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RESEARCH ARTICLE

THE IMPACT OF IDEOLOGY MISFIT ON OPEN SOURCE SOFTWARE COMMUNITIES AND COMPANIES[1]

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Corporate involvement in open source software (OSS) communities has increased substantially in recent years. Often this takes the form of company employees devoting their time to contribute code to the efforts of projects in these communities. Ideology has traditionally served to motivate, coordinate, and guide volunteer contributions to OSS communities. As employees represent an increasing proportion of the participants in OSS communities, the role of OSS ideology in guiding their commitment and code contributions is unknown. In this research, we argue that OSS ideology misfit has important implications for companies and the OSS communities to which their employees contribute, since their engagement in such communities is not necessarily voluntary. We conceptualize two different types of misfit: OSS ideology under-fit, whereby an employee embraces an OSS ideology more than their coworkers or OSS community do, and OSS ideology over-fit, whereby an employee perceives that their coworkers or OSS community embrace the OSS ideology more strongly than the employee does. To develop a set of hypotheses about the implications of these two types of misfit for employee commitment to the company and commitment to the OSS community, we draw on self-determination theory. We test the hypotheses in a field study of 186 employees who participate in an OSS community. We find that OSS ideology under-fit impacts the company and the community in the same way: it decreases employee commitment to the company and commitment to the OSS community. In contrast, we find that OSS ideology over-fit increases commitment to the company but decreases commitment to the OSS community. Finally, we find that employees' commitment to their company reinforces the impact of their commitment to the OSS community in driving ongoing code contributions. This provides a holistic view of OSS ideology and its impacts among an increasingly pervasive yet understudied type of participant in OSS research. It provides insights for companies that are considering assigning their employees to work in OSS communities as well as for OSS communities that are partnering with these companies.

Keywords: Open source software, OSS ideology, P–E fit, misfit, self-determination theory, commitment, code contribution, polynomial regression

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Introduction

The success of open source software (OSS) development has led a growing number of companies to seek to leverage this model of development (Fitzgerald 2006; Germonprez et al. 2016; Ho and Rai 2017; Stewart et al. 2006). Companies devote resources, including employee labor, to OSS initiatives (Hann et al. 2013; Spaeth et al. 2015). However, the return on such investments has been mixed (Capra et al. 2011; Stewart et al. 2006). While companies such as IBM, Novell, and Red Hat have achieved some success in their OSS community collaborations (Munga et al. 2009), other companies have failed. For instance, Xara, a commercial software company, mismanaged an effort to garner developer commitment and participation because it fundamentally misunderstood the ideology that drove contributors to participate (Willis 2007). Ideology represents "relatively coherently interrelated sets of emotionally charged beliefs, values and norms that bind some people together and help them make sense of their worlds" (Trice and Beyer 1993, p. 33). As such, it serves as a frame of reference for predicting and relating to others in an environment (Hartley 1983). Although Xara released 90% of its code to the community, it did not cater to developers' interest in the core 10% of the application, thus failing to adhere to the expected openness and sharing that underlies the ideology common in OSS communities. This proved to be a major sticking point for community developers—who ultimately abandoned the project because Xara did not address their needs (Willis 2007).

As the Xara experience illustrates, ideology informs developers' commitment to OSS community development efforts. Commitment drives performance in traditional organizations (Angle and Lawson 1994; Somers and Birnbaum 1998), citizenship behavior in virtual communities (Yong et al. 2011), participation intention in virtual communities (Xie et al. 2008), contribution intention in virtual communities (Xie et al. 2008), and actual contribution behavior in online communities (Bateman et al. 2011; Wiertz and Ruyter 2007). Because they are typically not bound by financial contract (Crowston et al. 2012), contributors have control over when they join and leave OSS communities, making commitment to virtual communities in general, and OSS communities in particular, important. As with many online communities, without a binding sense of relatedness between members, OSS communities experience high levels of membership turnover (Oh and Jeon 2007; Ransbotham and Kane 2011), with many developers making only one contribution before leaving (Pham et al. 2013; Pinto et al. 2016; Zhou and Mockus 2012). Attracting and retaining developer contributions is a challenging but essential endeavor for OSS community leaders (Crowston et al. 2012). Developer code contributions—in the form of new features, enhancements, and bug fixes—constitute the lifeblood of OSS communities as they ensure the long-term viability of the software product (Crowston et al. 2012). For these reasons commitment may represent one of the strongest drivers of developer code contribution to the OSS community and such contributions are essential to the OSS community, impacting adoption and market share (Crowston et al. 2006; Subramaniam et al. 2009).

