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Going off-piste: The role of status in launching unsponsored R&D projects

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Abstract

Many established organizations rely on unsponsored R&D projects to sustain and support corporate renewal. These ideas emerge out of the dark corners of the organization, often as a result of inventors' proactive creative efforts. Yet, little is known about the precise origins of these creative efforts and what drives individuals to decide for or against engaging in such behavior. Building on the notion of middle-status conformity, we argue that there will be a curvilinear (U-shaped) relationship between inventors' status and their participation in autonomous inventive efforts. We argue that this effect is further moderated by factors influencing the saliency of existing status-granting institutions, specifically the novelty of the technological domain of the invention, the competitive position of the wider organization, and the geographic location of the inventors. Using a unique dataset of invention disclosures from a global technology-based firm, we largely find support for our hypotheses. From the analysis, we develop implications for theories of innovation, networks, and status to enrich our understanding of proactive forms of creative efforts.

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Abstract

Many established organizations rely on unsponsored R&D projects to sustain and support corporate renewal. These ideas emerge out of the dark corners of the organization, often as a result of inventors' proactive creative efforts. Yet, little is known about the precise origins of these creative efforts and what drives individuals to decide for or against engaging in such behavior. Building on the notion of middle-status conformity, we argue that there will be a curvilinear (U-shaped) relationship between inventors' status and their participation in autonomous inventive efforts. We argue that this effect is further moderated by factors influencing the saliency of existing status-granting institutions, specifically the novelty of the technological domain of the invention, the competitive position of the wider organization, and the geographic location of the inventors. Using a unique dataset of invention disclosures from a global technology-based firm, we largely find support for our hypotheses. From the analysis, we develop implications for theories of innovation, networks, and status to enrich our understanding of proactive forms of creative efforts.

Keywords: Unsponsored invention; creativity; invention; status; inventors; proactive creativity; bootlegging; creative deviance; middle-status conformity.

INTRODUCTION

Often, the most creative, breakthrough ideas are generated by recombining knowledge from different domains to produce unexpected yet highly valuable solutions (Dahl & Moreau, 2002; Fleming & Sorenson, 2001). Many of these ideas arise at the margins of organizations as the result of autonomous actions by individuals and teams (Burgelman, 1983b; Burgelman & Sayles, 1988; Rosenkopf et al., 2001). However, in such initiatives, individuals and teams may also develop ideas that do not fit clearly within the organization's intended set of actions, in that they are not in line with the organization's strategy or resource position (Burgelman, 1983a). Accordingly, management often attempts to bound the organization's creative efforts into ‘official’ projects by creating institutions and structures to influence and direct individuals’ creative efforts through training, resource allocation, communication and coordination, and the bestowment of the legitimacy that come with being an ‘official’ project (Cooper, 1990).

At the same time, an abundance of research suggests that some individuals consciously break out of these structures to engage in innovative efforts they consider more valuable or simply more interesting (Mainemelis, 2010; Unsworth, 2001). Of course, such ‘unsponsored’ innovation projects (initiatives launched by individuals outside the R&D programs of organizations and to which they need to dedicate time and organizational resources on top of their regular work), if left untended, will produce a garden of weeds and dilute the organization’s ability to innovate effectively and efficiently (Kanter et al., 1997). At the same time, however, such projects may be the very harbingers of novelty, a chance for organizations to break away from their routines, filters, and frames (Burgelman, 1983a). Thus, by (unnecessarily) bounding individuals’ creativity, managers may sometimes by stifling the very output they desire—innovation—and individuals may take it upon them to purposefully break these rules.

In this context, recent work points to the importance of looking at the individuals engaging in proactive creative efforts (Amabile, 1996; Shalley et al., 2004; Unsworth, 2001), such as bootlegging (Augsdorfer, 2005; Criscuolo et al., 2014), creative deviance (Mainemelis, 2010), or open innovation (Henkel 2009). In particular, Criscuolo and colleagues (2014) show how individuals can increase their innovative output—as captured by their contribution toward their employers’ innovative performance—by engaging in unsponsored invention efforts. Findings such as these highlight that our insights into the effects of unsponsored invention projects are severely restricted by our lack of understanding of who chooses to engage in them, and why. This is particularly the case as research on unsponsored invention largely looks at those individuals engaging in such behavior, but cannot observe those individuals that choose not to do so (or who are unwilling or unable to admit doing so)[1], a typical issue of selection, common to many areas of innovation studies (Kovács & Denrell, 2008). In turn, we maintain that in order to be able to understand how and why unsponsored projects may eventually contribute to the innovative performance of a firm, we must first gain a better understand of why individuals would choose to engage in such behavior.

To address this question, we propose to extend existing arguments through an institutionalist perspective. If we conceive, as others before us, of engagement in unsponsored inventions as a form of benevolent proactive creativity (Mainemelis, 2010; Unsworth, 2001), such behavior implies that individuals, willingly or implicitly, ignore the goals, structures, and rules of the organization, and thus violate the norms and criteria by which their behavior is evaluated. Specifically, following the idea of creativity as a social process embedded in organizational structures and (larger) networks (e.g., Perry-Smith & Shalley, 2003; Perry-Smith, 2006), such a perspective allows us to invoke categorization and status-related arguments (e.g., Perretti & Negro, 2006) to explain which individuals should be the most likely source of unsponsored ideas, and shed light on factors limiting or boosting such behavior.

In this vein, first, we argue that individual engagement in unsponsored projects should be subject to middle-status conformity (Phillips & Zuckerman, 2001). People with high and low status in the organization will be less fearful of any ramifications of unsponsored creativity (in particular in case of failure): high status individuals have the confidence to be break away from existing norms and lay claim to organizational resources, and low status individuals operate

[1] In addition, given that those individuals launching unsponsored inventions should be expected to act in good faith, it is not clear whether we can draw on existing work explaining deviant behavior that has clearly foreseeable negative downstream consequences to the employer. Also, while, Gino and Ariely (2012) make clear how any type of creative effort lends itself to some form of ethical violation, our argument is largely restricted to people not following instructions because of a genuine belief that not doing so will lead to a better outcome, in particular for the party providing the instruction, that is, the firm.

largely outside contests for status. In contrast, middle-status people should fear a loss of position (i.e., worse evaluations by their managers) and prestige (i.e., worse evaluations by their peers), and thus feel required to 'follow the rules' and conform to the project structure of the organization.

Second, we expect the (U-shaped) effect of middle-status conformity on engagement in unsponsored invention to be moderated by the salience of the rules, norms, and structures imposed by the organization in the work context (also see, e.g., Mainemelis, 2010; Merton, 1968). Here, we focus on three key contextual factors: technological, competitive and locational. We suggest that for ideas in new technological areas, there will be a relaxation of the effects of inventor status on conformity, with middle-status individuals being more willing to break away from the organization's project structure: as evaluation schemes may be more lenient in new technological areas (Pontikes, 2012), the additional illegitimacy of working in unsponsored projects in a new category should be relatively small. We further argue that the effect of status on conformity will be shaped by the organization's competitive position, with the effects of status on unsponsored invention to be magnified in 'bad times', and diminished in 'good times.' This is because individuals should expect that evaluators' schemes shift to become much more rigid when the firm is under pressure (Phillips et al., 2013; Staw et al., 1981). Finally, we propose the location of the creative effort will also shape the impact of status on unsponsored invention, with a heightened effect of status on unsponsored invention closer to corporate headquarters where monitoring of categorical conformance should be expected to be highest (e.g., Bacharach & Lawler, 1980), and by further empirically exploring how such behavior may be driven by individual affiliation with a dedicated research center.

We investigate these ideas by drawing on a unique dataset of all inventions recorded by a multinational organization from the mid-1990 to the late-2000s, which provides information on whether an invention is part of a sponsored project or not. We assess the degree of status of inventors by their position in the inventor network in the years prior to their invention, and examine how this position shapes the propensity for unsponsored invention. Using this information, we find some support for our hypotheses. Crucially, we find clear evidence for middle-status conformity; yet, we find this effect to be moderated only by the organizations competitive position and inventor affiliation with a research center.

