

## Organizations coupled with communities: The strategic effects on firms engaged in community-coupled open innovation

Jonathan Sims

Management Division, Babson College,  
Wellesley, Massachusetts 02457 USA, jsims@babson.edu

Victor P. Seidel

F.W. Olin Graduate School of Business, Babson College,  
Wellesley, Massachusetts 02457 USA, vseidel@babson.edu

### Abstract

The study of open innovation has primarily focused on the benefits and consequences of inbound or outbound innovation exchange between firms; however, increasingly firms may be engaged in simultaneous inbound and outbound exchange forming a “coupled” approach. Furthermore, firms increasingly collaborate with communities as sources of innovation, but how does such “community-coupled open innovation” affect a firm? Through an in-depth study of 250 firms collaborating with a leading open source software community, we show how this approach incorporates not only the exchange of intellectual property but also the provision of help. We find that while community-coupled open innovation does not affect productivity, it can expand a firm’s social ties, lead to a more conservative strategic posture, and shift its innovation focus. Implications for our theories of open innovation in the context of communities are discussed.

JEL Codes: O31, O35, C2, L33



This is the open-access public version of the article forthcoming in *Industrial and Corporate Change*. The definitive version formatted for publication is available at <http://doi.org/10.1093/icc/dtw043>, and the citation is:

Sims, J. and Seidel, V.P. (2016) Organizations coupled with communities: The strategic effects on firms engaged in community-coupled open innovation *Industrial and Corporate Change* doi:10.1093/icc/dtw043

## **1. Introduction**

Studies of open innovation emphasize that in a world marked by technological change and worker mobility, firms prosper when they purposely engage with their external environment (Chesbrough & Bogers 2014; West et al. 2014). With few notable exceptions, the majority of open innovation research has rightfully and historically considered the external environment primarily as relationships between firms. Recently, scholars have identified communities as an under-researched area within open innovation (Randhawa et al. 2016). Today, collaboration between firms and external communities plays an increasingly important role; indeed, O'Mahony and Lakhani (2011) argued that the role communities play in organizational theory deserved more attention, positing that “organizations may be in the shadow of communities” (p. 3). Scholars have emphasized the important position that a variety of community forms play in the organizational lives of firms. For example, user communities help shape product development (Hienerth 2006; Hienerth & Lettl 2011; Lakhani & von Hippel 2003); trade associations influence common standards among firms (Fleming & Waguespack 2007; Rosenkopf & Tushman 1998; Waguespack & Fleming 2009); and open-source software communities provide resources and opportunities for software firms of all sizes (Bonaccorsi et al. 2006; West & Gallagher 2006b; West & O'Mahony 2008).

From a practical standpoint, firms are increasingly dependent upon communities for their growth and survival (O'Mahony & Lakhani 2011). In fact, a number of firms can tie their own origins and growth to the existence of an external community. Red Hat, for example, was founded to provide professional services to firms that use the open-source

and community-led Linux operating system. In the automotive sector, Local Motors, a firm hosting a large online community of vehicle designers, has been responsible for a variety of vehicle innovations (Seidel & Langner 2015). Traditional firms, including Disney and BMW, are also increasingly collaborating with communities as sources of innovation (King & Lakhani 2013), with shifts in the nature of firm-community collaborations over time (Seidel et al. 2016).

As firms collaborate with communities, there are three different ways in which they may engage with them—which the open innovation literature has termed inbound, outbound, and coupled processes. (Enkel et al. 2009; Tucci et al. 2016; Vanhaverbeke et al. 2008; West & Gallagher 2006a; West & Lakhani 2008). Through the inbound process, firms import external knowledge or resources to develop internal innovations. This is the most commonly researched process (West & Bogers 2014) building on related bodies of work such as absorptive capacity (Cohen & Levinthal 1990). In the outbound process, firms license or transfer internally developed innovations outside the firm (Chesbrough 2003). Finally, the coupled process is defined as “coupling the inbound and outbound processes by working in alliances with complementary partners” (Gassmann & Enkel 2004). While some have theorized that this combination of inflows and outflows can be beneficial to a firm (Chesbrough et al. 2006; Enkel et al. 2009), to date there has been less empirical research examining the coupled process (West et al. 2014), and very little examining the coupled process as it relates to firm collaboration with communities, what we term “community-coupled open innovation.”

While community-coupled open innovation may be expected to be of interest to firms, there are several possible consequences to a firms’ strategy. With both inflows and

outflows of intellectual property, it is not clear whether productivity would be increased or decreased under this approach. With intensive collaboration and potential co-dependence on the community, it is not clear whether an array of a firm's strategic characteristics—such as social ties, strategic posture or innovativeness—might be altered through such close collaboration. With such unknowns, our research question was to investigate how community-coupled open innovation alters the productivity and strategic characteristics of a firm.

To explore the effect of community-coupled open innovation on firms' strategic characteristics, we conducted an in-depth study of 250 software development firms collaborating with members of the Drupal software community—a community of over 35,000 developers developing open-source website software tools. We find community-coupled open innovation incorporates not only the exchange of intellectual property but also the outbound provision of help. In exploring how community-coupled open innovation affect firms' productivity, social ties, strategic posture, and innovativeness, we find that while community-coupled open innovation does not impact firm productivity, it can expand a firm's social ties and can shift strategic posture and innovativeness. Our contribution is to show how organizations coupled with communities will experience flows of both intellectual property and help, and how the different nature of these flows will change organizations themselves in fundamental ways.

In the next sections we review literature on open and coupled innovation and the rise of firm-community collaborations as a means to develop our hypotheses that we tested with our unique sample of firms. We then present our results and the implications

of our findings to our theories of open and coupled innovation in the context of firm-community collaboration.

## **2. Theoretical background and prior literature**

Two dynamics have been of increasing importance in innovation studies: the rise of community-forms of organizing as sources of innovation, and the use of open innovation processes by firms. We briefly review each of these areas before developing our specific hypotheses in relation to community-coupled open innovation.

### **2.1 Communities as distinct forms of organization**

Defined as “voluntary collections of actors whose interests overlap and whose actions are partially influenced by this perception” (O'Mahony & Lakhani 2011, 4), communities have long interested organizational scholars for both theoretical and practical reasons. Theoretically, communities are distinct from either markets or firms, and their existence is not easily explained by leading theories of the firm (Williamson 1991). Communities are an example of a Powell's “network form” of organization (1990), or what Williamson would call a hybrid form—“that are located between markets and hierarchies” (1991, 80).

While geographic proximity among members was once expected (Hillery, 1955), today's communities are bound by technology, not geography. They are *collectivist-democratic organizations* (Rothschild-Whitt 1979), whose governance, unlike firms, is based on collective authority and participation, informal relationships, and egalitarian norms. These norms help engender a common identity and a sense of belonging among community members (von Hippel, 2007), which can help to motivate participation

(Hertel et al. 2003; Lakhani & Wolf 2005). While most work has examined the motivations of individual community contributors, others have shown that communities can be a means by which individuals increasingly launch (Hienerth 2006) or advance (Hienerth & Lettl 2011) their own companies. While taking a wide range of forms—such as user, brand, trade, and open source communities—all share certain traits, including voluntary membership and meritocratic governance processes that allow motivated participants to seek and obtain leadership roles (O'Mahony & Ferraro 2007).

Since communities are so distinct from firm forms of organization, we might expect that firm-community collaborations will entail unique challenges that are not apparent in firm-to-firm collaboration. We next provide an overview of what is known about open innovation that may inform how we might view tight engagement between firms and communities.

## **2.2. Coupled innovation processes with communities**

A coupled approach to open innovation is defined as the purposeful and simultaneous use of both inbound and outbound open innovation—whether that collaboration is with firms or communities. As an example in an inter-firm context, Gassman and Enkel defined coupled open innovation as the practice of “linking outside-in and inside-out by working in alliances with complementary companies during which give and take are crucial for success” (2004, 1). In this study, the concept of coupled innovation is consistent with the interactive model proposed by Piller and West (2014). Namely, it conforms to their model in that knowledge creation can take place through a co-creation process that involves multiple firms and an external community.

Gassman and Enkel's 2004 conception, and much of the research that followed, studied coupled open innovation among larger firms, building on the work on firm alliances (Piller & West 2014). Coupled open innovation looks somewhat different when used by firms working closely with an external community than just between firms, for a number of reasons. First, firm-community relationships are often based on reciprocity. In exchange for using the community's software code, a firm may contribute their own code to the community, a process known as "free" or "selective revealing." (Henkel 2006; 2009; Schweisfurth et al. 2011; Villarroel et al. 2013). Secondly, and related to the idea of reciprocity, firm-community exchanges are often nonmonetary in nature (Dahlander & Gann 2010). Communities and firms exchange intellectual property (IP), such as in the form of software code, or help more often than money. Third, community-engaged firms typically embrace community priorities and support community governance. Because a community can influence their success and survival, it is not rare to see firm leaders promoting the interests of the community, or investing considerable time becoming involved in community governance.

