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Swarm of Innovators: Information, Leadership and Innovation

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A Swarm of Innovators: Information, Leadership and Innovation[ξ]

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Abstract

We study the interplay between innovation, communication in an organization and leadership. Although a firm requires both strong leadership and sufficient communication in order to innovate, we posit that frequent communication – particularly amongst strong leaders and in larger firms – can lead to disagreement and innovation breakdown. Using a survey of 3000 French firms we find that, on their own, firm size, regular communication and result-oriented leadership are all positively associated with innovation. However, there is a negative relationship between successful innovation and: (i) frequent communication in larger firms; and (ii) frequent communication with result-oriented leadership. Key words: innovation; communication; breakdown; leadership.

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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).

Biologists have studied communication, social interactions and group behavior in fish (Reebs, 2000), honeybees (Vissher, 2003), zebra (Fischnoff, Sundaresan, Cordingley, Larkin, Sellier, & Rubenstein, 2007), chimpanzees (Boehm, 1999) and baboons (Kummer, 1968). Motivated by honeybee swarms where only few individuals (about 5%) guide the group to a new nest with a high degree of accuracy,[1] Couzin, Krauze, Franks, and Levin (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.[2]

Innovation in firms shares many of the same tradeoffs as faced by migratory herds or by colonies in search of food: innovation requires an idea; this information needs to be communicated effectively to convince others, particularly those in leadership roles; and, finally, the group needs to move as a cohesive unit if the innovation is to be implemented successfully. While the communication of information[3] and styles of leadership[4] have separately been identified as drivers of innovation, the relationship between both variables 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: *(i)* the interaction between the type of leader, the frequency of communication and the likelihood of successful innovation; and *(ii)* the relation between firm size, diffusion of information and innovation.

[1] Reebs (2000) made a similar study for fish shoals.
[2] A similar result arises in a different context in the 'law of the few' (Galeotti & Goyal, 2010), in which individuals in a network rely on a minority of informed influencers rather than incurring the costs of personally acquiring information.
[3] See Gladstein (1984), Ancona and Caldwell (1992), Griffin and Hauser (1992) and Citrin, Lee, and McCullough, (2007).
[4] See Barczak and Wilemon (1989), McDonough and Barczak (1991) and Norrgren and Schaller (1999).

Successful organizational change must overcome two obstacles: *inertia*[5] – the aversion of individuals for change (see for example Hodgson and Knudsen, 2006) – and *breakdown* – the tendency for a group to splinter and lose cohesion when faced with change (Wang, Ying, Jiang, & Klein, 2006). The more people 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 increasing the number of people involved increases the likelihood of disagreement and breakdown. The possibility of breakdown also depends upon the managers' style of leadership and is more likely with particularly head-strong, less comprising leaders.

We examine these ideas 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 larger organizations and in firms that regularly communicate about the prospects for new technological developments. We also find that the probability of successful innovation is lower in: (i) larger firms that communicate regularly; and (ii) firms that communicate regularly about technological or organizational change and have strong result-oriented leaders. These results are consistent with the arguments above — while communicating relevant information is crucial to successful innovation, its effectiveness depends on both the organization' size and leadership style.

2. Theoretical Background and Research Hypotheses

Figure 1 outlines our key empirical hypotheses on the interaction between innovation, communication and leadership. We will use a running example of foraging bees to help motivate our discussion of innovation and change in organizations.

[5] Organizational inertia may be due to *inability* – lack of resources, established decision processes, inability to perceive the possibility or need for change – or *unwillingness* – vested interests, ideological or cultural factors and fear of change (Ahrne & Papakostas, 2003).