Ideology galvanizes prosocial outcomes for OSS teams (Stewart and Gosain 2006) and individuals (Ke and Zhang 2009). Indeed, since the inception of the OSS movement, ideology has played a major role in motivating developers and creating a sense of relatedness among them (Choi et al. 2015; Ljungberg 2000; Stewart and Gosain 2006). However, the role of ideology may be changing. Recent trends indicate that commercial companies encourage their employees to engage OSS communities (Dahlander and Magnusson 2008; Henkel 2008; Munga et al. 2009). Lakhani and Wolf (2005) found that 40% of developers received payment from commercial companies in exchange for contributions to OSS communities and increasingly companies pay their employees to add code to OSS efforts (Homscheid et al. 2015). In fact, much of the maintenance for the Eclipse platform comes from IBM employees (Wagstrom 2009) and unpaid developers make only 13.6% of the contributions to the Linux kernel (Corbet et al. 2013). RedHat, Sun Microsystems and Ximian (formerly Helix Code) all devote full-time paid employees to contribute to GNOME—an OSS community (German 2003). That such employees represent an increasing proportion of OSS communities challenges our assumptions about the role of ideology in motivating developers to commit to OSS communities and make associated contributions.

The engagement by commercial companies with OSS communities generates entanglements in employees' development work (Alexy et al. 2013; Dahlander and Magnusson 2008; Faraj et al. 2016; Germonprez et al. 2016). That is, the work they perform simultaneously affects the interests of the company and the community to which they contribute. Indeed, von Krogh et al. (2012) suggest that OSS development increasingly constitutes a social practice comprised of individual developer norms, community norms, and company influence. Commercial companies must walk a fine line in that their efforts aim to obtain tangible benefits from their investments (Schaarschmidt et al. 2015), but the OSS community must not perceive them as being overly driven by profit motives, lest they alienate the community (Stewart et al. 2006). These divergent motives suggest a need to reexamine and expand our treatment of ideology in OSS communities. Importantly, it necessitates consideration of the ideological position of the commercial company, the employee, and the OSS community because ideology plays a large part in motivating developers, establishing their relationship to others,

and shaping how work gets accomplished (Stewart and Gosain 2006, von Krogh et al. 2012). Of particular interest in this research is *whether* and *how* ideological differences affect the employees charged with conducting development work in OSS communities. Against this backdrop, our core research question is: *How do differences in ideology between employees and their coworkers, and between employees and the OSS community, affect employee commitment and code contribution to the community?*

In an effort to address this research question, we draw upon two theoretical perspectives. First, we draw upon P–E fit theory (Kristof-Brown et al. 2005). Because P–E fit theory explicitly recognizes the need to treat the person and the environment in which they are embedded as separate entities that jointly affect human behavior, it represents an appropriate theoretical lens for our research question (Kristof-Brown et al. 2005; Kristof-Brown and Guay 2011). It provides an ideal theoretical vehicle for examining the ideological position of employees, their coworkers, and the OSS community as distinct entities while also examining their joint impact on employee commitment and contributions. We focus on *misfit* between person and environment, which we define as the extent to which the employee perceives differences between themselves and their coworkers, and between the employee and the OSS community in terms of their embrace of an ideology that affects their work. We focus on *perceived* differences because we believe that an employee's perceptions of an organization's ideology derive from the employee's experience of the work and relations with members of that organization—be it coworkers or the OSS community members. When we refer to an employee's perception of those with whom they work through the company, we refer to the perceived coworker ideology.

