a level of investment that is lower than that required by bilateral ones (Hsieh et al., 2007). Unilateral governance structures are indeed more efficient

to deal with high-decomposable problems since they do not require an onerous formal system for communication and joint decision making, which is not necessary for evaluating and transferring the knowledge in such a case (Casciaro, 2003).

On the other hand, engaging in a relationship with a bilateral governance structure, seekers can strictly cooperate with the winning solver and set-up a specific common language that allows them to overcome the difficulties arising from the exchange of several and interdependent knowledge elements (Nickerson and Zenger, 2004). Moreover, when a seeker can work more closely with the winning solver, the flow of detailed and specialized knowledge concerning the value of the solution transferred overcomes the intrinsic difficulties of evaluating the nature of problems with a low level of decomposability (Gulati and Singh, 1998; Felin and Zenger, 2014).

In sum, more complex and onerous bilateral governance structures can better support seekers to insource knowledge related to the solution of problems with a low level of decomposability, whereas the less costly and simpler unilateral governance structures are more efficient in transferring knowledge related to the solution of problems with a high level of decomposability. As a result, the degree of problem decomposability seems to be a convincing driver of keeping different governance structure options open. The decomposability of the problem allows seekers to use more market-based problem-solving governance structures (i.e., unilateral structures) because it provides a clear solution criterion with a low level of complexity.

Accordingly, we posit the following hypothesis:

Hypothesis 1: High-decomposable (low-decomposable) innovation problems are positively related with the seeker's preference toward unilateral (bilateral) governance structures.

Formulation of the problem

Once a problem to broadcast has been identified, seekers have to formulate it by describing the requirements that the desired solution must fulfil (Afuah and Tucci, 2012; von Hippel and von Krogh, 2015). Because solvers rely exclusively on information provided by seekers, the formulation of the problem is a critical step for seeker firms aiming at finding valuable solutions (Natalicchio et al., 2017). However, the description of an innovation problem is not an easy task and the problems broadcast to the crowd can be well-delineated or poorly-delineated (Simon, 1962). A problem is poorly-delineated when the seeker fails to communicate or describe knowledge elements that are valuable in its resolution (Afuah and Tucci, 2012; Natalicchio et al., 2017). The accuracy with which seekers may formulate the problem depends on both confidentiality issues and the amount of tacit knowledge connected to the problems, i.e., knowledge that cannot be codified or captured in drawings or writing but can only be obtained through observation and practical experience (Martin and Salomon, 2003; Nonaka and von Krogh, 2009; Sieg et al., 2010; Natalicchio et al., 2017). The formulation of the problem may affect the value of the solution proposals. In fact, since solvers may not possess certain knowledge elements and cannot follow a formalized and unambiguous problem-solving approach, this may lead them to develop poor quality and defective solutions (Fernandes and Simon, 1999; von Hippel and von Krogh, 2015).

We argue that the formulation of the problem impacts the governance structure choice of the working relationship, which allows seekers to increase the value of the insourced knowledge (Nickerson and Zenger, 2004; Leiblein and Macher, 2009).

Bilateral governance structures provide seekers with advantages necessary in managing poorly-delineated problems by overcoming the deficiencies of the problem formulation (Lam, 2000; Felin and Zenger, 2014). In fact, bilateral governance structures offer seekers a formal system of coordination that allows them to set-up a common language and carefully work with the winning solvers (Casciaro, 2003). By establishing such close cooperation, the seeker and

solver can share tacit knowledge elements related to the problem through mutual observation of their work, compensating for the poor formulation of the problem when it was broadcast (Grandori, 2001; Cummings and Teng, 2003; Squire et al., 2009). Moreover, when the seeker can closely work with the winning solver, trust arises between them (Moorman et al., 1992; Nooteboom, 1996). In such a circumstance when a seeker can rely on trust at the interpersonal level, they are more inclined to share elements of knowledge previously omitted in the description of the problem due to confidentiality reasons (Nickerson and Zenger, 2004).

Conversely, since an accurate formulation of the problem increases the value of solution proposals, unilateral governance structures may represent a proper choice when broadcasting a well-delineated problem (Natalicchio et al., 2017). In such a case, the formulation of the innovation problem requires seekers to communicate explicit knowledge that is easy to codify by using drawing and writing schemes (Nonaka and von Krogh, 2009). To describe the knowledge elements of a well-delineated problem, then, seekers do not need organizational mechanisms that allow the sharing of components of tacit knowledge and the development of mutual trust (Gulati and Nickerson, 2008). Thus, when broadcasting well-delineated problems, seeker can benefit from efficiency related to unilateral governance structures that are simpler and less costly due to the less onerous administrative structure (Casciaro, 2003).

In sum, more complex and onerous bilateral governance structures can better support seekers to insource knowledge related to the solution of poorly-delineated problems, whereas less costly and simpler unilateral governance structures are more efficient in transferring knowledge related to the solution of well-delineated problems.

In accordance with this reasoning, we posit the following hypothesis:

Hypothesis 2: Well-delineated (poorly-delineated) innovation problems are positively related with the seeker's preference toward unilateral (bilateral) governance structures.