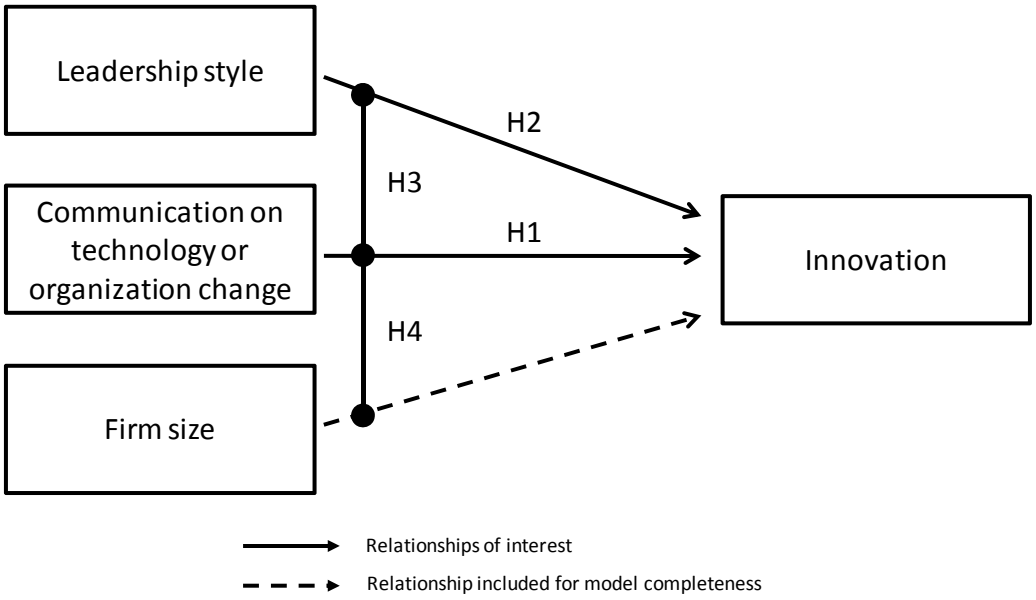

Figure 1: Conceptual Model and Hypotheses

2.1 Information and Innovation

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.[6]

In a similar way, leaders in an organization need to transfer the information they have about potential innovations to others in the organization in order for such innovation to take place. We hypothesize that there will be a positive relationship between communication regarding new technologies and the likelihood of successful innovation. We stress the importance of the content of the communication, rather than the communication process itself. This is summarized in Hypothesis 1.

Hypothesis 1: Communication regarding technology is positively related to innovation.

[6] For a discussion of the waggle dance of bees see, for example, - Riley, Greggers, Smith, Reynolds, and Menzel, (2005) and Seeley, Visscher, and Passino, (2006).

2.2. Leadership and Innovation

The waggle dance is used not only to communicate information, but to convince others of it. 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.)

Similarly, 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 pursues their goals vigorously are more likely to be able to convince others of their viewpoint, and are therefore more likely to successfully innovate.

For this reason, we distinguish between: *result-oriented* goals such as maximizing profit, implementing the best possible innovation, implementing the firm's objectives and so forth; and *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 successful 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. This is summarized in Hypothesis 2.

Hypothesis 2 Result-oriented leadership is positively associated with innovation. People-oriented leadership is negatively associated with innovation.

Our hypothesis that leadership style influences the likelihood of innovation is consistent with the findings of Cummings and O'Connell (1978), who find that leadership is one of the most important factors affecting innovation.

Moreover, our two categorizations of leadership parallel those in the literature. In their meta-analysis, Fleishman, Mumford, Zaccaro, Levin, Korotkin, and Hein (1991) noted that leadership could be essentially split into two broad categories: task-focused and person-focused behaviors.[7] In a similar way Burke, Stagl, Klein, Goodwin, Salas, and Halpin (2006) suggest that the latter leadership style could emphasize maintaining close social relationships and group cohesion. Sarin and O'Connor (2009) distinguish between *achievement-oriented* leadership (which emphasizes the goals and expectations in relation to the end result of the project) and a *consideration style* of leadership (where the leader is friendly and approachable and demonstrates interest in the well-being of the team members). They find that the former increases the quality of communication within a product-development team and makes communication more informal, while the latter has a negative impact on the effectiveness of communication within the team.

2.3 Leadership, Communication and Innovation

In relation to animal herds, Couzin, Krauze, Franks, and Levin (2005) show that, where the 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 a focused leader is 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.

The same logic applies to a firm. Strong result-oriented leaders are more likely to inspire followers and engender change. However, an emphasis on result-oriented outcomes or an increase in the number of leaders makes disagreement and breakdown more likely, as this could pull the group in different directions or to stall the innovative

[7] The dichotomy between directive and participative leadership styles is along this line. See Blake and Mouton, (1964).

process. [8] To address this problem, an organization may reduce the amount of communication about innovation, because frequent communication naturally fosters participation[9] and helps give rise to a greater number of informal leaders.

Consequently, as in the animal world, there is a tradeoff. While frequent communication helps foster good ideas, it can also lead to disagreement and a failure to innovate, especially in organizations with result-oriented leaders. The novel prediction here is that the optimal level of communication in an organization depends on the style of leadership. These arguments are summarized in Hypothesis 3.

