Progressing to the Center: Coordinating Project Work

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Project forms of organizing are theorized to rely upon horizontal as opposed to vertical lines of authority, but few have examined how this shift affects progression—how people advance in an organization. We argue that progression without hierarchy unfolds when people assume lateral authority over project tasks without managing people. With a longitudinal study of a mature, collectively managed open source software project, we predict the individual behaviors that enable progression to lateral authority roles at two different stages. Although technical contributions are initially important, coordination work is more critical at a subsequent stage. We then explore how lateral authority roles affect subsequent behavior—after gaining authority, individuals spend significantly more time coordinating project work. Our research shows how people progress to the center as opposed to up a hierarchy, and how progression differs by stage and specifies the theoretical relationship between lateral authority roles and the coordination of project work.

Key words: coordination; project work; knowledge work; technical work; open source software; lateral authority; communities of practice; community project; technical community; community forms

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Introduction

Where we see a horizontal rather than a vertical authority… we [see] less of that kind of authority which puts one man over another… where each man decides for himself when he needs to discuss a matter with another.

—Mary Parker Follett (in Graham 1995, p. 187)

Theorists have long predicted that project work relies less on vertical lines of authority and more on horizontal modes of authority to achieve collective work outcomes (Barley and Kunda 2001, Daft and Lewin 1993, Miles and Snow 1986, Powell 1990). In scientific and technical industries, individuals frequently contribute to projects that span organizational boundaries and rely on horizontal authority to coordinate collective work (Fleming and Waguespack 2007, O’Mahony and Ferraro 2007, Rosenkopf et al. 2001, von Hippel and von Krogh 2003). Project forms of organization are not the only forms to rely on a horizontal rather than a vertical basis of authority. Horizontal authority is also relevant in matrix organizations, where project managers vie with function managers for the resources necessary to accomplish project tasks (Galbraith 1973, 1977). Organizations that are “self-managed,” such as academia and Congress, nominate, elect, or appoint a subset of their peers to serve in coordinating or governing roles that offer horizontal authority over tasks, but not necessarily over individuals (Hall 1996).

The question is, who gains horizontal authority, and how do they use it? We know little about how progression in organizations that rely on horizontal authority differs from progression in organizations that depend on vertical authority. Progression refers to advancement or progress and is typically measured by gains in responsibility or skill. On its face, the notion of progression without hierarchy might appear paradoxical—how can individuals advance in organizations that are relatively flat? We tease apart this paradox by showing that progression without hierarchy can be achieved when individuals “progress toward the center” (touching more areas of the project) as opposed to “up a career ladder” (managing more individuals). However, this type of progression differs from traditional notions of progression in critical ways. Traditionally, when individuals progress in organizations with internal labor markets, they move through positions that grant them increasing degrees of responsibility (Althauser 1989, Doeringer and Piore 1971, Osterman 1984) and often include vertical authority over individuals in the same system (Marcson 1960).

Recently, career theorists have argued that traditional notions of progression make several assumptions that no longer reflect workplace realities: (1) stable organizations in stable environments, (2) an intraorganizational focus, (3) career mobility from the standpoint of hierarchical positions, and (4) mobility within large organizations (Arthur 1994). Thus, career theorists have argued that competence, identity, achievement, and community may be critical to a conception of progression that does not depend on hierarchy (Arthur 1994, Ibarra 2004). However, few have empirically explored how progression might unfold in organizations that lack a strong vertical basis of authority.
Because our research examines a project that relies only on lateral authority, we use the term lateral authority as opposed to horizontal authority to indicate task-based authority, without necessarily inviting orthogonal contrast between horizontal and vertical systems. To operationalize lateral authority for empirical study, we define it as authority over collective work that does not include vertical authority over individuals. When individuals gain lateral authority, they gain responsibility and decision rights over a greater proportion of collective work without supervising others. For example, when projects depend on experts from multiple organizations (Powell 1990, von Hippel and von Krogh 2003), individuals at the center of such projects often coordinate collective work without necessarily “managing” the performance and careers of project contributors (e.g., Hargadon and Bechky 2006, Long Lingo and O’Mahony 2010).

Our research examines the behaviors that predict individual’s progression to successive positions of lateral authority and how progression, once achieved, affects subsequent behavior on a collectively managed open source software project. With longitudinal data of all project interactions over a six-year period, we analyzed the behaviors most likely to predict which individuals gained authority over the project’s collective work. Drawing from the literature on knowledge and technical communities, we tease apart the effects of three well-theorized behaviors: (1) technical contributions, (2) technical communication, and (3) coordination work. Our longitudinal data set offers a unique opportunity to view cohorts moving through two successive stages of progression and to parse which behaviors were more important at each stage. We found that although technical contributions predicted an individual’s progression at an early stage, they did not explain progression at a later stage, when coordination work became more critical. To explore how new authority roles, once gained, actually affected the coordination of knowledge work, we also examined how individual behavior changed once individuals assumed new roles.

Contrary to our informants’ expressed belief that new lateral authority roles would not change their behavior, we found an immediate post-progression effect: project members contributed significantly more effort to the project after progressing to lateral authority roles, most notably with respect to coordination work.

Our research provides theoretical traction toward understanding how progression occurs in organizational forms that rely on a lateral basis of authority. First, we refine and operationalize lateral authority in a way that permits others to build on it. In doing so, we offer a conception of progression that is more compatible with new forms of work organization (Smith 1997, Barley and Kunda 2004) than extant theories provide, showing how project contributors can progress by gaining authority over tasks as opposed to individuals. Second, a two-stage empirical model allows us to parse how progression mechanisms differ by stage. Activities that foster coordination on the project become more important as individuals gain authority over core project activities. Third, we show that the articulation of lateral authority roles fosters the coordination of collectively managed knowledge work and thus the sustainability of such systems. Together, these findings further our understanding of how collectively managed projects “self-organize”: lateral authority roles permit coordination activities that, left undone, might otherwise challenge such a project’s survival.

Lateral Authority and Progression

Follett is credited with coining the concept of horizontal authority in the late 1920s, when she made the argument that authority should not depend on one’s hierarchy of rank but where knowledge and expertise was closest—at the task level. Frustrated with the inefficiencies of command and control organizations, she noted that “the notion of horizontal authority has not yet taken the place of that of vertical authority. We cannot, however, succeed in modern business by always running up and down a ladder of authority” (Follett 1941/2003, p. 173). Few scholars would argue that effective leaders rely upon vertical authority alone to coordinate work. It is often reserved for terminating debates or settling disputes (e.g., Bennis 1959, Dalton 1959, Mintzberg 1973, Simon 1976). Simon (1976) acknowledged that authority could operate in a “sideways” manner, but the concept has remained nebulous. Contingency theorists took up the cause of “lateral connections” to help coordinate work—culminating in the matrix organization where both vertical (most often functional) and horizontal (most often product or project) bases of authority competed over the control of work (Galbraith 1973, 1977). Despite this early heritage, the neglect of lateral relationships has been a tradition in our field (Landsberger 1961). Little research has examined how organizational forms that lack hierarchical controls coordinate work (Okhuysen and Bechky 2009). Thus, although the idea of lateral authority is far from new, it is rarely applied in context.

If more knowledge work is likely to occur in project-based organizations that depend upon lateral authority (Powell 1990, Adler 2001, Barley and Kunda 2004, Adler and Heckscher 2006), then this has serious and underappreciated implications for opportunities for progression, as traditionally defined. Yet some scholars have recognized that when work is organized horizontally, opportunities for progression do not disappear. For example, scientific and technical professionals often seek progression in terms of knowledge, acumen, and skill rather than managerial positions (Zabisky and Barley 1996),
which can separate individuals from their chosen discipline (Goldner and Ritti 1967) and render their skill base obsolete (Rothman and Perrucci 1970). As a result, academics and practitioners have wrestled with the challenge of how to reward experts who do not seek progression to managerial authority, but seek alternative rewards such as greater autonomy (Bailyn 1991).