Search space of the problem

The search space of the problem reflects the bundle of knowledge and fields of expertise useful in dealing with its resolution process (March, 1991). Seekers may or may not be familiar with the knowledge and expertise that characterize the search space of the problem they broadcast (von Hippel, 1994; Lopez-Vega et al., 2016). In particular, when the search space overlaps the seekers' knowledge capabilities, seekers perform local searches aiming at insourcing and implementing innovations that are similar to their existing knowledge base (March, 1991; Natalicchio et al., 2017). In turn, when the search space of the problem does not overlap the seekers' knowledge capabilities, seekers perform distant searches aiming at exploring and absorbing innovations that are different from their existing knowledge base (March, 1991; Natalicchio et al., 2017). The search space of the problem influences the coordination required between a seeker and solver to understand and transfer the knowledge. When problems require a distant searching process, transfer of knowledge is more difficult, costly and time consuming, since seekers have to deal with knowledge they are not familiar with and may therefore lack the absorptive capacity necessary to assess and insource the knowledge related to the solution (Cohen and Levinthal, 1990; Nooteboom, 2000). Moreover, seekers may overvalue the quality of solution proposals, facing the risk of insourcing poor quality or even ineffective winning solutions (Afuah and Tucci, 2012; Mayer and Salomon, 2006).

We argue that the search space of the problem impacts the governance structure choices of the working relationship that supports a seeker in the understanding and insourcing of new knowledge (Cohen and Levinthal, 1990; Nickerson and Zenger, 2004).

Specifically, bilateral governance structures are more beneficial for managing the challenging coordination requirements seekers face when the search space of the problem does not overlap their knowledge capabilities (Sampson, 2004). Bilateral governance structures are

characterized by a set of organizing principles that act as mechanisms by which it is possible to codify the knowledge into a language accessible to a wider range of individuals (Kogut and Zander, 1992). Thanks to these mechanisms, then, bilateral governance structures make transferring and sharing knowledge easier and less costly for a seeker who has to deal with distant and unfamiliar knowledge (Conner and Prahalad, 1996). Moreover, when unanticipated contingencies occur, bilateral governance structures also provide greater flexibility to renegotiate and adapt a relationship than unilateral ones (Conner and Prahalad, 1996). Such flexibility is critically required when seekers face distant searches, since they may incur renegotiation costs related to learning opportunities and difficulties related to unfamiliar knowledge that seekers are not able to foresee (Sampson, 2004).

Contrarily, when the problem space overlaps the seekers' knowledge capabilities, seekers do not face difficulties in understanding and absorbing the knowledge of the winning solution and assessing its quality, so unilateral governance structures might be preferable (Cohen and Levinthal, 1990). In such a case, to insource the knowledge elements related to the winning solutions, seekers can leverage their existing capabilities and do not need to strictly cooperate with solvers to understand the knowledge and build new capabilities (Kogut and Zender, 1992; Sampson, 2004). Thus, when broadcasting problems with a near search space, seekers can exploit the efficiency of less costly unilateral governance structures that are indeed less committed and can offer to the solver a level of investment that is commensurate with what the innovation problem requires (Contractor and Ra, 2002; Casciaro, 2003).

In sum, more complex and onerous bilateral governance structures can better support seekers in insourcing knowledge related to the solution of problems with a distant search space; whereas, less costly and simpler unilateral governance structures are more efficient in transferring knowledge related to the solution of problems with a near search space.

Accordingly, we posit the following hypothesis:

Hypothesis 3: Innovation problems with a distant search (near search) space are negatively related with the seeker's preference toward unilateral (bilateral) governance structures.

DATA AND METHODS

Data collection and measures

To test our hypotheses, we built an ad-hoc database considering all the crowdsourcing for innovation contests broadcast on NineSigma (Lopez-Vega et al., 2016) in a five-year time window (2010-2014). Data are collected from the RFP documents, and the contest is the unit of analysis. Each observation is fixed at the date of submission and does not require a study across time; the dataset is then structured as cross-sectional. During our observation period, 787 crowdsourcing for innovation contests were broadcast on the platform; however, some observations were removed because following an update to the platform's archive, some RFP documents were not available. The final sample consists of 582 challenges.

The variable *Unilateral governance structure* measures the governance structure preferred by the seeker to manage the working relationship with the winning solver. The seeker can propose one or more governance structures, and they range from unilateral (i.e., licensing agreements, technology/patent/product acquisition, consulting, supply agreements and contracted research) to bilateral (i.e., joint development and partnerships). If in the RFP document a seeker proposes only a type of unilateral governance structure (or even more than one), she/he has a preference toward unilateral governance structures. Instead, if the seeker proposes only a type of bilateral governance structure (or even more than one), or if the seeker proposes both unilateral and bilateral governance structures, she/he does not have any preference toward unilateral governance structures. Thus *Unilateral governance structure* is modeled as a binary variable, assuming the value 1 if the seeker has a preference toward unilateral governance structures, 0 otherwise.

The explanatory variable *Decomposability* of the problem is a count variable measuring the number of technical areas (e.g., engineering, chemistry or healthcare science) to which the problem can be decomposed, as described in the RFP (Natalicchio et al.,2017). For example, considering the problem related the development of a system to improve visibility during bad weather (NineSigma, 2012 – ID challenge REQ9172895) that involved several and distinct knowledge elements, ranging from mechanical engineering, electrical/electronic engineering to information science, the variable *Decomposability* assumes a value equal to 3.