Based on our findings, we make three contributions to the literature. First, we bring attention to the drivers of individual proactive creative behavior (e.g., Amabile, 1996; Unsworth, 2001), of which unsponsored R&D projects are a type. By theorizing how such behavior may be driven by status consideration, we explain which individuals should be more or less inclined to engage in such behavior and why this is the case, and thus pave the way for more elaborate studies of the outcomes of such processes. Second, we extend extant work on creativity as a networked process (e.g., Ibarra, 1993; Perry-Smith, 2006). In particular, our theorizing places the creative efforts of individuals in context of the domain, time, and location of the creative effort to show how these factors result in idiosyncratic evaluations of the network-related benefits of proactive creative behavior by individuals. Finally, we contribute back to the literature on middle-status conformity (Phillips & Zuckerman, 2001; Phillips et al., 2013). Notably, we go beyond applying these theory to yet another context, but use this opportunity to theorize and empirically validate key assumptions underlying this perspective: by showing how idiosyncratic and changing evaluative schemes impact individual status-attainment opportunities and, thus, behavior, we also highlight how this literature may for example inform, and be informed by, ongoing discussion in the organizational literature on categorization.

UNSPONSORED INVENTION IN CONTEXT

Understanding Unsponsored Invention

The concept of unsponsored invention has strong affinity with, yet important differences from, other concepts in the wider literature on creativity and innovation. First, unsponsored invention can be seen as a form of proactive creativity, the purposeful effort of individuals to develop ideas not explicitly requested by their organization (Unsworth, 2001). In studies of creativity, it has been suggested that individuals, given the right environment and mental outlook, will engage in creativity without explicit organizational support (Amabile, 1996; Anderson et al., 2014). However, studies of proactive creativity tend to focus on non-R&D environments, where creativity is not a direct expectation of the nature of a person's job (Shalley et al., 2004). In contrast, in R&D, individuals and groups are rewarded for their contribution to their organization's innovation outputs (Griffin & Hauser, 1996). In addition, they are selected because of their talent and ability to generate creative ideas for their organization in complex, challenging scientific and technological domains. As such, these individuals have both strong motivation and training, as well as the job requirement to be creative (Sauermann & Cohen, 2010).

Second, unsponsored invention may present an example of bootlegging, which involves underground innovative efforts to nurture embryonic ideas outside the project structure of the organization (Augsdorfer, 2005; Criscuolo et al., 2014) or a case of creative deviance, where individuals or groups work on ideas that have been previously rejected by the organization (Mainemelis, 2010). As such, individuals and teams that attend to unsponsored inventions may place themselves at some risk, as such efforts may be seen to be of low value to the organization, or even a waste of organizational resources. In response, individuals and teams may be reluctant to declare their efforts to innovate outside the project structure of the organization, as this may expose them to a degree of professional and personal risk (Mainemelis, 2010). At the same time, unsponsored inventions could be potentially advantageous to individuals. Senior R&D managers are liable to be aware of the role of serendipity in the creative process, and that their R&D staff may take the organization in unexpected directions. Therefore, as much as declaring these ideas to the organizations may create risks for individuals or teams, it may also generate rewards, if these ideas are taken up by the organization (Criscuolo et al., 2014). Hence, unsponsored ideas have a dual character, a potential of negative sanction, but also the possibility of reward. This gives them an ambiguous quality, and may create a degree of uncertainty among individuals and teams about whether this activity is ‘acceptable’ within their work context.

Third, unsponsored invention involves creative outputs that are potentially patentable. In most organizations, individuals and teams are legally obligated to disclose their inventions to their organization. Indeed, if they fail to actively tell their organization about an invention, they risk legal action. Therefore, although unsponsored inventions may be developed outside the project structure of the organization, individuals are required expose these ideas to the wider organization for scrutiny and assessment. In this sense, unsponsored inventions are not hidden from the organization, as bootleg projects may be.

Status and Unsponsored Invention

The key question we ask in this paper is: why would individuals (not) engage in such unsponsored inventions? This question is relevant for theory and practice alike. As mentioned before, for academic work, shedding light on this process allows us to understand better what happens before we observe the outputs of creative endeavor, such as a product or a patent, and thus address potential issues of selection bias. For practice, we may identify levers to steer, motivate, or—if so desired by management—even abolish such behavior.

Our key theoretical position is that status of an inventor will be directly related to their willingness to engage in unsponsored invention. Specifically, in most R&D settings, individuals are assessed on and rewarded for their contributions to the firm's innovative achievements. Like other creative individuals, innovators generally seek status for their creative efforts. Here, status not only refers to position in the organization hierarchy, but also to recognition as determined by their position in the networks of their peers: like scientists, inventors strive to be recognized by their peers for their accomplishments (Merton, 1973). However, unlike scientists whose status is assessed within the public domain of science, inventors tend to seek status within their organizations (Allen, 1984). In this context, many large R&D-intensive firms have developed sophisticated reward systems that bestow titles, increased autonomy, and promotions to inventors for their individual contributions to the wider innovative efforts of the firm. For example, IBM has created the title of 'Master Inventor' for those inventors who have made multiple, valuable inventions (Dahlander et al., 2015). Thus, inventors need recognition by their peers and their wider organization for their efforts to capture some of the personal credit from their creative achievements—and before they are subsumed into the wider organization efforts—to further their careers as well as their own sense of achievement.

Accordingly, an inventors' status is a reflection of their position in the firm's network of invention, and how central they are to core of the organization's inventive efforts. Individuals in central positions within a firm's inventor network have been able to generate reputation and relationships that reflect their importance to the inventive outputs of the organization. As a result, Perry-Smith (2006) as well as Perretti and Negro (2006) find that individuals with high centrality in the network, which can be equated to high innovation status, have a greater willingness to lay claim to organizational resources. Moreover, individuals with high inventor status may be more willing to take risks that their other less accomplished colleagues shy away from (Nerkar & Paruchuri, 2005). High centrality in the inventor network also allows individuals to draw upon supportiveness of colleagues to further their inventive efforts. Moreover, inventors with high centrality may be able to call on ties to other highly connected individuals to access resources and insights that others more marginal positional are unable to access (Ibarra, 1993).

Middle-status Conformity and the Propensity to Engage in Unsponsored R&D Projects

Although the discussion above suggests status in the inventor network makes individuals more likely to develop inventions, it says little about the effect of status on the likelihood of inventors developing unsponsored inventions. We argue that individual willingness to break away from formal structure of the organization may be driven by their position in the larger social structure. The central idea here is that the degree of individual non-conformism is shaped by their relative position in the status hierarchy of their organization. In particular, individuals in the middle of the status hierarchy should be more likely to conform to formal systems, rules and regulations relative to individuals at low or high positions (Asch, 1951; Blau, 1960). This idea is rooted in the notion of middle-status conformity, which reflects 'social psychological dispositions' that characterize specific structural positions (Phillips & Zuckerman, 2001). Middle-status conformity suggests that individuals in the middle of the status hierarchy have more to gain from conformance to organizational norms and rules, as they seek to obtain higher status in the organization for themselves. In contrast, individuals with high status seek to differentiate themselves from others, and gain little for themselves from conformity. Individuals with low status are outside the battle for status in general, and their nonconformity largely represents disengagement from the status competition.

Although the notion of middle-status conformity is an established theoretical concept in sociology (e.g., Phillips & Zuckerman, 2001; Phillips et al., 2013), its implications for proactive forms of creativity remain poorly developed. We suggest that unsponsored invention comes with two types of risks for individuals on the pathway to a higher status level: position-related and peer-related. First, by developing inventions outside of the project structure of the organizations, individuals and teams may expose themselves to critical assessment about how they spend their time and effort with regards to standard operating procedures associated with promotion, evaluation, or resource allocation. As a consequence, management may withdraw resources from them—and even put their job at risk—but, most importantly, managers may refuse to grant inventors opportunities to increase their status through promotion or assignment to high value projects. Second, engaging in unsponsored invention projects also raises questions about whether inventors' creative efforts are aligned with the organization's needs or requirements. Although misalignment may often (also) be the cause of sanctioning by managers, it raises a subtle, yet distinct, second issue related to status considerations, namely the problem of the 'illegitimacy discount' (see Zuckerman, 1999): if unsponsored ideas happen outside the (knowledge) domains and categories peers can evaluate, peers should withdraw their attention from the respective inventors and evaluate their unsponsored efforts more negatively. In the following, by explicating position- and peer-related risks, we describe the implications of engaging in unsponsored R&D projects for individuals at different positions in the status hierarchy.