One solution is a “dual” career track, which allows specialists to achieve greater autonomy and status without assuming managerial responsibilities (Bailyn 1991, Katz et al. 1995). Instead of progressing along a managerial track, technical experts can receive equivalent status and rewards in a distinct but parallel technical track (Allen and Katz 1986). That is, “instead of greater authority, [technical experts] are rewarded with greater freedom to engage in their specialities” (Kornhauser 1963, p. 205). However, the degree to which dual-ladder career systems actually provided equivalent rewards was much debated (Goldner and Ritti 1967). Firms often diluted the “separate but equal” technical ladder by using it to reward individuals deemed unsuitable for the managerial track (Allen and Katz 1986).

Inspired by industrial research labs in the 1960s and 1970s, these scholars were at the forefront of understanding a key challenge for the 21st century—how to manage experts in knowledge-intensive industries (Powell and Snellman 2004) without managerial authority (Barley and Kunda 2004). However, this literature’s contribution has not been thoroughly mined because scholars in this tradition viewed the “challenge” of managing experts as a dyadic motivation/reward problem between managers and experts. How work was coordinated among experts was not explored. Barley and colleagues advanced in this direction by arguing that the infusion of technical work in more occupations would call for a horizontal organization of work (Barley 1995; Barley and Kunda 2001, 2004; Zabinsky and Barley 1996). In other words, “horizontally organized work…is focused less on power and more on expertise. In a horizontal system, different groups of practitioners jointly contribute their distinctive efforts to the execution of work tasks…collaboration rather than command, is the key to getting work done” (Zabinsky 1997, p. 130). Yet the antecedents and consequences associated with lateral authority remain unexplored. In contrast with the literature on technical careers, which promised experts greater autonomy over their own work, lateral authority provides individuals with increased responsibility over collective work. As opposed to examining separate but equal hierarchies, our research explores how progression occurs on a project that only depends on lateral authority, where progression is best conceptualized as movement toward the center.

**Communities and Knowledge Work**

Thus, we draw upon the literature on occupational communities and communities of practice that examines how individuals solve problems and share knowledge within informally constituted networks of shared practice that are not limited by organizational boundaries nor by vertical conceptions of authority (Bechky 2003, Brown and Duguid 1991, Van Maanen and Barley 1984, Wenger 2001). Although this literature typically examines communities from within the context of firms, it is still a relevant literature to inform our research because our focus is on how collectives coordinate knowledge work. From this literature, we identified three behaviors that could predict progression to a lateral authority role: the degree to which individuals engaged in (1) technical contributions, (2) technical communication, and (3) coordination work.

**Technical Contributions**

Individuals participate in knowledge communities to learn from each other (Wenger 1998) and close the gap between knowing and doing (Brown and Duguid 1991). Such communities depend on contributions from their members to attract participants and survive. Thus, individuals who contribute more technical contributions should be more likely to progress to positions of greater responsibility than those who contribute less (von Hippel and von Krogh 2003). By technical contributions, we refer to contributions to the “technical” core of a project’s work. For example, on a software project, a technical contribution would be working code.

There are several reasons why an individual’s technical contributions are likely to improve his or her chances for progression. First, other project participants may appreciate individuals who devote time and demonstrate significant effort toward project goals. Second, individuals may need to demonstrate a track record of project knowledge to gain authority to make decisions that affect more areas of the project. Project members may perceive individuals who make more technical contributions as more knowledgeable about project dependencies and thus as a more credible and trustworthy decision maker on projectwide affairs (e.g., Baldwin and Clark 2006, MacCormack et al. 2006). Finally, a number of scholars have suggested that individuals accumulate influence based on their ability to solve complex problems (von Krogh et al. 2003).

However, as Fleming and Waguespack (2007) suggest, there may be a threshold of contributions necessary to progress to a certain stage, after which technical project knowledge becomes less important. Much like traditional conceptions of managerial work (Mintzberg 1973), as individuals gain authority over collective work, they may find themselves engaged in more coordination work and less technical project work despite efforts to the contrary. Thus, although initially important, the importance of one’s technical contributions may dissipate at subsequent stages.
HYPOTHESIS 1 (H1). The technical contributions an individual initially makes have a positive effect on the probability of progressing to a lateral authority position, but this effect dissipates at subsequent stages.

Technical Communication
Not everyone may benefit directly from new technical contributions because one of the critical benefits of sharing knowledge is the ability to learn from others (Brown and Duguid 1991, Van Maanen and Barley 1984), which is more difficult to do after the work is completed. By engaging in collective problem solving, project members learn from modus operandi (the way a task appears in progress) as opposed to deconstructing opus operatum (what is visible after the task is finished) (Bourdieu 1990, Brown and Duguid 2001). Thus, posing and answering questions as the work is performed is essential to fostering learning (Bechky 2003).

When knowledge work is distributed, whether within an organization or outside it, engagement in conversational or discussion threads is the primary way in which individuals share knowledge and learn from each other on an ongoing basis (Orlikowski and Yates 1994, Yates et al. 2003). A conversational thread is “a stream of conversation in which successive contributions continue a topic, following an initial contribution which introduces a new topic” (McDaniel et al. 1996, p. 41). Because a discussion thread allows others to build on it, those who share their experiences and answer technical questions may gain the respect of their peers. Thus, individuals who are more active in technical discussions may be more likely to progress to positions of lateral authority than those who are less active.

HYPOTHESIS 2 (H2). Individuals who contribute more to technical discussions will have a greater probability of progressing to lateral authority positions than those who contribute less to technical discussions.

Coordination Work
Coordination has been defined as managing interdependencies to achieve collective goals (Crowston 1997, Mintzberg 1973) and is a central purpose of organizations. Coordinating individual contributions to achieve a collective outcome is an ongoing challenge for all organizations (Galbraith 1973, 1977; Lawrence and Lorsch 1967; March and Simon 1958) but can be an even greater challenge if project members are distributed (Sproull and Kiesler 1991), from different organizations (Hinds and Bailey 2003), or engaged in work that involves the manipulation of symbols (Okhuysen and Bechky 2009). Organizational forms that “operate completely outside of traditional boundaries . . . create challenges for integration” (Okhuysen and Bechky 2009, p. 495) because they may not share the same norms, cultures, tools, or languages (Hinds and Kiesler 2002).

In addition, large complex projects are often disaggregated into more manageable modules or subprojects (Baldwin and Clark 2006). The more differentiated the subsystems, the more difficult their integration (Lawrence and Lorsch 1967). Many subprojects can fragment knowledge if efforts to integrate them into a coherent whole are not made (Mintzberg 1973). To foster integration, technical tools can prevent individuals from working on the same thing at once and enable tracking of project activities. These systems foster shared understanding of the work completed and provide accountability as to who has accomplished what task—two elements critical to the coordination of work (Okhuysen and Bechky 2009). With standardized interfaces to organize the receipt of contributions from different parties, such systems help manage planned interdependencies (Thompson 1967) but provide little visibility as to work in progress. Thus, technical tools may not be sufficient to deal with unplanned or emerging contingencies. If there is no specified role for fostering integration, there may be an unmet need for coordination work. Follett predicted that “legitimate authority comes from coordination” (Graham 1995, p. 150). Thus we suspect that those who take on coordination work may gain the confidence, trust, and respect of others on the project and be more likely to progress to a position of lateral authority.

HYPOTHESIS 3A (H3A). Individuals who engage in more coordination work will be more likely to progress to positions of lateral authority.

