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Leadership, communication and innovation

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Abstract

We study the interplay between communication, leadership attributes and the probability of successful innovation. Although a firm requires both strong leadership and sufficient communication to overcome inertia, we posit that frequent communication – particularly amongst strong managers and in larger firms – can cause leaders to pull the firm in different directions, resulting in disagreement and a failure to successfully innovate. Using a uniquely detailed establishment-level data set we find that, on their own, firm size, regular communication and result-oriented leadership are all positively associated with innovation. However, as predicted by our model, the use of frequent communication in successfully innovating firms is moderated: (i) when leaders tend to be strongly focussed on results; and (ii) in larger firms.

Key words: innovation; communication; leadership; inertia.
JEL classifications: D2; L2

1 Introduction

'Fundamentally, success in war, as in business is based on leadership. Other factors - information, preparation, organization, communication, motivation, and execution - also contribute to success, but the effectiveness of these factors is entirely determined by the quality of leadership provided.' Sun Tzu (Krause, 1996).

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Innovation drives firm profitability and success; more than 70% of senior executives in a McKinsey survey suggested that innovation was one of the top three factors underlying their organization's future growth (Barsh et al., 2008). However, innovation is by no means automatic. Innovation requires an idea; this information needs to be communicated convincingly to others; and, finally, the group needs to move as a cohesive unit if the innovation is to be successfully implemented. While communication[1] and styles of leadership[2] have separately been identified as drivers of innovation, the interaction between both of these factors has not received as much attention. Here we study the relationship between a firm's ability to innovate, its communication protocols and its managers' leadership style. Specifically, we examine whether a successful innovator moderates their internal communication about potential change when they have strong leaders and in larger organizations.

Successful organizational change must overcome (at least) two obstacles: (i) inertia, namely the aversion of individuals to change;[3] and (ii) breakdown, the tendency for a group to splinter and lose cohesion when faced with change (Wang et al., 2006). The more people are involved and the greater their access to information, the more likely it is that someone will have a good idea. A tradeoff arises, however, because likelihood of disagreement and breakdown increases as the number of leaders involved grows. Moreover, the possibility of breakdown depends upon the managers' style of leadership; disagreement is more likely with particularly head-strong, less comprising leaders.

To investigate these relationships, we develop a theoretical model in which leaders advocating for change – who we term *innovation champions* – need to 'push' sufficiently hard for an innovation to be implemented. This is required to overcome individuals' inherent preference for the status quo. Innovation champions are individuals who emerge to identify an idea and promote it with conviction, persistence and energy, and who are willing to risk their position and reputation to ensure its success.[4] A new idea needs someone who will not only recognize it, but who will exercise the required social and political effort to garner the necessary internal support and resources (Howell, 2005). Champions are also pivotal to

[1]See Tushman & Katz (1980), Fidler & Johnson (1984), Ebadi & Utterback (1984), Ancona & Caldwell (1992b), Lievens & Moenaert (2000), Howell & Boies (2004) and Sarin & O'Connor (2009).

[2]See for example Barczak & Wilemon (1989), McDonough & Barczak (1991) and Norrgren & Schaller (1999).

[3]Organizational inertia can arise for a variety of reasons. For example, firms might face resistance to change due to vested interests, ideological factors or from fear. See Ahrne & Papakostas (2001) and Hodgson & Knudsen (2006).

[4]See Schön (1963) and Tushman & Nadler (1986).

both innovation speed and success (Markham, 1998). Most successful new product introductions have one or more champions, and without champions organizations can have a lot of ideas but few tangible innovations.[5] Champions make a decisive contribution by actively and enthusiastically promoting the innovation, building support, overcoming resistance and inertia.[6]

For a firm to move as one in a new direction, an innovation champion needs to effectively communicate her vision. As workers are generally risk averse, the likelihood of successful innovation is enhanced if leaders can reduce the uncertainty associated with a proposal (Souder & Moenaert, 1992). Frequent communication plays a key role in achieving this;[7] indeed, frequent communication has been found to be positively associated with innovation performance.[8] Of course, the content and quality of communication are also important (Sarin & O'Connor, 2009, Maltz, 2000). For instance, where appropriate, champions will need to communicate regarding technology or the firm's organizational strategy.[9] To capture these nuances in our study, we examine separately frequency of communication about: (1) information regarding company's strategies and guidelines, and (2) information on technological and organizational change.

As noted above, in the process promoting change, champions need to ensure that they do not pull the organization in different directions, as this could cause the organization to split, rendering innovation impossible.[10] While there are many different types of leader,[11] two key styles emerge: (i) leaders focused on outcomes or results (result-oriented leaders); and (ii) leaders who emphasize personal relationships (people-oriented leaders).[12] We predict that result-oriented leadership is more likely to be associated with successful innovation. Moreover, when a firm's champions are very determined (result-oriented), fewer advocates (or communication) are required to successfully overcome inertia.[13] However, there is a

[5]See Howell & Higgins (1990), Markham et al. (1991) and Markham & Griffin (1998) for a discussion.

[6]These points are also made in Howell & Higgins (1990) and Markham (1998).

[7]See Lievens & Moenaert (2000) and Ebadi & Utterback (1984).

[8]For a further discussion, see Tushman (1977), Ancona & Caldwell (1992a, 1992b), Gladstein (1984) and Sarin & O'Connor (2009).

[9]See, for example, Tushman & Nadler (1986) and Burgelman (1983).

[10]New ideas often conflict with other proposals, leading champions and antagonists to actively oppose each other (Markham, 2000).

[11]For an examination of different leadership styles see Bass (1990), Tichy & Devanna (1986), House & Howell (1992) and Howell (2005).

[12]This dichotomy parallels the arguments in Bass (1990), Fleishmann et al. (1991), Yukl (2006), Burke et al. (2006) and Sarin & O'Connor (2009).

[13]In a different context, (Galeotti & Goyal, 2010) find the *law of the few*, in which individuals in a network rely on a minority of informed influencers rather than incurring the costs of personally acquiring information.

tradeoff related to leadership style; the more forcefully the champions push for their preferred option, the greater the chance that the group will split. As a result, other things equal, the stronger (or more result-focused) they are, the fewer leaders in an organization should be involved if innovation is to be successful.

Leadership style also affects how a firm would choose to communicate. Champions with different visions can interact in ways that generate conflicts.[14] Moreover, result-oriented leadership can exacerbate this issue. Taking this into account, an organization with result-focused leaders will want to minimize opportunities for disagreement. This suggests that innovating firm with result-oriented leaders will limit the frequency of communication.[15]

In a similar way, the greater the proportion of the firm involved in the innovative process, the greater the chance of conflict and breakdown. This is particularly pertinent for larger organizations. As a result, we predict successful innovation requires a smaller proportion of champions in a firm as organization size increases.[16]

To illustrate the model's predictions, consider the familiar example of communication and leadership style within an academic department. First, let us focus on departmental communication. In a small department, many key decisions are often made in department meetings, even if the chair has formal decision-making rights. Regular meetings discussing proposals might be the norm. Hiring decisions for instance could be brought to the group as a whole, as could tenure decisions and proposals for new courses or programs. With a small group, a high level of engagement is typically necessary to properly assess candidates, or to fully flesh out the implication for changes to the department's teaching program. In terms of our model, there is a high proportion of innovation champions in a small department.