Since managers may disapprove of inventors going 'off-piste', unsponsored invention carries a position-related risk for inventors. In particular, for middle-status individuals, the risks of nonconformity may be high, as the potential for sanctioning by senior managers for developing unsponsored invention may limit their opportunities for advancement within the organization. Middle-status individuals may fear for position if exposed to critical scrutiny, and therefore they are liable to ‘keep their heads down’ by not engaging in unsponsored invention. For high-status individuals, the fear of disapproval by managers is liable to matter less, as they already have strong track records. As such, their high status provides a buffer that allows them to behave outside organizational expectations (Perretti & Negro, 2006; Phillips & Zuckerman, 2001; Phillips et al., 2013). For low-status individuals, disapproval from managers also has less potency, as they may be outside the status hierarchy in any case and therefore feel lower requirements to subject their behavior to managerial control. In line of this argument, (Phillips et al., 2013) make clear how categorical non-conformance should be less likely to be punished if evaluators have trust in the individuals that they will keep up their level of contribution towards their own category. This should be the case for high-status and low-status actors, who have shown their respective (lack of) competence in the past.

At the same time, since unsponsored inventions are outside the project structure of the organizations, the potential for peer-related risk arises. For inventors with middle status, they may feel a strong pressure to ensure their efforts are closely tuned to the requirements and wishes of their managers and peers, who provide the means and recognition for them to climb the status hierarchy (Huy, 2002). However, if invention happens outside well-accepted categorical boundaries, the individuals creating them may credibly fear an illegitimacy discount (Zuckerman, 1999), in that those inventions will receive less attention, less praise, and, ultimately, less peer recognition than inventions within known categories. Again, these concerns should be most salient in middle-status individuals. Opposite, for high-status individuals, their past performance might make them more willing to initiate efforts that diverge from the firms’ current set of intended actions (Nerkar & Paruchuri, 2005). This is because their high status should allow them to transcend categorical boundaries so that their actions, even if they cannot be properly evaluated by their peers, should be considered favorably, as shown for example in the emergence of Nouvelle Cuisine (Rao et al., 2003). As such, high-status inventors should be more likely to engage in unsponsored invention. In turn, low status individuals are liable to have a high degree of disengagement from the organization's R&D strategy, anyway, and therefore feel unencumbered from engaging in unsponsored invention.

Taken together, we posit that willingness to engage in unsponsored invention be reduced for middle-status individuals and teams, but greater for those in low and high in status.

> H1. The network status of the inventor(s) has a U-shaped relationship with the likelihood of an invention being unsponsored.

Boundary Conditions of the Effect of Middle-status Conformity

The effect of middle-status conformity should be contingent on the scope conditions of the respective behavior (Phillips & Zuckerman, 2001). Specifically, as acknowledged by this literature (Phillips & Zuckerman, 2001; Phillips et al., 2013: 387-390), varying external conditions may lead to status-granting procedures being applied differently to individuals depending on what they do and when or even where they do it. We suggest that several boundary conditions may shape the willingness of inventors to engage in unsponsored invention by affecting how individuals perceive position- and peer-related risk. In particular, we propose that the level of technological novelty, the competitive position of the firm, and the geographic location of the individual inventor influence the salience of norms and bestowment of status, thereby varyingly fostering middle-status conformity in different work contexts.

Leniency, or the moderating effect of technological novelty

Our arguments on middle-status conformity rest on the assumption that middle-status individuals need to fear that they are negatively evaluated by their relevant audiences—managers and peers—for engaging in unsponsored invention projects, as individual innovative behavior would fall outside established categories of proper and official R&D. However, for unsponsored project to be considered ‘outside’ categorical boundaries, something else must exist that defines what is ‘inside’ or representative of the category (Negro et al., 2010; Vergne & Wry, 2014). Oppositely, when standard innovative behavior, that is, the official corporate R&D projects, were happening outside established categorical boundaries already, we would expect the difference between official and unsponsored projects to disappear. That is, the less salient the categorical scheme by which evaluation happens, the more lenient evaluation should generally be toward categorical violations (Pontikes, 2012; Ruef & Patterson, 2009).

In our context, we expect the saliency of evaluative categories to be directly and inversely tied to the novelty of the technological domain in which the invention takes place. In a domain new to the organization, the organization should have established fewer norms and procedures as what to the right project is and how this should be conducted (Knudsen & Levinthal, 2007). In addition, efforts in this space would often be considered exploratory, so additional unsponsored efforts may more leniently be regarded as a learning opportunity, and failure be regarded more favorably be managers (March, 2006). Thus, middle-status individuals should be less concerned about position-related risk.

At the same time, given there may not yet be technological roadmaps or a clear strategy for new technological domains, status-granting individuals should struggle to differentiate between the value of official and unsponsored projects—simply put, from the knowledge domain perspective, all projects should be similarly hard to evaluate, irrespective of what type of project they are (Knudsen & Levinthal, 2007). In effect, this should decrease peer-related risk from engagement in unsponsored projects, lessening respective concerns for middle-status individuals.

In short, the novelty of the technological domain of an invention should cushion the consequences of it resulting from an unsponsored project. We thus posit:

> H2.The level of technological novelty of the invention will moderate the effect of inventor status on the likelihood of engaging in unsponsored invention, such that for inventions of high (low) technological novelty, the effect of status is reduced (enhanced).

Treachery, or the moderating effect of competitive position

It is clear that the competitive position of the organization may have significant impact on creative efforts of its staff (Amabile & Conti, 1999). In 'good times'—when a firm has a strong or even dominant position in its market—a firm may have extra resources to support creative efforts. Such slack may allow the firm to relax organizational accountability, allowing staff to engage in 'playful' or even 'foolish' creative efforts (Levinthal & March, 1981; Levinthal & March, 1993; March, 2006) in order to (purposely) create in a wide range of options, which may be distant from the firm's current efforts (McGrath & Nerkar, 2004). As a result, the organization may be able to be display greater tolerance of efforts that break away from its formal strategy. In contrast, in 'bad times'—when the firm is under severe competition pressure—resources should be scarcer. As such, organizations are liable to turn to near-market and immediate solutions, limiting employees' efforts that do not conform to the pressing needs of the organization: under competitive threat, organizations are liable to make a "mechanistic shift", requiring their staff to display greater adherence to formal rules, regulations and routines (Staw et al., 1981). In this environment, the risks of breaking away from the organization's intended course of action may be high for individuals, undermining the psychological safety required to be creative in areas outside the firm's project structure (Amabile & Conti, 1999; Edmondson, 1999).

The competitive position at the organizational level may also shape the effect of status on individual propensity to engage unsponsored invention. Regarding position-related risk, when an organization has surfeit of resources and is more relaxed about conformance, even middle-status inventors may feel that there are fewer risks, but maybe higher benefits to turning to unsponsored invention projects. In this context, unsponsored invention is a safer option than in bad times, as the firm's tolerance of playfulness lowers the potential of position-related sanctions. In contrast, during the 'mechanistic shift' associated with bad times, the pressure to conform by middle-status individuals will be heightened. The organization is liable to have little space for unprogrammed creative efforts (Staw et al., 1981), and may proactively punish individuals who break away from their formally mandated projects (Amabile & Conti, 1999).

The latter effects are reinforced when considering peer-related risk. In situations of high competitive pressure, employing the firm's resources for what may be considered personal interest should be viewed similarly to treachery by other members of the organization (Phillips et al., 2013): given that middle-status inventors lack status or perceived competence from past success, peers will not expect a priori that they will deliver on their unsponsored projects. In turn, their efforts that break away from existing categorization schemes should be viewed in the most negative of lights, namely as a purposive and conceited wasting of firm resources. Oppositely, in periods of high performance, the firm may even be actively encouraging misalignment in order to identify new opportunities to continue its overperformance (e.g., Iyer & Davenport, 2008). The firm's goal of taking on different futures may encourage middle-status inventors to bring ideas to the organization that are well outside its current markets and strategy, and evaluators should positively reward novelty just for novelty's sake. Taken, together, we thus posit:

> H3. The level of competitive pressure faced by the broader organization will moderate the effect of inventor status on the likelihood of engaging in unsponsored invention, such that in periods of low (high) performance, the effect of status is enhanced (reduced).