Hypothesis 3: Regular communication is less likely in innovating firms with result-oriented leaders.

2.4 Size, Communication and Innovation

As noted above, the number of informed (scout) bees per hive is relatively small, which is unsurprising given the resource cost inherent in having scout bees. Indeed, Couzin, Krauze, Franks, and Levin (2005) show that the proportion of an animal group that needs to be informed for an accurate decision to be made is declining in the size of the group. The intuition is that if an absolute number of informed individuals is needed, the proportion of a group 'in the know' will be declining it its size.

We again apply this logic to an organization. A certain level of communication will be necessary to ensure a high probability of successful innovation. But communication has a real resource cost – not only is it costly to undertake but it can lead to disagreement amongst group members. Consequently, we predict there will be less

[8] Breakdown can take the form of a fracture organization, moving in different directions. Alternatively, breakdown can mean that the innovation process stalls, burdened by disagreement and discussion.
[9] Frequent communication can foster participation in different ways. For example, an interactive leadership style (Burpitt, & Bigoness, 1997; Markham, 1998) aims at empowering employees to innovate and become innovation leaders themselves. Shared leadership (Pearce, & Conger, 2003; Pearce, 2004) and team leadership (Zaccaro, Rittman, & Marks, 2001) emphasize the emergence of 'informal' leaders throughout a dispersed organization. Collaborative innovation and transferable leadership (Rodriguez, & Solomon, 2007) focus on the collaborative interaction of voluntary contributors; in this case leadership is not in the hands of an individual or a group of individuals, but is embedded in the organization as a whole and its participants. Generative leadership (Lane, & Maxfield, 1996; Surie, & Hazy, 2006) promotes information flow and feedback seeking, and insists that knowledgeable individuals be allowed to interact with minimal friction and under conditions that catalyze innovation.

frequent communication about technological change in larger firms, as described in Hypothesis 4.

Hypothesis 4 Frequent communication is less likely in large innovating firms.

It is worth noting here that many other studies focused on the direct relationship between firm size and innovation.[10] While we include the direct relationship between innovation and firm size as a control, we are interested in the novel interaction between the communication style adopted, firm size and an organization's ability to innovate.

3. The data set and variables

We investigate the hypotheses developed above using the L'enquête REPONSE 2004-05,[11] a French matched employer-employee survey of almost 3000 commercial establishments with more than 20 employees in the non-agricultural sectors of the economy. 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: Innovated

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.[12] This forms the basis for our dependent variable, *Innovated*, which is coded 1 if a firm made one of the three possible innovations and one of these changes was identified as the most important change that occurred at the firm over the period.

[10] See Carnisón-Zornosa, Lapiedra-Alcami, Segarra-Ciprés, and Boronat-Navarro, (2004), for a meta-analysis; they report 53 empirical studies published between 1970 and 2001.

[11] This survey has been used by Acemoglu, Aghion, Lelarge, Van Reenen, and Zilibotti,. (2007) to assess the relationship between decentralization and distance to frontier.

[12] 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. 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 considered a firm *Innovated* if it implemented one of the last 3 innovations and, if more than one change occurred, the most important change was one of the last 3 changes.

Innovated is coded 0 if none of these innovations occurred or if they were not identified as the most important change. For the estimation sample, the left-hand column of Table 1 in the Appendix shows the proportions of establishments that implemented the different possible changes: 17 percent of establishments implemented a significant technological change; 37 percent introduced a major organizational change; and 42 percent introduced a new product or service. Altogether 96 percent of establishments – representing 2453 firms – implemented at least one of the three innovations. However, not all of these innovations were denoted as being the most significant; rather, only 745 establishments identified one of these three innovations as the most important change in preceding three years. The right-hand column in Table 1 shows that new technology was the most important change in approximately 20 percent of establishments, while organizational change and new product or service were the most important changes in 53 and 28 percent of cases, respectively. We focus on these 3 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 and risk. Rather, we would like to examine significant innovations that involve a deliberate decision on the part of the firm's leaders.

3.2 Explanatory variables

Table 2 in the Appendix provides summary statistics for the main variables of interest (Table 2a provides details for the other controls). While being careful to not imply causation, a strong case can be made that our variables capture some important elements of our theoretical framework described above and that our results highlight some interesting relationships between leadership, communication and innovation.