Second, while P–E fit theory provides an ideal vehicle for the treatment of these three entangled entities, it provides little theoretical explanation for the effects of misfit on commitment. To theorize the influence of misfit we consider the contexts that enable developers to feel confident and in control when executing OSS development work and at the same time feel related to others around them. Thus, we leverage self-determination theory (SDT) as a lens to understand employees' reactions to misfit in ideology. This theory is well suited for this study because, like P–E fit, it pays particular attention to how an individual's social context influences their attitudes (Greguras et al. 2014). In particular, it is a motivational theory that takes into account how personal motives interface with the environment—through feelings of control, competence and relatedness—to influence outcomes (Deci and Ryan 1987). As such, it provides a theoretical rationale for why different forms of misfit yield distinct outcomes. Our core proposition is that employees will be increasingly committed in conditions where the environment offers them opportunities to fulfill their psychological needs for autonomy, relatedness, and competence.

We examine these issues in a field study of 186 company employees who engage with the GNOME project. The insights yielded from the empirical study contribute to theory in several important ways. First, we contribute to a theoretical understanding of OSS ideology as encompassing employees, company coworkers, and the OSS community instead of the extant literature's emphasis on the ideology of a single entity (Henkel 2008). Second, by focusing on misfit in ideology using self-determination theory, we provide a theoretically nuanced understanding of the conditions under which ideological misfit benefits companies and the OSS community as well as conditions under which such differences can be detrimental in terms of promoting employee commitment. Our attention to misfit constitutes a key departure from prior fit literature in information systems and human resource management, which has tended to emphasize the effects of fit (Schilling et al. 2011). Much of the literature on P–E fit theory has not directly theorized the impact of misfit, largely assuming that such situations leave people with the "sense that they do not belong and feeling unfulfilled by their work" (Vogel et al. 2016, p. 1561). In contrast to this body of work, drawing on self-determination theory, we explain the conditions under which misfit can yield positive impacts. Third, this research contributes to P–E fit theory by theorizing the impacts of misfit across different organizational entities, namely, companies that epitomize the traditional context within which P–E fit has been studied and the OSS community, which represents a fundamentally different form of organization that relies primarily on digital communication (Faraj et al. 2016). By incorporating a focus on misfit across multiple entangled organizational entities, we demonstrate the different ways in which misfit affects employees' commitment to each entity. This serves as an important call to future P–E fit research to move beyond a focus on misfit with a single entity.

Theoretical Background

OSS Ideology

Ideologies can focus on politics, marketing, or other social systems and can be seen as positive, negative or neutral (O'Reilly 2006; Williams 1976). When an organization adopts an ideology, it provides a means for relating to, interpreting, and understanding what the organization participants do (Ashforth and Kreiner 1999). Organizations promoting an ideology provide individuals with a system of values, beliefs,

and norms that give purpose for their work (Besharov 2008). This guides individuals in evaluating the legitimacy of their behavior and leads them to find ideology-sanctioned work worthwhile (Ke and Zhang 2009). Ideology serves as a rallying point that galvanizes individuals and mobilizes their commitment to the organization's goals (Trice and Beyer 1993). Ideology holds extraordinary importance in OSS development where developers work primarily through technology-mediated means with no pay from the OSS community (although other companies may pay developers to contribute to OSS communities) (Seidel et al. 2000; Stewart and Gosain 2006).