When coordinating work in progress, the coordination mechanism that may be most critical is the ability to share knowledge across subproject boundaries (Galbraith 1973, 1977). In organizations, boundary spanning has been found to enhance innovation (Tushman 1977) and foster career progression (Katz and Tushman 1983). Individuals who span subproject boundaries may help transfer knowledge (Hansen 1999), identify new ideas (Allen 1977, Hargadon and Sutton 1997), enhance awareness of the broader project environment (Ancona and Caldwell 1992), and expose unattended or unidentified project interfaces (Sosa et al. 2007). To coordinate individual contributions, individuals need to share knowledge gained from other parts of the project (Fleming and Waguespack 2007). Thus, we suspect that individuals who engage in more boundary spanning work may also be more likely to progress to positions of lateral authority.

HYPOTHESIS 3B (H3B). Individuals who span more subproject boundaries will be more likely to progress to positions of lateral authority.

Consequences of Lateral Authority Roles
To further theory that specifies the relationship between lateral authority and the coordination of knowledge
work, we were interested not only in the antecedents that predicted progression but also in the consequences of assuming such a role. Moving into a new role may trigger new norms and expectations as well as new resources with which to fulfill those expectations (Turner 1986). Furthermore, the articulation of role structures is another means by which coordination can occur—particularly in project-based organizations that lack hierarchical coordination structures (Bechky 2006). Individuals often use role structures to coordinate their behavior and avoid errors in high-reliability organizations (Weick 1993, Weick and Roberts 1993). Even temporary projects, such as film sets, provide structure through the continuous enactment of role expectations (Bechky 2006).

Progressing to a role that offers a clear basis of lateral authority may foster an individual’s ability to engage in coordination work by granting them the legitimacy to do so, by providing them with more information about the project, by communicating role expectations, or by simply resolving ambiguity over who has authority over what. All of these mechanisms may be at play, prompting individuals who assume lateral authority roles to use these roles to further coordination work.

HYPOTHESIS 4 (H4). After progressing to positions of increasing authority, individuals will increase their effort devoted to coordination work.

Our longitudinal data set of 24,694 people contributing to an open source software project over six years allows us to determine whether technical contributions, technical communication, or coordination work were more likely to predict progression to a lateral authority role and to examine how an individual’s behavior changed in each of these areas after assuming such a role.

Research Setting

Because understanding project forms requires detailed, contextually sensitive data (Barley and Kunda 2001), we first describe our research setting and then explore how lateral authority and progression were operationalized in this context. We selected an open source software project for study because these projects are collectively managed, operating without vertical authority (Lakhani and von Hippel 2003) and relying almost exclusively on horizontal authority (von Krogh and von Hippel 2006). Open source projects are collectively managed if they are independent, pluralistic, representative, and embrace decentralized decision making and autonomous participation (O’Mahony 2007, p. 144). Wikipedia is a well-known collectively managed project. We conducted over a dozen ethnographic interviews prior to our quantitative analyses and drew from numerous reports, articles, and archival information to inform our description of the research setting.

GNOME, the open source software project we study, develops a user-friendly desktop application that provides a Windows-like environment for Linux and a platform for developing applications that integrate with the desktop. Because the project had operated successfully since 1998, it provided the opportunity to explore phenomena that might be less available in more nascent settings. Like other open source software projects, GNOME had recently developed an organization with new roles, allowing us to follow cohorts moving through successive stages of this system. Finally, this setting offered compatible longitudinal data from multiple data sources to test our hypotheses.

Within two years of inception, several thousand individuals from all over the world expressed interest in contributing to the GNOME project. With rapid growth, a number of individuals began to voice concerns as their ad hoc mode of organizing showed signs of strain. As one founding member recalled, “There was no formal decision making, you just had this sort of total chaos... there was nobody that could just come in and say... let’s work it out and then decide, this is what we’re gonna do, because there was no way to make a decision, there was no one in charge.”

After much discussion on project mailing lists, project members created a nonprofit foundation (e.g., O’Mahony and Bechky 2008) to help the project manage its increasing scale:

When GNOME was a smaller project, [the founder or the community] was able to make most of the key decisions... We need a more structured environment to smoothly integrate new citizens into the community... The foundation will provide a forum that is elected by the GNOME community, that is accountable to that community, and that will conduct its affairs in the open.

(GNOME Foundation 2000)

The foundation provided a way to formalize membership roles and help foster decision making, but how this would unfold was unspecified. As one informant recounted, “Most projects have a very well-defined hierarchy, technical hierarchy. So, at some stage someone says, ‘Yes it goes in’ or ‘No it doesn’t.’... And in GNOME that last stage is missing. Now we have the foundation.”

Lateral Authority in Context

With the foundation’s launch, project members designed two new lateral authority roles: foundation members and a board of directors. Both roles provided lateral authority as they gave project contributors responsibility for more domains of the project’s collective work without granting them authority over individuals. As the project founder emphasized, even with this new structure, “All the technical decisions are still in the hands of the developers.” Contributors remained free to work on areas of interest to them and to withdraw from the project at
any time. Project members recognized the need for new roles to coordinate their work but preferred these roles to be limited: “[We] do not like bureaucracy or authority or anything like that right? But...at some point you have to have some level of organization if you’re going to get all those interests pulling in the same direction.” With some ambivalence toward authority in general, project members provided minimal definition for these new roles, leaving much latitude as to how individuals would interpret them. Our longitudinal, quantitative analysis allows us to explore how new lateral authority roles were enacted. This collectively designed system provides two unique affordances for advancing authority: (1) it offers an opportunity to examine how a lateral authority system operates in the absence of vertical authority, and (2) it permits examination of progression as determined by peers as opposed to by those in higher positions of authority. When vertical authority is stripped away, a more precise theoretical delineation of lateral authority can be revealed.

Methods

We examine the antecedents predicting two successive stages of progression (foundation member and board director) and thus run two separate models for each dependent variable.

Dependent Variables

**Progression Stage 1: Project Member.** To become a member, individuals apply to a volunteer membership committee by listing their contributions to the GNOME project when they have accomplished a “nontrivial contribution,” defined as “any activity which contributes to the development of the project at a level significantly above that expected of a normal user or fan of GNOME” (Friedman 2002). The committee reviews applications as they are received and makes decisions based on membership guidelines set by the board of directors. Once granted, membership must be renewed every two years. Membership grants individuals lateral authority by offering them the right to (1) admit new members, (2) nominate and elect a board of directors, and (3) decide on software release criteria. Members exercise these rights vigorously—whereas the first two areas occur only at a few times a year, members voice their opinion on release criteria throughout the year and can attend members-only meetings. A class of members provided the project with a way to recognize those committed to the project. As one board director explained, “We get twenty people a day saying ‘I’m going to do this, or I want to do this,’ you know? People try to get involved and it’s just too many people. There is no way we can deal with them. And the fact is 99% of those people disappear after two weeks...about 1% actually end up becoming valuable contributors.”

We measured new member\(_i\), with a binary variable taking the value 1 if individual \(i\) in year \(t\) became a new member in the foundation. We cross-checked website data with information from the mailing list and membership applications from 2000 to 2005 to ensure reliability. We focused only on new members and dropped observations after an individual was subject to membership renewal because we were only interested in predicting the first year a person received membership. This provides a conservative test of our hypotheses because the likelihood of renewing membership is very high once becoming a member. The alternative approach using membership renewal yields similar results.

**Progression Stage 2: Board Director.** The next stage of lateral authority is an elected board director position. Foundation board directors move “toward the center” by gaining the right to make decisions regarding the project’s assets and resources and gaining the ability to represent the project to the public. Rather than a move to the center of the project’s technical core, these rights allow board directors to move toward the center by affecting more areas of the project than either members or nonmembers could. For example, the board of directors can grant companies permission to use GNOME’s brand and trademarks, push the project to close on a specific release date, fund a technical conference, and shape the technical direction and policies of the project. As one board director explained, “It’s not really feasible to have all several hundred GNOME developers vote on every little thing that comes up, you don’t just want to have direct democracy there, so the compromise we came to was this board who would be elected by them [the members] that would sort of take care of the day to day details.” At the same time, members recognized that the board did not gain authority over individuals—a distinguishing feature of lateral authority: “It’s not like the board can tell several hundred developers what to do...we’re all just volunteers, so there’s some cat herding going on.”