The variable *Size* indicates the total number of people working at the firm. There is a large literature on the relationship between the size of a firm and its propensity to innovate. *Size* is included as a control, but we are also interested in the interaction between *Size* and the communication strategy adopted by the firm.

As reported in Table 3, 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. Over 50 per cent of enterprises regularly disseminate information regarding strategies and objectives. On the other hand, while firms often provide information about potential innovation to the workforce (43 per cent of workplaces did so) a significant number communicated only occasionally and never (approximately 43 and 14 per cent, respectively) on technological and organizational change with their workforce.

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

In Section 2 we predicted a positive relationship between successful innovation (*Innovated*) and communication about future technological or organizational changes (*Communication Technology*). Successful adoption requires new ideas to be disseminated in order to develop and effectively implement a new plan. Notably, our discussion in Section 2 focused on communication about technology as opposed to communication on the firm's overall strategy.

Hypothesis 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 *Size*Communication Technology*, 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. Again, for completeness, we include *Size*Communication*

Strategy, the interaction term between size and if a firm communicates regularly (coded as 1) or occasionally or never (0) on strategy.

Firm directors were asked whether their managers were (i) totally, (ii) somewhat, (iii) not really or (iv) not at all, driven by: satisfaction from good achievement; identification to company's objectives; satisfaction from overcoming challenges; desire to satisfy customers; fear of losing job; hope for a promotion; financial incentives; attracting regard by the boss; and attracting colleagues' regard.

To create an index of the leadership style of managers at each organization we score each possible motivating factor: 3 for totally; 2 for somewhat; 1 for not really; 0 for not at all. To measure the strength by which managers are *Result Oriented* (*RO*), we sum the motivation scores for the four factors: satisfaction from good achievement; identification to company's objectives; satisfaction from overcoming challenges; and desire to satisfy customers.[13] 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 find motivation in attracting their colleagues or boss's regard will be more likely to put an emphasis on personal relationships and group cohesion. The measure of the degree to which managers are motivated by *People Oriented* (*PO*) factors is the sum of the manager's motivation scores for: fear of losing job; hope for a promotion; financial incentives; attracting regard by the boss; and attracting colleagues' regard.[14]

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 ω, defined as $\omega = \frac{RO}{(RO + PO)}$; $\omega \in [0,1]$, where $\omega = 1$ for fully *result-oriented* managers, and $\omega = 0$ when managers are totally people/consideration oriented. Hypotheses 1 and 2 suggest that

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

[14] Again, 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 for the other two factors, their *People Oriented* score would be 6. 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.

new ideas and a *result-oriented* approach foster innovation. 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 in the firm. 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 *Communication Technology*$*\omega$. We predict a negative relationship between *Innovated* 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 *Communication Strategy*$*\omega$.

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

Several other control variables are also used, including dummy variables at the 1-digit level. The key theoretical predictions for the main variables of interest are outlined in Table 4 in the Appendix.

4. Results

First, consider the direct relationship for the key variables, shown in Table 5. There is a positive correlation between *Innovated* and each of the following: *Innovation Important*; *Communication Technology*; *Communication Strategy;* and *Size* (all at the 1% level of significance). It is worth noting that *Innovated* is not significantly correlated with ω, suggesting a multivariate analysis would be useful. Other notable relationships include the positive and significant relation between both *Size* and *Communication Technology* and *Size* and Communication *Strategy* (both significant at the 1% level). We also find that stronger result-oriented leadership, as measured by ω, is negatively correlated with *Size*.

This negative relationship suggests that managers in larger organizations are more motivated by developing personal relationship – more political perhaps – than managers in smaller operations. Moreover, another possible explanation for this relationship is that in large organizations too many head-strong managers advocating different positions could cause breakdown.

To further investigate the firm's communication protocols and their innovation outcomes, we estimate the probability of *Innovated* as a maximum likelihood probit. As above, we define that a firm successfully *Innovated* to be *I=1* and failed to innovate to be *I=0*. Letting X be the independent regressors and β the vector of coefficients to be estimated, the latent variable *I** can be expressed as

$$I^* = \beta' X + \varepsilon, \qquad (1)$$

where ε is an error term normally distributed. The probit can then be estimated as

$$Prob(I=1) = \Phi(\beta' X) \qquad (2)$$

and

$$Prob(I=0) = 1 - \Phi(\beta' X), \qquad (3)$$

where $\Phi(.)$ is the standard cumulative normal.