Over time, various ideologies and belief systems have surfaced in OSS communities (AlMarzouq et al. 2005; Dedrick and West 2008; Stallman 2002). Of these, two focal ideologies exist: one proposed by the Free Software movement represented by the Free Software Foundation, and the other by the Open Source movement, represented by the Open Source Initiative (AlMarzouq et al. 2005). Both movements share the same development tools, approaches, and websites such as SourceForge.net (Dedrick and West 2008). However, they also differ from each other. The Free Software Foundation has a narrower focus and prefers restrictive licenses that limit commercial appropriation of code, while the Open Source Initiative holds a more inclusive view, embracing both the licences the Free Software Foundation prefers and licenses that allow for commercial appropriation (Dedrick and West 2008; Stewart et al. 2006). While in principle these two movements embody somewhat different ideologies, in practice OSS communities often embrace elements of both.

OSS ideology can create predictability in developer behaviors and enable them to make sense of the actions of others (Stewart and Gosain 2006). Based on prior literature, narratives, and discourse analysis of actual OSS developers in practice, Stewart and Gosain (2006) identified three tenets of OSS ideology: values, beliefs, and norms. Values refer to preferences for some behaviors or outcomes over others (Trice and Beyer 1993). Canonical documents such as "The Jargon File," "The New Hacker Dictionary," and "The Cathedral and the Bazaar" reflect the OSS values (Raymond 2001). OSS values include sharing, helping, knowledge, cooperation, and reputation. Beliefs refer to understandings of causal relationships (Trice and Beyer 1993). Process beliefs describe how OSS processes lead to certain outcomes. Beliefs provide a set of mutual knowledge about cause–effect relationships, which enables rational assessment of other participants' behaviors based on an understanding of the reasoning driving these behaviors. Freedom belief is so core to the OSS ideology that if an application is not free to use it is not considered OSS (www.opensource.org). Moreover, many OSS projects embrace this belief as reflected in their use of licenses with provisions for keeping the source code freely available (Stewart et al. 2006). Norms refer to expectations regarding participant behavior (Trice and Beyer 1993). Norms enshrined in the OSS ideology include an avoidance of forking, ensuring appropriate distribution of code changes through the proper channels (e.g., through the role of committers) and maintaining named credit for each developer's contributions (Stewart and Gosain 2006). These norms make OSS community activities more predictable and facilitate developer coordination.

The OSS ideology drives benefits for OSS communities and commercial companies. For instance, the style of work the ideology promotes may lead to higher quality code because of the sharing of knowledge and increased testing (Rolandsson et al. 2011). The OSS ideology also facilitates faster creation of unique, cutting edge solutions (Rolandsson et al. 2011). For these reasons, some commercial companies, including Nokia, SAP, and Hewlett-Packard, seek to mimic OSS coding styles (Lindman et al. 2008; Mockus and Herbsleb 2002; Stol et al. 2011). When Netscape announced, in 1998, that they would release their Communicator project, they stated that they did so in an attempt to emulate the successful development approach used in projects like Linux (Mockus and Herbsleb 2002). However, some aspects of the OSS ideology work better for OSS communities than for commercial companies.

Embracing the OSS ideology limits the ways in which companies generate revenue. To charge fees for software, commercial companies keep source code confidential (Henkel 2008) and do not embrace the OSS belief that they should make source code freely available (Stewart and Gosain 2006). In fact, commercial company leaders may perceive this logic as contradictory to the company's main financial incentives. Even if a company gives some of its software away for free, it could sell other software applications (Bonaccorsi et al. 2006). In contrast, because OSS communities often do not aim to profit from the sale of software, giving software away for free coincides with community goals. For these reasons, the way the OSS ideology is embraced by members of the company and the way the OSS ideology is perceived in OSS communities may differ.

In addition to issues related to generating revenue, the OSS ideology can keep developers motivated to contribute code (e.g., to attain status), which is important for OSS communities because financial incentives may not come from the OSS community. Status motivates OSS developers (Fang and Neufeld 2009) and acts as a way to govern the OSS community (Daniel et al. 2013). Companies offer developers financial incentives, thus status motivation may not play the same role for companies as it does for OSS communities.