Because only foundation members can be nominated for the annually elected board of directors, the second level of progression is conditioned on the first. As a result, the data set we use to predict the board directors is smaller than the one used to predict new members. To predict the probability of being elected to the board of directors, we measured board director\(_i\), with a binary variable taking the value 1 if an individual \(i\) was elected in year \(t\). For these two dependent variables, we retrieved all election data from the foundation’s creation in 2000 to the year 2005. We defined individuals as entering the population the year they sent at least one e-mail to a mailing list. Individuals were dropped from the analysis if no further interactions ensued after two years because some individuals contributed once or twice and then remained inactive, and our interviewees did not consider these individuals part of the community.
Independent Variables
To test our hypotheses, we combined multiple sources of information into a new database. Multiple sources of data help to avoid common method bias. More specifically, our independent variables are derived from four primary sources: (1) the project’s website, (2) mailing list archives, (3) the concurrent version system (CVS) (which manages the checking in and out of software source code), and (4) the bug database, Bugzilla (which tracks the identification and resolution of technical problems in the source code). We used data from 1999 to 2004 to predict outcomes from 2000 to 2005.

To obtain a list of all individuals that contributed to the project, we downloaded all of the 387,626 e-mails sent to project mailing lists between 1999 and 2004 to our database. These data included information about the e-mail of the sender, date, subject, message content, who the sender responded to, and a conversation thread identifier. Unique individuals were identified first by their e-mail addresses and second by checking whether the same individual owned two e-mail addresses. Different ways of writing the same name were manually accounted for by checking alternatives (compare Linus Torvalds; L. Torvalds; Torvalds, Linus). This procedure resulted in a set of 24,694 unique individuals who sent at least one response to any mailing list during the time of study.

A mailing list is a simple communication technology that broadcasts an e-mail to a list of subscribers signed up to that particular list. GNOME has 28–137 mailing lists, depending on the year, targeting different areas of the project. Each list is a subcommunity focused on a subsection of the project. For example, one mailing list is devoted to a tool for profiling memory usage and finding memory leaks. Individuals identify the mailing lists appropriate for their queries and avoid posting messages to multiple lists as “cross-posting is discouraged.” Prior research has noted the importance of mailing lists in communities and projects (Kuk 2006, Lee and Cole 2003) but has typically only investigated a fraction of all interactions.

Our analysis is based on the project’s complete communication venues: all 137 mailing lists active between 1999 and 2004. Mailing lists that contained only automated updates were deleted because they did not represent opportunities for interactions among individuals. Because this project was globally distributed, these data enable the tracking of all interactions within all of the community’s primary communication networks. Initiating discussions, posting questions, and responding to mailing list queries are vital contributions to the community’s efforts to develop, maintain, improve, and foster the usage of their software. We also downloaded all commits of source code to GNOME’s CVS to our database to develop measures of technical contribution. CVS tracks changes in source code and reveals when an individual submitted a source code change, in what directory, and the nature of the contribution. We downloaded data for the 1,146 individuals that contributed 1,915,085 technical contributions from 1999 to 2004. We draw from all of these data sources to measure three types of antecedents for progression: (1) technical contributions, (2) technical communication, and (3) coordination work.

Technical Contributions. We measure technical contributions by the number of code commits, submitted by individual i in year t from individual submissions of source code checked in the CVS. Source code that has been checked in CVS has gone through the community’s peer review process, where individuals evaluate the code to see whether the contribution constitutes an improvement to the code base. We derived an alternative measure by counting the number of resolved bugs, submitted by individual i in year t in the Bugzilla database. Because the distribution was heavily skewed, we took the natural log for many of these measures. Because zeros exist, we added one to all these measures before the natural log.

Technical Communication. We content-coded the 137 mailing lists used by the GNOME community to distinguish different types of project activities. We sampled messages on each list to determine the list’s focus of conversation and consolidated our codes into two basic categories of theoretical interest: technical discussions and coordination work. The bulk of the mailing lists (between 96.5% and 99.5%, depending on the year) was focused on technical discussions. Because measures of both the initiation and responses to mailing list discussions were highly correlated, we selected one measure to avoid multicollinearity concerns. We selected responses to threads as opposed to the initiation of questions, as responses were more likely to be indicative of progression. We measured individuals’ number of responses to technical discussions, by counting the number of responses individual i posted in year t.

Coordination Work. Two technical systems helped coordinate software development. The CVS system coordinated work by communicating code changes after they were submitted, and the Bugzilla system coordinated work by showing which tasks were resolved or left unresolved. Although these two systems helped project contributors manage interdependence within well-defined areas, there were few feedback mechanisms in place to foster the mutual adjustment needed to manage ongoing interdependence across subproject boundaries (Thompson 1967). Thus, we measured coordination work in two ways: engagement in coordination discussions and boundary spanning.

Coordination discussions. Mailing lists coded as coordination discussions focused on organizing projectwide affairs such as code releases, conferences, the project
website, or the foundation’s governance. A very small percentage of all communication within the community was devoted to coordination (never reaching 3.5% in any given year). Thus, obtaining significant results may constitute a very stringent test of the importance of coordination work. We measured individuals’ number of responses to communication boundary spanning, by counting postings to the coordination mailing lists for individual \( i \) in year \( t \).

Boundary spanning. We measured two types of boundary spanning: technical boundary spanning and communication boundary spanning. With CVS data, we measured an individual’s breadth of technical boundary spanning, by the number of subprojects to which individual \( i \) contributed source code divided by the overall number of subprojects in year \( t \). Technical boundary spanning differs from technical contribution, which measures an individual’s raw count of technical contributions—all of which could be directed to one specific module. Those with a higher technical boundary spanning score are more likely to obtain general project knowledge than those specializing in a single technical area. With mailing list data, we also measured an individual’s breadth of communication boundary spanning, by the number of mailing lists an individual \( i \) posted a message to in year \( t \) divided by the overall number of mailing lists in year \( t \). Whereas the first measure of boundary spanning indicates the proportion of the project’s technical subcomponents touched or modified by an individual, the second measure indicates the proportion of the project’s communication venues in which an individual participated.

Control Variables

Number of Ties. Because individuals who hold more structurally central positions within a social network are more likely to enjoy greater influence than those at the periphery of the network (Brass 1984) and to be promoted within organizations (Burt 1992, 2004), we controlled for an individual’s structural centrality in the project’s network.

To obtain a measure of the number of ties with other project contributors, maintained by an individual \( i \) in year \( t \), we counted the number of participants an individual interacted with in shared threads across all of the mailing lists. Following Freeman (1979), we used degree centrality, which measures the number of individuals an individual is connected to in the network. Because there is a tendency for ties to weaken and dissolve over time (Burt 2000), the probability of tie decay increases over time. We experimented with different tie decay rates of one to three years, and because we obtained very similar results, used a tie decay rate of one year. We developed several definitions of a tie using both directed and undirected networks. We constructed networks showing who responded to whom to obtain directed ties to derive in-degree centrality measuring the number of individuals that send an e-mail directed to an individual \( i \) in year \( t \). We also measured out-degree centrality by measuring an individual \( i \)’s interactions with other individuals in the community in year \( t \). The undirected network and the directed network measures were very correlated (>0.87 for different degree centrality measures). In reading conversation threads, we discovered that many individuals responded to the initial message of a thread. Because this suggested that all responders to a thread initiated were thus connected and because the average number of messages per thread was small (387,626 e-mails/127,046 conversation threads = 3.05 e-mails per thread), we used undirected ties.