Propinquity, or the moderating effect of inventor location

The location of inventors can have a significant impact on their propensity to engage in different forms of creativity. Traditionally, organizations concentrate their explorative, creative efforts close to their main headquarters, trying to ensure a tight alignment between R&D efforts and corporate strategy (Bartlett, 1986; Vernon, 1966). Moreover, co-location of R&D and senior decision makers helps to lower monitoring costs. As such, R&D efforts at or close to corporate headquarters tend to be subject to a higher degree of fidelity and coordination than R&D efforts undertaken in removed locations (e.g., Medcof, 2001). Indeed, separation from headquarters may provide a degree of freedom for inventors to diverge from organizational rules, norms, and requirements. In part, this stems from the fact that distributed R&D sites are often set up to tap into unique expertise held in locations distinct from the headquarters (Bartlett & Ghoshal, 1989; Kuemmerle, 1996) and over time may even develop strategic independence (Frost et al., 2002; Mudambi & Navarra, 2004). Moreover, some foreign R&D sites may be inherited by the organizations through prior acquisitions, and therefore might not be fully integrated or aligned to the organization's ways of working (Frost & Zhou, 2005; Håkanson & Nobel, 2001) . Accordingly, it is likely that these sites are home to creative ideas, skills, and knowledge that differ from the efforts expected by managers located at the corporate headquarters.

Drawing on this context, we suggest that the location of inventors shapes the effect of status on the likelihood of engaging in unsponsored invention. First, regarding position-related risk, since inventors working at headquarters are subject to greater oversight, they are liable to face a higher risk of sanctioning when engaging in ideas outside the organizational expectations. This means middle-status inventors working in HQs have a greater incentive to conform to organizational expectations and not bring forward unsponsored creative efforts than those individuals working away from HQ. Individuals in periphery locations will have greater scope to work outside the direct purview of senior managers, and therefore may be more willing to undertake unsponsored invention.

Regarding peer-related risk, we should expect that individuals working at HQs place more importance on participating in the status and power games taking place there, which may be integral to success in the bureaucracy (e.g., Bacharach & Lawler, 1980; Pfeffer, 1981). In turn, this requires individuals at HQ to play 'by the book'—rising through the ranks of the status hierarchy should be easiest and happen fastest by aptly executing the routines and appealing to the evaluation criteria it holds sacrosanct. Middle-status individuals should thus do their best to conform to existing expectations. Indeed, this argument is in line with propositions from the creativity literature suggesting that individuals may be 'too central' to be creative, as such a location would put them under too high a scrutiny to take any slack (Perry-Smith & Shalley, 2003). Oppositely, individuals away from the strict monitoring of headquarters should feel less bound by politics and rules. Rather, in particular people who are geographically peripheral may genuinely feel that HQ has little control over their day-to-day activities, and they may even be actively encouraged to improvise. For example, in the internationalization of firms, we should expect that evaluation systems developed in the home country become blended with national culture—not the least by hiring local people with different socialization—and may also be purposively adapted when existing processes simply do not work. In turn, we posit,

> H4. The physical location of the inventor in the organization will moderate the effect of inventor status on the likelihood of engaging in unsponsored invention, such that the effect of status is enhanced for inventors located at the corporate headquarters.

Relatedly, we would also expect an effect of employees being located at dedicated R&D centers. However, we refrain from developing a directional hypothesis, as we expect conflicting effects for middle-status individuals considering position- and peer-related risks. As regards the former, in line with our preceding arguments, we would expect managers to be much more tolerant toward individual engagement in unsponsored projects. At the same time, however, the status competition in dedicated R&D centers may be particularly pronounced (Allen, 1984; Merton, 1973). Thus, we would expect middle-status individuals to be more liable to worry about peer-related risks from engaging in unsponsored projects.

DATA AND METHODS

Research setting

Our study focuses on the entire population of inventors and inventions at Venus, a pseudonym for a large, technology-based company operating in a complex technology industry. In order to better understand the nature of R&D and invention processes inside Venus, we carried out 30 exploratory interviews with inventors, internal agents, R&D managers evaluating invention disclosures and helping inventors develop them further (so-called "patent engineers"), experts, and managers of legal and IP departments, as well as taking part in numerous formal and informal meetings. Further, one of the authors spent 40 days observing a team of patent engineers dealing with the evaluation of new invention disclosures and the maintenance of Venus' patent portfolios. In addition, we carried out several retrospective interviews with former R&D managers to better the understand nature of R&D in the organization.

Over the past 20 years, Venus has invested significantly in R&D and actively sought to protect its inventions. To do so, it employed many scientists and engineers whom it rewarded and promoted for their innovative achievements, as well as an Intellectual Property (IP) unit to create, monitor and evaluate its patent portfolio. Although Venus's R&D efforts were housed in a variety of dedicated centers across the world, it also maintained a strong R&D presence at its corporate headquarters. In general, R&D efforts were closely tied to its commercial efforts, as much of the attention in R&D was focused on developing technologies to support and enable the development of new products and new product families.

R&D at Venus was organized using conventional R&D management approaches, with individuals and teams assigned to work on projects that were selected by senior management during a stage-gate process that used multi-criteria assessment to judge the value of project ideas to the organization. Unlike in some firms, individuals within Venus were not given free time to engage in their own projects and therefore R&D staff had all their time allocated to officially supported projects. This was confirmed in a number of interviews with R&D managers who all stressed the fact that their job was to ensure that their engineers and scientists would deliver official projects on time, as exemplified by the following quote by a senior R&D manager:

> *"In my experience, people doing their own pet projects (not always innovative I'm* afraid) at the expense of the project they are assigned to are more likely to be *'sanctioned' by their peers."*

Therefore, R&D employees had very little autonomy and few slack resources, both time and money, to generate unsponsored inventions. According to our interviewees (and in line with our theorizing), most unsponsored inventions should have been developed by high performing individuals who had both many ideas and also the capacity to work on their official projects as well as on their unsponsored ideas. Unsponsored inventions would however come to the surface as inventors had an incentive to report them because of the different award schemes in place to reward the most prolific inventors.

Sample and Unit of Analysis

As in many large technology-based companies, all Venus employees are required to document their inventions and to submit them to an online repository system. Thus, even if an invention originates from an unsponsored project, individuals are legally obliged to report it to their employer if it is the result of the work they conducted at work or using work resources. Once submitted, inventions are assigned to patent engineers who help the inventors to make sure their invention is fully documented and accurately described. They also prepare an initial evaluation of the invention. Much like an academic review process, this evaluation includes a prior art search, an assessment of whether the invention is useful to the firm, in that it could be incorporated into products and services, and an actual suggestion as to whether the firm should patent it. Both the invention and its evaluation are passed on to a patent board, a formal committee of internal experts that decides whether an invention should be patented. In Venus, there are twelve patent boards, which evaluate inventions in specific technological domains.

To explore our research questions, we draw upon these records of inventors and inventions developed at Venus. While the dataset consists of around 40,000 invention reports, we can only draw on a subset for which we can clearly infer whether the invention is part of an official or an unsponsored project. This is because, while inventors are encouraged to note in the invention disclosure any official project to which the invention is connected, it is the patent engineer assigned to the invention who is ultimately responsible for recording such linkages in the database by checking a ‘Yes’ or ‘No’ tick-box.[2] In our interviews with patent engineers, it was clear that the decision of whether to assign an invention to a formal project was made independently, and without the direct influence of inventors or their managers. Rather, to make this assessment, patent engineers would look at the overlap in the nature of the invention and the R&D project database to determine whether the invention was tied to project or not.

Unfortunately, not all patent engineers are consistent in performing this task, and neither

[2] The patent engineer can additionally specify which project the invention is connected to in a text box. For an invention that is part of an official project, the project codename would normally be entered in this field, while unsponsored inventions have entries such as ‘none’, ‘none at present’, ‘any’ or ‘this has been and remains a skunkwork’.

the ‘Yes’ nor the ‘No’ box is ticked in the project field for a significant number of inventions. Around a quarter of inventions in the database therefore have no information regarding whether or not they are sponsored, forcing us to omit them from our analysis. Our sample is further reduced as the calculation of inventor status and constraint variables (see next section) uses data on the inventor network over three years prior to the focal invention, resulting in the first three years of our dataset being used solely for the calculation of these variables. Finally, missing data on the technological classification of some inventions result in a number of other observations being excluded. Our analysis sample therefore consists of around 25,000 inventions (co)invented by a total of around 7,500 individuals over a fourteen-year period.