Achieving status represents a key aspect of the OSS ideology and OSS communities, but may denote a difference between OSS communities and commercial companies. Given the fact that OSS ideology may not play the same role for companies and the OSS community; and yet the two may be entangled in employees' development work, we investigate its impact for both.

The Need to Incorporate Company and OSS Community OSS Ideology

Employee OSS ideology varies in terms of how closely each person's ideology reflects the tenets identified earlier, with some employees occupying one end of the spectrum and those who do not see a big deal with this ideology sitting at the other end (de Laat 2007; Ljungberg 2000; Rolandsson et al. 2011). As companies encourage employees to commit their effort to OSS initiatives, the proportion of them motivated by the ideology and functioning according to the coordination mechanisms it dictates is shifting (Capiluppi et al. 2012; O'Mahony and Ferraro 2007). An employee could feel more motivated by the company's needs than by the employee's personal desire to adhere to the OSS ideology (Dahlander and Wallin 2006).

With the exception of Ke and Zhang (2009), prior literature on the role of ideology (summarized in Table 1) has almost exclusively focused on the ideology of developers to understand a developer's OSS attitudes and behaviors (Benbya and Belbaly 2010; Henkel 2008; Xu et al. 2009). Some studies find that developer ideology does not impact their contribution (Henkel 2008), others find that it positively impacts their contribution (Benbya and Belbaly 2010), and yet others find that it negatively impacts their task effort (Ke and Zhang 2010).[2]

To explain the lack of relationship between ideology and prosocial outcomes, Henkel (2008) suggests that identification with the OSS community—as opposed to ideology—is the main factor motivating developers to contribute, and positive experiences with technical support determine the developer's identification with the OSS community. Ke and Zhang (2009) propose that they may not have found a positive relationship between ideology conviction and commitment and contribution because they measured OSS conviction against the OSS ideology in general and commitment and contribution on a particular task on a specific project.

[2]For ease of exposition, we use the terms *developer OSS ideology*, *coworker OSS ideology*, and *OSS community OSS ideology* to refer to each entity's adherence to the principles enshrined within the OSS ideology (Stewart and Gosain 2006).

Most research has not explicitly accounted for coworker and OSS community ideology. The literature implicitly assumes that the employee perceives that OSS community members embrace the OSS ideology. Indeed, in one study that begins to suggest that fit with the OSS community may be important, Ke and Zhang (2009) imply that OSS community members embrace the OSS ideology and conceptualize ideology conviction as the extent to which a developer shares the OSS ideology values. We believe that it is theoretically meaningful to disentangle the OSS ideology of the employee from their perception of the degree to which coworkers and the OSS community embrace the OSS ideology.

Differences exist in how much coworkers and members of the OSS communities embrace (or are perceived to embrace) OSS ideology. Stewart and Gosain (2006) point out that each OSS community differs in how much it conforms to the overarching OSS ideology. Stewart et al. (2006) argue that commercial company-sponsored OSS initiatives experience difficulty in attracting developer participation when compared to nonprofit oriented companies, partly because developers do not see such companies as embracing OSS ideology. Similarly, Spaeth et al. (2015) contend that developers feel motivated to participate in an OSS initiative when they perceive that the sponsoring company is open (i.e., encourages mutual knowledge exchange between itself and participants in that OSS community). Such openness reflects one of the values in the OSS ideology. Taken together, research suggests that companies and OSS communities vary in how much they embrace the OSS ideology. Consequently, the assumption that OSS communities support OSS ideology and that increasing developer OSS ideology should positively affect developers' commitment may be inaccurate.