The results are shown in Table 1. As mentioned, our empirical results do not imply causality. They do, however, provide some interesting relationship between successful innovation and some of the factors highlighted in the theory.

Concentrating on Model I in the left-hand column, note the positive and direct relationship between *Innovated* and ω and *Innovated* and *Communication Technology* is significant at the 5% and 1% levels respectively. The positive relationship between successful innovation and *Communication Technology* is consistent with Hypothesis 1 in Section 2; innovation requires new ideas and communication of those ideas. This finding is consistent with the previous literature. The social exchange of information within the organization is likely to develop creativity (Perry-Smith, & Shalley, 2003) and corporate entrepreneurship (Kelley, Peters, & O'Connor, 2008), which in turn will foster innovation

capability. Furthermore, interfunctional communication is important to new product success (Moenaert, & Souder, 1990; Griffin, & Hauser, 1992). Also, formal and informal socialization mechanisms for knowledge sharing between buyer and supplier have been shown to positively influence buyer's performance in product development (Lawson, Petersen, Cousins, & Handfield, 2009).

Hypothesis 2 predicts successful innovation is more likely with result-oriented leadership. This prediction is consistent with our estimation results of a positive relationship between strong result-oriented leadership (ω) and successful and important innovation. In order to overcome inertia, innovation requires sufficiently strong leadership. Our results also show a positive relationship between *Innovated* with both *Size* and the *Innovation Important*; these estimated coefficients are significant at the 5% and 1% levels respectively. The significance of the *Innovation Important* coefficient suggests that setting *ex ante* objectives would be crucial in determining *ex post* success.

The interaction of *Comm Technology*ω suggests a negative relationship between goal-oriented leadership, regular communication and *Innovated* (5% level of significance). This result is consistent with Hypothesis 3; frequent communication has the cost of increasing the potential for conflict and breakdown, particularly in an organization with goal-oriented leaders.

The estimated coefficient on *Comm Technology*Size* is negative and significant (at the 5% 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 is consistent with Hypothesis 4 that successful innovation in larger organizations is facilitated by less communication.

Finally, note that the estimated coefficients for *Communication Strategy* as well as the interaction terms *Comm Strategy*Size* and *Comm Strategy*ω were all insignificant. Our hypotheses relate to communication about innovation specifically 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.

Table 1: Successful major innovation: probit coefficients (standard errors in parentheses)[a]

	Model I		Model II		Model III	
	Coef	SE	Coef	SE	Coef	SE
*Size*1000*	.016**	.007	.017**	.007	.0159**	.008
Omega (ω)	.688**	.332	.675**	.334	.684**	.336
Communication Technology	.379***	.088	.377***	.088	.383***	.090
Communication Strategy	.085	.092	.086	.092	.089	.093
*Comm Technology*Size*1000*	-.016**	.008	-.017**	.008	-.019**	.008
*Comm Strategy*Size*1000*	.010	.009	.009	.009	.011	.009
Comm Technologyω*	-.434**	.217	-.417*	.218	-.428*	.220
Comm Strategyω*	-.027	.230	-.021	.230	-.034	.232
Innovation important	.170***	.058	.178***	.060	.180**	.060
National Market	-		.034	.076	-	
European Market	-		-.097	.098	-	
Worldwide Market	-		-.030	.081	-	
Priority profit	-		-		.008	.064
Priority growth	-		-		.276***	.081
Priority quality	-		-		.046	.086
Industry DVs	YES		YES		YES	
Log likelihood	-1608.956		-1603.644		-1548.119	
Number of obs	2579		2572		2499	

Notes: *** Significant at 1% level; ** significant at 5% level; * significant at 10% level

4.1 Robustness checks

Model II includes explanatory dummy variables on the firm's type of market being *National*, *European* or *Worldwide* (with a default of a domestic market). The inclusion of these dummy variables did not affect the size or significance of the key estimated coefficients. However, none of these new estimates were significant at

conventional levels. Model III includes controls for whether the firm's priorities are profit, growth or quality. These dummies are chosen because a firm with a profit or a growth focus may have different propensities to innovate as compared with a firm that has a strategy of minimizing costs, for example. Our key estimated coefficients of interest are not significantly altered in this new specification. In Model III the estimated coefficient on the *Priority Growth* dummy variable is positive and significant (at the 1% level). This is consistent with the notion that innovation is one of the main ways a firm can grow and expand their market share.