With respect to our level of analysis, this implies that we have about dyadic 55,000 inventor-invention observations: given that an invention may have multiple inventors, yet each inventor may have multiple inventions, we create a pooled-cross sectional sample, in which each inventor of each invention is included. This way, can also simultaneously cluster standard errors at both the level of the individual and the invention (see Kleinbaum et al., 2013)

Dependent variable

Unsponsored invention is operationalized (for all individuals per individual-invention dyads) as a binary variable taking on a value of 0 if the respective invention is recorded as being associated with an official Venus project, and taking on a value of 1 if it is not.

Independent variables

Inventor status is measured as each individual’s Bonacich power, calculated from the one-mode network of inventors within Venus over the three years prior to the focal invention (Bonacich, 1972). Inventors’ status is thus determined by the extent to which they co-invent together with other high-status inventors in this time window. This variable is highly skewed, so we rescale it by adding 1 and taking the natural logarithm of the resulting values (see also Nerkar & Paruchuri, 2005).

To capture the extent to which an invention is technologically novel, we calculate the number of inventions in the same (combination of) 3-digit technology class(es) disclosed inside Venus before the year of the focal invention. Venus has its own internal technology classification, with 21 one-digit, 153 two-digit, and 314 three-digit technology classes. We interpret a higher number of prior invention disclosures in a focal invention's (combination of) technology class(es) as reflecting reduced technological novelty of the focal invention, in line with Fleming's (2001) measure of cumulative combination usage.[3]

Competitive performance is operationalized as a binary variable equal to 1 for inventions submitted during a period in which Venus' net income was below that of rivals, and 0 otherwise. We use this measure to capture whether the organization was outperforming its rivals. During the period of study, Venus had mixed fortunes relative to its rivals. In some periods, it was dominant, whereas in others it was a laggard.[4] We use a proxy for its net income relative to rivals, as a way of capturing 'good' and 'bad' times in its respective market.

Headquarters' (HQ) influence on the inventor is measured using a binary variable equal to 1 if the team member's office address is that of the firm's headquarters, and 0 otherwise. Similarly, whether or not an inventor is a research center employee is measured using a binary variable which is equal to 1 if the inventor's office address is given as being in one of Venus' research centers, and 0 otherwise.

Control variables

[3] In results available on request from the authors, we used alternative measures of technological novelty: the number of inventions in the same (combination of) 3-digit technology class(es) disclosed inside Venus over a period of 1 to 5 years prior to the focal invention; and binary variables equal to 1 if the invention represents a new combination of technology classes at 1-, 2-, and 3-digit levels. The results are fully consistent with those presented here.

[4] We are unable to report specific time windows of high or low performance, as this would disclose the identity of our firm.

We control for a number of key variables that have been found to be associated with inventive output in prior studies relating to the inventor team. Team size has been found to be an important factor affecting inventive activity and outcomes (e.g., Singh & Fleming, 2010). We thus control for the number of inventors in the inventor team. We also control for inventor team joint experience, measured as the number of prior inventions submitted by the inventor team, the experience diversity of the inventor team, captured by the number of technology classes team members have previously patented in (Singh & Fleming, 2010). Crucially, we must also account for alternative explanations of individual deviant behavior that relate to access to information and skill (see, e.g., Phillips & Zuckerman, 2001: 381f.). Thus, we include the inventor's constraint, operationalized using Burt's constraint measure (e.g., Nerkar & Paruchuri, 2005) calculated from network of inventors over the three years prior to the focal invention. Additionally, we control for the inventor's inventing and patenting experience, using a measure of the year of first invention of the inventor in Venus' systems, and the number of prior patents of the inventor. As unsponsored invention may be a side effect of other inventive activity, we control for such spillovers by counting the number of other invention submissions made by the inventor in the two months before and after the submission date of the focal invention. Finally, we include several controls to capture temporal or technology-related effects: the month and year in which the invention is submitted, a dummy variable for time periods during which the economy of Venus' largest geographical market was in recession, and fixed effects for the patent board to which the invention was submitted for evaluation.

RESULTS

--- Insert Tables 1-3, Figures 1-5 about here ---

Table 1 contains the summary statistics of our sample. Around 11% of inventor-invention observations in our sample are of unsponsored inventions. Our independent variables have quite a wide range and vary significantly from invention to invention. Correlations between the variables used in our analysis are reported in Table 2. While some of our control variables show medium levels of pair-wise correlation, these, as well as other indicators of multicollinearity do not point to any reason for concern (e.g., Echambadi et al., 2006; Echambadi & Hess, 2007).

To test our hypotheses, we run probit regressions with heteroscedasticity-robust standard errors clustered by both inventor and invention to account for non-independence between observations along these dimensions. The regression results can be seen in table 3. Model (1) in the first column is our controls-only baseline. We add the status measures in Model (2), which for reasons of simplicity, we will also use to interpret H1.[5] In Models (3)-(6), we introduce the interaction terms corresponding to the H2-H4 and to our exploratory inquiry of research center employment. We draw on these models to understand the individual contributions these variables make toward model fit, and to be able to compare changes in coefficient values and significance levels to the full model, to shed light on potential multicollinearity issue. In addition, to simplify the interpretation of our interaction hypotheses, we plot the respective predicted margins in Figures 1-5.

Looking at our results, we see that H1 is confirmed. While the estimated coefficient on inventor status is negative and highly significant, the coefficient on its square term is positive and also highly significant. As log(inventor status + 1) increases from 0 to 1 the likelihood of an invention being unsponsored falls from around 12% to around 8%, before rising to around 14% as log(inventor status + 1) increases to 2, as also shown in Figure 1. Notably, however, we see how our effects are driven by a small share of high-status individuals within Venus, as the value

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5 Would we use the correct operationalization, which would be to calculate the respective marginal effects of the status-variables in our full model, we would arrive at nearly identical results, but is considerably more difficult to explain. Simply interpreting the coefficient of the inventor-status(-squared) variables in the full model, of course, would be incorrect.

of the inventor-status variable is lower than 1 for over 95% of inventor-invention dyads while only 23 inventors in our sample have values of inventor-status variable greater than 2. Turning to H2, we find it not supported as the estimated coefficients on the interactions between technological novelty and inventor status and its square are not significant in any specification (also see Figure 2). For H3, we find partial support: as highlighted by the full line in Figure 3, we find that the relationship between status and engagement in unsponsored project somewhat weakens in good times. As indicated by the striped line, we find that while all but the lowest-status inventors are less likely to engage in unsponsored projects during bad times, the inverted-U relationship between inventor status and the likelihood of engaging in unsponsored projects is more pronounced during periods of low competitive performance. Looking at H4, whether or not a team member is working at HQ has no significant effect on their engagement in unsponsored projects. Finally, regarding the effect of research center membership, we gain strong traction for a moderated relationship. Turning to Figure 5, we see how the inverted-U shape is much more pronounced for research center employees, with inventions of low- to moderate-status inventors being less likely to be unsponsored than those of their colleagues employed outside of the research centers, while inventions of higher status research center employees are far more likely to be unsponsored than those of equally high-status non-research center employees. In turn, this would suggest that peer-related risk outweigh potential position-related benefits for middle-status inventors when it comes to engaging in unsponsored invention projects in a research center.

DISCUSSION AND IMPLICATIONS

In this paper, we set out to explore the drivers of individual engagement in unsponsored R&D projects, a behavior vital to the innovative success of many corporations. In particular, we argued that we needed to understand more about why individuals would choose, or, not choose, to exhibit such behavior so that research looking at the outcome of such projects would not fall victim to issues of selection bias. In essence, our explanation for engagement in unsponsored projects rested on extending the notion of middle-status conformity to this context: individuals of middle-status should be most worried to lose out in the race for recognition in the firm as managers disliking their actions would delay or prevent promotions, and peers' non-understanding of distant knowledge endeavors would result in those being ignored or disrespected. Finally, we also considered how changes to evaluation schemes due to invention novelty, the competitive standing of the firm, and the location of the individual cause these position- and peer-related risks to vary at the level of the individual-invention dyad.

We found that, indeed, engagement in unsponsored R&D projects is a result of middle-status conformity: high- and low-status individuals, both of whom can act largely outside the competition for status in the firm, are more likely to exhibit this behavior than are middle-status individuals. Contrary to our hypotheses, we did not find this basic relationship to be influenced by categorical novelty or for individuals working at headquarters, but only by firm performance and for individuals working at R&D centers. Nevertheless, our results provide a clear first look at how individual engagement in unsponsored R&D project is driven by status-considerations, and how these, in turn are subject to firm-level influence.