In community-coupled open innovation, we may expect that differences between firms and communities may lead to tactical or strategic changes to firms that may differ from those observed in inter-firm collaboration. Past studies of inter-firm collaboration, for example, have focused on how this can lead to changes in productivity (Reagans & Zuckerman 2001) social ties between firms (Westphal et al. 2006), strategic posture (DeSarbo & Grewal 2008), and innovativeness (Sampson 2007). We sought to test these effects in the context of community-coupled open innovation.

As part of introducing our hypothesis development on what changes might occur, we can diagram the relationship between firms and a community that we will explore. Figure 1 provides an illustration of community-coupled open innovation. Both the firm and the community produce their own software products, as indicated by the right-facing arrows. The inbound process (what a firm "takes" from a community) is dominated by the transfer of IP, in the form of software code, from the community to the firm. Firms that only take code are often known as free-riders (Dyer and Nobeoka, 2000). Community-coupled open innovation requires that a firm simultaneously practice the outbound process as well, which we posit involves both the provision of IP (software code) and help to community members. We develop our hypotheses regarding the role of IP and help, and explore the consequences for firms, in the following sections.

-- INSERT FIGURE 1 ABOUT HERE --

### **3. Hypotheses**

#### ***3.1 Providing help in community-coupled open innovation***

Communities are associated with the reciprocal exchange of help between members. Membership often necessitates that one helps other members, and benefits often accrue to those who help others. For example, in their study of open-source software communities, Lakhani and von Hippel (2003) found that those who provided to the Apache software community experienced direct learning benefits. Since community-forms of organization are so focused on reciprocity (Von Krogh et al. 2012), it is not



surprising that help is widely provided within communities, but is it also prevalent when firms collaborate with communities?

The provision of help is also a social norm *within* organizations, especially those involved in innovation work (Grodal et al. 2015), where it has also been associated with creativity and problem solving (Hargadon & Bechky 2006). Within open innovation research, however, many studies have focused on larger firms and the more formal practice of licensing IP, rather than the provision of help (Dahlander & Gann 2010). Indeed, firms may be expected to receive little IP in exchange for providing assistance to diverse community members. However, while the study of providing help between firms and communities is less explored, we expect that by becoming involved with an external community, firms involve themselves in the norms of reciprocal exchanges. The expectations of reciprocity and the social motivations that promote participation simply make the formalized exchange of IP more cumbersome and less common. Thus, providing help would be expected to go beyond simply providing intellectual property but instead consist of advice, mentoring, or other forms of volunteer assistance. Among open source communities, helping not only includes writing exciting new code for the firm, but also providing day-to-day support (Lakhani & von Hippel 2003). In the case of software firms collaborating with communities, we expect that exchange involves more than IP, but also includes help, leading us to the following hypothesis:

*H1. Community-coupled open innovation will be associated with the provision of both intellectual property (i.e. software code) as well as help.*

### ***3.2 Community-coupled open innovation and productivity***

When moving from inbound open innovation to community-coupled open innovation, it is not immediately clear what the impact will be on firm productivity due to flows of intellectual property both into and away from the firm. The impact of inbound open innovation is clear; multiple studies have shown that external environments can be a valuable source of knowledge that contributes to firm innovation (e.g. Henkel 2006; Pittaway et al. 2004; Rigby & Zook 2002). Prior work has shown that by using free software provided by the community, firms can reduce the costs of their own internal development (Samuelson 2006), as well as reallocate otherwise costly licensing fees required by private software providers (Bonaccorsi et al. 2006). Gruber and Henkel (2006) showed that the use of open source code could reduce the liability of smallness in entrepreneurial startups by freeing these firms from the necessity of engaging in costly internal R&D. Open source code is not only free, but typically reliable (Lerner & Tirole 2002).

The effect of coupled innovation on firm productivity – where both inbound and outbound open innovation processes are in play – is less clear. Studies that have investigated the effect of coupled open innovation on firm productivity have focused heavily on R&D and technology collaborations between firms as proxy for the coupled process (West & Bogers 2014). In one such study, Faems et al. (2010) found that while a diversity of R&D allies increased both innovation and financial performance, the increase was not enough to offset higher management costs, suggesting there may be no effect.

By including outbound process where both IP and help is provided, this may decrease productivity, given the time and effort required to provide both IP and help to

the community. However, adding outbound engagement with a community, coupled innovation processes could foster increased reciprocal relationships with the community, leading to efficiencies. By coupling outbound IP and help with inbound IP, a firm may be able to take advantage of the insights of other firms and community members who build on insights provided to them. While the effect on productivity in using coupled innovation has not been explicitly tested before, on balance we expect the reciprocal benefits of outbound and inbound innovation will lead to improved firm productivity.

*H2. Community-coupled open innovation will be associated with an increase in a firm's productivity.*

### **3.3. Community-coupled open innovation and social ties**

Open innovation initiatives can have implications for social ties. For example, past studies found that when firms implement open innovation initiatives, they strengthen their own social capital (Rass et al. 2013). When firms work closely with communities, a range of new social ties are formed. In the case of outbound open innovation, Henkel (2009) described “champions of revealing,” in the form of firms that serve to bridge ties between firms and communities by providing their knowledge to communities.

Two mechanisms would support the development of social ties under community-coupled open innovation. First, by simultaneously engaging in inbound and outbound open innovation, a firm and its boundary spanners signal their support of the community. By using the community's software, the firm signals their embrace of the community's product. When allowing or encouraging employees to volunteer their own time to the

community's goals, a firm signals its trust of the community's governance. By sharing code, a firm helps promote the development and growth of a technology standard it has adopted as its own (Bonaccorsi et al. 2006; Fosfuri et al. 2008; Gruber & Henkel 2006; Henkel 2006). Gerber and Henkel (2006) argued that by sharing code with communities, firms demonstrate their technical proficiency to the community. The benevolent act of providing software code can signal that a firm is able to provide the help required to use or extend such code, encouraging others in the community to seek advice and guidance.

Second, coupled innovation also provides the impetus for boundary spanners—employees who are also active with community members—to increasingly interact with and learn from each other (Wang & Ramiller 2009). In some cases, engaging in inbound open innovation may require more than simply using the community's product—it may necessitate asking for help in how to use that product. Likewise, outbound open innovation can commit the firm to supporting and updating code that they share. In both cases, the firm is led to engage increasing numbers of community members in an ongoing dialogue, fostering further social ties. We express our resulting hypothesis as:

*H3. Community-coupled open innovation will be associated with an increased number of social ties between a firm and a community*

### ***3.4 Community-coupled open innovation and strategic posture***

A firm's strategic posture describes its overall competitive orientation along a scale that ranges from entrepreneurial to conservative (Covin & Slevin 1989; 1990). Firms with a more entrepreneurial strategic posture take risks more frequently and are more likely to compete aggressively with others (Miller & Friesen 1983), while

conservative strategic postures are characterized by an approach that is more reactive, defensive, and risk averse (Covin & Slevin 1989). Studies have shown higher performance to be associated with a more entrepreneurial posture in hostile environments, but a more conservative posture in benign environments (Covin & Slevin 1989; Miller & Friesen 1983). In relation to open innovation, Hung and Chiang (2010) found that managers with a higher entrepreneurial orientation were more likely to perceive a positive relationship between open innovation and firm performance.

However, it may be that firms that adopt a coupled open innovation approach may be aligned with a more conservative position. By both taking from and giving to the community, firms are the beneficiaries of and support a munificent environment, where community governance and norms reduce uncertainty among members (O'Mahony & Ferraro 2007; Shah 2006). Rather than having to engage in risk taking in the face of uncertainty, firms that practice community-coupled open innovation can rely on that community's support, leading us to state the hypothesis:

*H4. Community-coupled open innovation will be associated with a less entrepreneurial (more conservative) strategic posture.*

### ***3.5 Community-coupled open innovation and innovativeness***

We can also expect community-coupled open innovation to affect the types of innovation projects that a firm takes on. Scholars have long classified innovativeness along a continuum that stretches from incremental to radical (Dewar & Dutton 1986; Henderson & Clark 1990). Incremental innovations meet the needs of current customers by relying on established designs (Dewar & Dutton 1986; Ettlie et al. 1984; Henderson & Clark 1990), reinforcing a firm's core competencies, and are commonly found in

decentralized and complex organizations (Benner & Tushman 2003). Radical innovations represent significant departures from past practices and occur when firms “ask a new set of questions, to draw on new technical and commercial skills, and to employ new problem solving approaches” (Henderson & Clark 1990, 9). While coupled innovation could lead to more radical innovations due to a wider variety of ideas circulating between firm members and community members (Holmes & Smart 2009), we expect coupled open innovation will lead to more incremental innovations overall, as we develop next.