In Model IV in Table 2 we include controls for firm's type of market, the priorities of the firm and the criteria used to determine if an employee receives a pay increase or a bonus. These criteria are: *Absenteeism; Seniority; Intensity of effort; Ability deal with unforeseen event; Achievement of individual objectives; Involvement in objectives of firm;* and *Contribution to team*. Similar estimates were obtained as with the previous specifications. *Size*, result-oriented leadership (ω), *Communication Technology* and *Innovation Important* were all positive and significantly related to *Innovated*. Likewise, the interactions term *Comm Technology*Size* and *Comm Tech*ω* were negative and significantly related to the probability of successful innovation (at the 5 and 1% levels respectively). The results also suggest that firms that rewarded employees for their *Intensity of Effort* were less likely to successfully innovate. Presumably, the incentive and rewards used by a firm will be chosen with its overall objectives in mind. It is often contended that having the time and scope to think freely is an essential input in the generation of new ideas. Perhaps this result is a reflection of this. Another factor may be that firms that measure the effort of employees and managers rather than focus on outcomes are less likely to generate new (often risky) innovations.

Model V, shown in the right-hand column of Table 7, allows for an alternative specification of leadership quality. Previously, ω measured the importance of result-oriented motivations relative to people-oriented factors. In Model V we enter *Result-Oriented (RO)* and *People-Oriented (PO)* factors, as defined in Section 3, into the estimation separately. Following this, the estimation also includes the interaction terms with *Comm Technology*RO leader*, *Comm Technology*PO leader*, *Comm Strategy*RO leader* and *Comm Strategy*PO leader* (replacing the interaction terms with ω). The

estimates again show a positive and significant relationship between *Innovated* and: *Communication Technology*; *Size*; and *Innovation Important*. As in the original model, the interaction term *Comm Technology*Size* is negative and significant (at the 5% level).

Interestingly, *Result-Oriented* leadership is positively related to the probability of successful innovation, whereas *People-Oriented* leadership is associated with failure to innovate, with both coefficients significant at the 5% level. The interaction terms *Comm Technology*RO leader* and *Comm Technology*PO leader* are negative and positive, as predicted, although not significant at conventional levels.

Finally, Table 6 in the Appendix displays the estimated coefficients when the firm size is entered as categorical dummies for firms between 50 and 99 employees (*Size 2*), 100 to 199 employees (*Size 3*), 200 to 499 employees (*Size 4*), 500 to 999 employees (*Size 5*), 1000 to 4999 employees (*Size 6*), 5000 to 9999 employees (*Size 7*) and 10 000 or more employees (*Size 8*). The omitted category is firm with less than 50 employees.

We also include interaction terms with the respective firm-size dummies and *Comm Technology*. In general, the previous results hold with this new specification; larger firm size is associated with a higher probability of innovation, particularly for firms with more than 5000 employees. Similarly, there is a positive relationship between *Innovated* and: *Innovation Important*; *Communication Technology*; and ω, all statistically significant at the 5%, 1% and 10% levels respectively. The interaction terms between the firm size dummies and *Comm Tech* are negative as predicted; note that the coefficient on *Comm Technology*Size 8* is negative and significant at the 1% level.

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 being able to manage the process so as to maintain group cohesion. Successful business innovation requires similar characteristics – a firm (via its leaders) needs to be sufficiently aware of potential new techniques or products, advocate for change while not causing the group to splinter. Leadership plays an important role in successful innovation both in identifying an exciting change, but also by effectively leading the organization

Table 2: Innovation: probit estimates for alternative specifications [a]