Implications for Theory

Based on our findings, we present contributions to theories of organizing innovation.

The drivers of individual proactive behavior.

First, we answer to recent calls to pay more attention to the non-programmed or even "dark side" of innovation (Anderson et al., 2014). By its very nature, innovation cannot perfectly planned, and a significant share of it may even happen outside the scope of managerial oversight and control in the form of individual proactive creative behavior (Amabile, 1996; Shalley et al., 2004; Unsworth, 2001). While these efforts may, eventually, be beneficial for the firm and the individual (Criscuolo et al., 2014), they need not be (Kanter et al., 1997). Rather, individuals deviating from the corporate line may bring havoc upon themselves, and possibly the organization. In this context, we present a novel theoretical explanation for why individuals would choose to engage in creative behavior. By linking to the sociological literature on status and status attainment, we provide a novel guideline to explain non-conformist, yet well-intended behavior in the innovation context (cf. Gino & Ariely, 2012). We show how idiosyncratic perceptions of the risk of losing status—be it through promotion or peer-recognition—help determine whether individuals embark on such efforts or not. By extension, these insights also speak to the selection issue our kind of study may help address: if it is indeed largely low- and high-status actors that engage in unsponsored R&D projects, we would expect a related, bi-modal distribution in the outcome of such projects, and possibly even two distinct chains of events in which such projects manifest. Accordingly, our results point to a need of explicitly including status-based considerations—or at least, controls—in studies of inventor creativity to ensure that this essential driver of their efforts is appropriately accounted for. Similarly, we call for future work to shed light on the differences in the structure, conduct, and performance of (unsponsored) invention projects depending on the status of the person initiating the project as well as its team members.

Individual proactive creative behavior and networks.

Second, we contribute to discussions of creativity as a networked activity (e.g., Perry-Smith & Shalley, 2003; Perry-Smith, 2006). In particular, our results highlight how larger, intra-organizational networks and organizational norms and design choices come together to influence individual creative behavior. First, in line with existing work (Ibarra, 1993; Nerkar & Paruchuri, 2005; Perretti & Negro, 2006; Perry-Smith, 2006), we show how differences in individuals' network positions explain differences in their proactive creative behavior, and provide a status-based explanation for this variation. In particular, we introduce and elaborate the position- and peer-related considerations that individuals will undergo when evaluating such behavior. Second, we extend the existing perspective by theorizing the idiosyncrasy of individuals' evaluation schemes in this context. Specifically, we inquire whether it matters when, what, and where individuals consider such behavior and we find that time (with respect to the organizational performance at that time) and place (whether individuals work in a dedicated research unit or not) indeed matter. In particular, our finding that high-status individuals responded most strongly to poor organizational performance gives credence to (Perry-Smith & Shalley, 2003)'s theoretical considerations that individuals may be too central: we would expect that highly-central individuals shy away from laying claims to organizational resources in bad times because such actions should be all the more visible and detrimental to their status. In these situations and for these actors in particular, proactive creative behavior may even be considered treacherous (Phillips et al., 2013). However, if high-status people are indeed the most creative in the organization, such dynamics would give rise to a catch-22 in which the most creative people of the organization, for status-considerations, would refrain from trying to generate those new, groundbreaking ideas that may serve the firm. Indeed, we see great value in elaborating these considerations in further studies, in particular of qualitative nature and connecting them to work on disruptive innovation and organizational cognition, and how these tie to organizational failure (Christensen, 1997; Tripsas, 2009).

Individual proactive creative behavior and middle-status conformity.

Third, our insights also allow us to contribute back to theorizing on middle-status conformity. As (Phillips & Zuckerman, 2001) aptly describe, this literature started out with the individual as the level of analysis (e.g., Asch, 1951; Blau, 1960). Thus, by looking at individual-level creative behavior, we return to the core of the respective argument, and show that it holds in an important context. More importantly, however, we pave the way for substantial extensions. In particular, we shed light on what Phillips and Zuckerman called the "scope conditions" of their argument (p. 389), namely that environmental conditions may significantly impact the individual-status attainment process. Specifically, extending on their insight, we maintain that idiosyncratic and changing environmental settings will lead to individuals of the same a priori status or rank exhibiting different behavior in expectance of the respective status-related effects. These effects, so we argue, stem from contextual variables rooted in the place and time at which individuals are considering their behavior and also determine how others around them will evaluate such behavior. As such, we show how the basic middle-status conformity argument can be extended beyond the scope conditions originally identified by Phillips and Zuckerman, and thus call for a more fruitful integration of the literature on middle-status conformity with other streams of discussion drawing on arguments of evaluation frameworks, such as the emerging literature on categories (Vergne & Wry, 2014). Such work holds much promise given how these two literatures share an important theoretical tradition in Zuckerman's (Zuckerman, 1999) work on the categorical imperative.

Limitations

Our study has several limitations. First, although we explore the question of which individuals engage in unsponsored invention, we do not explore the performance implications of these ‘off-piste’ creative efforts. As a result, it is not clear whether these creative efforts were a cost or a benefit to the organization. Second, by focusing on inventor status, we are unable to account for other forms of status progression by individuals and teams within the organizations. Since status may be achieved in R&D organizations through managerial roles as well as technical accomplishments, it is possible that some individuals and groups are able to obtain status outside the bounds of the invention network. Accessing human resources data would help to remedy this concern, but given the scale and time frame of our study, this information is simply not available. Third, although we have information from a large pool of inventors working across range of settings and at different times, all the information is drawn from the same organization, raising concerns about the generalizability of our findings. It may be that particular characteristics of this organization help shape the results we find. However, in our defense, gaining access to this type of information remains difficult to researchers and using public information (such as patents) provides no information about whether the invention was unsponsored or not. Surveys of inventors can help identify unsponsored patents, but these studies rely on patented inventions to identify the inventors. As a result, many unsponsored inventions – which may not have been patented by the organization – are liable to be unreported.

Implications for Practice

For practice, our work points to several ways in which companies may choose to tackle the topic of unsponsored R&D projects. Notably, in this paper, we are not saying that unsponsored invention is good or bad but instead looking at its underlying drivers. In turn, companies may use these to promote or prohibit unsponsored inventions. For example, companies that want more unsponsored inventions should think about measures to decrease middle-status inventors concerns about position- and peer-related risk. By contrast, companies that want to abolish such efforts may try to rhetorically label them as a malicious way of wasting firm resources, and punish transgressive employees accordingly. While the truth is probably somewhere between these two extremes, current practice shows how tolerance for unsponsored invention, thanks to tales of successes by firms such as 3M and Google, goes a long way. Nevertheless, organizations that are less abundant in resources need to find ways to hold R&D staff (and inventors) accountable for their creative efforts.

TABLES AND FIGURES

Table 1: Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Unsponsored invention	~55,000	0.108	0.310	0	1
Inventor status	~55,000	0.211	0.333	0	2.850
Technological novelty	~55,000	59.038	121.410	0	759
Research center employee	~55,000	0.253	0.435	0	1
HQ employee	~55,000	0.106	0.308	0	1
Competitive performance	~55,000	0.156	0.362	0	1
Team size	~55,000	3.139	2.058	1	22
Joint experience	~55,000	2.739	13.334	0	312
Experience diversity	~55,000	12.597	10.207	1	59
Spillovers	~55,000	6.489	11.661	0	129
Constraint	~55,000	0.280	0.272	0.039	1.125
No. prior patents	~55,000	8.915	12.882	0	109
Year of first invention*	~55,000	22.638	4.079	0	32
Recession	~55,000	0.183	0.387	0	1
Month of submission	~55,000	6.656	3.507	1	12
Year of submission*	~55,000	7.849	3.116	0	13

* To maintain anonymity of our data source, the summary statistics reported for these variables have been transformed by subtracting the earliest years from the true values.