Formulation of the problem is operationalized as a count variable measuring the number of requirements that the solution must fulfil, as expressed by the seeker in the RFP (Sieg et al., 2010; Wielens, 2013). These conditions may be related to physical characteristics (e.g., the dimension or weight of a new product/material) or to the functionality of the solution (Arranz and Arroyabe, 2012; Lopez-Vega et al., 2016). For example, focusing on a request for a new transparent material replacing glass in automobiles (NineSigma, 2014 – ID challenge REQ0247749), the seeker firm specified in the RFP that the new material must have (1) no performance degradation even after being used outdoors for 15 years; (2) a hardness rating greater than H; (3) a weight lower by 40% or more compared to glass; and (4) a visible light transmittance rate equal to 80% or more. In such a case, the variable *Formulation* assumes the value 4. Due to the skewness of the data, we used the logarithm of the variable.

The *Search space* of the problem is a binary variable, measured by comparing the industry to which the seeker belongs and the technical areas of the challenge (Afuah and Tucci, 2012; Lopez-Vega et al., 2016). If the knowledge related to the technical area of the problem does not overlap the knowledge possessed by the seeker, *Search space* assumes the value 1, 0 otherwise. Consider, for example, a problem aimed at improving the properties of a resin (NineSigma, 2011 – ID challenge REQ1172128). Since it involves knowledge related to the chemical area, its search space overlaps the knowledge possessed by a seeker belonging to the

chemical industry. In such a case, the variable *Search space* assumes the value 0. Consider instead a problem related to the development of a new technology to print labels on cardboard containers used for shipping a company's product (NineSigma, 2013 – ID challenge REQ7141960). Because this problem requires knowledge from mechanical engineering and information science, its search space does not overlap the knowledge possessed by a seeker belonging to the chemical industry. Thus in such a circumstance, the variable *Search space* assumes the value 1.

We also include a number of control variables in our model. We control for the effect that the seeker's industry (*Seeker industry*) has on the seeker's governance considerations (Oxley, 1997) through seven dummy variables representing the core activities of seekers (*Automotive and transportation*, *Chemicals and materials*, *Electronics and semiconductors, Food and beverage*, *Healthcare*, *Manufacturing* and *Other industries*). Moreover, we control for the *Technical area of the challenge* through four dummies representing the main knowledge elements of the innovation problems broadcast on NineSigma (*Engineering, Chemistry and material science, Healthcare science* and *Other areas*). Moreover, since a seeker may prefer to address its challenge to a restricted pool of solvers according to their knowledge capabilities (Simula and Ahola, 2014), we control for this circumstance with the variable *Pre-selection:* a binary variable assuming the value 1 when the seeker decides to open its call to a smaller group of solvers opportunely selected, 0 otherwise. Furthermore, we control whether the seeker reveals to the solvers their preferences toward possible approaches to adopt in solving technical problems (Wielens, 2013; Lüttgens et al., 2014) through the variable *Advice. Advice* is operationalized as a continuous variable measuring the natural logarithm of the number of advice statements expressed by the seeker. Finally, we control for the possibility of the seeker providing financial support to the winning solver; *Financial* is a binary variable that assumes the value 1 if the seeker provides financial support to the winning solver, 0 otherwise.

ANALYSIS AND RESULTS

Unilateral governance structure models an alternative between two possible occurrences, so both logit and probit models are appropriate; convenience and convention determine the choice between them (Long, 1997; Hoetker, 2007). We decide to apply a probit model. Moreover, as robustness check, we run the regression using the logit model, obtaining the same results.

The descriptive statistics and the correlation values are provided in Table 1. The pairwise correlation matrix does not reveal any criticalities. Moreover, we used the variance inflation factors (VIFs) test to check for multicollinearity, and we found that no variable had a VIF greater than 6 (Stevens, 1992); therefore, multicollinearity is not a problem for this study.

The probit estimation results are illustrated in Table 2. Starting with the control variables, we find in Model 1 that dummy variables indicating the industry of the seeker are all significant and negative, except for *Food and beverage,* meaning that seeker firms belonging to the significant industries do not have a preference toward unilateral governance structures compared to seekers operating in *Other industries* (omitted since used as a baseline category). Dummy variables indicating the *Technical area of the challenge* are not significant. Furthermore, *Pre-selection* is significant and has a positive impact, meaning that if the seeker addresses the challenge to a restricted group of solvers according to their knowledge capabilities, she/he has a preference toward unilateral governance structures. The control variable *Advice* is significant and has a negative coefficient, suggesting that firms which provide possible approaches to solve an innovation problem do not have a preference toward unilateral governance structures. Finally, the control variable *Financial* is not significant.