In the variable reported, we created a two-mode network (Wasserman and Faust 1994) with two distinct sets of social entities: (1) the authors of the e-mails and (2) the conversation threads in which these individuals interacted. We converted the two-mode data to one-mode data, representing interactions among individuals in one thread. In other words, we assumed that individuals interacting in the same thread have a tie and represent a fully connected clique (Newman 2001). When converting to a one-mode data set, directionality is omitted, and ties are treated as symmetric.

Location. Individuals taking part in open source projects are often distributed across geographical boundaries (e.g., Hinds and Bailey 2003). However, as shown by O’Mahony and Ferraro (2007), face-to-face interaction can be important. Working with the data available, we controlled for whether location influenced the possibility of gaining authority by coding whether an individual was geographically located in the United States. To do so, we examined the time zone of sent e-mails and their domain. We checked various secondary data on the GNOME website to develop this measure and also distinguished between individuals from South America and North America.

Tenure. Because more-experienced individuals were likely to have richer communication and collaboration networks and, by extension, be more knowledgeable about the project and how to gain lateral authority (Pearce 1993), we controlled for an individual’s tenure. We measured tenure, by the number of years of activity in the GNOME mailing lists for each individual \( i \) in year \( t \).

Corporate Affiliations. Some individuals may be paid by firms to work on the project and thus spend more time on the project than volunteers (Dahlander and Wallin 2006), which could affect their chances of progression. Using e-mail data, we coded whether an individual sent at least one response from a firm in any given year. We identified whether contributors had an affiliation with a
start-up, i.e., a firm whose business model is based on GNOME, or an affiliation with an incumbent, i.e., an established firm participating in the GNOME community. These measures were coded for individual i in year t to control for any progression effects that might stem from an individual’s corporate affiliation.

Results
The GNOME community underwent incredible growth during the time of our study with the number of individuals participating in the project almost doubling. E-mail volume followed a similar trend, increasing from 38,428 in 1999 to 80,963 in 2003. With this increase in scale, the number of subcommunities also increased dramatically—from 28 in 1999 to 119 in 2004.3 Increased specialization within the project led to less communication within each subcommunity. The mean e-mails per subcommunity decreased by almost half, from 1,372.4 in 1999 to 638.9 in 2004. Thus, during this time, the community became larger and more specialized. The number of commits, or contributions of source code, increased during the first two years of our study, with a peak of 381,602 commits in 2001, and declined slightly thereafter, although the number of individuals committing code continued to rise. In 1999, 287 individuals committed code, doubling to 577 individuals in 2004. Over the course of the study, 1,146 individuals committed source code—far fewer than the 24,694 individuals who contributed to project mailing lists. These data illustrate different degrees of participation, with larger numbers contributing to project discussions, smaller numbers contributing code, and still smaller numbers yet achieving membership or a board director position.

The Antecedents of Lateral Authority
We developed panel data with yearly observations for all individuals. We used a one-year lag for the independent variables in the specification of models to test whether behavior at time \( t - 1 \) influenced the likelihood of becoming a new member or board director at time \( t \). Thus, the independent and control variables begin in 1999, the year before members began to be appointed and board directors elected. Becoming a member of the foundation is dichotomous with a very skewed distribution: there are a much larger share of zeros than ones, because only a small proportion of contributors become members. Logistic regressions assume that distributions are symmetric—that there are similar shares of zeros and ones (Greene 2000)—which does not suit our data. To address this problem, we adopted a random-effects complementary log-log model, which fits maximum likelihood models with dichotomous dependent variables. Complementary log-log models are discrete-time survival models with a proportional hazard assumption (Wooldridge 2002).4 For predicting elected board directors, the skewed distribution of zeros and ones were less pronounced, so we used a random-effects logistic regression for this model.

Hausman et al. (1984) advised testing to assess whether a random- or fixed-effects approach is suitable for panel data. There are two reasons why a fixed-effects model is not applicable. First, the complementary log-log model used in the analyses has no command for a conditional fixed-effects model because there is not a sufficient statistic that would allow the fixed effects to be conditioned out of the likelihood. Second, with the asymmetric distribution of zeros and ones, there is little variation in the dependent variable, which would result in many observations dropped from the analyses. Following Greene’s (2000) advice, when using random effects, we account for possible unobserved heterogeneity by including time-invariant control variables.

There are some high correlations between the independent variables. We therefore conducted several assessments to avoid problems of multicollinearity for both our complementary log-log and logistic regressions. Because the primary concern with multicollinearity is among the independent variables, the functional form of the dependent variable is less relevant (Menard 2002). This suggests that one can adopt methods associated with ordinary least squares (OLS) regressions, such as variance inflation factors (VIFs). The highest VIF score was 3.5, and the average score was 2.1, well below the generally accepted threshold level of 10 (Greene 2000). Second, we stepwise included the independent variables to assess how each one altered our results. The effects were stable across the different regressions, suggesting that multicollinearity was not an issue (Menard 2002). Third, we randomly omitted 20% of the sample and created three subsamples and reran the analyses. If multicollinearity was a problem, coefficients would differ dramatically even with small changes in the sample (Greene 2000). These sensitivity analyses provided strong support for our results. Given these three tests, we are confident that multicollinearity is not a problem for our analyses. Because each level of progression is a different dependent variable, we present the full set of results for all hypotheses at each step of progression separately, moving from (1) becoming a member to (2) becoming elected to the board of directors. Tables 1 and 2 present the descriptive statistics for becoming a new member and board director, respectively. Because only current members can be elected to the project’s board of directors, the appropriate population for analysis in Table 2 is foundation members as opposed to all individuals who have contributed to the project.

Progression Stage 1: Becoming a New Member. The first five columns in Table 3 report the results from the random-effects complementary log-log regressions, predicting new member at time \( t \) as a function of the independent variables and control variables at time \( t - 1 \).
All continuous independent and control variables are standardized in the regressions (mean = 0, standard deviation = 1). Dummies are not standardized because it is not meaningful to think about a one standard deviation change for these variables. Model 1 is the baseline model including only the control variables. In Model 2, we include the two variables measuring technical contributions. Model 3 adds the variable measuring technical communication, and the final model, Model 4, includes our three coordination variables. We use Model 4 to interpret our results.

Technical contributions are important in predicting membership, as our two measures, *number of commits* and *number of resolved bugs*, are both positive and significant. The more code an individual contributes and has accepted by peer review, the more likely that individual is to gain lateral authority. This strong, significant effect indicates that making technical contributions valued by the community is necessary to become a full-fledged member of the community. This lends support to H1—technical contributions are initially important in gaining lateral authority.

### Table 1 Descriptive Statistics for New Member Data Set (n = 74,249)

<table>
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<td></td>
</tr>
<tr>
<td>No. of responses to coordination discussions</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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</tr>
<tr>
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<tr>
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<td>−0.02</td>
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### Table 2 Descriptive Statistics for Board of Directors Data Set (n = 1,619)

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<th>12</th>
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<td></td>
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<td></td>
</tr>
<tr>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>No. of responses to technical discussions</td>
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<td>0.42</td>
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<td></td>
<td></td>
<td></td>
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</tr>
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</tr>
<tr>
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<td></td>
</tr>
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<td>No. of resolved bugs</td>
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<td>2.483</td>
<td>0.093</td>
<td>0.028</td>
<td>3.333</td>
<td>0.599</td>
<td>191.56</td>
<td>0.555</td>
<td>0.140</td>
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<td>1.558</td>
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<td>Std. dev.</td>
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<td>0.934</td>
<td>1.864</td>
<td>0.084</td>
<td>0.065</td>
<td>3.210</td>
<td>1.073</td>
<td>313.98</td>
<td>0.497</td>
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</table>
Hypothesis 3: Coordination

Table 3 Antecedents of Lateral Authority: Predicting Progression to Membership and Board Director Roles