Table 2: Correlations

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**
1. Unsponsored invention	1.000												
2. Inventor status	-0.016	1.000											
3. Technological novelty	0.039	-0.040	1.000										
4. Research center employee	-0.036	-0.056	0.050	1.000									
5. HQ employee	0.005	0.072	-0.049	-0.200	1.000								
6. Competitive performance	-0.053	0.119	0.079	0.049	-0.058	1.000							
7. Team size	-0.076	-0.017	-0.009	-0.007	0.001	0.103	1.000						
8. Joint experience	0.096	0.072	0.038	0.039	-0.014	0.002	-0.160	1.000					
9. Experience diversity	0.008	0.261	0.053	-0.011	-0.020	0.340	0.281	0.167	1.000				
10. Spillovers	0.047	0.013	0.051	0.011	-0.019	0.025	0.458	0.099	0.254	1.000			
11. Constraint	-0.008	-0.099	0.014	0.033	0.000	-0.067	-0.087	0.040	-0.038	-0.062	1.000		
12. No. prior patents	0.017	0.598	0.010	-0.013	-0.007	0.181	-0.085	0.302	0.388	0.061	-0.080	1.000	
13. Year of first invention	-0.024	-0.342	0.104	0.090	-0.084	0.276	0.148	-0.049	0.031	0.100	-0.161	-0.330	1.000
14. Recession	-0.067	0.029	-0.019	0.022	-0.024	0.232	0.052	-0.005	0.095	0.007	-0.044	0.026	0.110

Table 3: Regression results

DV: Unsponsored invention	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Team size	-0.088***	-0.089***	-0.088***	-0.088***	-0.089***	-0.088***	-0.086***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.019)
Joint experience	0.005*	0.005+	0.005+	0.004+	0.005+	0.004+	0.004+
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Experience diversity	-0.001	0.001	0.000	0.001	0.001	0.001	0.000
	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)
Spillovers	0.010***	0.010***	0.009***	0.010***	0.010***	0.010***	0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constraint	-0.151**	-0.150**	-0.143**	-0.150**	-0.150**	-0.163**	-0.157**
	(0.056)	(0.056)	(0.055)	(0.056)	(0.056)	(0.056)	(0.056)
No. prior patents	-0.003	-0.000	-0.001	-0.000	-0.000	0.000	0.000
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Year of first invention	-0.011+	-0.016*	-0.016*	-0.016*	-0.017*	-0.017*	-0.017*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Recession	-0.263***	-0.259***	-0.260***	-0.258***	-0.259***	-0.269***	-0.269***
	(0.046)	(0.046)	(0.047)	(0.047)	(0.046)	(0.048)	(0.048)
Month	-0.004	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Year	0.013	0.017	0.018	0.017	0.017	0.016	0.018
	(0.011)	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)	(0.011)
Technological novelty	0.000	0.000	-0.000	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Research center employee	-0.178***	-0.176***	-0.174***	-0.115*	-0.176***	-0.171***	-0.113+
	(0.051)	(0.052)	(0.052)	(0.058)	(0.052)	(0.051)	(0.058)
HQ employee	0.004	0.011	0.011	0.010	-0.010	0.009	0.011
	(0.056)	(0.054)	(0.054)	(0.055)	(0.060)	(0.054)	(0.061)
Firm low performance	-0.222***	-0.211***	-0.213***	-0.205**	-0.210**	-0.033	-0.038
	(0.066)	(0.066)	(0.067)	(0.066)	(0.067)	(0.079)	(0.078)
Network status		-0.525***	-0.590***	-0.401**	-0.561***	-0.423***	-0.367*
		(0.120)	(0.116)	(0.135)	(0.142)	(0.131)	(0.169)
Network status^2		0.291***	0.316***	0.212*	0.315**	0.241**	0.183
		(0.074)	(0.069)	(0.084)	(0.101)	(0.080)	(0.121)
Network status x			0.001				0.001
Technological novelty			(0.001)				(0.001)
Network status^2 x			0.000				0.000
Technological novelty			(0.001)				(0.001)
Network status x				-0.934*			-0.852*
Firm low performance				(0.406)			(0.411)
Network status^2 x				0.358			0.270
Firm low performance				(0.299)			(0.336)
Network status x					0.168		-0.041
HQ employee					(0.294)		(0.312)
Network status^2 x					-0.094		0.037
HQ employee					(0.153)		(0.167)
Network status x						-0.705**	-0.671*
Research center employee						(0.269)	(0.283)
Network status^2 x						0.509**	0.502**
Research center employee						(0.170)	(0.188)
Patent board fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-5.187	-1.747	-3.985	-1.691	-1.627	0.107	-2.570
	(17.193)	(17.649)	(17.000)	(17.627)	(17.624)	(17.924)	(17.179)
Log pseudolikelihood	-18,743.27	-18,700.85	-18,688.51	-18,683.54	-18,699.93	-18,668.28	-18,639.75
N	~55,000	~55,000	~55,000	~55,000	~55,000	~55,000	~55,000
Number of inventors	~7,500	~7,500	~7,500	~7,500	~7,500	~7,500	~7,500
Number of inventions	~25,000	~25,000	~25,000	~25,000	~25,000	~25,000	~25,000

+ p<0.1; * p<0.05; ** p<0.01; *** p<0.001. Probit regression; robust standard errors clustered by inventors and inventions are in parentheses.

Figure 1: Effect of network status on probability of invention being unsponsored (dotted lines represent 95% confidence interval)