	Mean	Std. dev.	VIF	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) Unilateral governance structure	0.13	0.34	1.11	1																	
(2) Automotive and transportation	0.12	0.33	1.60	-0.05	1																
(3) Chemicals and materials	0.14	0.35	1.66	0.0003	-0.15*	1															
(4) Electronics and semiconductors	0.12	0.32	1.58	-0.06	-0.14*	-0.15*	1														
(5) Food and beverage	0.11	0.31	1.63	0.08	-0.13*	-0.14*	-0.13*	1													
(6) Healthcare	0.14	0.31	2.12	-0.10*	-0.15*	-0.16*	-0.14*	-0.14*	1												
(7) Manufacturing	0.19	0.39	1.78	-0.07	-0.18*	-0.20*	-0.18*	-0.17*	-0.19*	1											
(8) Engineering	0.35	0.48	2.63	-0.03	0.19*	-0.12*	0.22*	-0.19*	-0.24*	0.13*	1										
(9) Chemistry and material science	0.33	0.47	2.62	0.008	-0.007	0.29*	-0.13*	-0.12*	-0.15*	0.05	-0.51*	1									
(10) Healthcare science	0.15	0.36	2.34	-0.08	-0.14*	-0.06	-0.14*	-0.04	0.57*	-0.08*	-0.31*	-0.29*	1								
(11) Pre-selection	0.14	0.35	1.25	0.09*	0.03	0.002	-0.09*	0.02	0.05	0.05	-0.07	-0.05	0.16*	1							
(12) Advice	1.44	0.70	1.13	-0.10*	0.001	0.06	-0.07	0.05	-0.11*	0.06	0.03	0.06	-0.10*	-0.17*	1						
(13) Financial	0.80	0.40	4.68	-0.07	-0.08*	-0.04	-0.04	-0.03	-0.02	0.10*	0.03	0.04	-0.04	-0.12*	0.17*	1					
(14) Decomposability	1.13	0.37	1.05	-0.02	0.01	0.05	0.11*	-0.06	-0.01	-0.06	0.04	-0.01	-0.01	0.02	0.12*	-0.05	1				
(15) Formulation	2.00	0.72	1.10	0.04	-0.08	0.02	-0.04	-0.08	0.06	0.02	0.06	0.07	-0.02	-0.35*	0.12*	0.19*	0.04	1			
(16) Search space	0.20	0.40	1.12	0.10*	0.06	0.03	-0.07	0.04	-0.02	-0.08	0.002	-0.05	-0.15*	-0.07	-0.03	0.04	-0.02	0.12*	1		
(17) Timeline phases	1.84	0.63	1.20	-0.04	-0.008	0.04	-0.04	-0.09*	-0.07	0.0009	0.07	0.10*	-0.11*	-0.17*	0.10*	0.25*	0.001	0.31*	0.03	1	
(18) Words	4.26	1.27	4.41	0.01	-0.06	0.02	-0.04	-0.06	0.05	0.03	0.04	0.08	-0.01	-0.35*	0.10*	0.13*	0.03	0.88*	0.09*	0.23*	1

* $p < 0.05$

Table 1. Descriptive statistics and correlations

	Preference toward unilateral governance structure				
	Model 1	Model 2	Model 3	Model 4	Model 5
Seeker industry					
Automotive and transportation	-0.861**	-0.863**	-0.820**	-0.888***	-0.844**
	(0.265)	(0.265)	(0.272)	(0.267)	(0.272)
Chemicals and materials	-0.532*	-0.530*	-0.546*	-0.567*	-0.567*
	(0.233)	(0.233)	(0.232)	(0.228)	(0.228)
Electronics and semiconductors	-0.916***	-0.913**	-0.882**	-0.874**	-0.842**
	(0.278)	(0.279)	(0.278)	(0.278)	(0.281)
Food and beverage	-0.306	-0.312	-0.283	-0.293	-0.284
	(0.247)	(0.247)	(0.249)	(0.245)	(0.248)
Healthcare	-1.023***	-1.019**	-1.108***	-1.055***	-1.132***
	(0.311)	(0.310)	(0.311)	(0.310)	(0.313)
Manufacturing	-0.818***	-0.820***	-0.814***	-0.805***	-0.806***
	(0.223)	(0.223)	(0.225)	(0.223)	(0.225)
Technical area of the challenge					
Engineering	-0.113	-0.114	-0.231	-0.0702	-0.193
	(0.218)	(0.218)	(0.219)	(0.213)	(0.216)
Chemistry and material science	-0.105	-0.107	-0.182	-0.0248	-0.117
	(0.218)	(0.218)	(0.221)	(0.214)	(0.220)
Healthcare science	-0.434	-0.435	-0.515+	-0.318	-0.415
	(0.298)	(0.298)	(0.289)	(0.296)	(0.290)
Pre-selection	0.336+	0.339+	0.567**	0.358+	0.576**
	(0.184)	(0.183)	(0.201)	(0.185)	(0.201)
Financial	-0.226	-0.233	-0.305+	-0.250	-0.333*
	(0.164)	(0.162)	(0.166)	(0.164)	(0.163)
Advice	-0.225*	-0.220*	-0.257**	-0.214*	-0.240*
	(0.0950)	(0.0974)	(0.0971)	(0.0950)	(0.0996)
Decomposability		-0.0624			-0.113
		(0.198)			(0.203)
Formulation			0.349**		0.327**
			(0.110)		(0.109)
Search space				0.312*	0.255+
				(0.163)	(0.165)
_cons	-0.0151	0.0545	-0.591+	-0.138	-0.525
	(0.258)	(0.309)	(0.318)	(0.260)	(0.365)
N	582	582	582	582	582
Log-pseudolikelihood	-204.33	-204.29	-200.22	-202.68	-199.06
Wald chi^2	46.54	47.74	54.90	48.56	59.39
Pseudo R^2	0.1015	0.1017	0.1196	0.1088	0.1247
Prob>chi^2	0.0000	0.0000	0.0000	0.0000	0.0000
Standard errors in parentheses; + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$					

Table 2. Results of probit estimations

In Model 2 the independent variable *Decomposability* is not significant, thus H1 is not supported. Model 3 supports H2, since the coefficient of the independent variable *Formulation* is significant and positive. In Model 4 the coefficient of the independent variable *Search space* is significant and positive, contrary to what we hypothesized in H3. Finally Model 5, which includes all of the independent variables, confirms the previous results by supporting hypothesis H2 but not H1 or H3.