Such an inclusive and collegial communication process is less likely in a larger academic group. Change could be problematic if everyone in the department is involved. Too many meetings create opportunities for disagreement and politicking, stymieing effective change. This could be true for hiring decisions – advocates in each subfield might argue for a new hire from their area. A similar issue could arise with proposals about degree structures

[14]While some disagreement may help the innovative process (Van de Ven & Grazman, 1997 and Markham, 1998), too much conflict consumes resources and reduces the likelihood of successful innovation (Venkataraman et al., 1992, Chakrabarti & Hauschildt, 1989, Markham, 2000 and Klerkx & Aarts, 2013).

[15]For example, the founder of Amazon.com, Jeff Bezos, has been quoted in Stone (2013) as saying 'Communication is a sign of dysfunction ... We should be trying to figure out a way for teams to communicate less with each other, not more'.

[16]It is noteworthy that a similar tradeoff is highlighted by Couzin et al. (2005), discussed below.

or the direction of the department. Rather than involving everyone, decisions are instead made by subcommittees. This facilitates communication within smaller groups while limiting involvement of the group more broadly, reducing the proportion of champions as the size of the department increases.

Second, consider how leadership style affects communication about change within an academic department. Again, take hiring as the example. A strong-minded academic or chair of department might be able to push through bureaucratic and other impasses to successfully champion the hiring of a promising candidate where a less strident supporter might fail; that is, strong leadership facilitates change. But if the senior professors in a department are relentless advocates for hiring in their own sub-fields, involving them in the hiring process will invariably lead to conflict. As a result, the chair in a department with uncompromising colleagues might try limit their involvement in hiring or other key decisions, preselecting a field for the potential hire or by setting up a committee charged with the decision. More involvement might be possible with less driven, more compromising professors; fruitful discussions could involve more people in the department, but only if they are willing to compromise.

From our model, we derive four key empirical predictions. We examine evidence of these relationships using unique firm-level data that details: innovative outcomes; communication strategies regarding both technological and organizational change; and leadership style in regards to the factors that motivate its leaders. We find that innovation is more likely in plants: (i) that regularly communicate about the prospects for new technological developments; and (ii) with result-focused leaders. We also find that these direct relationships are moderated taking into account the key interactions between communication protocols, type of leadership and the size of the firm. Specifically: (iii) successful innovators with strong result-focused leaders limit communication regarding technological change; and (iv) larger plants that successfully innovate also restrict communication within the organization. These results are consistent with our theoretical framework – while communicating relevant information is crucial to successful innovation, its effectiveness depends on the firm's other internal characteristics, notably its size and leadership style of its managers.

The literature on innovation has emphasized various factors. One stream focuses on incentives to innovate in the face of different market structures, highlighted by the monopoly-

versus-competition (or Schumpeter-versus-Arrow) debates.[17] Other papers study the relationship between internal factors (skilled labor, workplace organization, and so on) and the ability for firms to adopt new technologies (see Caroli & Van Reenen (2001) and Bresnahan et al. (2002) for instance). All these factors are clearly important; our paper takes a complementary approach. Following De Canio et al. (2000), we emphasize how the internal architecture of an organization – in our case, leadership and communication protocols – affect a firm's ability to innovate.[18]

We also draw heavily on the economics literature about leadership. Hermalin (1998) examines leadership in a moral-hazard-in-teams model. Team effort is essential for a good outcome and the leader can signal her private information (about the technology) by taking a costly action. In our model, rather than leading by example, champions encourage agents to adopt their proposed idea through the frequency – and force – of their communication. In Rotemberg and Saloner (1993) a firm considers how a leader's style affects workers' incentive to invest. They show that hiring a more empathic leader can induce agents to put in greater effort in discovering new projects.[19] In this way, hiring a particular type of leader is a commitment by the firm to adopt the corresponding ex post strategy in an incomplete contracting environment.

While we also emphasize leadership style, our focus is on the interaction between communication and leadership, and the tradeoff between having an implementable innovation and disagreement.[20] Bolton et al. (2013) show that leader resoluteness can help induce agents to follow a leader's proposal; resoluteness also helps overcome coordination issues.[21] Strong leadership in our paper can also play this coordination role. However, in our environment, when there is more than one innovation champion, resoluteness has the potential downside of provoking disagreement and innovation breakdown.[22]

This study is also motivated by leadership and communication within communal ani-

[17] See Arrow (1962), Greenstein & Ramey (1998), Aghion et al. (2005), Gilbert (2006), Chen & Schwartz (2013), Tirole (1988), for example.

[18] Also see the survey articles of Shane & Ulrich (2004) and Belloc (2012).

[19] Aghion & Tirole (1997) make a similar argument in their model of formal and real authority; the principal can induce greater effort from the agent if she can commit that the agent will have greater real decision-making authority.

[20] In his survey on leadership and corporate culture, Hermalin (2012) also emphasizes that leadership style matters; in particular, see Section 2.3.4.

[21] In Dessein & Santos (2006) communication is also required inside the firm so as to coordinate on adopting changes, but there are no leaders in their model.

[22] In Bolton et al. (2013) resoluteness has the potential cost that the leader does not change the proposed project in the light of new evidence. Also see Bolton et al. (2010).

mals. Foraging animals, like bees, constantly need to seek out new sources of food. This requires leaders (or scouts in the case of bees) to find the food, but also to communicate and convince the rest of the group that this is the best course of action (see Visscher, 2003). Businesses often face a similar problem as do bees – they need to be constantly looking for new opportunities – they need to change and adapt in order to survive, if not thrive. Our model essentially presents a tradeoff between overcoming inertia in an organization, while at the same time trying to avoid excessive conflict so as to ensure there is no breakdown in which advocates pull the firm in different directions. Innovation in a firm shares many of the same tradeoffs faced by migratory herds or by colonies in search of food. For example, motivated by honeybee swarms where only a few individuals (about 5%) guide the group to a new nest with a high degree of accuracy,[23] Couzin et al. (2005) study leadership and information-transfer in animal groups looking for the location of food or for a migration route. They show that: the proportion of informed individuals needed to successfully guide a group is decreasing in its size; and that the proportion of leaders in a group is smaller when these leaders 'push' for their preferred direction more strongly.[24] In many ways our paper applies the insights of Couzin et al. (2005) to innovation in organizations.