	Model IV		Model V	
	Coef	SE	Coef	SE
*Size*1000*	.019**	.009	.019**	.009
Omega (ω)	1.023**	.406	-	
Communication Technology	.464***	.105	.410***	.102
Communication Strategy	.013	.108	.042	.105
Result-oriented (RO) leadership	-		-.033*	.018
People-oriented (PO) leadership	-		.038*	.023
*Comm Technology*Size*1000*	-.018**	.009	-.019**	.009
*Comm Strategy*Size*1000*	.008	.010	.009	.010
*Comm Technology** ω	-.676***	.257	-	
*Comm Strategy** ω	.111	.272	-	
*Comm Technology*RO leader*	-		-.045*	.024
*Comm Technology*PO leader*	-		.021	.024
*Comm Strategy*RO leader*	-		.003	.024
*Comm Strategy*PO leader*	-		-.001	.024
Innovation important	.192***	.066	.189***	.066
No Absenteeism	-.084	.101	-.078	.101
Seniority	.133	.147	.127	.147
Intensity of effort	-.139*	.083	-.141*	.083
Ability deal with unforeseen event	.076	.083	.080	.083
Achievement of ind obj	.074	.086	.071	.086
Involvement in obj of firm	.044	.082	.049	.082
Contribution to team	.059	.083	.056	.083
National Market	-.077	.085	-.073	.085
European Market	-.151	.108	-.149	.108
Worldwide Market	-.128	.090	-.128	.090
Priority profit	-.022	.070	-.019	.070
Priority growth	.152*	.089	.153*	.089
Priority quality	.035	.098	.032	.098
Industry DVs	YES		YES	
Log likelihood	-1281.285		-1283.1	
Number of obs	2045		2046	

Notes: *** Significant at 1% level; ** significant at 5% level; * significant at 10% level

through the process.

Our hypotheses highlight 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.

Innovative firms might adjust their communication protocols to the style of their leaders. While communication helps facilitate innovation, having too many strong, result-oriented leaders involved increases the likelihood that the group splits. Consequently, we hypothesize a negative relationship between an inclusive communication process and result-oriented (strong-minded) leaders. This prediction is supported by our empirical estimates that show a positive relationship between communication on technology and innovation, but a negative and significant relationship between *Result-Oriented* leadership, communication on strategy and successful innovation.

We also have a nuanced prediction that larger firms that are successful innovators will restrict communication in regards to new technological changes relative to smaller innovators. After a critical number is reached, involving more people in the decision to innovate does not markedly increase the likelihood getting a good idea but it does increase the likelihood of breakdown or disagreement. Again, this prediction is supported by our empirical evidence. While we find a positive and significant relationship between size and successful innovation, there is a negative and significant relationship between successful innovation and the interaction between size and frequent communication on technology. Also notable are our results that communication on technology (and its interaction terms) is significantly related to the probability of successful innovation, but this is not the case for communication on the firm's strategy and objectives.

Our research touches on the relationship between leadership, the frequency of communication and successful innovation. We do not, however, investigate the relationship between innovation, leadership and the type of communication, be it inclusive, directive, consultative, and so on. We leave this important question for future research.

Appendix: Tables

Table 1: What is an important innovation?

Type of change	Workplaces implemented the following type of change (n = 2579)	If a change was made, the change was the most important change in last 3 years
Technology	440 (.171)	144 (.192)
Organizational	943 (.366)	395 (.530)
New product or service	1070 (.416)	206 (.277)
Total number of changes	2453	745

Notes: Source: L'enquête REPONSE 2004-05, Questionnaire Representant de la Direction. The number and proportions (in parentheses) of establishments that implemented the specified change in the last three years from a total of 2579 establishments from the basic estimation sample (middle column). Multiple innovations are possible. For each establishment in the sample, the right-hand column shows the number (and proportion) of each type of innovation that were the most important specified change in the last three years.

Table 2: Summary statistics of the estimation sample (N = 2579)

Variable	Mean	Standard Deviation
Innovated	.363	.481
Size	3867.817	6593.587
Omega	.543	.094
Communication Technology	1.303	.688
Communication Strategy	1.426	.691
Communication Technology*size	5316.76	10357.54
Communication strategy*size	6334.781	11881.76
Communication technology*ω	.237	.278
Communication strategy*ω	.294	.278
Innovation important	.301	.459

Source: L'enquête REPONSE, (2004-05), Questionnaire Representant de la Direction. These summary statistics relate to the estimation sample for Model I. For the variables used in Model I the sample size is 2579.