Our data shows that some seekers do not have a preference between unilateral and bilateral governance structures at the moment the challenge is broadcast. However, choosing a specific governance structure to manage the working relationship with the winning solver is predicated on the development of a preference. Because we examine RFPs from the time the challenge was broadcast, our regression analysis does not take into account later self-selection for a preferred governance structure and may result in biased coefficient estimates due to omitted variables that affect both the development of a preference and the resulting outcome (Hamilton and Nickerson 2003). For this reason, following Jeppesen and Lakhani (2010), we control for sample selection bias using a probit model with sample selection correction (Van de Ven and Van Praag, 1981). This model is an extension of the Heckman model (Heckman 1979). The original Heckman model assumes a binary choice for selection into the sample and a continuous outcome for the main dependent variable, while its extension takes into account the statistical properties of a two-stage discrete choice estimation (Heckman 1979). Given that governance considerations about the seeker-solver working relationship consist of two binary outcomes – (1) the presence or absence of a preference toward a specific governance structure and (2) having a preference toward a unilateral or bilateral governance structure – the adapted version of the Heckman model will be more appropriate than its traditional version.

The results of two-stage probit estimations with the Heckman correction are reported in Table 3. The first stage models the process of the selection into the sample, i.e., the presence or absence of a preference toward a specific governance structure; the second stage models the binary choice between a unilateral or bilateral governance structure and includes an error correction term obtained from the first stage estimation. Performing the Heckman correction, we get the same results of the probit estimation shown in Table 2 without controlling for the self-selection bias.

	First stage: developing a preference			Second stage: unilateral vs. bilateral preference		
	Model1	Model2	Model3	Model4	Model5	Model6
Seeker industry						
Automotive and transportation	-0.321	-0.328	-0.343	-2.757***	-2.570**	-2.182***
	(0.232)	(0.229)	(0.234)	(0.621)	(0.867)	(0.571)
Chemicals and material	-0.432+	-0.435+	-0.457*	-1.843**	-2.245*	-1.077+
	(0.225)	(0.226)	(0.221)	(0.699)	(0.961)	(0.621)
Electronics and semiconductors	-0.713**	-0.719**	-0.685**	-2.640**	-2.758*	-1.486*
	(0.257)	(0.256)	(0.256)	(0.918)	(1.185)	(0.683)
Food and beverage	-0.045	-0.041	-0.031	-1.538*	-1.912**	-1.440*
	(0.228)	(0.228)	(0.226)	(0.602)	(0.678)	(0.625)
Healthcare	-1.040***	-1.040***	-1.052***	-2.480*	-2.297	-0.877
	(0.287)	(0.287)	(0.284)	(1.139)	(1.719)	(0.774)
Manufacturing	-0.668**	-0.667**	-0.654**	-2.112**	-2.181+	-1.008+
	(0.209)	(0.209)	(0.209)	(0.751)	(1.174)	(0.609)
Technical area of the challenge						
Engineering	-0.228	-0.220	-0.183	-0.329	-0.715	0.082
	(0.208)	(0.209)	(0.205)	(0.511)	(0.712)	(0.447)
Chemistry and material science	-0.164	-0.158	-0.103	-0.305	-0.840	0.047
	(0.207)	(0.209)	(0.204)	(0.529)	(0.727)	(0.476)
Healthcare science	-0.053	-0.049	0.036	-1.435*	-2.516***	-1.181*
	(0.254)	(0.256)	(0.255)	(0.571)	(0.763)	(0.553)
Pre-selection	0.529**	0.516**	0.547***	0.399	1.030	-0.497
	(0.163)	(0.171)	(0.165)	(0.717)	(0.940)	(0.361)
Financial	-0.251	-0.243	-0.265+	-0.569	-0.787	-0.069
	(0.155)	(0.157)	(0.155)	(0.469)	(0.555)	(0.363)
Advice	-0.218*	-0.222*	-0.214*	-0.446	-0.686	-0.073
	(0.092)	(0.090)	(0.090)	(0.311)	(0.510)	(0.226)
Decomposability	-0.066			-0.241		
	(0.189)			(0.452)		
Formulation		-0.015+			1.407***	
		(0.090)			(0.338)	
Search space			0.265+			0.694+
			(0.154)			(0.355)
Selection correction term				5.406	3.739	7.258***
				(3.657)	(5.268)	(0.469)
Constant	0.115	0.068	-0.061	-0.083	-0.644	-3.850***
	(0.300)	(0.283)	(0.247)	(2.103)	(2.794)	(0.599)
N	582	582	582	129	129	129
Log-pseudolikelihood	-248.20	-248.25	-246.89	-45.89	-33.53	-46.17
Wald chi^2	54.21	53.18	55.02	29.95	40.19	90.38
Prob>chi^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Standard errors in parentheses; $^{+}\ p < 0.10$, $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Table 3. Results of probit estimations with sample selection correction

Focusing on the second stage, in Model 4 the independent variable *Decomposability* is not significant, thus H1 is not supported. Model 5 supports H2 since the coefficient of the independent variable *Formulation* is significant and positive, meaning that when the problem is easy to formulate, seekers develop a preference toward a unilateral governance structure

compared to a bilateral one. In Model 4 the coefficient of the independent variable *Search space* is significant and positive meaning that, contrary to what we hypothesized in H3, when searching for solutions that are distant from their knowledge bases, seekers prefer unilateral governance structures over bilateral ones.