Community-coupled open innovation may lead to more incremental innovations due to the increased formation of social ties between the community and the firm. Collectively, the social ties from coupled innovation form what Ingram and Roberts call a “friendship network” where “the multiplex character of friendships . . . creates increased levels of trust, empathy, and reciprocity” (2000, 389). These ties improve communications between organizations, and those that share them are more likely to approach problem solving together (Uzzi 1996). At the same time, these same social ties create “mechanisms of social control” that enforce norms that support the community’s common interests (Ingram & Roberts 2000). Henderson and Clark (1990) argued that established communication channels are an antecedent of incremental innovation because they connect those trying to solve problems with those who have solved similar problems in the past. Whether improving the community’s ideas or learning from others on the application of ideas (Gruber & Henkel 2006), both technical problems lend themselves to the transfer of detailed knowledge that solves incremental problems, not the creation of radical innovations, leading us to the hypothesis:

*H5. Community-coupled open innovation will be associated with more incremental innovations.*

In summary, we expect that community-coupled open innovation will have effects on the type of exchange and on the core attributes of firms themselves. We expect not only IP but also help to be provided from firms to communities, and we expect that community-coupled open innovation will have effects on firms in terms of their productivity, social ties, strategic posture, and innovativeness. We next describe our method to test for these outcomes.

#### **4. Methodology and Data**

We tested our hypotheses using a sample of firms that worked with the Drupal open source software community, a community that at the time had over 35,000 registered developer members. Drupal is the name of both an open source software platform and the community responsible for its development. The community's primary focus is the creation and continued development of a content management system (CMS) that allows its users to create interactive internet websites. At the time of our study, Drupal was enjoying a surge of popularity, and it was used by approximately 4.9% of all websites that use a CMS. Popular websites including Twitter.com, Pinterest.com, WhiteHouse.gov and Economist.com have been created using the community's software (W3Techs, 2016).

Firms collaborating with the Drupal community provides an ideal setting for studying community-coupled open innovation. First, the community has been widely embraced by firms both large and small, providing generalization of results. Second,

Drupal is similar to many other open source software communities. The community's product is widely and freely shared with others (Dahlander 2007), and its governance processes are largely meritocratic, offering firms and their employees the opportunity to play an active role within community leadership and opportunities to engage in truly coupled processes.

We collected survey data from 250 firms that were members of the Drupal Association. The average firm age was 23 years old, but over 50% were 10 years old or younger. Twenty percent were sole proprietorships and 59% had 20 or fewer employees. The 250 survey responses collected represent a response rate of approximately 40% of a total target population of corporate members of the Drupal Association at the time. The typical respondent was either an executive or developer in a software firm. A power analysis suggested that to achieve statistical power of 0.8 with an effect size of 0.15 with three independent variables (covering inbound, outbound, and coupled innovation) with a p-value of 0.05, we would need a sample of at least 76 firms. A response of 250 well exceeded this target.

#### **4.1 Questionnaire design and variable constructs**

We designed a questionnaire that was sent to key informants at each firm. An overview of this questionnaire is given in the Appendix. To create our dependent variables, we adapted existing validated questionnaire items from other management studies. We describe each dependent variable in turn.

**Productivity.** For software creation productivity, we were interested in a definition of productivity specific to the software industry, while being consistent with traditional definitions of productivity measuring a ratio of output to input (Scacchi, 1995:



Maxwell, 2001). In our survey, we approached this issue by asking each firm, “In the last year, what was the average total cost (including development and support) of a typical product or client job?” This question is a measure of input. To convert to productivity, we take the inverse of this measure; that is, one unit of output (a client job) divided by the average cost of a client job. Note that as the average cost of a client job goes up, productivity will decrease. Conversely, as the average cost of a client job goes down, productivity will increase. We examined whether the distribution of the productivity measure was linear. It was found to be nonlinear, so we converted the measure to a linear distribution by using a logarithmic transformation of this variable for subsequent analysis.

**Social ties.** To measure social ties, we adapted questionnaire items used by Westphal (1999) to measure social ties between a firm and the community. Specifically, we asked respondents, “How many individuals outside your company, but involved in the Drupal community, do you consider to be acquaintances or friends?”

**Strategic posture.** Strategic Posture was measured by adapting questionnaire items used by Covin and Slevin (1989; 1990) that assess technological innovativeness, risk taking, competitive intensity, and independence. We constructed our variable to test for the degree of entrepreneurial strategic posture.

**Innovativeness.** Questionnaire items measuring incremental vs. radical innovation were adapted items from Green and Gavin’s (1995) validated scale. We constructed our variable to test for the degree of incremental innovation.

**Controls.** We included seven control variables that were not part of our theory development, but could influence our statistical results: firm size, performance, growth, age, whether the founder also served as the CEO, and the duration of engagement

between firms and the Drupal community. Firm size has shown significance in other studies of firms adopting open source business models (Bonaccorsi et al. 2006), including some that have shown smaller companies to be more likely to donate code to the Linux open source community (Gruber & Henkel 2006). We measured firm size by the number of employees. Since none of our hypotheses theorized a direct connection between open innovation practices and firm performance, we chose to control for this variable. As our sample consisted predominantly of private firms, market- and accounting-based measures of performance were not readily available. Consistent with others who have studied performance among private firms, we adapted Likert-scale questionnaire items from Dess (1987). These items ask respondents to compare their firm's performance to industry peers in both total sales growth and a personal assessment of overall performance. Similarly, we wanted to evaluate the role of open innovation practices separate from firm growth. We controlled for the annual growth rate by calculating the annual change in company size, as measured by the change in employee count from 2010 to 2012. Because we did not theorize about the statistical relationship between firm age and open innovation practices, we controlled for firm age. Respondents were asked to provide the year the company was founded. Younger software firms are often led by their founder. We controlled for this variable because we wanted to isolate open innovation practices of the firm, regardless of whether the founder was still the leader of the firm. A single questionnaire item asked whether or not the firm founder is the current CEO. The final control variable, "duration of engagement," emerged from our exploratory factor analysis. It collectively measured the length of time a firm had been involved with the Drupal

community. We used this as a control because we did not explicitly theorize that the duration of engagement would influence firm practices.

**Degree of community-coupled open innovation.** Since validated questionnaire items did not exist for our independent variable, the degree of community-coupled open innovation practices, we first conducted interviews with multiple firms that worked with various open source software communities. Working with the Drupal Association, the nonprofit arm of the Drupal community, we then developed 18 questionnaire items that measured various aspects of exchange between a firm and an open source community (see appendix). Measures were designed to collect information on the type, intensity, and duration of firm-community engagement. For example, we collected information on firm behaviors including soliciting help, incorporating community code into the firm's own software products, volunteering, and offering help to other members of the community.

## **4.2 Exploratory factor analysis**

Following data collection, we used exploratory factor analysis (EFA) to reduce the number of items. In our first analysis, we examined all 18 items using principal axis extraction. We used an oblique (promax) rotation because initial interviews suggested that our theoretical constructs (i.e., inbound, outbound, and coupled open innovation) might be correlated. This analysis identified four factors with eigenvalues over 1. Of the 18 survey items, six items had high cross-loadings with other items, and were subsequently removed through a process of multiple exploratory analyses. The final 12 items were then analyzed again using the same extraction (principal axis) and rotation (promax), this time specifying a four-factor solution (each of these factors had an

eigenvalue greater than 1). The pattern matrix of these four factors is shown in Table 1. To test the robustness of these results, we conducted a variety of analyses using alternate extraction and rotation methods, including principal factors extraction and varimax and oblique rotation. We also conducted several analyses using various numbers of factors to rotate. These analyses consistently produced similar results, and were also consistent with the more common criterion of eigenvalues  $> 1$  for rotation. Factor 1, “Duration of engagement,” includes high loadings on three items that ask respondents about the number of years their firm has worked with the Drupal community. We concluded that this variable measures how long a firm worked with the community, but does not cleanly identify any specific firm behavior or theorized construct. We used this measure in our analysis as a control variable. Factor 2, “Inbound IP” includes items that measure the intensity with which a firm relies on Drupal. Specifically, this item includes high loadings for using Drupal since the firm’s inception, the percentage of employees using the community’s software, and the percentage of products and services based on the community’s software. Factor 3, “Outbound IP” contains items with high loadings on questionnaire items asking about firms’ code contributions to the community, and factor 4, “Outbound Help” contains high loadings for items measuring the degree to which the firm encouraged their employees to volunteer in the community, paid employees to volunteer, and assisted other firms in the community for free. Consistent with most studies that measure inbound and outbound open innovation processes as continuous variables (Dahlander & Gann 2010), we created our three continuous independent variables by adding the standardized values for each respective component variable. Cronbach alpha results were all satisfactory, at 0.7, 0.8, and 0.8 for the items combined

for inbound open innovation, outbound open innovation related to providing code, and outbound open innovation related to help, respectively; all exceeded the 0.70 recommended minimum for multi-item scales (Santos 1999).