<table>
<thead>
<tr>
<th>Hypothesis 3: Coordination</th>
<th>New member</th>
<th>Board director</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of responses to coordination discussions</td>
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<td>0.101*** 0.0968**</td>
</tr>
<tr>
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<td>-0.0364 -0.041</td>
</tr>
<tr>
<td>Technical boundary spanning</td>
<td>0.429***</td>
<td>0.297*** 0.293***</td>
</tr>
<tr>
<td></td>
<td>-0.0526</td>
<td>-0.0946 -0.0864</td>
</tr>
<tr>
<td></td>
<td>0.0345</td>
<td>-0.0962 -0.0964</td>
</tr>
<tr>
<td></td>
<td>-0.0299</td>
<td>-0.0629 -0.063</td>
</tr>
</tbody>
</table>

Hypothesis 2: Technical communication

| No. of responses to technical discussions | 0.592*** 0.449*** | 0.495*** 0.151 0.134 |
| No. of responses to communication discussions | -0.0575 -0.0639 | -0.158 -0.169 -0.184 |

Hypothesis 1: Technical contribution

| No. of code commits | 0.830*** 0.655*** 0.623*** | 0.174*** 0.0832 0.112 0.0963 |
| No. of resolved bugs | -0.0264 -0.0302 -0.0313 | -0.0692 -0.0732 -0.0778 -0.103 |
| | -0.0375 -0.0353 -0.0368 | -0.0618 -0.062 -0.0601 -0.0603 |

Control variables

| No. of ties with other project contributors | 0.644*** 0.455*** 0.178*** 0.0528 | 0.136*** 0.112*** 0.049 | -0.0649 -0.0603 |
| Location | 0.388*** 0.529*** 0.411*** 0.409*** | 0.411 0.443 0.346 | -0.00286 -0.0148 |
| Affiliation with start-up | -0.153 -0.16 -0.156 -0.163 | -0.546 -0.568 -0.573 -0.529 -0.533 |
| Affiliation with incumbent | 4.762*** 2.108*** 1.905*** 1.823*** | 0.88 0.716 0.545 0.69 | 0.674 |
| | -0.573 -0.639 -0.535 -0.589 | -0.587 -0.603 -0.613 -0.58 -0.585 |
| | -0.767 -1.075 -1.501 -1.238 | 0.121 |
| Tenure | 0.440*** 0.633*** 0.517*** 0.601*** | 0.0322 -0.00986 -0.0267 -0.419 -0.438 |
| | -0.133 -0.127 -0.128 -0.129 | -0.323 -0.332 -0.336 -0.34 -0.351 |
| | 0.0387 0.0391 0.039 0.0392 | 0.0391 -0.039 0.0391 -0.039 0.0391 |
| | -0.001 -0.01 -0.01 -0.01 | -0.001 -0.01 -0.01 -0.01 |
| Inverse Mills ratio | | | | | | -0.147 -0.619 |

Year effects

| Year included | 0.328*** 0.980*** 0.961*** 1.023*** | 5.435*** 6.296*** 7.254*** 6.600*** 6.341*** |
| | -0.22 -0.243 -0.288 -0.308 | -0.931 -1.076 -1.202 -1.068 -1.519 |
| No. of individual years | 74.249 74.249 74.249 74.249 | 1.619 1.619 1.619 1.619 | 1.619 1.619 | 1.619 1.619 1.619 |
| No. of individuals | 24.694 24.694 24.694 24.694 | 616 616 616 616 | 616 616 616 |
| Degrees of freedom | 10 12 13 16 | 10 12 13 16 | 10 12 13 16 |
| Log likelihood | -2.817 -2.312 -2.260 -2.196 | -199.8 -186.3 -180.8 -168 -168 |

Note. Standardized coefficients are reported.

**p < 0.05; ***p < 0.01 (two-tailed test).

We tested H2 by investigating an individual’s contributions to technical discussions. The coefficient for number of responses to technical discussions is positive and significant, lending support to H2: individuals that contribute more to technical discussions are more likely to become members. In supplementary analyses, we also investigated the number of new discussion threads initiated, but this was insignificant.

We tested the first coordination hypothesis (H3A) with the number of responses to coordination discussions. The coefficient is positive and significant at the 1% level lending robust support for H3A. Despite the fact that coordination discussions are a small percentage of all project communications, the more an individual responds to coordination discussions initiated by others, the more likely they are to be awarded with project membership. We also tested the importance of boundary spanning behavior (H3B) with two different measures: communication boundary spanning and technical boundary spanning. Whereas the communication boundary spanning is significant at the 1% level, the technical boundary spanning is insignificant. Together, these results show that engagement in coordination work is an important predictor of membership—although technical boundary spanning is unimportant.

It is worth noting the strong significant negative effect on the baseline coefficients when predicting both members and board of directors. This suggests that the...
baseline probability of gaining lateral authority is low for becoming a member or a board of director.

Progression Stage 2: Becoming Elected to the Board of Directors. The last five columns of Table 3 present random-effects logistic regression estimates of individuals’ likelihood of becoming elected to the board of directors at time t, as a function of the independent variables and control variables at time \( t - 1 \). Model 5 is the baseline and includes only the control variables. In Models 6–8, we stepwise include the independent variables. Because becoming a board director is conditioned on being a member of the foundation, it is possible that the selection of becoming a member also affects the likelihood of becoming a board director (e.g., Heckman 1979). To account for this possibility, we developed the Inverse Mills ratio from the first models predicting membership and include this in the models predicting the board of directors. This variable is included in Model 9 but is insignificant.

Unlike our regression results predicting membership, the results reported in the last five columns of Table 3 provide no support for technical contribution as an important predictor of progression to board director. Hypothesis 1 posited that technical contributions are initially important to gaining lateral authority but dissipate over time. Because the technical contribution variables—number of code commits and number of resolved bugs—are insignificant for becoming an elected board member but positive for becoming a new member, these combined results lend support to H1.

Hypothesis 2 posited that engagement in technical communication would predict progression. When the number of responses to technical discussions is added to Model 7, it is significant at the 5% level, but this effect disappears when our three coordination variables are added in the full Model 8. Thus, we find no support for H2—technical communication is not an important predictor for progression to the board of directors, although it is for membership.

Model 8 in Table 3 provides strong support for both of our coordination hypotheses (H3A and H3B) for progression to board director. The coefficient for the number of responses to coordination discussions is significant at the 5% level, providing strong support for H3A. Individuals who engage in more coordination discussions are more likely to be elected to the project’s board of directors, despite the fact that such discussions are few. Our results for boundary spanning (H3B) are more nuanced. In support of H3B, the communication boundary spanning coefficient is positive and significant at the 1% level. Project members that engage in more communication venues are more likely to become board directors. However, technical boundary spanning is insignificant, which does not support H3B. The type of boundary spanning that is important to predicting progression at both member and board director levels is boundary spanning in communication venues rather than technical boundary spanning. Together, these results support our coordination hypotheses (H3A and H3B) at both stages of progression and offer some important refinements.

Endogeneity can emerge from different sources including reverse causality, self-selection, and omitted variables (Hamilton and Nickerson 2003). Our control variables control for the most important individual characteristics that could influence progression to lateral authority. First, given that our theoretical interest is who progresses on a project as opposed to who joins a project, any effects from an omitted variable that affected initial sorting into the community are negligible. Second, reverse causality should not be a problem, because we lag all independent and control variables to predict the probability of gaining lateral authority in the following year. Third, because the system was newly designed, participants were not likely to “game” the system by behaving like members before becoming members. During the first two years, when we observed the independent variables, the foundation was not in place, and there was no membership criteria. Logically, therefore, individuals could not game the system because there was no a priori guidance on membership behavior. We did a sample split with the first two years separated from the last four and reestimated our models as a robustness check. If individuals prematurely behaved like members, we would expect the results to change. This was not the case. Thus, we conclude that endogeneity concerns do not bias our results.