Post-hoc endogeneity analysis

Endogeneity occurs for several reasons, such as measurement errors, simultaneity or reverse causality, and omitted variable bias (Wooldridge, 2002; Abdallah et al., 2015). In our study, reverse causality is not plausible; it would not be possible for a seeker who prefers to manage the working relationship through specific governance structures to change the attributes of the technical problem she/he is attempting to solve. In fact, the attributes of the technical problem, such as the decomposability, the formulation and the search space of the problem (Afuah and Tucci, 2012; Felin and Zenger, 2014), are intrinsic characteristics of the problem itself; they are given and cannot be changed by the seeker. In turn, omitted variables bias may be a real concern in our model and could increase the effect that *Decomposability, Formulation* and *Search space* have on the dependent variable.

To adequately address endogeneity concerns related to our independent variables, we used the instrumental variable (IV) method (Wooldridge, 2002; Hamilton and Nickerson, 2003). We used two different instruments, *Timeline phases* and *Words*. *Timeline phases* exogenously influences *Formulation* and *Search space,* but it does not affect the dependent variable, *Unilateral governance structure*. *Timeline phases* measures the number of phases through which the seeker regulates the timeline for the winning solver to develop the proposed solution. Each phase of the timeline is defined by intermediate results the solver has to reach, allowing seekers to assess the solvers' knowledge and skills step-by-step; this enables the seeker to assess if the solution effectively solves the technical problem and whether the solver

possesses the knowledge required to solve the innovation problem (Koza and Lewin, 2000). Following Plourde et al. (2014), we validated the instrument; *Timeline phases* significantly and negatively affects the variables *Decomposability* (β=0.28 with p-value=0.000) and *Search space* (β=0.32 with p-value=0.002), while *Unilateral governance structure* does not (p-value=0.320). The second instrument, *Words,* exogenously influences the variable *Formulation* but does not affect the dependent variable, *Unilateral governance structure*. Specifically, *Words* measures the number of words used by a seeker to express the conditions that the solution must fulfil. As stressed by Gefen et al. (2016), the seeker uses the length of the description of requirements to better describe the innovation problem. We found that *Words* is a valid instrument, as *Words* significantly and positively affects *Formulation* (β=0.49 with p-value=0.000) while *Unilateral governance structure* does not (p=0.73).

Because *Search space* is a binary variable, while *Decomposability* and *Formulation* are not, we used different IV techniques tailored to these variables to perform our endogeneity analysis. Specifically, in order to treat endogeneity related to *Decomposability* (H1) and *Formulation* (H2), we used the IV probit estimation procedure (Wooldridge, 2002), as done in previous studies (e.g., Plourde et al., 2014). Table 4 shows that IV probit estimations produce the same results as the standard probit estimation (Table 2). Moreover, the insignificant Wald test also indicates in this case that endogeneity concerns do not affect *Decomposability* and *Formulation* (Wooldridge, 2002). Moreover, following previous scholars (e.g., Fairlie, 2006), we adopted the bivariate probit estimation approach (Angrist, 2001) in order to treat endogeneity related to *Search space* (H3). Bivariate probit estimation solves our potential endogeneity concerns by simultaneously estimating two probit models, as shown in the last two columns of Table 4. Bivariate probit produces the same results as the standard probit estimation (Table 2). Most importantly, such a procedure also returns a Wald test to check for the existence of exogeneity (Monfardini and Radice, 2008); the Wald exogeneity test is insignificant,

meaning that endogeneity concerns do not affect *Search space* (Wooldridge, 2002). Thus, the post-hoc endogeneity analysis provides consistency with previous results and so validates our interpretations.

	IV probit (H1)	**IV probit** (H2)	**Bivariate probit** (H3)	
	Unilateral governance structure	Unilateral governance structure	Unilateral governance structure	Search space
Seeker industry				
Automotive and transportation	-0.860**	-0.822**	-0.835**	0.282
	(0.264)	(0.272)	(0.257)	(0.227)
Chemicals and materials	-0.540*	-0.546*	-0.584**	0.283
	(0.232)	(0.232)	(0.209)	(0.216)
Electronics and semiconductors	-0.937***	-0.884**	-0.642*	-0.429+
	(0.276)	(0.278)	(0.302)	(0.260)
Food and beverage	-0.308	-0.285	-0.194	-0.153
	(0.247)	(0.249)	(0.246)	(0.263)
Healthcare	-1.022***	-1.108***	-1.079***	0.149
	(0.309)	(0.311)	(0.303)	(0.276)
Manufacturing	-0.812***	-0.815***	-0.653**	-0.181
	(0.222)	(0.225)	(0.236)	(0.218)
Technical area of the challenge				
Engineering	-0.126	-0.231	0.142	-0.647***
	(0.215)	(0.219)	(0.219)	(0.195)
Chemistry and material science	-0.112	-0.182	0.272	-0.833***
	(0.217)	(0.221)	(0.234)	(0.203)
Healthcare science	-0.440	-0.517+	0.0907	-1.446***
	(0.296)	(0.288)	(0.332)	(0.355)
Pre-selection	0.332+	0.557**	0.397*	-0.0896
	(0.183)	(0.203)	(0.175)	(0.199)
Financial	-0.227	-0.304+	-0.288+	0.181
	(0.161)	(0.166)	(0.150)	(0.156)
Advice	-0.232*	-0.253**	-0.158+	-0.137
	(0.0990)	(0.0962)	(0.0940)	(0.0914)
Decomposability	0.0879			
	(0.320)			
Formulation		0.330**		
		(0.116)		
Search space			1.630**	
			(0.617)	
Phase timeline				0.376***
				(0.105)
_cons	-0.0909	-0.557+	-0.620+	-0.404+
	(0.401)	(0.336)	(0.325)	(0.241)
N	582	582	582	582
Log-pseudolikelihood	-303.69	-212.33	-459.51	
Wald chi^2	46.99	53.72	163.43	
Prob>chi^2	0.0000	0.0000	0.0000	
Wald exogeneity test	0.36	0.09	2.06	