-- INSERT TABLE 1 ABOUT HERE --

### **4.3 Regression analysis**

A correlation table across all of our dependent and independent variables is given in Table 2. Each hypothesis was tested using ordinary least squares (OLS) regression. This approach assumes independence and that the dependent variables are normally distributed. For variables that were not normally distributed in the raw survey data (i.e., productivity, firm size, and firm age) we used a log transformation in our regression. OLS results can be, however, sensitive to both multicollinearity and the influence of outliers. To assess multicollinearity, we calculated tolerance statistics and Variance Inflation Factor (VIF) values for each regression test. VIF values were all well below the recommended cutoff of 10 (Cohen et al. 2003), indicating that multicollinearity is not a major concern. To address the potential influence of outlier variables, we conducted a robustness check using Cook's Distance, which is useful for identifying outlier cases that may affect regression accuracy. Following Bollen and Jackman (1990), for each regression, we excluded cases where Cook's Distance was greater than  $4/n$ , where  $n$  is the number of cases included the original regression.

-- INSERT TABLE 2 ABOUT HERE --

## 5. Results

In Hypothesis 1, we suggested that providing help, not only IP, would be a component of community-coupled open innovation. We find support of this hypothesis in our exploratory factor analysis (Table 1). The analysis identified two distinct factors of the outbound component—providing IP (i.e., software code) and providing help. Since collapsing these factors into a single construct would yield an unexceptional Cronbach alpha of 0.65, we concluded that the factor analysis identified two distinct outbound components: IP and help. Community-coupled open innovation engages both inbound and outbound exchange, and so we find support for the provision of help as part of coupled innovation processes.

The results of testing Hypothesis 2, which proposed that community-coupled open innovation would be associated on balance with higher software creation productivity, are provided in Table 3. This hypothesis was not supported. In these results we can see that inbound IP was by itself associated with higher rates of productivity (coefficient = 0.249,  $p < 0.05$ ), and outbound IP was associated with lower rates of productivity (Table 3, coefficient = -0.121,  $p < 0.05$ ). Yet together, engaging in community-coupled open innovation was non-significantly related to productivity (coefficient = 0.004, n.s.).

-- INSERT TABLE 3 ABOUT HERE --

Hypothesis 3 argued that community-coupled open innovation would lead to the increased development of social ties between firms and the community, and the results are given in Table 4. This hypothesis was supported for community-coupled open innovation that involved sharing IP (code) (Table 4, coefficient = 0.043,  $p < 0.01$ ), but not for providing help (Table 4, coefficient = 0.007, n.s.).

-- INSERT TABLE 4 ABOUT HERE --

Hypothesis 4 argued that firms engaged in community-coupled open innovation would have a less entrepreneurial strategic posture. This was found to be the case for firms that engaged in providing help (Table 5, coefficient =  $-0.073$ ,  $p < 0.05$ ), but not for providing code (Table 5, coefficient =  $-0.38$ , n.s.).

-- INSERT TABLE 5 ABOUT HERE --

Hypothesis 5 proposed that community-coupled open innovation would be associated with an increase in incremental innovations. This hypothesis was supported for providing code (Table 6, coefficient = 0.041,  $p < .05$ ). When providing help, we found a significant result in the opposite direction than hypothesized (Table 6, coefficient =  $-0.037$ ,  $p < .05$ ). In other words, community-coupled open innovation that involved providing help led to innovations that were more radical in nature.

-- INSERT TABLE 6 ABOUT HERE --

Our results point to a range of ways that community-coupled open innovation has effects on firms, and we discuss our results in detail next.

## **6. Discussion**

We explored the consequences of community-coupled open innovation, in which a firm works closely with an external community in ways consistent with the “coupled” process theorized and explored within open innovation studies (Gassmann & Enkel 2004; West & Bogers 2014). By making use of data from 250 firms that had engaged with the Drupal open source software community, we found that firms provide not only IP but also help to community members. We were able to test how community-coupled open innovation affected internal characteristics of firms—specifically productivity, social ties, strategic posture, and innovativeness. In this section, we discuss our understanding of our findings in context of wider work on open innovation and firm-community collaborations.

Our first interest was in whether firms coupled with communities would provide help as well as IP, and we found that the provision of help is a component of community-coupled open innovation. This finding helps to bridge the community and open innovation literatures, and helps to clarify understating of open innovation in a community setting. Prior open innovation research has primarily examined the exchange of IP between firms in either the inbound or outbound processes. (West & Bogers 2014). We found that IP was only part of the exchange for firms that use coupled processes.



This is consistent with our understanding that communities promote a shared sense of belonging (von Hippel, 2007) and expectations of reciprocity (Von Krogh et al. 2012).

The finding that community-coupled open innovation does not affect software creation productivity (tested in Hypothesis 2) was surprising and important to our evolving theories of coupled open innovation processes. Prior research has suggested that practicing inbound open innovation would benefit productivity (Bonaccorsi et al. 2006; Samuelson 2006), and others have shown that sharing personal knowledge can cost time (Haas & Hansen 2007). On balance, however, we had expected that the inflows and outflows of community-coupled open innovation would lead to increased productivity, but instead we found no effect. Certainly, prior research on providing code has shown how it can benefit the contributor (Henkel et al. 2014). While benevolence may be a motivating factor for providing code in a community setting, there are other tangible benefits such as the development of social ties that can be important as a firm seeks to strengthen its reputation and play a larger role in the community.

Our findings indicated that IP and help acted in different ways regarding social ties, innovativeness, and entrepreneurial strategic posture. We explain this due to the different nature of information flows of IP and help: IP is highly modular, being easy to scale and easy to re-use (Baldwin & Clark 2006); while “help” is context specific. We describe how the nature of these two flows of information lead to different firm effects in community-coupled open innovation.

With IP being modular, scalable, and reusable, it leads to ease of wide sharing among a community, increasing the number of social ties. In contrast, with help being

context- and project-specific, there are no strong effects on the expansion of the number of social ties—though individual ties may deepen.

The modularity and reusability of IP contributes to a negative effect on innovativeness. Incrementalism is fostered when more modules of code circulate through community-coupled open innovation. Providing code requires a firm to be attuned to the relatively incremental needs of other community members. Open source software is predominantly incremental, as firms must consider numerous technical interdependencies to ensure that their contribution maintains compatibility with the existing product. Incremental contributions that maintain compatibility and continuity with existing users are more likely to be accepted by the community. Second, providing code also requires a firm to focus on its own core competencies and current capabilities, behaviors that several researchers found to be associated with incremental innovations (Ancona & Caldwell 1992). Research on new product development supports this assertion; Bonner and Walker (2004) have shown that highly embedded customer feedback was more likely to lead to the success of incremental products.

Help has an opposite effect on innovativeness, as the context-dependent nature of providing help on specific projects leads to new questions and possible new insights for new innovations in the given domain. A firm's current product line would be expected to see more radical innovations within its existing markets, due to new insights from the provision of help.

However, the provision of help was found to lead to less-entrepreneurial strategic posture. Providing help reinforces existing social ties, tightening the firm and community; this increases strategic inertia. While by providing help a firm may have

more innovative products within existing markets and using existing partners, it will take on a more conservative strategic posture limiting its exploration of new markets with new partners. The fundamental differences in the nature of knowledge flows encapsulated in IP and help explain the firm effects in community-coupled open innovation.

## **6.1 Contributions and implications**

One major contribution of our study is to show that social relationships (i.e. providing help) play an important role in the coupled process. Recent studies (Grant & Patil 2012; Grodal et al. 2015) have shown that the exchange of help is an important and common behavior within organizations; here we show it to be an integral and consequential component of relationships between firms and an external community. We also show that community-coupled open innovation has both tactical (e.g. productivity) and strategic consequences, but all are not necessarily beneficial. Whether or not a firm provides help to a community can have strategic consequences, notably a more conservative strategic posture.