2 A model of innovation champions

In this section we develop a parsimonious model to highlight the key tradeoff between generating and disseminating innovative ideas within an organization and the cost of potential conflict that can arise between leaders advocating competing projects. Necessarily it abstracts from many fundamental aspects of an organization, including agency and the structure of hierarchies. In many ways, actors here are non-strategic in that they play their type (follow their traits) as in an evolutionary game-theoretic framework. Further to this, in our approach we consider organizational change to come from the collective action of many actors within a firm, rather than from a directive (which will be automatically followed) from senior management. This presupposes that the *implementation* of a change is vital, and it cannot be introduced without the willing participation of (enough) people throughout the

[23] Reebs (2000) made a similar study for fish shoals.

[24] In a similar manner, other researchers have studied communication, social interactions and group behavior in fish (Reebs, 2000), honeybees (Visscher, 2003), zebra (Fischhoff et al., 2007), chimpanzees (Boehm, 1999) and baboons (Kummer, 1968).

firm.

To be explicit, to successfully innovate an organization needs 'innovation champions' to determine which project (or direction) to adopt, and for these champions to drum up sufficient support within the group in order to ensure successful implementation. As noted above, a similar process occurs in nature. For instance, just like knowing which innovation to adopt, foraging bees need to know where the best flowers are. In order to gather this information, the hive sends out a select number of scouts. On arriving back at the hive, each scout engages in the famous 'waggle' dance to communicate the type, quantity and location of these flowers to the rest of the workers.[25]

To capture some of these key aspects of a firm's innovative process, we model innovation as a tradeoff between advocacy and inertia. In Lewin's (1951) force-field theory of change, adaptation occurs when the forces for change overcome resistance, be it at the organization, group or individual level. In our context, innovative forces represent the influence that the champions exert on the organization to promote their projects, and are related to the frequency of communication/information, the number of champions and their style of leadership.

Specifically, first assume a firm is made up of s individuals, of which p is the proportion of innovation champions. Innovation champions, or leaders, are charged with discovering new innovative ideas and promoting these ideas with the rest of the firm.

Second, successful innovation involves the firm moving in a new direction. This requires that champions exert sufficient pressure or generate enough excitement about the new idea such that there is sufficient support in the firm to overcome individuals' tendencies for inertia. Specifically, a firm of s workers has a level of inertia (resistance to change) of $K(s)$ given $s > 0$, where $K(s)$ is the average level of inertia per worker. In order to be induced to support change, each agent in the firm must have greater pressure applied to them to move than $K(s)$. We make the following assumptions regarding $K(s)$.

Assumption 1. Average level of inertia $K(s)$ is decreasing in s.

A similar assumption is adopted by Couzin et al. (2005). They suggest some minimum number of leaders is required for change, and this number does not increase with the size of the group. In our academic department example, an equivalent situation would be that a

[25] For a discussion of the waggle dance of bees see, for example, Riley et al. (2005) and Seeley et al. (2006).

minimum number of professors is required for a change to be implemented, and this number is (largely) the same, regardless whether the department is small or large. Note, however, our assumption is less restrictive than Couzin et al. (2005) in that all we require is that $K(s)$ is decreasing in its argument. Moreover, we place no additional restrictions on $K(s)$, even though we expect the total inertia of a firm $K(s)s$ to be increasing in s.

Finally, the amount of pressure for change depends on the number of champions as well as how hard they each push (or advocate) for their innovation. To capture this, we assume that each innovation champion has the same strength of leadership, $\omega > 0$. Here, ω represents how strongly and effectively each champion advocates for their idea.

2.1 One potential innovation

Assume for the moment that there is just one potential idea for innovation, which can be thought of as a new direction for the firm. Also assume that the champions are informed about this prospective innovation. To promote their desired change, the champions need to advocate sufficiently vigorously to overcome inertia in the organization. This means successful innovation requires that:

$$p\omega s \geq K(s)s. \tag{1}$$

Equation (1) suggests that the total push for change, on the left-hand side of the equation, is the product of the total number of champions and their strength of leadership ω. On the right-hand side, $K(s)s$ is the total level of inertia in the organization. The champions need to have a loud enough collective voice to overcome inertia if the firm is to successfully innovate.

Greater participation necessitates more communication. From equation (1), more communication (higher p) increases the left-hand side of the equation as there are more informed individuals. Consequently, we hypothesize that there will be a positive relationship between communication regarding new technology and the likelihood of successful innovation. Moreover, this prediction stresses the importance of the content of the communication. This discussion is summarized in Prediction 1.

Prediction 1. Ceteris paribus (that is, holding firm size and leadership constant), successful innovation is positively related to communication.

Further to this, innovation is more likely the more vociferously each champion advocates

for change, given by ω. This suggests result-focused leaders – that is, leaders mainly focused on outcomes or results – are more likely to successfully advance change. Leaders in an organization must convince – or cajole – others that their proposed innovation is the right way forward for the firm. Like a dancing bee, leaders who pursue their goals vigorously are more likely to be able to convince others of their viewpoint, and are therefore more likely to successfully innovate.[26] This is summarized in the following prediction.

Prediction 2. Ceteris paribus (for a given firm size and communication structure), successful innovation is positively related to result-oriented leadership.

In our empirical analysis below (Sections 3 and 4, we can distinguish between: (i) result-oriented goals such as maximizing profit, implementing the best possible innovation, implementing the firm's objectives and so forth; and (ii) people-oriented goals such as personal betterment and social standing. Other things equal, the greater the weight leaders place on objective or result-oriented outcomes, the more strongly they will advocate change, which will increase the likelihood that the firm will successfully innovate. Conversely, the less weight placed on objective motivations, the more likely an individual will compromise and avoid the conflict inherent in difficult change. Consequently, we propose that people-oriented leadership will be associated with lower rates of innovation, while result-oriented leadership will be positively associated with innovation.

2.2 Two potential innovations

In a similar manner to the case when two or more bee scouts discover flowers, firms often must decide between competing ideas. To model these situations, we assume that there are two potential ideas (or directions) that the champions could discover. Now, it is not only important for the champions to overcome inertia, but for successful innovation everyone in the firm has to move in the same direction. The firm will split if the two groups of champions pull sufficiently hard in different directions (innovation breakdown). If this occurs, there is no possibility that an innovation will be successfully implemented.

[26] In a bee hive, the waggle dance is used not only to communicate information, but to convince other bees of its voracity. In order to reach consensus about the best food source, each scout must try to convince the other scouts that their discovery is superior by performing their dance with extra vigor: the more vigorous, the more convincing. When convinced of another position, that scout changes from dancing its own dance to dancing the waggle of the other scout. This process continues until all the scouts are in agreement, shown by the way that they are all performing the same dance.