The critical value of the Wald exogeneity test at a significance of 0.05 is 3.84; the null hypotheses are exogenesis of *Decomposability*, *Formulation* and *Search space*. In the IV probit estimations *Decomposability* is instrumented with the variable *Phase timeline*, while *Formulation* is instrumented with the instrumental variable *Words*.

Standard errors in parentheses; $^{+}\ p < 0.10$, $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Table 4. Results of endogeneity analysis

DISCUSSION AND CONCLUSIONS

Analyzing detailed data gathered from 582 challenges broadcast on the NineSigma platform we get three main results from the empirical investigation. First, we provided confirmation that well-delineated innovation problems lead seekers to prefer unilateral governance structures to manage the working relationship with the winning solver. This finding suggests that when problems can be easily formulated, the constitution of more complex organizational structures that allow the integration of omitted tacit knowledge is unnecessarily onerous. Thus, since in such a case the seeker does not need to offer additional information to the description of the problem in the RFP document for increasing the value of the solution proposals, they can benefit from a more efficient and less costly unilateral governance structure.

Second, we did not find support for the negative relationship between an innovation problem characterized by a distant search space and the seeker's preference toward unilateral governance structures. On the contrary, we found a positive relationship, meaning that when seekers engage in crowdsourcing activities to acquire knowledge distant from their existing capabilities, they have preferences toward unilateral governance structures. A possible explanation for this counterintuitive finding may be that crowdsourcing contests are often used by organizations to more effectively and efficiently search for and absorb knowledge in unfamiliar areas (Afuah and Tucci, 2012). Developing new capabilities in areas in which a firm has none, or which are relatively distant from the firm's core competences, may be very difficult, costly, and time consuming (March, 1991). In dealing with a solution related to a search space that does not involve familiar knowledge elements, seekers cannot leverage their existing capabilities and so face the risk of being unable to absorb and integrate the new knowledge (Cohen and Levinthal, 1990). Under these circumstances, the seeker may prefer not to enter into a committed, costly and time consuming relationship with a bilateral governance structure, thus preferring unilateral ones. This is in line with the Real Option perspective that

generally encourages firms to delay demanding investments characterized by a high level of uncertainty and establish less committed relationships that enable companies to withdraw from the investment at any point in time (Folta, 1998; Dalziel 2009). Relationships with unilateral governance structures allow the seeker to learn about the new and unfamiliar knowledge and, at the same time, develop the absorptive capacity necessary to integrate it without engaging in a time and cost consuming investment (Cohen and Levinthal, 1990; Kogut and Kulatilaka, 2001; van de Vrande et al., 2006). As such, seekers facing the risks related to a distant knowledge search may use unilateral governance structures to learn about the new and the unfamiliar knowledge while evaluating the decision to enter into more committed relationships with a bilateral governance structure (Kogut, 1991; Folta and Miller, 2002). The lower level of commitment offered by unilateral governance structures may thus overcome the benefits related to mechanisms of knowledge transfer offered by bilateral ones when engaging in crowdsourcing exploratory activities (Folta, 1998; Mayer and Salomon, 2006).

Finally, we did not find empirical confirmation of the effect that the decomposability of the innovation problem has on seekers' preference toward alternative governance structures. Such a non-significant result could be due to the supporting role offered by the NineSigma crowdsourcing platform in the evaluation process of solution proposals. In fact, as also emerged from the qualitative evidence we gathered through our interviews, NineSigma managers assist seekers in screening all solution proposals and selecting the winning one. Thus seekers who trust the intermediary role played by the platform in understanding the knowledge related to the solutions and assessing their quality may not be influenced by the decomposability of the problem when evaluating the governance structure of the crowdsourcing relationship.

Contribution to literature and practice

Examining the match between problem attributes and appropriate working relationships, this paper contributes to the literature streams on innovation crowdsourcing and makes two interesting contributions.

First, we enrich the discussion in the literature by providing evidence that seekers have preferences toward specific governance structures for managing the working relationship with the winning solver. Although growing scholarly attention has been paid towards crowdsourcing governance implications (e.g., Pénin and Burger-Helmchen, 2011; Afuah and Tucci, 2012; Poetz and Schreier, 2012; Malhotra and Majchrzak, 2014; Nickerson et al., 2017), previous studies have neglected to investigate the governance structure that manages the seeker-solver working relationship. Our main findings are that well-delineated innovation problems and the distance of the knowledge from a solver's existing knowledge capabilities tend to act as complements in specific governance structure decisions. The literature from the problem-solving perspective suggests that governance structure decisions associated with innovation contests are specified up front and most appropriate to solve well-defined, decomposable, or simple (i.e., non-complex) problems (Felin and Zenger, 2014) by providing a prize award instead of a property rights agreement (i.e., a licensing or contractual agreement). Our findings appear to contradict available research in innovation contests; we argue that the problem attributes can vary from well-structured, well-defined, simple and decomposable problems to poorly-structured, less defined, complex and less decomposable problems based on the needs of the seeker's organization, which then match the seeker's governance choice selection. Our findings suggest that the working relationship between seekers and solvers goes beyond governance, fulfilling a coordinating role of aligning seeker and solver expectations; this role does not necessarily conflict with the design of crowdsourcing for innovation contests in relation to problem attributes.