O'Mahony and Lakhani argued that organizations may lie "in the shadow of communities" (2011, p. 3). In our study, we surveyed companies that all depended upon the Drupal open source community. Prior work on communities has focused on the social relationships among community members, including reciprocity, co-creation, and respect for shared norms (Ingram & Roberts 2000). Communities like Drupal are a source of resources for firms, but our study of community-coupled open innovation notes that firms make important contributors to the community in return. Rather than being merely in their shadow, as O'Mahony and Lakhani (2011) suggested, organizations may be

increasingly be coupled with communities in a manner that shapes them in significant ways.

For software managers and entrepreneurs, this work provides insight into how to best manage a relationship with an external community. Specifically, it demonstrates that two different forms of outbound open innovation—providing code and providing help—can lead to different results. This suggests that managers should consider what mix of inbound and outbound practices are most appropriate for achieving their strategic objectives. Recent research has suggested that in order to capture value from open innovation, firms must link their open innovation efforts with their larger strategic objectives (Randhawa et al. 2016). Premeditated and purposeful community engagement may become one vehicle that firms use to achieve such strategic objectives. Specifically, our findings suggest managers should give careful consideration to their objectives related to innovativeness and overall strategic posture when considering the degree and nature of their community participation.

While our study setting was a prominent open source software community, growth in firm-community collaboration extends well beyond software, including communities that facilitate the creation of consumer products from t-shirts (Piller 2010) to cars (Seidel & Langner 2015) or use new technologies such as 3D printing (West & Kuk 2014). Hosted communities present their own opportunities and challenges, as we've seen with efforts such Netflix (Villarroel et al. 2013) or Quirky (Kortmann & Piller 2016). While hosted communities may differ in important ways, each requires a firm to contemplate how it chooses to use inbound, outbound, or coupled open innovation

processes. The use of purposeful practices can, as has been shown here, have significant implications for productivity, social ties, strategic posture, and innovation.

This study also provides some interesting insight for community leaders, especially those who hope to incentivize managers to contribute to the community. For example, more radical innovations may cause disruptions for an open source community because they may be less likely to satisfy the relatively incremental needs of current users. Purposely influencing the nature of firm involvement—for example, by promoting the contribution of code—may help a community prevent “forking,” a process in which the code is split into multiple versions incompatible with each other (Lerner & Tirole 2002).

This research has certain limitations, which provide opportunities for future research. Our focus was on community-coupled open innovation, in which a firm's work closely with a singular and independent external community. As we know, firms now interact with a variety of community types, both external and firm-hosted, with different governance mechanisms for soliciting contributions from members (West & Sims Forthcoming). Future studies may wish to examine the consequences of how firms work with these different forms of communities simultaneously. One methodological limitation is our use of survey methods to collect data for statistical analysis, which could lead to common method bias. This limitation was difficult to avoid because the overwhelming majority of participating firms were privately held, making secondary data sources difficult to find or verify. Future research may address this problem by identifying creative ways to obtain additional data from the community itself or from other secondary sources. Additionally, we used a cross-sectional research design, which

limits our findings to associations and prevents one from assuming causality. Future studies can address this limitation by using a longitudinal design.

## **6.2 Future research and conclusion**

This study shows that the community-coupled process is a complex exchange in which providing help plays a major role. We believe our findings present several opportunities for future research. For example, our study found that community-coupled open innovation led to the formation of social ties. Others may want to explore the nature of these ties between a firm and a community. While community ties among members are known for reciprocity and trust, it is possible that social ties between firms and a community may have different characteristics. For example, in the open source setting, strong social ties between a subset of members could inspire them to fork the community's software. Also, by developing ties through community-coupled open innovation, firms may have certain privileges in charting the course for innovations.

Another extension would be a closer examination of the community itself. How do firm-community relationships change over time? Seidel et al. (2016) suggested that certain communities and crowds were more appropriate partners at some stages of the technological lifecycle than others. Could this also be the case for community-coupled open innovation? Another open research question is whether community-coupled firms become more reliant on a single community over time, or if they are able to concurrently source innovations from a variety of external sources (West & Sims Forthcoming).

In conclusion, we examined community-coupled open innovation, in which firms engage an external community using the process of coupled open innovation. In summary, we empirically demonstrated that the outbound process of community-coupled open

innovation includes the provision not only of IP but also of help. Furthermore, while community-coupled open innovation did not contribute to short-term productivity, the distinct characteristics of IP and help led to different strategic effects. Practices that involved revealing IP/code were associated with stronger social ties and more incremental innovations, while those that involved providing help were associated with more radical innovations and a more conservative strategic posture. We hope that our work on organizations coupled with communities helps to advance the study of the coupled process in open innovation, as well as the increasingly common ties between firms and communities.

### **Acknowledgements**

The authors wish to thank Christopher Tucci, Frank Pillar, Joel West, Craig Crossland, Andrew Henderson, our anonymous reviewers, and the organizers of the 2014 Harvard Open and User Innovation Conference and the first World Open Innovation Conference. We also thank Jacob Redding, Megan Sanicki, the staff of Drupal Association, and the members of the Drupal community for their time and support. Financial assistance was provided by the Herb Kelleher Center for Entrepreneurship and the McCombs School of Business at the University of Texas at Austin.

## References

- Ancona, D. G. and D. F. Caldwell (1992), 'Bridging the Boundary - External Activity and Performance in Organizational Teams', *Administrative Science Quarterly*, **37**, 634-665.
- Baldwin, C. Y. and K. B. Clark (2006), 'The Architecture of Participation: Does Code Architecture Mitigate Free Riding in the Open Source Development Model?', *Management Science*, **52**, 1116-1127.
- Benner, M. J. and M. L. Tushman (2003), 'Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited', *Academy of Management Review*, **28**, 238-256.
- Bollen, K. and R. Jackman (1990), 'Regression Diagnostics: An Expository Treatment of Outliers and Influential Cases', in J. Fox and J. S. Long (eds.), *Modern Methods of Data Analysis*, Sage, Newbury Park, CA: 257-291.
- Bonaccorsi, A., S. Giannangeli and C. Rossi (2006), 'Entry Strategies under Competing Standards: Hybrid Business Models in the Open Source Software Industry', *Management Science*, **52**, 1085-1098.
- Bonner, J. M. and O. C. Walker (2004), 'Selecting Influential Business-to-Business Customers in New Product Development: Relational Embeddedness and Knowledge Heterogeneity Considerations', *Journal of Product Innovation Management*, **21**, 155-169.
- Chesbrough, H. and M. Bogers (2014), 'Explicating Open Innovation: Clarifying an Emerging Paradigm for Understanding Innovation', *New Frontiers in Open Innovation*. Oxford: Oxford University Press, Forthcoming.
- Chesbrough, H. W. (2003), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Boston: Harvard Business School Press.
- Chesbrough, H. W., W. Vanhaverbeke and J. West (2006), *Open Innovation: Researching a New Paradigm*, Oxford: Oxford University Press.
- Cohen, J., P. Cohen and G. Stephen (2003), *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*, Hillsdale, NJ: Erlbaum.
- Cohen, W. M. and D. A. Levinthal (1990), 'Absorptive-Capacity - a New Perspective on Learning and Innovation', *Administrative Science Quarterly*, **35**, 128-152.
- Covin, J. G. and D. P. Slevin (1989), 'Strategic Management of Small Firms in Hostile and Benign Environments', *Strategic Management Journal*, **10**, 75-87.