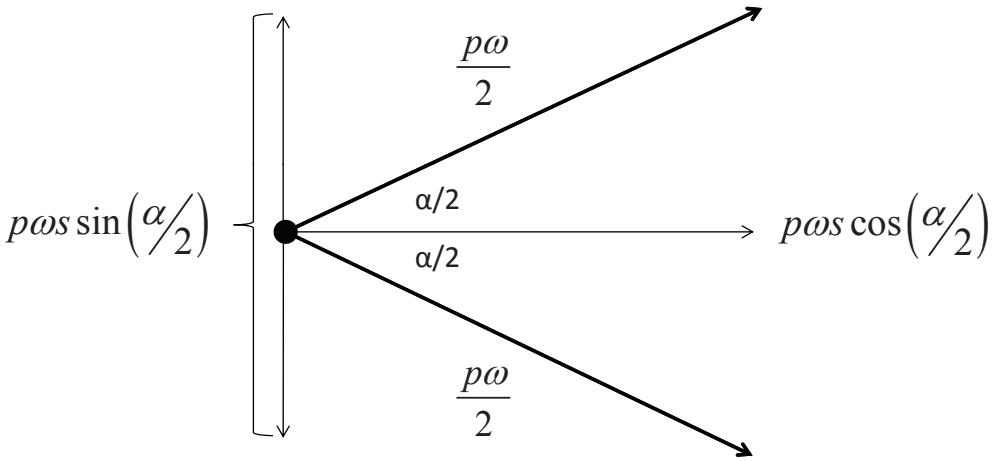

Figure 1: Tradeoff between inertia and innovation breakdown

To model this formally, assume that the probability of the firm getting two new potential ideas is equal to $f_2 > 0$, whereas $f_1 > 0$ is the probability that the champions only discover one idea.[27] For simplicity, if the firm discovers two ideas, half the champions advocate for each change. As before, all leaders push for their idea with the same ω.

With two potential ideas the champions will inevitably advocate different directions, potentially pulling the firm apart.[28] To model this, consider a firm in its current position at the origin (the status quo), as illustrated in Figure 1. Each idea requires the firm to move in some direction indicated by the bold arrows. Without loss of generality, assume that the angle between the two innovation directions is a random variable α supported on $[0, \pi]$ with a known probability distribution function $g(\alpha)$, and that the central direction between the two ideas is represented by the horizontal line.

As before, in order to overcome inertia, the champions need to push the firm with sufficient force. With two potential ideas this requires that there is adequate horizontal push for an idea, or that:

$$p\omega s \cos(\alpha/2) \geq K(s)s. \tag{2}$$

[27] As two potential ideas are sufficient to ascertain the tradeoffs involved, we do not consider the possibility of the firm to have more than two potential ideas or to have zero ideas; that is, $f_1 + f_2 = 1$. We also assume that f_1 and f_2 are constant.

[28] A possibility that we are not considering here is that different ideas could create a tournament within the firm, improving the quality of the final decision implemented. Similarly, aspects of competing ideas could be combined to generate a better final proposal. This is a positive effect of having more than one potential innovation. We do not explicitly consider this quality dimension to innovation (which is complementary to our analysis), and we leave this to future research.

On the other hand, consider the vertical pull between the two groups of champions as pressure for the group to break up. If this pressure is sufficiently large it will be greater than the group's tendency to stay together; as a result the group will split. To capture this, let the cohesive instinct of each individual to stay together in one group be G. Here, G can be interpreted as the level of cohesion per individual, with Gs being the total cohesion in the organization. In order for the group to remain cohesive it is necessary that:

$$p\omega s \sin(\alpha/2) \leq Gs. \tag{3}$$

In equation (3), the left-hand side is the push in separate directions coming from the two groups of champions. The right-hand side shows the total level of cohesion; below this level the firm will be able to avoid the pressure to split.

The firm's problem is to maximize the probability of successful innovation with respect to p. Specifically, a firm maximizes:

$$f_1 \mathbf{P}\left[p\omega \geq K(s)\right] + f_2 \mathbf{P}\left[p\omega \cos(\alpha/2) \geq K(s), p\omega s \sin(\alpha/2) \leq Gs\right],$$

where $\mathbf{P}$ denotes probability.

It is clear that p has to be chosen high enough such that $p\omega \geq K(s)$, otherwise the objective function is equal to zero. Given this, the maximization problem can be simplified to

$$\max_p \mathbf{P}\left[p\omega \cos(\alpha/2) \geq K(s), p\omega \sin(\alpha/2) \leq G\right] \tag{4}$$

subject to

$$p\omega \geq K(s).$$

From equation (4), when there are two potential innovations, p needs to be set so as to maximize the probability that both conditions (overcoming inertia and maintaining cohesion) are satisfied. The following lemma outlines the solution to the maximization problem given in equation (4).

Lemma 1. *A firm maximizing the probability of successful innovation chooses p such that:*

$$(p\omega)^2 = (K(s))^2 + G^2. \tag{5}$$

Proof: See Appendix A.

Note that the condition in equation (5) holds independently of the distribution $g(\alpha)$. The competing constraints – maximizing the horizontal 'push' against inertia and minimizing the vertical pressure from the two groups of champions – work in opposite directions. As a result, there is a unique p, given by equation (5), that ensures the two constraints coincide, effectively maximizing the probability of successful innovation.

Several predictions arise out of the model of innovation champions with two potential innovations. When ω is high, there is a higher likelihood of breakdown. To mitigate this problem, an organization may wish to reduce the proportion of champions, p, and hence the need for communication about innovation. This can be seen as equation (5) holds for a lower p when ω is higher. As in the animal world, there is a tradeoff; frequent communication strengthens the push for change, but it can also lead to disagreement and a failure to innovate. Moreover, the likelihood of breakdown is especially problematic with result-oriented leaders, as summarized in Prediction 3.

Prediction 3. Ceteris paribus, successful innovation requires less communication in a firm with result-oriented leaders.

Couzin et al. (2005) have a parallel logic in relation to animal herds. Their model shows that, when a leader is driven primarily by a sense of the best direction to take rather than maintaining cohesion of the group, the leader is more likely to lead the herd in its preferred direction. However, they also note that focused leaders are more likely to pull the group apart. Moreover, the greater the number of strong leaders in a group, the more likely the group is to fracture. This is extremely problematic for social animals, as the success of the collective relies on group cohesion. This suggests a tradeoff; an increase in the number of leaders increases the likelihood that the group moves in the best direction, however it also increases the probability of group breakdown.

Finally, our model suggests a relationship between successful innovation, communication and the size of the firm. Other things equal, we predict that less frequent communication about technological change is required to ensure successful innovation in larger firms. This discussion is summarized in Prediction 4 below.

Prediction 4. Ceteris paribus, successful innovation requires less communication in larger firms.

Again, Couzin et al. (2005) in a different framework derive a similar prediction, arguing that the informed proportion of an animal group required for decision accuracy is declining in the size of the group. Going back to our familiar example, a large academic department is unlikely to adopt the same collegial process adopted by a smaller group. In a large department many key decisions are made by an executive of a few key professors or by the chair alone. Indeed, final decisions could be reported to faculty meetings as a *fait accompli*, or circulated by email, not to solicit contributions but purely to inform the group that the decision has been made.