Second, governance structure decisions in innovation contests has rarely been studied with the lenses of problem-solving perspective and the knowledge-based view, yet we provide systematic evidence that governance structure decisions vary significantly in ways consistent with knowledge requirements, defined as the key underlying features of the problem attributes governed by the seeker. We believe these two views have complementary potential in investigating knowledge-governance considerations in the crowdsourcing context. Even if governance issues addressed by the knowledge-based view are limited to keeping knowledge within a firm, this view is indeed very helpful in illustrating the central role of knowledge creation and management in sustaining a firm's competitive advantage (Leiblein, 2003). In addition, whilst the problem-solving perspective is a useful lens to explain how organizations generate value while they define, create and solve problems, this view is too firm-centric and focuses on what problems the organizations are required to resolve and when (Felin and Zenger, 2016). The problem-solving perspective needs to more effectively incorporate seeker organizational resources and knowledge; scholars utilizing a knowledge-based perspective should also consider how different types of governance may affect knowledge transfer and protection. Instead of seeing the knowledge-based view and problem-solving perspectives as contradictory, this study explores how they can inform one another through examination of a topic common to both: how governance decisions are affected by the characteristics of problem related to the knowledge required for developing, evaluating and transferring a solution.

In addition, even if the complementarity of the problem-solving perspective and the knowledge-based view has shown potential in investigating governance issues, we believe they are not sufficient to explain the complex process of knowledge transfer between the seeker and solver in the crowdsourcing context. In fact, to explain the unexpected and counterintuitive result related to the relationship between the search space of the problem and the governance structure preferred by the seeker, we also needed to invoke the Real Option theory (Folta, 1998).

Different from the knowledge-based view and the problem-solving perspective, the Real Option approach emphasizes the role played by uncertainty in affecting governance structure decisions (Leiblein, 2003). When the transfer of knowledge involves a distant and unfamiliar search, seekers may lack the capabilities to absorb the new knowledge from the crowd and may be unable to integrate it with their exiting knowledge base (Cohen and Levinthal, 1990). In such a case, seekers have to also include uncertainty considerations related to the value they can capture from the winning solution in their governance decisions. Including these considerations in their decision processes, seekers may prefer a unilateral governance structure as an initial investment to experiment with the distant knowledge of the winning solution and then evaluate the possibility of following up on this investment with a more committed governance structure. Thus, the knowledge-based view and the problem-solving perspective offer better predictions for the preferred governance structure when considering the tacit knowledge related to the problem broadcast, while the Real Option theory provides better support when considering the risks a seeker faces when engaging in distant knowledge searches. In conclusion, governance considerations in the crowdsourcing context need to be investigated under several theoretical approaches to take on board all the complex aspects characterizing the transfer of knowledge between the seeker and the solver.

The results of this study also present important implications for managers who design crowdsourcing for innovation contests. Firms' managers have to match their decisions about a governance structure to manage the crowdsourcing relationship with the attributes of the problem they are attempting to solve. In particular, managers should prefer bilateral governance structures (e.g., a joint development contract) when they cannot provide the crowd an accurate formulation of the problem at the moment it is broadcast. In such a circumstance, in fact, more interaction and face-to-face personal contact between seekers and solvers is required to communicate to the winning solver certain knowledge that is not possible to codify through

writing or drawing. Further, managers should govern the crowdsourcing relationship through unilateral structures when pursuing the objective of insourcing knowledge that is located far away from their knowledge competencies. In such a case, since seekers may not be able to assess the true value of the solution and absorb the related knowledge, it could be preferable to firstly engage in a less committed investment to start exploring unfamiliar knowledge and then evaluate more costly and tighter relationships. Finally, seekers should not be concerned about the decomposability of the problem when evaluating the governance structure of crowdsourcing relationships. Specifically, seekers have to be aware of the role of the crowdsourcing platform in helping them to evaluate solution proposals involving interrelated components of knowledge and to develop a common language to share knowledge with the winning solver.

Limitations and future research

Despite providing interesting arguments and empirical results, we must still consider certain limitations. First of all, we tested our hypotheses through secondary data. The major limitation related to secondary data is that no new constructs of interest may be added, as the archival data already exists. Moreover, seekers are often flexible with regard to the specific governance structure as an outcome of an RFP and may be willing to accept a variety of forms of collaboration. Thus, a governance structure could be administered in a number of different ways, with varying degrees of collaboration, following the selection of a specific proposal. A better-grounded analysis of the proposed relationships and challenge attributes could be explored via in-depth longitudinal case research.

Finally, this study focuses on a platform for innovation competitions (NineSigma). Although the context is surely the most appropriate for the issue under investigation, it would be unwise to broadly generalize our findings to either other crowdsourcing platforms for innovation competitions (e.g., InnoCentive or Yet2) or crowdsourcing platforms for idea

competitions (e.g., CrowdSPRING or 99designs), which award monetary rewards to winning solvers instead of establishing seeker-solver working relationships.

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