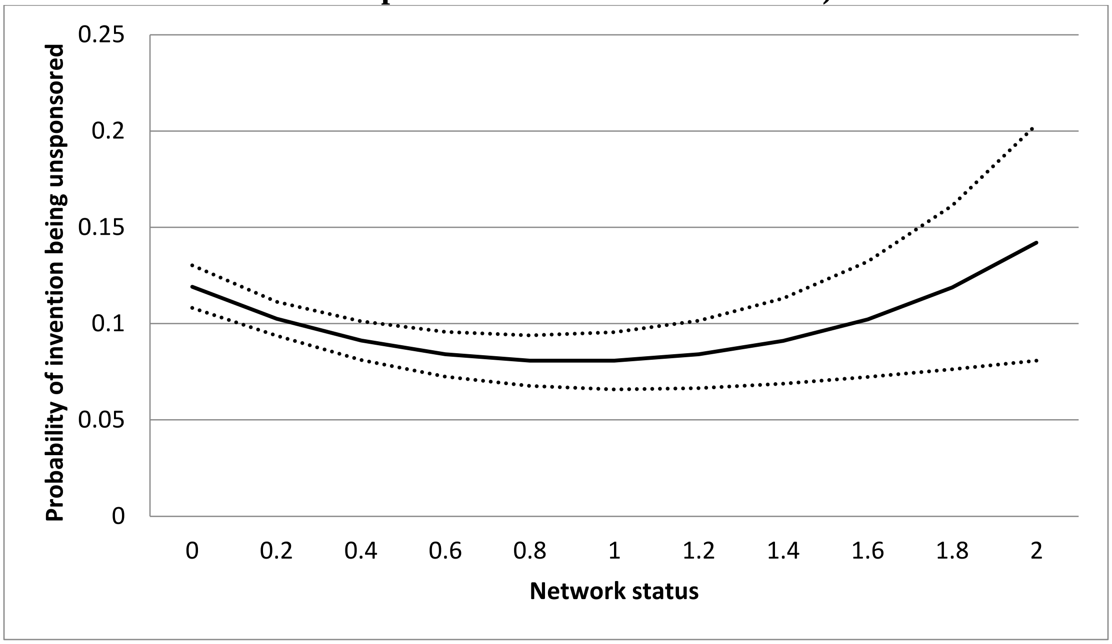


Figure 2: Interaction between network status and technological novelty

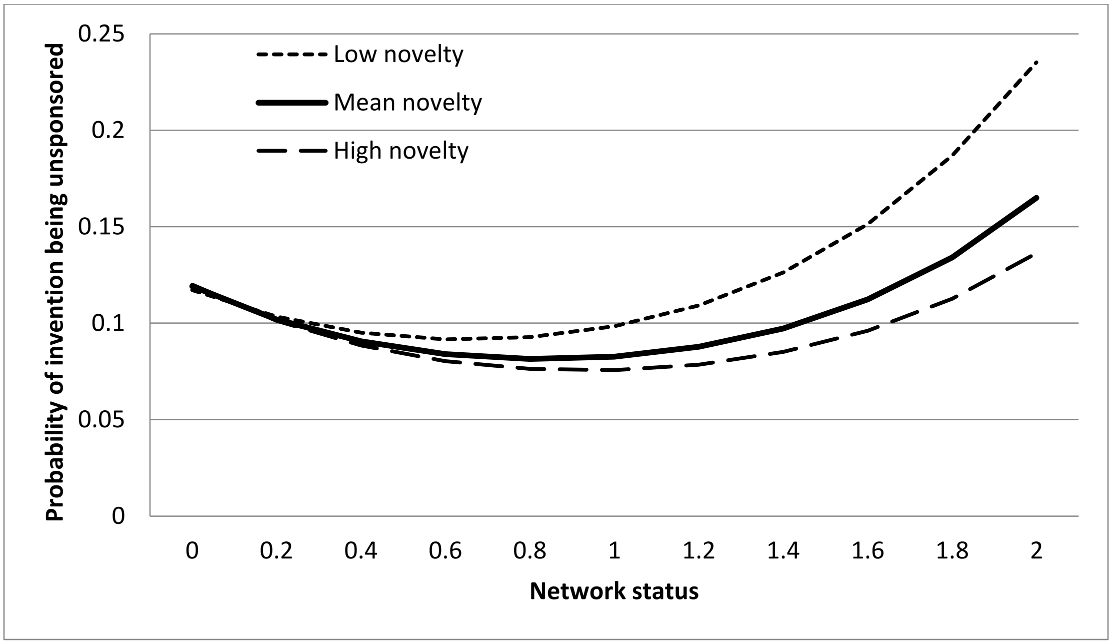


Figure 3: Interaction between network status and firm low performance

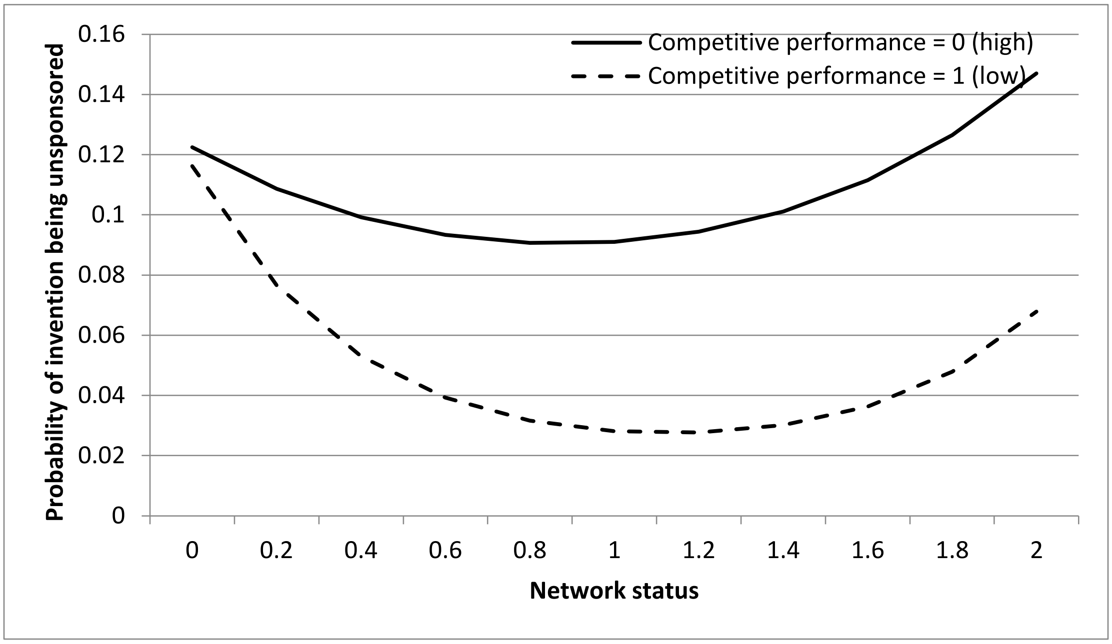


Figure 4: Interaction between network status and employee at HQ

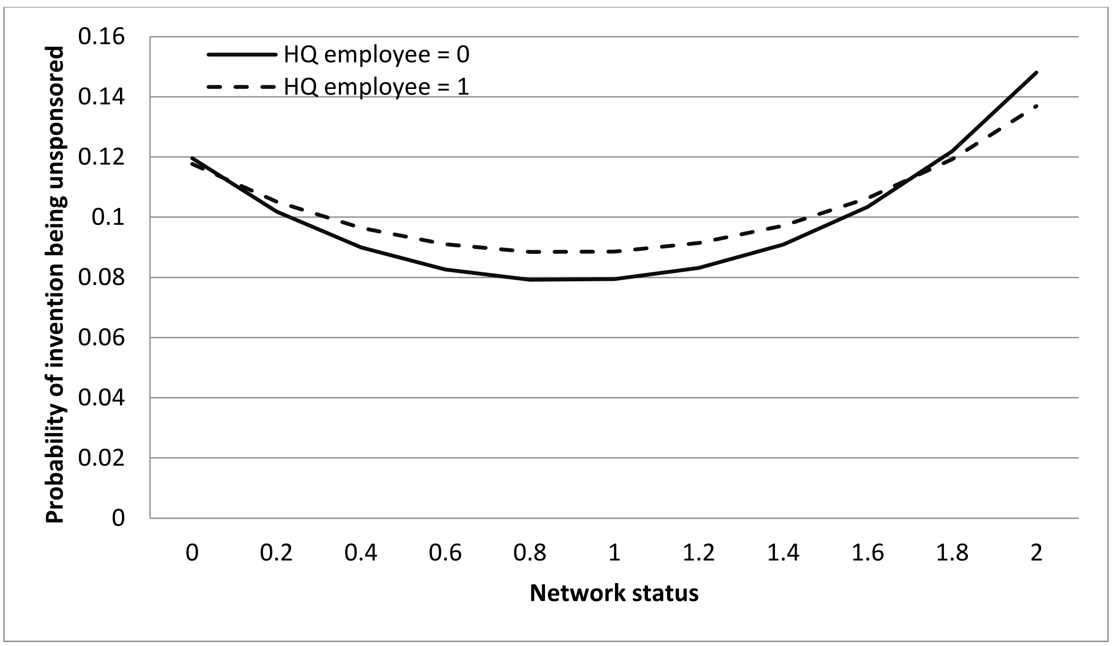
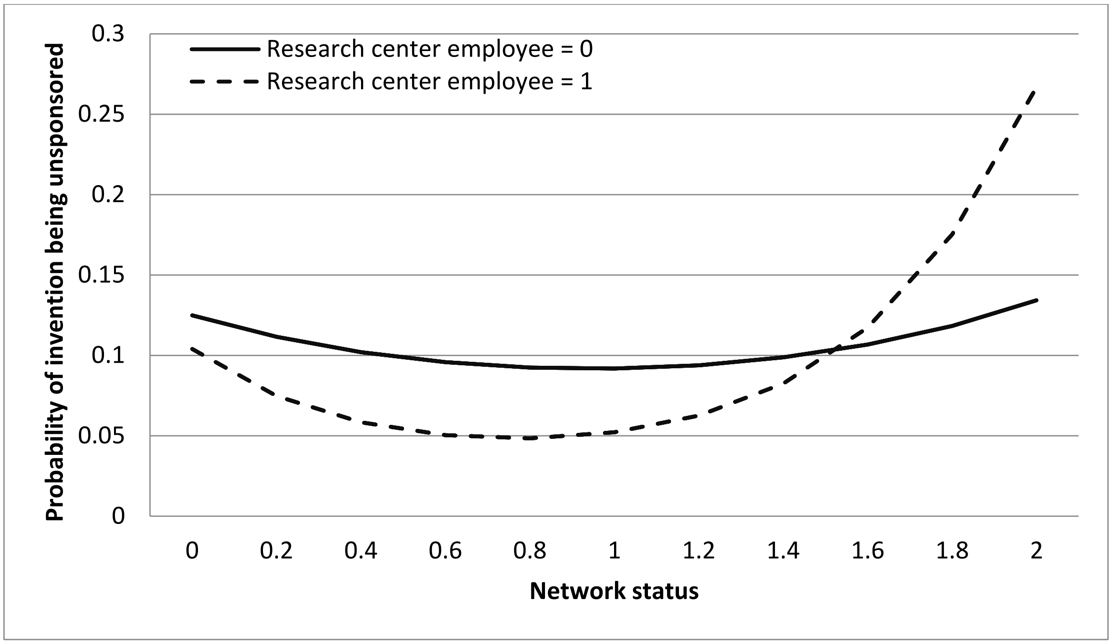


Figure 5: Interaction between network status and research center employee



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