3 The data set and variables

We investigate the predictions developed above using the L'enquête REPONSE 2004-05, a French matched employer-employee survey of almost 3000 commercial establishments with more than 20 employees in the non-agricultural sectors of the economy.[29] This survey provides a unique opportunity to study the relationship between the business strategy of a firm, its communication protocol, the leadership style of its managers and the innovation outcomes achieved.

3.1 Dependent variable: Innovation

We identify establishments that during the previous three years introduced: (1) a significant technological change; (2) a major organizational change; or (3) a new product or service. Firm directors indicated the different types of change that their firm made in the last three years and the one that was the most important.[30] We consider a firm successfully implemented an *Innovation* if it implemented: (i) a technological change; (ii) an organizational change; or (iii) an introduction of a new product/service in the last three years, and this innovation was the most important change that the firm underwent in that time period, coded 1 if this is the case and 0 otherwise. For our estimation sample of 2227 plants, 646 plants implemented an important *Innovation*: 122 adopted an important technological change, 350 adopted an important organizational change and 174 introduced a new product or service.

[29] This data has also been used by Acemoglu et al. 2007.

[30] The possible changes were: (i) a change of ownership, (ii) a change of top management, (iii) a significant increase or decrease of staff, (iv) a change of salary policies or working hours, (v) a physical move, (vi) a technological change, (vii) an organizational change, or (viii) an introduction of a new product/service.

We focus on these three changes as they are all crucial for a firm's success and they are internally instigated in that they depend on the organization's architecture and leadership. Moreover, by only considering important innovations we reduce the likelihood of including trivial changes that might have been introduced as part of a routine process or involve little resource cost or risk. Rather, we would like to examine significant innovations that involve a deliberate decision on the part of the firm's leaders.

Table 1: Summary statistics of the sample (N = 2227)

Variable	Mean	Std Dev.
Dependent variable		
Innovation	.290	.454
Independent variables		
Size	3963.74	6651.408
ω (Leadership)	.543	.094
Result-oriented (RO) leadership	10.631	1.663
People-oriented (PO) leadership	9.233	2.681
Communication on Technology	1.293	.687
Communication on Strategy	1.423	.689
Communication Technology*size	1820.027	4952.842
Communication Strategy*size	2738.28	5994.605
Communication technology*ω	.234	.277
Communication strategy*ω	.292	.278
Comm Technology*RO leader	4.608	5.444
Comm Technology*PO leader	3.969	4.946
Innovation important	.303	.460

Notes: a. Source L'enquête REPONSE 2004-05.

3.2 Explanatory variables

Table 1 provides summary statistics for the main variables of interest. While being careful to not imply causation, a strong case can be made that our variables capture some important elements of our theoretical model described above and that our results highlight some interesting relationships between leadership, communication and innovation. The key predictions

from the model and the anticipated estimated coefficient signs are outlined in Table 2.

Size of the organization. The variable *Size* indicates the total number of people working at the firm. There is a large literature on the direct relationship between the size of a firm and its propensity to innovate.[31] As well as the direct relationship between *Size* and *Innovation*, we are also interested in our novel prediction relating to how organizations of different sizes adjust their communication strategies regarding technology.

Table 2: Key predictions from theoretical framework

Variable	Theoretical prediction	Coeff sign
ω (Leadership)	Prediction 2	(+)
Result-oriented (RO) leadership	Prediction 2	(+)
People-oriented (PO) leadership	Prediction 2	(-)
Communication on Technology	Prediction 1	(+)
Communication on Strategy	NP	(?)
Communication Technology*size	Prediction 4	(-)
Communication Strategy*size	NP	(?)
Communication technology*ω	Prediction 3	(-)
Communication strategy*ω	NP	(?)
Comm Technology*RO leader	Prediction 3	(-)
Comm Technology*PO leader	Prediction 3	(+)
Innovation important	NP	(+)

Notes: Positive, negative and ambiguous predicted estimated coefficient sign from the theoretical model are represented by: (+), (-) and (?). NP indicates no prediction from the theoretical model.

Communication. From the survey, we know whether a firm disseminates information to all employees about (a) the strategies and guidelines of the company or group and (b) the prospects for organizational or technological change either: (i) regularly; (ii) occasionally; or (iii) never. In the estimation sample, approximately 54 percent of establishments regularly disseminate information regarding strategies and objectives, while roughly 35 and 12 percent of establishments do so occasionally or never, respectively. Similarly, 43, 44 and 13 percent of establishments disseminate information to all employees about the prospects for technological or organizational change, respectively.

Focusing on communication regarding the prospects for technological or organizational change, we generate a variable *Comm Technology*, coded as 2 if an establishment communicates regularly with its employees, 1 if it communicates occasionally and 0 if it never

[31] See for example Camisón-Zornoza et al. (2004) for a meta-analysis of 53 empirical studies between 1970 and 2001.

communicates. We use this variable as a proxy for the proportion of informed innovation champions from the model in Section 2. Similarly, *Comm Strategy* is coded as 2 if an establishment communicates regularly on strategy or the overall objectives of the group, 1 if it opts to communicate occasionally and 0 if it never communicates with its employees on this issue.

Prediction 1 suggests a positive relationship between successful innovation and communication about future technological or organizational changes (*Comm Technology*). Successful adoption requires new ideas to be disseminated in order to develop and effectively implement a new plan. Notably, this prediction relates to communication about technology, as opposed to communication on the firm's overall strategy, captured by *Comm Strategy*.

Further to this, Prediction 4 suggests a nuanced relationship between firm size, communication and successful innovation. If innovation requires a relatively small proportion of the group to be informed, larger firms that successfully innovate will have relatively less communication about new technological prospects than smaller firms. To empirically examine this prediction, we include an interaction term *Comm Technology*Size*, which is the size of the workplace multiplied by the variable indicating whether the firm communicates regularly on technology or organizational changes (coded as 1) or it communicates occasionally or never (0). The predicted sign of the coefficient on this interaction term is negative. For completeness, we include *Comm Strategy*Size*, the interaction term between size and if a firm communicates regularly (coded as 1) or occasionally or never (0) on strategy.

Leadership. Leaders are driven by different motivations or innate personal traits. Some managers seek the satisfaction derived from performing tasks well, overcoming of challenges and the sense of duty working towards the goals of the organization. Other managers, however, are motivated by pay or promotion, the need for love, affection, and belonging or from seeking approval from leaders or groups. Our data allows us to capture these differences in leaders.[32] Firm directors were asked whether their managers were (i) totally, (ii) somewhat, (iii) not really or (iv) not at all, driven by: (a) satisfaction from good achievement; (b) identification to company's objectives; (c) satisfaction from overcoming challenges; (d) desire to satisfy customers; (e) fear of losing job; (f) hope for a promotion; (g) financial incentives; (h) attracting regard by the boss; and (i) attracting colleagues' regard. We assign a score for each motivating factor of: 3 for totally; 2 for somewhat; 1 for not really;

[32]See for example Barbuto & Scholl (1999), Barbuto (2005) and Gumusluoglu & Ilsev (2009).