Table 2a: Summary statistics of the estimation sample (continued)

Variable	Mean	Standard Deviation
C (Mining)	.002	.048
D (Manufacturing)	.352	.478
E (Electricity, Gas, Water)	.021	.142
F (Construction)	.065	.246
G (Automobiles)	.166	.372
H (Hotels and Restaurants)	.023	.151
I (Transport and Communications)	.069	.252
J (Finance)	.051	.220
K (Real Estate and Business Enterprises)	.157	.364
L and M (Public Administration and Education)	.004	.062
N (Health and Social Work)	.071	.256
O, P and Q (Community, Social, Personal; Household Activities, Extra-territory activities)	.021	.144
National Market	.229	.420
European Market	.121	.326
Worldwide Market	.277	.448
Priority profit	.332	.471
Priority growth	.149	.356
Priority quality	.026	.159
No Absenteeism	.278	.670
Seniority	.097	.453
Intensity of effort	1.609	1.273
Ability deal with unforeseen event	.724	.981
Achievement of ind obj	1.111	1.282
Involvement in obj of firm	.911	1.086
Contribution to team	.854	.980

Source: L'enquête REPONSE, (2004-05), Questionnaire Representant de la Direction. These summary statistics relate to estimation same for Model I. For the variables used in Model I the sample size is 2579.

Table 3. Communication protocols on firm strategy and innovation [a,b]

Frequency of communication	Communicate on strategy	Communicate on innovation
Regularly	1542 (.529)	1252 (.431)
Occasionally	984 (.338)	1237 (.426)
Never	389 (.133)	417 (.144)
Total number of workplaces	2915 (1.0)	2906 (1.0)

Notes: a. Source: L'enquête REPONSE, (2004-05), Questionnaire Representant de la Direction. b. The number and proportions (in parentheses) of establishments that disseminated information to all employees on: the strategies and guidelines of the enterprise or group (center column); the prospects for technological or organizational change (right-hand column).

Table 4: Empirical predictions from theoretical model

Variable	Predicted relationship to *Innovated*
Communication Technology	+ *(Hypothesis 1)*
Omega (ω)	+ *(Hypothesis 2)*
Comm Technology$*\omega$	- *(Hypothesis 3)*
*Comm Technology*Size*	- *(Hypothesis 4)*

Table 5: Correlations between key variables [a, b]

	ω	Size	Communication technology	Communication strategy	Innovated	Innovation important
ω	1.0					
	2662					
Size	-0.0619	1.0				
	0.0016					
	2605	2861				
Communication	-0.0161	0.0674	1.0			
technology	0.4070	0.0003				
	2643	2839	2906			
Communication	-0.0403	0.1722	0.3926	1.0		
strategy	0.0382	0.0000	0.0000			
	2652	2847	2898	2915		
Innovated	-0.0107	0.0770	0.1390	0.1273	1.0	
	0.5805	0.0000	0.0000	0.0000		
	2662	2854	2902	2911	2922	
Innovation	-0.0712	0.0034	0.1270	0.1493	0.1087	1.0
important	0.0002	0.8552	0.0000	0.0000	0.0000	
	2662	2857	2905	2914	2922	2955

Notes: a Source: L'enquête REPONSE, (2004-05), Questionnaire Representant de la Direction. b Each cell contains: the correlation between the selected variables, the p value and the number of observations for that cell.

Table 6: Successful innovation with alternative measure of firm size: probit estimates[a]

Variable	Coef	Se	Variable	Coef	SE
Size 2	.147	.172	*No Absenteeism*	-.089	.100
Size 3	.091	.160	*Seniority*	.132	.146
Size 4	.258	.153	*Intensity of effort*	-.152*	.082
Size 5	.210	.156	*Ability deal with unforeseen event*	.072	.082
Size 6	.212	.146	*Achievement of ind obj*	.082	.085
Size 7	.366*	.202	*Involvement in obj of firm*	.039	.082
Size 8	.504***	.163	*Contribution to team*	.041	.083
Omega (ω)	.923**	.413	*National Market*	.041	.080
Communication Technology	.482***	.105	*European Market*	-.010	.098
Communication strategy	.014	.107	*Worldwide Market*	-.001	.080
*Comm Technology** ω	-.456	.345	*Priority profit*	-.023	.069
*Comm Strategy** ω	.146	.261	*Priority growth*	.190**	.087
Innovation important	.222***	.066	*Priority quality*	.068	.098
*Comm Tech*Size 2*	-.087	.252			
*Comm Tech*Size 3*	-.079	.226			
*Comm Tech*Size 4*	-.425*	.217			
*Comm Tech*Size 5*	-.156	.218			
*Comm Tech*Size 6*	-.179	.196			
*Comm Tech*Size 7*	-.222	.282	Industry dummies	Yes	
*Comm Tech*Size 8*	-.415*	.218	Log likelihood	-1300.080	
			Number of obs	2045	

Notes: *** Significant at 1% level; ** significant at 5% level; * significant at 10% level

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