- Covin, J. G. and D. P. Slevin (1990), 'New Venture Strategic Posture, Structure, and Performance: An Industry Life Cycle Analysis', *Journal of Business Venturing*, **5**, 123.
- Dahlander, L. (2007), 'Penguin in a New Suit: A Tale of How De Novo Entrants Emerged to Harness Free and Open Source Software Communities', *Industrial & Corporate Change*, **16**, 913-943.
- Dahlander, L. and D. M. Gann (2010), 'How Open Is Innovation?', *Research Policy*, **39**, 699-709.
- DeSarbo, W. S. and R. Grewal (2008), 'Hybrid Strategic Groups', *Strategic Management Journal*, **29**, 293-317.
- Dess, G. G. (1987), 'Consensus on Strategy Formulation and Organizational Performance: Competitors in a Fragmented Industry', *Strategic Management Journal*, **8**, 259-277.
- Dewar, R. D. and J. E. Dutton (1986), 'The Adoption of Radical and Incremental Innovations: An Empirical Analysis', *Management Science*, **32**, 1422-1433.
- Enkel, E., O. Gassmann and H. Chesbrough (2009), 'Open R&D and Open Innovation: Exploring the Phenomenon', *R & D Management*, **39**, 311-316.
- Ettlie, J. E., W. P. Bridges and R. D. O'Keefe (1984), 'Organization Strategy and Structural Differences for Radical Versus Incremental Innovation', *Management Science*, **30**, 682-695.
- Faems, D., M. De Visser, P. Andries and B. Van Looy (2010), 'Technology Alliance Portfolios and Financial Performance: Value - Enhancing and Cost - Increasing Effects of Open Innovation', *Journal of Product Innovation Management*, **27**, 785-796.
- Fleming, L. and D. M. Waguespack (2007), 'Brokerage, Boundary Spanning, and Leadership in Open Innovation Communities', *Organization Science*, **18**, 165-180.
- Fosfuri, A., M. S. Giarratana and A. Luzzi (2008), 'The Penguin Has Entered the Building: The Commercialization of Open Source Software Products', *Organization Science*, **19**, 292-305.
- Gassmann, O. and E. Enkel (2004), 'Towards a Theory of Open Innovation: Three Core Process Archetypes', Citeseer.
- Grant, A. M. and S. V. Patil (2012), 'Challenging the Norm of Self-Interest: Minority Influence and Transitions to Helping Norms in Work Units', *Academy of Management Review*, **37**, 547-568.

- Green, S. G., M. B. Gavin and L. A. Aimers (1995), 'Assessing a Multidimensional Measure of Radical Technological Innovation', *IEEE Transactions on Engineering Management*, **42**, 203-214.
- Grodal, S., A. J. Nelson and R. M. Siino (2015), 'Help-Seeking and Help-Giving as an Organizational Routine: Continual Engagement in Innovative Work', *Academy of Management Journal*, **58**, 136-168.
- Gruber, M. and J. Henkel (2006), 'New Ventures Based on Open Innovation ,Â an Empirical Analysis of Start-up Firms in Embedded Linux', *International Journal of Technology Management*, **33**, 356-372.
- Haas, M. R. and M. T. Hansen (2007), 'Different Knowledge, Different Benefits: Toward a Productivity Perspective on Knowledge Sharing in Organizations', *Strategic Management Journal*, **28**, 1133-1153.
- Hargadon, A. B. and B. A. Bechky (2006), 'When Collections of Creatives Become Creative Collectives: A Field Study of Problem Solving at Work', *Organization Science*, **17**, 484-500.
- Henderson, R. M. and K. B. Clark (1990), 'Architectural Innovation - the Reconfiguration of Existing Product Technologies and the Failure of Established Firms', *Administrative Science Quarterly*, **35**, 9-30.
- Henkel, J. (2006), 'Selective Revealing in Open Innovation Processes: The Case of Embedded Linux', *Research Policy*, **35**, 953-969.
- Henkel, J. (2009), 'Champions of Revealing--the Role of Open Source Developers in Commercial Firms', *Industrial & Corporate Change*, **18**, 435-471.
- Henkel, J., S. Schöberl and O. Alexy (2014), 'The Emergence of Openness: How and Why Firms Adopt Selective Revealing in Open Innovation', *Research Policy*, **43**, 879-890.
- Hertel, G., S. Niedner and S. Herrmann (2003), 'Motivation of Software Developers in Open Source Projects: An Internet-Based Survey of Contributors to the Linux Kernel', *Research Policy*, **32**, 1159.
- Hienert, C. (2006), 'The Commercialization of User Innovations: The Development of the Rodeo Kayak Industry', *R&D Management*, **36**, 273-294.
- Hienert, C. and C. Lettl (2011), 'Exploring How Peer Communities Enable Lead User Innovations to Become Standard Equipment in the Industry: Community Pull Effects', *Journal of Product Innovation Management*, 175-195.
- Holmes, S. and P. Smart (2009), 'Exploring Open Innovation Practice in Firm - Nonprofit Engagements: A Corporate Social Responsibility Perspective', *R&D Management*, **39**, 394-409.

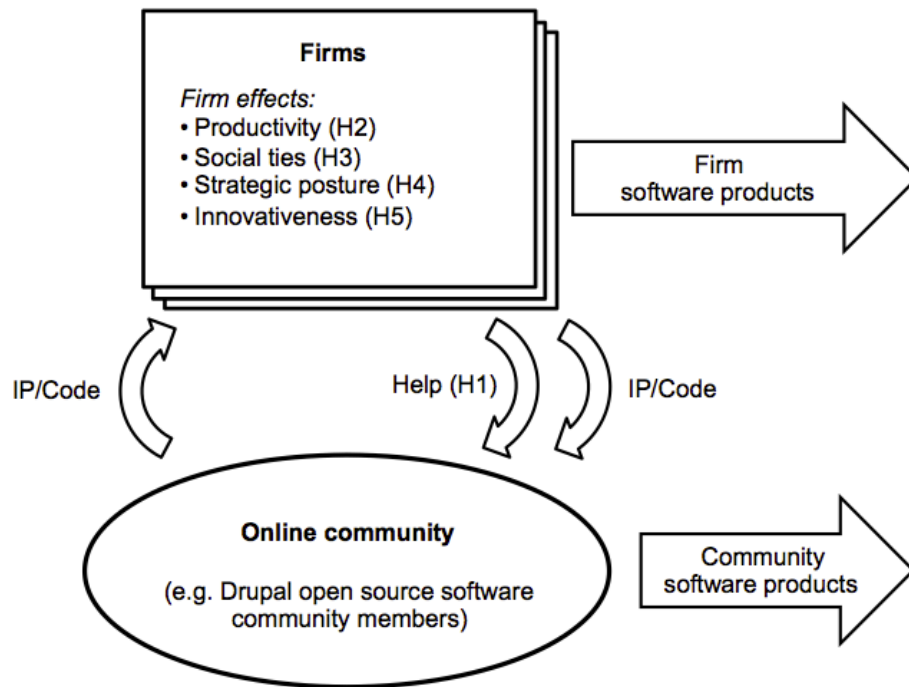
- Hung, K.-P. and Y.-H. Chiang (2010), 'Open Innovation Proclivity, Entrepreneurial Orientation, and Perceived Firm Performance', *International Journal of Technology Management*, **52**, 257-274.
- Ingram, P. and P. W. Roberts (2000), 'Friendships among Competitors in the Sydney Hotel Industry', *American Journal of Sociology*, **106**, 387-423.
- King, A. and K. R. Lakhani (2013), 'Using Open Innovation to Identify the Best Ideas', *MIT Sloan Management Review*, **55**, 41.
- Kortmann, S. and F. Piller (2016), 'Open Business Models and Closed-Loop Value Chains', *California Management Review*, **58**, 88-108.
- Lakhani, K. R. and E. von Hippel (2003), 'How Open Source Software Works: "Free" User-to-User Assistance', *Research Policy*, **32**, 923-943.
- Lakhani, K. R. and R. G. Wolf (2005), 'Why Hackers Do What They Do: Understanding Motivation and Effort in Free/Open Source Software Projects', in J. Feller, B. Fitzgerald, S. Hissam and K. R. Lakhani (eds.), *Perspectives on Free and Open Source Software*, MIT Press, Cambridge, Mass: 3-22.
- Lerner, J. and J. Tirole (2002), 'Some Simple Economics of Open Source', *Journal of Industrial Economics*, **50**, 197-234.
- Miller, D. and P. H. Friesen (1983), 'Strategy-Making and Environment: The Third Link', *Strategic Management Journal*, **4**, 221-235.
- O'Mahony, S. and F. Ferraro (2007), 'The Emergence of Governance in an Open Source Community', *Academy of Management Journal*, **50**, 1079-1106.
- O'Mahony, S. and K. R. Lakhani (2011), 'Organizations in the Shadow of Communities', *Research in the Sociology of Organizations*, **33**, 3-36.
- Piller, F. (2010), 'Open Innovation with Customers: Crowdsourcing and Co-Creation at Threadless', *A Guide to Open Innovation and Crowdsourcing*, Edited by Paul Sloane, London: Kogan-Page: 106-112.
- Piller, F. and J. West (2014), 'Firms, Users, and Innovation: An Interactive Model of Coupled Open Innovation', *H. Chesbrough, W. Vanhaverbeke, J. West (Eds.), New Frontiers in Open Innovation*, Oxford University Press, Oxford.
- Pittaway, L., M. Robertson, K. Munir, D. Denyer and A. Neely (2004), 'Networking and Innovation: A Systematic Review of the Evidence', *International Journal of Management Reviews*, **5-6**, 137-168.
- Powell, W. W. (1990), 'Neither Market nor Hierarchy: Network Forms of Organization', *Research in Organizational Behavior*, **12**, 295-336.