0 for not at all.

To create an index of leadership style, we divide these possible motivating factors into two groups, *Result-Oriented (RO)* and *People-Oriented (PO)* factors. To measure the strength by which managers are motivated by *Result-Oriented* concerns, we sum the scores for factors (a)-(d), namely: satisfaction from good achievement; identification to company's objectives; satisfaction from overcoming challenges; and desire to satisfy customers.[33] Similarly, to measure the degree of *People-Oriented* leadership, we sum the score for the motivating factors (e)-(i), specifically: fear of losing job; hope for a promotion; financial incentives; attracting regard by the boss; and attracting colleagues' regard.[34] Managers who find their motivation in achieving results, satisfying customers or overcoming challenges are more prone to convey this sense of purpose to their team members. On the other hand, managers more concerned about a promotion or losing their job, and who are motivated by attracting their colleagues or boss's regard will be more likely to put an emphasis on personal relationships and group cohesion. Financial incentives and the fear of unemployment belong to the second category since they also tend to depend on the boss's (personal) opinion of the individual.

Table 3: Pairwise correlations for estimation sample (N = 2227)

	Innovation	Size	Omega	RO Leader	PO Leader	Comm Tech	Comm Strat
Innovation	1.000						
Size	0.095	1.000					
	(.000)						
Omega	-0.012	-0.067	1.000				
	(0.565)	(0.001)					
RO Leader	0.050	0.015	0.346	1.000			
	(0.020)	(0.489)	(0.000)				
PO Leader	0.028	0.071	-0.820	0.161	1.000		
	(0.173)	(0.001)	(0.000)	(0.000)			
Comm Tech	0.124	0.068	-0.006	0.128	0.073	1.000	
	(0.000)	(0.001)	(0.765)	(0.000)	(0.001)		
Comm Strat	0.130	0.191	-0.044	0.109	0.093	0.379	1.000
	(0.000)	(0.000)	(0.039)	(0.000)	(0.000)	(0.000)	

Notes: Source L'enquête REPONSE 2004-05. p-values in parentheses.

Our two categorizations of leadership parallel those in the existing literature. In their meta-analysis, Fleishman et al. (1991) note that leadership could be essentially split into

[33]For example, if a manager is somewhat motivated by each of these factors, she/he would achieve a *Result-Oriented* score of 8.

[34]As another example, if managers are motivated totally by fear of losing their jobs, somewhat by the hope of promotion, not really by financial incentives and not at all by the other two factors, their *People-Oriented* score would be 6.

two broad categories: task-focused and person-focused behaviors.[35] In a similar way Burke et al. (2006) suggest that the latter of these leadership styles emphasizes maintaining close social relationships and group cohesion. Sarin and O'Connor (2009) distinguish between achievement-oriented leadership that emphasizes the end result of the project, and a consideration style of leadership where the leader is friendly, approachable and demonstrates interest in the well-being of team members. They find that the former increases the quality of communication as well as making it more informal, while the second leadership style reduces the effectiveness of communication.

Of course, managers can be motivated by a combination of objective and political interests, but the overall motivational balance will affect their leadership style. To reflect this, we measure the relative importance of *Result-Oriented* leadership factors by ω, where $\omega = \frac{RO}{RO+PO}$. Note that by definition $\omega \in [0, 1]$. Consequently, $\omega = 1$ for fully *Result-Oriented* managers, whereas $\omega = 0$ if managers are totally *People Oriented*. Prediction 2 suggests a higher ω will be associated with innovation. Consequently, we predict a positive relationship between the probability of successful innovation and ω.

However, if leaders are relatively more result-oriented (with a high ω) there is a higher probability of disagreement – and innovation breakdown – in the firm (Prediction 3). Consequently, with a higher proportion of driven managers, a successful innovator is more likely to communicate less frequently within the organization about the prospects for future innovation. To capture this effect empirically, we interact communication of technology (coded 1 if regularly and 0 if occasionally or never) with ω, labeled as *Comm Technology*$*\omega$. We predict a negative relationship between *Innovation* and this interaction term. For completeness, we also include an interaction term for ω and communication on strategy (coded 1 for regular strategy communication and coded 0 if the firm occasionally or never communicates), termed *Comm Strategy*$*\omega$.

Other controls. Several other control variables are also used. A firm's innovation strategy could well be a crucial factor in determining its innovation outcomes. Directors were asked to assess the three key elements on which their firm's strategy is based and rank them by importance (from first to third). We created the variable *Innovation Important* (coded 1) if 'innovation' was mentioned as one of the three elements, and 0 otherwise. We predict

[35]The dichotomy between directive and participative leadership styles is similar to the categorization of leadership in Blake & Mouton (1964).

a positive relationship between *Innovation* (which measures outcomes ex post success) and *Innovation Important*.

Several alternative specifications were estimated. All estimations include NAF industry dummy variables, at the 2-digit level. Models III and IV include dummy variables that indicate: (a) union interference with the conduct of the establishment, the categories being (i) absolutely, (ii) somewhat, (iii) somewhat not and (iv) not at all; and (b) whether union activity in the labor pool outside the establishment is (i) very intense, (ii) intense, or (iii) not very intense. These two sets of dummy variables aim to control for the effect on innovation from union activity inside the firm and in the labor market in which a firm draws its employees.

4 Results

The pairwise correlations for the key variables of interest are illustrated in Table 3. *Size* is significantly correlated with *Innovation*, indicating that larger firms tend to innovate more. Both types of communication within the firm – *Comm Technology* and *Comm Strategy* – are associated with successful innovation. The pairwise correlations with *Innovation* are .124 and .130 for communication on technology and strategy, respectively. Both are significant at the 1% level.

The relationship between our leadership variables and innovation are also of interest. *Omega* is negatively correlated with *Innovation*, but not at a significant level. On the other hand, *Result-Oriented* leadership is positively correlated with *Innovation* – this unconditional correlation is consistent with Prediction 2. We will explore this relationship further below in our econometric modeling. *People-oriented* leadership is not significantly correlated with innovation by firms.

Some of the other correlations are worth noting. Firstly, *Omega* and *Size* are negatively and significantly correlated (-0.067, at the 1% level). This relationship suggests that larger firms have less head-strong, results-focused leaders, and instead have more people-oriented managers. The attributes of a successful leader in a small firm may well be different from those required to get ahead in larger, more bureaucratic organizations; getting on with people and pleasing superiors and colleagues might be more important in a larger firm to get ahead than in a smaller operation. This relationship is further borne out by the positive and

significant correlation between *Size* and *People-Oriented* (0.071, 1% level of significance). *Result-Oriented* and *People-Oriented* leadership are also associated with more of both types of communication (*Communication Technology* and *Communication Strategy.*)

To investigate the conditional relationships between innovation, communication protocols and leadership styles we estimate a probit model of the probability of innovation. The estimation results are shown in Table 4. Models I and III include ω and its respective interaction terms with *Comm Strat* and *Comm Tech*. Models II and IV use the alternative leadership measures of *Result-Orientated* and *People-Orientated* managers, and their respective interactions. Models III and IV include union-activity dummy variables. All models use clustered standard errors on the 2-digit level industry categories. Of course, given the reduced-form structure of our estimates, we do not imply any causality from our results. Further comment on causality is made at the end of this section.