Implications of P–E Misfit for Commitment

Commitment is a psychological bond that steadies individual behavior under conditions when the individual might be inclined to change (Bateman et al. 2011). We focus on the affective form of organizational commitment, which underscores the emotional attachment between an individual and their organization (Meyer and Allen 1991). Several reasons exist for the significance of emotional attachment in a digital environment like an OSS community. First, given that contracts do not bind developers to OSS communities and there are many communities to which one can contribute, developers come and go at any time (Fang and Neufeld 2009; Pham et al. 2013; Pinto et al. 2016; Zhou and Mockus 2012), making developer commitment to OSS communities important.

Table 1. Summary of Independent Variables Similar to OSS Ideology in OSS Research

Article	Independent Variables	Dependent Variables	Level of Analysis
Benbya and Belbaly 2010	Developer Ideology	(+) Participation Type (+) Effort	Individual
Ke and Zhang 2010	Developer Ideology Align with OSS Ideology	(–)Task Effort	Individual
Xu et al. 2009	Developer Ideology	(+) Involvement	Individual
Henkel 2008	Developer Ideology	(NS) Developer Contribution	Individual
Choi et al. 2015	Passive User Ideology	(+) Endorsement (+) Community Involvement (+) User-brand Extension (+) Word-of-mouth	Individual (Passive User)
Bagozzi and Dholakia 2006	Identification with open source movement	(+) Linux User group social identity	Individual
Alexy et al. 2013	Identification with OSS community	(+) Individual-level Support for Adoption of OSS Development	Individual
Chou and He 2011	Team Ideology (Values and Norms)	(+) Collaborative Elaboration (+) Communication Decoding Competence (+) Communication Encoding Competence	Team
Stewart and Gosain 2006	Team Ideology (Values, Norms and Beliefs)	(+) Communication Quality (+) Affective Trust (–) Task Completion	Team

Relationship between variables designated by NS not significant, + positive, – negative

Second, developers generally do not interact face-to-face, limiting feelings of interpersonal relatedness and making it easier to leave to work on other projects (Seidel and Stewart 2011; Stewart and Gosain 2006). Consistent with this logic, affective commitment leads to an intention to participate in online communities (Jin et al. 2010) and represents the only form of commitment that prompts online community participants to post replies—a behavior that requires more effort than reading posts (Bateman et al. 2011). Affective commitment likely plays a similar role in influencing developers to make code commits—a particularly effortful form of contribution to OSS communities. Committed participants contribute more to OSS development (Ke and Zhang 2009). In addition, commitment to the company is associated with several desirable employee behaviors such as better performance (Jauch et al. 1978), punctual attendance (Mathieu and Zajac 1990), citizenship behavior (Mathieu and Zajac 1990), job satisfaction (Dishon-Berkovits and Koslowski 2002), and staying with the organization (Cotton and Tuttle 1986; Thatcher et al. 2002).

Commitment is an essential construct in traditional and virtual environments, and many antecedents of organizational commitment exist, including personal characteristics (such as ability, salary, perceived personal competence), job characteristics (such as task autonomy, challenge, and job scope), group-leader relations (such as group cohesiveness and participative leadership), organizational characteristics, and role stresses (Mathieu and Zajac 1990). The theories used to identify these antecedents can be grouped into motivations related to two major theoretical bases: social exchange theory (Liden et al. 2003) and procedural fairness (Siegel et al. 2005). While researchers often observe these relationships outside the OSS context, Table 2 overviews studies that have explored the antecedents of psychological ties binding developers to OSS development projects.

In addition to these theoretical perspectives, commitment has also been studied from a P–E fit perspective. *P–E fit* occurs when there is congruence between a person's characteristics and the characteristics of the environment in which that person operates (Hoffman and Woehr 2006). Harris and Mossholder (1996) found that a fit between an employee and their company in preferred and perceived culture was a significant predictor of employees' commitment to their company. Similarly, Ostroff et al. (2005) found that fit in values was a strong predictor of organizational commitment. For software development teams, increasing fit typically results in positive outcomes, such as improved work performance (Chilton et al. 2005, 2010; Shaft and Vessey 2006). These studies show that