Taken together, our results suggest that the criteria for entering into a social system are not the same as the criteria for managing that same system. To become a member, it is important to make technical contributions that are accepted by one’s peers, to resolve technical problems, and to respond to technical discussions. To be elected to the board of directors, the results are very different. Spanning communication boundaries and responding to coordination discussions are critical talents needed to garner the community’s confidence in a board director. These results help specify the types of behaviors that collectives reward with lateral authority. The question is, did people’s behavior change after gaining lateral authority? To address this, we explore the consequences of gaining lateral authority with differences-in-differences regressions at both levels of progression.

Consequences of Lateral Authority
To disentangle how people responded to new authority roles, we examined whether our independent variables changed after individuals acquired each type of authority role. To meaningfully compare individual behavior before and after progressing to each role, we focused
on those observations where we have data on the subsequent year (some individuals dropped out of the analysis and they were not observed after 2004). Table 4 compares individual’s behaviors before progressing to a member or board role with their behavior the year following. The third and seventh columns report the difference in behavior before and after progression and indicate significance with a simple t-test at the 5% level.

However, individuals that gained lateral authority could have changed their behavior because of other factors at the time of the treatment. Thus, we used a differences-in-differences approach to compare a treatment group (that gained authority) with a control group (that did not). This methodological approach has gained interest among social scientists in making causal inferences (see Morgan and Winship 2007 for a review) and has recently gained momentum in organization theory (e.g., Ding et al. 2008).

We matched individuals that became members with other individuals that did not, but still shared similar characteristics. The footnote for Table 4 provides a complete description of the matching and analytical technique. This analysis is focused on 547 individuals that became new members (the total sample therefore equals $547 \times 2 \times 2 = 2,188$ observations) and 28 individuals before and after being elected board director, as well as the control group of the same size ($28 \times 2 \times 2 = 112$ observations). With an identified control group to “difference out” confounding factors, we can isolate the treatment effect associated with gaining lateral authority (Bertrand et al. 2004). Columns 5 and 9 in Table 4 show the results from the differences-in-differences regressions for both dependent variables. To conserve space, we report whether the differences-in-differences coefficient was positive or negative at the 5% level for both members and board directors. A positive sign indicates that individuals that become members or board directors significantly increased that particular behavior (technical contribution, technical communication, or coordination work) within a year of assuming the position.

We found an immediate, significant change in behavior within a year of an individual gaining lateral authority relative to the control group. When individuals become members, they become increasingly active across all three categories (technical contribution, technical communication, and coordination work). Gaining even minimal lateral authority over project tasks results in intensification of effort to the project. Upon becoming a board member, individuals increase their coordination work and responses to technical questions, actually reducing their technical contributions to the project. These results suggest that gaining lateral authority has a dramatic effect on individual behavior—encouraging much more activity than exhibited one year prior. Although only members increased their technical efforts, coordination behavior increases at both levels. Because our preliminary field data suggested that our informants were quick to downplay the importance of these new authority roles, we were surprised by the magnitude of the behavioral changes we found. Lateral authority seems to give individuals license to help coordinate the increasingly specialized subprojects that formed in the project over time. It may seem contradictory to discover that clear authority roles enable coordination on a self-managed project, yet this discovery furthers our understanding of how collectively managed projects can sustain their efforts.

Discussion
Organization scholars have noted that when work is more likely to require the manipulation of information or knowledge (Barley and Orr 1997), horizontal forms of organizing such as project forms are more likely to emerge (Adler 2001, Barley and Kunda 2004, Adler and Hecktscher 2006). What is less recognized is that this type of transition is also likely to affect opportunities for career progression. Our research takes an important step toward explicating a different type of progression relevant for project-based organizations that operate with little to no hierarchy. Despite the fact that career theorists have noted that career theories are out of date with new workplace realities (Arthur and Rousseau 1996, DeFillippi and Arthur 1994), little research has connected changes in work organization with new modes of progression. The case for horizontal modes of progression (Zabuksky and Barley 1996) and for progression without managerial authority (Bailyn 1991) has been made. Yet the bulk of research has focused on the conflict that can occur as scientific or technical experts progress along a separate but equal track to a managerial hierarchy. Our research examined how progression occurred within a collectively managed project without this conflict, which permits a more precise examination of how lateral authority operates on its own.

Scholars have been slow to appreciate how collectively managed projects coordinate their efforts when formal vertical authority structures are not in place (Adler 2001, Adler and Hecktscher 2006, Okhuysen and Bechky 2009). The project we studied created two stages of lateral authority to help coordinate a rapidly scaling software project. The theoretical question we explored is, who progresses to new lateral authority roles? And, of equal importance, how do new lateral authority roles affect individuals’ subsequent behavior? We tested the relative importance of three different behaviors: (1) technical contribution, (2) technical communication, and (3) coordination work on a longitudinal data set that included two levels of progression. The ability to evaluate how cohorts move through stages of progression over time is rare in network research.

Our two-stage model allowed us to explicate how mechanisms change as individuals progress toward the
center. An individual’s technical contributions and technical communications explained progression to membership, but not to the board of directors. Technical problem solving is a “ticket of admission” to gaining lateral authority, but this effect dissipates at the next stage when coordination work becomes more important. Much like Congress or academia, although there is one set of criteria to enter the system, there is another set of criteria to gain your peers’ confidence in your ability to manage that same system. For example, professors who write the best papers may not necessarily be entrusted to become administrators. Finally, we were curious to know how lateral authority roles affected subsequent individual behavior. With a differences-in-differences approach, we found that individuals significantly increased their efforts to the project after gaining a position of authority, despite our informants’ willingness to downplay these new roles. Membership seems to deepen individual commitment and effort to the project, whereas board director roles trigger more coordination work. When no one is in charge, individuals may be reluctant to engage in coordination work for fear of violating project norms that value individual autonomy. In light of the project’s growth and increasingly fragmented subproject structure, lateral authority roles may have offered an important integrating mechanism that was missing previously.

Generalizability

We collected data that constituted a project’s comprehensive set of activities and interactions for a full six years with 24,694 people participating globally, but we acknowledge that this is only one project. More research is needed to assess the generalizability of our results. We coded project interactions focusing on three theoretical constructs of interest: technical contributions, technical communication, and coordination behavior. Future research could extend this understanding to the micro level by unpacking different types of coordination work. Data are not available to connect our data with longer-term career outcomes, but we suspect that progression in projects like the one we studied is correlated with other types of career success; future research could examine this link specifically. We studied a particular kind of project—one that was collectively managed and depended solely on

| Table 4 Consequences of Lateral Authority: Results from Differences-in-Differences Regressions Before and After Gaining Lateral Authority |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Variable                        | Before member   | After member    | Difference<sup>a</sup> | Diffs.-in-diffs.<sup>b</sup> |
| Technical contribution          |                 |                 |                               |                               |
| No. of code commits             | 395.3           | 605.5           | 210.2***                    | +                             |
| No. of bugs resolved            | 1.6             | 3.5             | 1.9**                       | +                             |
| Technical communication         |                 |                 |                               |                               |
| No. of responses to technical discussions | 31.4           | 51.4           | 20.0***                     | +                             |
| Coordination                    |                 |                 |                               |                               |
| Technical boundary spanning    | 0.0219          | 0.0280          | 0.0061*                     | +                             |
| Communication boundary spanning| 0.0618          | 0.0827          | 0.0209***                   | +                             |
| No. of responses to coordination discussions | 0.8             | 2.2             | 1.3**                       | +                             |
| Board director                  |                 |                 |                               |                               |
| Before elected                  | 2,539.3         | 1,834.2         | −705.1***                   | −                             |
| After elected                   | 4.6             | 5.3             | 0.7                         |                               |

<sup>a</sup>Difference between before and after gaining lateral authority and significance with \( p \)-test.

<sup>b</sup>Results from separate differences-in-differences regressions. These analyses are in support of H4.