Concentrating on Model III which includes the full set of industry and union controls, there is a positive and direct relationship between *Innovation* and *Communication Technology*, significant at the 1% level. The positive relationship between successful innovation and communicating in regards to the prospects for technology change is consistent with Prediction 1; innovation requires the prospect for change be communicated to the organization.

Prediction 2 suggests that successful innovation is more likely with driven or strong leaders. This prediction is consistent with our estimation results showing a positive and significant relationship (at the 1% level) between ω and *Innovation*.

Our results also show a positive relationship between *Innovation* and *Size*; the corresponding estimated coefficient is significant at the 1% level. In addition, the significance of the estimated coefficient for *Innovation Important* suggests that setting ex ante objectives would be crucial in determining ex post success.

Several of our predictions relate to the estimated coefficients on the interaction terms included in the model. As discussed in Section 2, the presence of strong leaders moderates the need for frequent communication in an establishment. Consistent with Prediction 3, the estimated coefficient for the interaction variable of *Comm Technology*$*\omega$ is negative (at the 5% level of significance); this suggests that the probability of successful innovation is dampened in the presence of both strong leaders and regular communication on technology. Frequent communication has the potential cost of increasing conflict and breakdown; this is particularly problematic in organizations with result-oriented leaders.

The estimated coefficient on *Communication Technology*Size* is negative and significant (at the 1% level), suggesting that, other things equal, larger firms that communicate about technology frequently with their employees have a lower probability of successful innovation. This result supports Prediction 4 that successful innovation in larger organizations is facilitated by less communication.

Finally, note that while the direct estimated coefficient for *Communication Strategy* is positive and significant (at the 10% level in Model III), the interaction terms *Communication Strategy*Size* and *Communication Strategy*$*\omega$ are all insignificant. Our predictions relate to communication about innovation (and related matters), and not about communication about other issues, such as a firm's overall objectives, which can be very broad and have limited direct connections with possible specific technological, organizational or product changes. These results are consistent with the notion that firms distinguish between communication regarding strategy and technology and that they adopt different protocols when communicating different things.

As noted above, Models II and IV include alternative measures of leadership, estimating the probability of innovation using *Result-Oriented* and *People-oriented* leadership measures separately, as well as their interactions with *Communication Technology*. Focusing on Model IV, which again includes the full set of industry and union dummies, it is notable that the estimation coefficients for *Size*, *Communication Technology* and *Innovation Important* remain positive and significant, all at the the 1% level. Similarly, the coefficient on the interaction term *Communication Technology*Size* is negative and significant (1% level), consistent with the idea that larger organization need a smaller proportion of the firm involved in the innovative process.

The results relating to our alternative measure of leadership style are consistent with our estimates using ω (Models I and III). Specifically, *Result-Oriented* leadership is associated with a significantly higher probability of successful innovation, whereas *People-Oriented* leadership is associated with a lower likelihood of innovation (significant at the 1 and 10 percentage levels, respectively). The interaction terms are also consistent with the estimates in Model I and with Prediction 3 – establishments with strong result-focused leaders that communicated frequently about technological change were significantly less likely to be successful at innovating (*Comm Technology*RO leader*, 10% significance level). This is consistent with the arguments that too much involvement by strong leaders can create a situation in which

champions pull the organization in different direction, leading to breakdown. Rather, fewer result-oriented leaders in the process might improve the likelihood of successful implementation in which the organization moves as one entity in the new direction.

A caveat to our analysis, as noted above, is that we do not estimate a structural model. Consequently, we cannot make statements about casuality between our key variables of interest. There could be some endogeneity issues in our empirical analysis. For example, successful innovators might have more need to communicate. Similarly, in an innovating firm managers might be less concerned about personal relationship, and more focused on outcomes.[36] Our analysis, however, is the first of its kind; previous studies have not examined the mitigating relation that leadership style has on a successful innovator's communication strategy. Importantly, our estimations are largely consistent with our theoretical framework.

4.1 Extensions

As a check on our results outlined in the previous section, we estimated several alternative models. Firstly, all models were re-estimated using a logit model (not displayed); qualitatively very similar results were obtained. Secondly, we estimate a multi-nominal logit for innovation (with the three categories of innovation being technical change, the introduction of a new product or service and a reorganization of the plant). The qualitative results are very similar to the results discussed above.

Third, the estimation residuals of the probit models above, adjusted for heteroscedasticity, are not normally distributed. To check the robustness of our results from the probit model, following Gallant & Nychka (1987), we estimate a semi-nonparametric discrete-choice model; this method has the advantage that it both requires less distributional assumptions and produces consistent estimates (De Luca, 2008). This semi-nonparametric approach is possible here because of our relatively large sample size.

The results are displayed in Table 5; Model V uses *Omega* and its interaction terms, whereas Model VI includes the leadership variables *Result-Oriented* and *People-Oriented*, and their respective interaction terms. Both models include industry and union control dummy variables.

These semi-nonparametric estimates are largely consistent with the probit estimates

[36]The possible reverse-casual link between the key interaction terms *Comm Tech*Size*, *Comm Tech*ω* and *Comm Tech*RO Leader* is less obvious.

above. *Omega* is again positively related to *Innovation*. Similarly, *Communication Technology* is also positively related to *Innovation* (1% level of significance). However, their interaction, Comm tech*ω is negatively and significantly related to innovation, again at the 1% level of significance. This suggests the use of frequent communication is mitigated in presence of strong leaders.

As in the probit estimates above, the coefficient for *Size* is positive and significant. But the coefficient for interaction of communication regarding technology and size, *Comm Tech*Size* is negative and significant. This is consistent with Prediction 4: successful innovation requires less communication in larger organizations.

Model VI utilizes the alternative measures of leadership. *People-Oriented* leadership is not significantly related to innovation, but the estimated coefficient for *Result-Oriented* leadership is positive and significant at the 5% level. The interaction *Comm Tech*RO leader* has a negative and significant relation to *Innovation*. Again, this is consistent with our prediction that strong leadership mitigates the use of frequent communication; while communication is necessary, too much communication can be costly (leading to breakdown) as it can facilitate conflict between driven leaders.