- Randhawa, K., R. Wilden and J. Hohberger (2016), 'A Bibliometric Review of Open Innovation: Setting a Research Agenda', *Journal of Product Innovation Management*.
- Rass, M., M. Dumbach, F. Danzinger, A. C. Bullinger and K. M. Moeslein (2013), 'Open Innovation and Firm Performance: The Mediating Role of Social Capital', *Creativity and innovation management*, **22**, 177-194.
- Reagans, R. and E. W. Zuckerman (2001), 'Networks, Diversity, and Productivity: The Social Capital of Corporate R&D Teams', *Organization Science*, **12**, 502-517.
- Rigby, D. and C. Zook (2002), 'Open-Market Innovation', *Harvard Business Review*, **80**, 80-89.
- Rosenkopf, L. and M. L. Tushman (1998), 'The Coevolution of Community Networks and Technology: Lessons from the Flight Simulation Industry', *Industrial & Corporate Change*, **7**, 311-346.
- Rothschild-Whitt, J. (1979), 'The Collectivist Organization: An Alternative to Rational-Bureaucratic Models', *American Sociological Review*, **44**, 509-527.
- Sampson, R. C. (2007), 'R&D Alliances and Firm Performance: The Impact of Technological Diversity and Alliance Organization on Innovation', *Academy of Management Journal*, **50**, 364-386.
- Samuelson, P. (2006), 'Ibm's Pragmatic Embrace of Open Source', *Communications of the ACM*, **49**, 21-25.
- Santos, J. R. A. (1999), 'Cronbach's Alpha: A Tool for Assessing the Reliability of Scales', *Journal of Extension*, **37**, 1-5.
- Schweisfurth, T., C. Raasch and C. Herstatt (2011), 'Free Revealing in Open Innovation: A Comparison of Different Models and Their Benefits for Companies', *International Journal of Product Development*, **13**, 95-118.
- Seidel, V. P. and B. Langner (2015), 'Using an Online Community for Vehicle Design: Project Variety and Motivations to Participate', *Industrial and Corporate Change*, **24**, 635-653.
- Seidel, V. P., B. Langner and J. Sims (2016), 'Dominant Communities and Dominant Designs: Community-Based Innovation in the Context of the Technology Life Cycle', *Strategic Organization*, **14**.
- Shah, S. K. (2006), 'Motivation, Governance, and the Viability of Hybrid Forms in Open Source Software Development', *Management Science*, **52**, 1000-1014.
- Tucci, C. L., H. Chesbrough, F. Piller and J. West (2016), 'When Do Firms Undertake Open, Collaborative Activities? Introduction to the Special Section on Open

- Innovation and Open Business Models', *Industrial and Corporate Change*, **25**, 283-288.
- Uzzi, B. (1996), 'The Sources and Consequences of Embeddedness for the Economic Performance of Organizations: The Network Effect', *American Sociological Review*, **61**, 674-698.
- Vanhaverbeke, W., V. Van de Vrande and H. Chesbrough (2008), 'Understanding the Advantages of Open Innovation Practices in Corporate Venturing in Terms of Real Options', *Creativity & Innovation Management*, **17**, 251-258.
- Villarroel, J. A., J. E. Taylor and C. L. Tucci (2013), 'Innovation and Learning Performance Implications of Free Revealing and Knowledge Brokering in Competing Communities: Insights from the Netflix Prize Challenge', *Computational and Mathematical Organization Theory*, **19**, 42-77.
- Von Krogh, G., S. Haefliger, S. Spaeth and M. W. Wallin (2012), 'Carrots and Rainbows: Motivation and Social Practice in Open Source Software Development', *MIS Quarterly*, **36**, 649-676.
- Waguespack, D. M. and L. Fleming (2009), 'Scanning the Commons? Evidence on the Benefits to Startups Participating in Open Standards Development', *Management Science*, **55**, 210-223.
- Wang, P. and N. C. Ramiller (2009), 'Community Learning in Information Technology Innovation', *MIS Quarterly*, **33**, 709-734.
- West, J. and M. Bogers (2014), 'Leveraging External Sources of Innovation: A Review of Research on Open Innovation', *Journal of Product Innovation Management*, **31**, 814-831.
- West, J. and S. Gallagher (2006a), 'Challenges of Open Innovation: The Paradox of Firm Investment in Open-Source Software', *R & D Management*, **36**, 319-331.
- West, J. and S. Gallagher (2006b), 'Patterns of Open Innovation in Open Source Software', in H. Chesbrough, W. Vanhaverbeke and J. West (eds.), *Open Innovation: Researching a New Paradigm*, Oxford University Press, Oxford: 82-106.
- West, J. and G. Kuk (2016), 'The complementarity of openness: How Makerbot Leveraged Thingiverse in 3d Printing', *Technology Forecasting and Social Change*.
- West, J. and K. R. Lakhani (2008), 'Getting Clear About Communities in Open Innovation', *Industry and Innovation*, **15**, 223-231.
- West, J. and S. O'Mahony (2008), 'The Role of Participation Architecture in Growing Sponsored Open Source Communities', *Industry & Innovation*, **15**, 145-168.

- West, J., A. Salter, W. Vanhaverbeke and H. Chesbrough (2014), 'Open Innovation: The Next Decade Introduction', *Research Policy*, **43**, 805-811.
- West, J. and J. Sims (Forthcoming), 'How Firms Leverage Crowds and Communities for Open Innovation', in A. Afuah, C. L. Tucci and G. Viscusi (eds.), *Creating and Capturing Value through Crowdsourcing*.
- Westphal, J. D. (1999), 'Collaboration in the Boardroom: Behavioral and Performance Consequences of Ceo-Board Social Ties', *Academy of Management Journal*, **42**, 7-24.
- Westphal, J. D., S. Boivie and D. H. Ming Chng (2006), 'The Strategic Impetus for Social Network Ties: Reconstituting Broken Ceo Friendship Ties', *Strategic Management Journal*, **27**, 425-445.
- Williamson, O. E. (1991), 'Strategizing, Economizing, and Economic-Organization', *Strategic Management Journal*, **12**, 75-94.

## Figures and Tables



**Figure 1.** Community-coupled open innovation with indication of hypotheses tested

**Table 1.** Factor Loadings

Questionnaire Item	Factor			
	1 Duration of engagement*	2 Inbound IP	3 Outbound IP	4 Outbound Help
Duration of Engagement*	<b>0.94</b>	-0.04	-0.06	-0.02
Years Seeking Assistance	<b>0.95</b>	0.02	-0.04	-0.04
Years Contribution	<b>0.75</b>	-0.02	0.12	0.12
Use Drupal Since Founding	-0.17	<b>0.63</b>	-0.06	0.04
Use of Drupal in Products (%)	0.18	<b>0.75</b>	0.02	-0.05
Employees using Drupal (%)	-0.01	<b>0.94</b>	0.01	-0.06
Contributions to Drupal Core	0.02	-0.07	<b>0.81</b>	0.04
Contributions to Drupal Docs	-0.01	0.12	<b>0.64</b>	0.10
Contributions to Drupal Themes	-0.04	-0.04	<b>0.99</b>	-0.10
Encouragement of Volunteering	-0.03	0.16	-0.07	<b>0.83</b>
Payment of Volunteers	0.04	-0.17	0.00	<b>0.83</b>
Assisting others for Free	0.00	0.19	0.12	<b>0.50</b>

Note: \* “Duration of Engagement” was used as a control variable



**Table 2.** Correlations of Key Variables

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Inbound IP	1													
2	Outbound IP	0.267**	1												
3	Outbound Help	0.504**	0.481**	1											
4	Coupled IP	0.042	0.539**	0.176*	1										
5	Coupled Help	-0.072	0.194**	0.029	0.493**	1									
6	Years Involved	0.142	0.271**	0.401**	0.097	-0.101	1								
7	Productivity	0.288**	-0.152	0.019	-0.043	-0.093	-0.027	1							
8	Social Ties	0.329**	0.556**	0.418**	0.545**	0.240**	0.257**	-0.080	1						
9	Incrementalism	0.093	0.101	0.032	0.070	-0.126	0.149	-0.082	0.032	1					
10	Entre. Posture	-0.024	0.102	0.166*	0.139	-0.073	0.122	-0.241**	0.150	0.058	1				
11	Firm Size (log)	-0.728**	-0.025	-0.319**	0.125	0.140*	-0.124	-0.333**	-0.071	-0.02	0.033	1			
12	Performance	-0.304**	0.143	0.008	0.268**	0.148	0.069	-0.425**	0.177*	-0.071	0.426**	0.399**	1		
13	Growth	0.108	0.179*	0.131	0.070	0.123	0.019	-0.127	0.184*	0.042	0.110	-0.023	0.186*	1	
14	Founder is CEO	0.547**	0.154*	0.323**	-0.031	-0.048	0.172*	0.124	0.171*	0.058	0.043	-0.671**	-0.204**	0.103	1
15	Firms age (log)	-0.724**	-0.142*	-0.307**	0.076	0.035	0.038	-0.178	-0.116	-0.061	-0.045	0.691**	0.204*	-0.231**	-0.618**

Note: \*P < 0.05, \*\*P < 0.01.