<sup>*</sup> \( p < 0.10; ** \( p < 0.05; *** \( p < 0.01 \) (two-tailed test).
lateral authority. However, our findings apply to many contexts as the need to coordinate work without authority over the individuals involved is ubiquitous. Our findings should have particular relevance to the following types of settings: (1) projects involving contributors from multiple organizations (e.g., Long Lingo and O’Mahony 2010); (2) peer-managed or collectively managed organizations such as Congress, academia, or Wikipedia; and (3) project managers in matrix organizations who lack vertical authority to coordinate project objectives.

**Contributions**

Our investigation of the antecedents and consequences of lateral authority enables us to make three distinct contributions to organizational theory: (1) a more specific conception of lateral authority and the type of progression afforded in project-based organizations, (2) an understanding of the different mechanisms that affect successive levels of progression, and (3) insight as to how lateral authority affects the coordination of knowledge work.

**Progression Without Hierarchy.** Despite the fact that lateral authority is considered a critical distinguishing feature of organizational forms in the growing void between market and hierarchy—namely, community (Adler 2001, Van Maanen and Barley 1984), project (Bechky 2003, Jones and Lichtenstein 2008), and network forms (Powell 1990)—little empirical attention has been devoted to lateral authority (e.g., Landsberger 1961) and how it affects progression. Few studies have explored how lateral authority operates when it is not in conflict with vertical authority. Our research shows the conditions and limitations under which lateral authority was granted, the behaviors that predicted which individuals were more likely to acquire it, and how it affected individual behavior.

Scholars of industrial research labs in the 1960s and 1970s recognized that firms would need to move toward a system of “colleague authority” (Marcson 1960, p. 72) to attract and retain technical talent. However, by focusing on the dyadic “strain and conflict” to attract and retain technical talent. However, by focusing on this theoretical as well as practical traction for those studying how careers in “flat” organizations unfold.

**Mechanisms Affecting Progression.** By combining several different sources of data to study cohorts over a six-year period, we parsed how mechanisms affecting progression changed at two distinct stages. Our two-stage model shows that technical contributions matter only for acquiring membership and that beyond this point, coordination work and spanning sub-project communication boundaries are critical to acquiring elected board positions. Boundary spanning has long been viewed as important to individual and team success in organizations and to supporting innovation outcomes (Allen 1977, Tushman 1977), but the empirical link between boundary spanning and coordination work has been only loosely specified. Our research suggests that this link may be more critical than previously acknowledged and that it is communication rather than technical boundary spanning that matters. We encourage scholars to further examine the relationship between boundary spanning and coordination work because it is likely to be an important predictor of the sustenance of collectively managed projects.

The fact that individuals in our context do less technical work and more coordination work as they assume lateral authority is not inconsistent with research on the essence of managerial work (Mintzberg 1973). Yet Mintzberg gave short shrift to coordination work, and in our context, it is the management of tasks and not people that is at stake. Our findings reinforce Follett’s initial claim—coordination work is a necessary, perhaps legitimating condition for gaining lateral authority (Graham 1995). Our research shows that those who focus on coordination tasks are then rewarded with the position. The behavioral predictors of progression that are consistently important in our study are coordination work (by any measure) front and center even though it remained a very small percentage (<4%) of all project activity. The fact that these results are significant at all is revealing. By exposing the importance of coordination work, we contribute an understanding of how individuals actually self-organize collective work in project-based organizations.

A result that we did not find is worthy of attention: an individual’s structural centrality was not predictive of progression. From a social network perspective, centrality in the project’s communication network should have been important to achieving both stages of progression because both events were determined by peers. Structural centrality initially appeared significant in our base models, but as we entered measures of technical contribution, communication, and coordination, these effects disappeared. Without the very specific behaviors that our unique data set enabled, it would have been easy to mistakenly attribute our findings to network centrality.
This suggests to us that network centrality may be a very broad measure that captures a host of behaviors and that future research should consider ways to refine such structural measures to include more specific behaviors linked to project and organizational outcomes.

Coordinating Knowledge Work. Scholars examining coordination practices often look at the mechanisms that allow individuals to coordinate individual work into an integrated whole (Okhuysen and Bechky 2009). Organizing structures (March and Simon 1958, Ouchi 1980), boundary objects (Bechky 2003, Carlile 2002), schedules, plans, meetings (Gittell 2000), and routines (Feldman 2000) all help individuals manage the dual processes that constitute coordination: disaggregating work into smaller parts that can be accomplished by individuals and reintegrating those contributions into a collective whole (Lawrence and Lorsch 1967).

Our research setting was globally distributed, so many traditional forms of coordination such as face-to-face meetings and physical boundary objects were not available. Furthermore, our research setting explicitly rejected routines, schedules, and anything reeking of “too much structure” as an anathema to the ethos of unfettered software development (e.g., O’Mahony and Bechky 2008). When the project grew, organizers developed more specialized subcommunities but communication within each subcommunity decreased. Few mechanisms ensured communication across subproject boundaries—an essential condition for coordinating technical work (Sosa et al. 2007). Thus, differentiation occurred without integration—a danger that Lawrence and Lorsch (1967) warned against. Given this fact, perhaps it is not a surprise to see individuals accelerate coordination work after acquiring lateral authority roles. However, given the project’s culture and norms, it is surprising to see that ambiguously defined roles have such a dramatic effect.

Several mechanisms may be responsible for explaining the postprogression increase in coordination work. First, an access to information argument: after moving into a new lateral authority role, individuals may gain more information that prompts them to engage with more subcommunities to diffuse that information and coordinate the community’s efforts. To explore the feasibility of this mechanism, we assessed the informational benefits that could accrue at each stage. Whereas board directors maintained a private mailing list, members did not have a separate communication channel from the rest of the project apart from an annual “state of the project” meeting. Thus, this explanation could apply to board directors but not to foundation members. Second, a role expectation argument: once in the role of member or board director, individuals may feel that there is an expectation for them to engage in more coordination work—with this effect being greater for the board of directors. However, in our initial interviews, our informants did not expect new project roles to change their behavior. These roles were broadly defined with no mention of coordination and only minimal rights and responsibilities identified a priori. Although we did not uncover any specific data to suggest role expectations were at play, we cannot fully rule it out.

Finally, a legitimacy argument: when individuals gain some degree of authority, the legitimacy that comes with this role may provide them license to engage in more coordination behavior than they would otherwise. In a community where norms against hierarchy are strong and coordination mechanisms weak, it may be difficult for individuals to take on additional coordination tasks even if there is a glaring need for them. An “authority vacuum” could exist where individuals did not coordinate project work because authority roles were unclear. Once acquiring a lateral authority role, individuals may have then pursued previously identified coordination work, reinforced by the legitimacy of their role. This could explain our immediate and dramatic effects.

We are not able to parse these explanations definitively, but all three explanations are in line with one underlying mechanism: role clarity. Our research suggests somewhat paradoxically that the specification and granting of lateral authority roles may foster individuals’ willingness to engage in coordination work, particularly in collectively managed, high-growth settings. When no one person is “in charge,” the challenge is to coordinate work without appearing to “take charge,” to avoid dampening individual motivation and enthusiasm for the project. Yet on a high-growth project where specialization is inevitable, some degree of integration is necessary to avoid fragmentation. Our research shows that with lateral authority roles validated and authorized by the collective, individuals dedicated to the project can be empowered to surmount this challenge.

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Endnotes
1 Member voting participation rate in board director elections ranged from 57% to 88%, depending on the year.
2 Unfortunately, data on meeting attendance are not available.
3 During the period under study, a total of 137 mailing lists were active, but not all in the same year.
4 We also estimated our regressions using skewed logistic and rare-event logistic regressions with similar results.
We did not collect data on individual aspirations for becoming part of the community, which would have required self-reported data. Our study relies on behavioral data. However, we did have data on successful and unsuccessful applications for membership for the first two years. A comparison of these two years of data revealed the same pattern as the regressions reported in our paper.

References


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