4.2 Note on causality

As noted, given the reduced-form model estimated, it is not possible to imply causality from our econometric analysis. While our theoretical model in Section 2 framed the question as one of the impact of leadership styles and communication protocols on the likelihood of successful innovation, it is plausible that all of these variables are jointly determined, or that there is some reverse causality at play. For example, if innovation is highly desirable, a firm's owner or senior management might be careful to implement communication protocols and to promote or hire the required types of leaders. Similarly, result-oriented leaders might prefer to work in an environment that is conducive to innovation. In many ways we are agnostic to the precise causal effect at play here – rather, a contribution of this paper is to highlight the nuanced interrelationship between communication, leadership style and innovation, along with their relationship to other firm characteristics (like size). These nuances have not previously been analyzed in the empirical literature. We leave a structural approach that can possibly identify more specific causal channels between communication, leadership and innovation to future research.

5 Concluding comments

Many social animals – like bees – need to collectively decide on an issue of importance, be it seeking out a new food source or a migratory path. This requires information about the best options, a means of communicating this to the group, while at the same time ensuring cohesion. Successful business innovation requires similar characteristics – a firm (via its leaders) needs to be sufficiently aware of potential new techniques or products, being able to advocate for change while not causing the group to splinter. Leadership plays an important role in this process.

Our model highlights these issues. Leadership is important for successful innovation, both in terms of ideas and motivation to overcome obstacles. This conclusion is supported in our empirical estimates, using establishment-level data. We find that firms with leaders motivated by objective, result-oriented factors, as opposed to political, social or self-interested factors, are more likely to successfully innovate. We also predicted that communication facilitates innovation, and this prediction is supported by our empirical estimates that show a positive relationship between communication about technology and successful innovation.

But innovative firms might adjust their communication protocols to the style of their leaders; that is, having too many result-oriented leaders involved increases the likelihood that the group splits. In fact, consistent with the prediction of the model, our empirical results suggest that successful innovators with result-focused leaders seem to temper the frequency of communication about the prospects for new technology. In addition, as predicted by our theory, large establishments that successfully innovate also tend to restrict communication about technological change.

In summary, our paper argues that the internal processes of the firm significantly affect a firm's ability to innovate. Our focus is on communication protocol, leadership and their interaction. No doubt other aspects of firm's internal organizational architecture are also important. Our findings are suggestive that internal organizational structure can help explain the dramatically different performance of seemingly comparable firms (see Bloom and Van Reenen, 2007, for example); not only do firms need the right type of leader, they also need the appropriate communication process.

Appendix A

Proof of Lemma 1

A firm maximizes

$$\max_{p} \mathbf{P}\left[p\omega\cos(\alpha/2) \geq K(s),\ \ p\omega\sin(\alpha/2) \leq G\right] \tag{6}$$

subject to

$$p\omega \geq K(s). \tag{7}$$

To prove the lemma, we solve the unconstrained maximization problem and then show the solution satisfies the constraint.

With the help of trigonometry, the maximization problem in (6) can be rewritten as:

$$\max_{p} \mathbf{P}\left[\cos(\alpha/2) \geq \frac{K(s)}{p\omega},\ \ \cos(\alpha/2) \geq \sqrt{1-\frac{G^2}{p^2\omega^2}}\right]. \tag{8}$$

Note that the right-hand side of the first inequality is decreasing in p, while the right hand side of the second inequality is increasing in p. To maximize the probability that both inequalities are satisfied at the same time, a firm chooses p so as to make the inequalities identical. This leads to the following relationship:

$$(p\omega)^2 = (K(s))^2 + G^2.$$

From this, it can be seen that inequality (7) is satisfied, proving the lemma. □

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Table 4: Successful significant innovation: probit coefficients (clustered standard errors in parentheses)

	Model I Coeff (SE)	Model II Coeff (SE)	Model III Coeff (SE)	Model IV Coeff (SE)
Size*1000	.023***	.024***	.023***	.024***
	(.006)	(.006)	(.006)	(.006)
Communication on Technology	.448***	.458***	.455***	.461***
	(.115)	(.089)	(.113)	(.090)
Communication on Strategy	.170*	.112**	.171*	.113**
	(.089)	(.050)	(.090)	(.049)
Communication Technology*Size*1000	-.026***	-.025***	-.025***	-.024***
	(.007)	(.007)	(.007)	(.007)
Communication Strategy*Size*1000	-.006	-.005	.005	.004
	(.008)	(.008)	(.008)	(.007)
ω (Leadership)	.918***	-	.944***	-
	(.283)		(.292)	
Communication technology*ω	-.599*	-	-.620**	-
	(.317)		(.308)	
Communication strategy*ω	-.155	-	-.155	-
	(.239)		(.240)	
Result-oriented (RO) leadership	-	.055***	-	.056***
		(.021)		(.021)
People-oriented (PO) leadership	-	-.024	-	-.026*
		(.016)		(.015)
Comm Technology*RO leader	-	-.045*	-	-.047*
		(.027)		(.026)
Comm Technology*PO leader	-	.014	-	.015
		(023)		(.022)
Innovation important	.240***	.235***	.237***	.233***
	(.067)	(.069)	(.068)	(.070)
Other variables				
Industry DVs controls	YES	YES	YES	YES
Union DVs controls	NO	NO	YES	YES
Log Psuedo likelihood	-1229.707	-1227.849	-1226.877	-1225.008
Pseudo R^2	.083	0.085	.0852	.087
No. of obs.	2227	2227	2227	2227

Notes: *** Significant at 1% level, ** significant at 5% level, * significant at 10 % level. Standard errors clustered at the 2-digit industry level.

Table 5: Probability of successful significant innovation: discrete-choice semi-nonparametric coefficient estimates (robust standard errors in parentheses)

	Model V Coeff (SE)	Model VI Coeff (SE)
Size*1000	.025**	.027***
	(.011)	(013)
Comm on Technology	.637***	.692**
	(.182)	(.283)
Comm on Strategy	.262***	.148*
	(.172)	(.080)
Comm Tech*Size*1000	-.021**	-.021*
	(.010)	(.012)
Comm Strategy*Size*1000	.006	.004
	(.010)	(.011)
ω (Leadership)	1.406**	-
	(.596)	
Comm tech*ω	-.962***	-
	(.356)	
Comm strategy*ω	-.302	-
	(.370)	
Result-oriented (RO) leadership	-	.069**
		(.034)
People-oriented (PO) leadership	-	-.022
		(.018)
Comm Tech*RO leader	-	-.062*
		(.034)
Comm Tech*PO leader	-	.008
		(.024)
Innovation important	.246***	.259***
	(.087)	(.117)
Other variables		
Industry controls	YES	YES
Union controls	YES	YES
χ^2	4.719	3.247
	(p = .030)	(p = .072)
Log Psuedo likelihood	-1246.359	-1245.510
No. of obs.	2227	2227

Notes: *** Significant at 1% level, ** significant at 5% level, * significant at 10 % level. Estimates include union control variables and 1-digit industry dummy variables . χ^2 statistic the likelihood ratio of probit to SNP model.