**Table 3.** Regression analysis explaining productivity

	<b>Model 1</b>		<b>Model 2</b>		<b>Model 3</b>	
<b>Variable</b>	<b>Coefficient</b>	<b>S.E.</b>	<b>Coefficient</b>	<b>S.E.</b>	<b>Coefficient</b>	<b>S.E.</b>
Constant	-6.927***	(1.005)	-8.379***	(1.052)	-8.419***	(1.073)
Firm Size (log)	-0.563***	(0.116)	-0.415**	(0.119)	-0.416**	(0.121)
Performance	-0.466**	(0.168)	-0.412*	(0.160)	-0.417*	(0.166)
Growth	0.003	(0.004)	0.004	(0.003)	0.004	(0.004)
Founder is CEO	-0.900	(0.470)	-0.493	(0.479)	-0.462	(0.491)
Firms age (log)	0.068	(0.196)	0.224	(0.231)	0.195	(0.239)
Years Involved	-0.057	(0.057)	-0.028	(0.065)	-0.019	(0.067)
Inbound IP			0.249*	(0.111)	0.234*	(0.114)
Outbound IP			-0.121*	(0.053)	-0.126*	(0.058)
Outbound Help			-0.091	(0.077)	-0.100	(0.080)
Coupled IP					0.004	(0.028)
Coupled Help					0.015	(0.027)

Note: \*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001

**Table 4.** Regression analysis explaining social ties

	<b>Model 1</b>		<b>Model 2</b>		<b>Model 3</b>	
<b>Variable</b>	<b>Coefficient</b>	<b>S.E.</b>	<b>Coefficient</b>	<b>S.E.</b>	<b>Coefficient</b>	<b>S.E.</b>
Constant	-0.542	(0.496)	-0.591	(0.423)	-0.274	(0.389)
Firm Size (log)	0.001	(0.052)	0.041	(0.045)	0.026	(0.040)
Performance	0.020	(0.086)	0.068	(0.069)	0.034	(0.064)
Growth	0.000	(0.002)	0.000	(0.002)	0.001	(0.002)
Founder is CEO	0.273	(0.230)	0.084	(0.189)	-0.032	(0.172)
Firms age (log)	-0.018	(0.098)	0.108	(0.085)	0.029	(0.079)
Years Involved	0.073*	(0.031)	0.010	(0.028)	0.015	(0.025)
Inbound IP			0.157**	(0.045)	0.116**	(0.042)
Outbound IP			0.165***	(0.029)	0.141***	(0.027)
Outbound Help			-0.001	(0.032)	0.009	(0.029)
Coupled IP					0.043***	(0.011)
Coupled Help					0.007	(0.010)

Note: \*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001

**Table 5.** Regression analysis explaining entrepreneurial strategic posture

	<b>Model 1</b>		<b>Model 2</b>		<b>Model 3</b>	
<b>Variable</b>	<b>Coefficient</b>	<b>S.E.</b>	<b>Coefficient</b>	<b>S.E.</b>	<b>Coefficient</b>	<b>S.E.</b>
Constant	-0.386	(0.862)	0.018	(0.935)	-0.075	(0.913)
Firm Size (log)	0.012	(0.085)	-0.025	(0.093)	0.018	(0.091)
Performance	1.069***	(0.143)	1.043***	(0.146)	0.987***	(0.144)
Growth	-0.013***	(0.003)	-0.013**	(0.003)	-0.012**	(0.003)
Founder is CEO	0.487	(0.397)	0.332	(0.412)	0.422	(0.401)
Firms age (log)	-0.166	(0.161)	-0.185	(0.182)	-0.206	(0.179)
Years Involved	0.070	(0.051)	0.048	(0.056)	0.023	(0.055)
Inbound IP			-0.085	(0.098)	-0.067	(0.096)
Outbound IP			0.018	(0.054)	0.007	(0.055)
Outbound Help			0.095	(0.071)	0.097	(0.069)
Coupled IP					0.038	(0.026)
Coupled Help					-0.073*	(0.026)

Note: \*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001

**Table 6.** Regression analysis explaining incrementalism

	<b>Model 1</b>		<b>Model 2</b>		<b>Model 3</b>	
<b>Variable</b>	<b>Coefficient</b>	<b>S.E.</b>	<b>Coefficient</b>	<b>S.E.</b>	<b>Coefficient</b>	<b>S.E.</b>
Constant	-0.668	(0.614)	-1.168	(0.646)	-1.095	(0.630)
Firm Size (log)	0.110	(0.064)	0.166*	(0.066)	0.159*	(0.065)
Performance	0.043	(0.104)	0.085	(0.103)	0.037	(0.102)
Growth	-0.001	(0.003)	-0.002	(0.003)	-0.001	(0.003)
Founder is CEO	0.403	(0.285)	0.469	(0.284)	0.472	(0.277)
Firms age (log)	-0.109	(0.123)	-0.003	(0.134)	-0.008	(0.133)
Years Involved	0.092*	(0.037)	0.073	(0.040)	0.065	(0.039)
Inbound IP			0.165*	(0.071)	0.144*	(0.071)
Outbound IP			0.066	(0.038)	0.032	(0.040)
Outbound Help			-0.069	(0.051)	-0.053	(0.051)
Coupled IP					0.041*	(0.018)
Coupled Help					-0.037*	(0.019)

Note: \*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001

## Appendix A: Survey question topics

Question topic	Response prompts
<i>Questions on how the firm receives support from the Drupal community</i>	
Use of software code from the community	1 (never) to 5 (very often)
Years using code from the community	1 (< 1 yr.) to 10 (10+ yrs.)
Used Drupal since founded	Yes / No
Use of Drupal support channels: IRC, Forums, Meetups, and other.	1 (never ) to 5 (very often)
Years company asked for assistance from community	1 (<1 yr.) to 10 (10+ yrs.)
Percentage of your current products or services based on the community	1 (none) to 5 (76-100%)
Employees that regularly interact with individuals in the community	number (count)
Other open-source communities the company works with	1 (none) to 4 (6 or more)
<i>Questions on how the firm contributes to the Drupal community</i>	
How often contribute code to the community	1 (never ) to 5 (very often)
How long contribute code to the community	1 (< 1 yr.) to 10 (10+ yrs.)
Percentage of contributions to Drupal accepted and incorporated into: Drupal Core, Modules, Documentation, Themes	1 (none) to 5 (76-100%)
How often encourage employees to volunteer time to the community	1 (never ) to 5 (very often)
How often pay employees for time spent working on contributions to the community	1 (never ) to 5 (very often)
How often does company assist other companies in the community free of charge	1 (never ) to 5 (very often)
<i>Questions about products and relationship with Drupal community</i>	
How many new products (or client jobs) company began in each of the past three years	number (count)
How many products (or client jobs) company completed in last year	number (count)
Average total cost of a typical product in the last year	number (cost)
Hours of development time for typical project	number (hours)
Percentage of time for each project engaged in debugging (i.e. not creating new code)	number (percent)
Percentage of the time for each project spent developing custom Drupal modules	number (percent)
<i>Questions on personal relationships with members of the Drupal community</i>	
Number of individuals involved in the community as acquaintances or friends	number (count)
People in community considered acquaintances but not close friends	number (count)
<i>Questions on firm's technical field</i>	
Progress of technical knowledge within field	1 (very slow) to 7 (very rapid)
How easy to gain necessary technical knowledge	1 (very easy) to 7 (very difficult)
How easy to adjust to the learning curve for Drupal	1 (very easy) to 7 (very difficult)
<i>Questions about firm performance</i>	
Total sale's growth when compared to other companies in my industry	1 (Bottom 20%) to 5 (Top 20%)
Overall performance when compared to other companies in my industry	1 (Bottom 20%) to 5 (Top 20%)
Speed of introduction of new products	1 (seldom first) to 7 (often first)
Risk tolerance	1 (low risk) to 7 (high risk)