Table 2. Summary of Dependent Variables Similar to Commitment in OSS Research

Article	Independent Variables	Dependent Variables	Level of Analysis
Ke and Zhang 2009	(–) Developer Ideology Align with OSS Ideology	Goal Commitment	Individual
Daniel et al. 2011	(NS) Organizational-OSS Conflict (–) Organizational-Developer Value Incongruence	Organizational Commitment	Individual
Homscheid and Schaarschmidt 2016	(–) Identification with the Community (NS) Identification with the Organization	Community Turnover Intentions	Individual (Firm Sponsored Developers)
Wu et al. 2007	(NS) Motivation on helping (+) Motivation on enhancing human capital (NS) Motivation on career advancement (+) Motivation on satisfying personal needs	Continuance Intention	Individual
Filippova and Cho 2016	(NS) Developer's Perception of Project Performance (+) Developers Identification with the Team	Intention to Remain in the Project	Individual

Relationship between variables designated by: NS not significant, + positive, – negative

consideration of person values and environment values separately and jointly affect commitment. *Misfit* occurs when a person has more of a characteristic than is provided in the environment or when the environment provides more of a characteristic than a person possesses (Kristof-Brown et al. 2005). For example, misfit can occur when a person's pace exceeds that of the work group (i.e., the individual has excess hurriedness) (Jansen and Kristof-Brown 2005). Increasingly, organization leaders want to understand the impact of misfit (Jansen and Kristof-Brown 2005; Vogel et al. 2016). Because of potentially divergent goals, the odds of misfit in terms of the degree to which employees, their coworkers, and OSS communities embrace the OSS ideology are fairly high.

Some studies show that misfit yields stress and turnover intentions (Hoffman et al. 2011; Kristof-Brown et al. 2005), while others suggest that misfit yields positive impacts because it can help organizations avoid the rigidity and stagnation that makes the organization less effective (Schneider 1987). In an attempt to gain knowledge about OSS communities and influence their decision making, companies sometimes hire an employee who embraces the OSS ideology more than their coworkers do. For example, Hewlett-Packard hired Bruce Perens, someone well known for OSS community activity (Fink 2002; Kogut and Metiu 2001; Robert and Schütz 2001). Indeed, as more studies consider misfit, they have shown that not all misfit leads to bad outcomes. Jansen and Kristof-Brown (2005) find that satisfaction is maximized when work group hurriedness slightly exceeds that of the individual and that individuals feel the least strain when individuals' hurriedness exceeds that of their work group. Thus, understanding when and if misfit yields positive or negative impacts is important. To gain insight on the theoretical underpinnings of the impact of misfit, we next introduce SDT.

Self-Determination Theory

In response to the belief in the 1950s and 1960s that behavior was based on external stimuli (Skinner 1953), SDT arose to point toward internal motives (Deci and Ryan 1987). The crux of SDT is that people universally hold a fundamental need for autonomy, competence, and a sense of relatedness (Ryan and Deci 2000). Autonomy is when a person feels free to choose their course of action, competence is a feeling of mastery over tasks, and relatedness is when a person senses a connection to, and support from, others. Cognitive evaluation theory, a sub-theory of SDT, suggests that external factors can facilitate a person getting these needs met (Ryan et al. 1983). For instance, if those in the environment provide appropriate feedback, that can help individuals feel competent (Ryan et al. 1983). Individuals seek to find and remain in environments that allow them to have their psychological needs met, while creating distance from those who make it difficult for their needs to be met (Greguras et al. 2014). When an environment meets an individual's psychological needs, individuals experience enjoyment and a freedom to express their most creative and vital self, and thereby feel a sense of well-being (Ryan and Deci 2000). Individuals feel intrinsically motivated to perform tasks that satisfy their need for autonomy, competence, and relatedness. They persist in doing these tasks without rewards because performing the task brings them pleasure. Greguras and Diefendorff (2009)

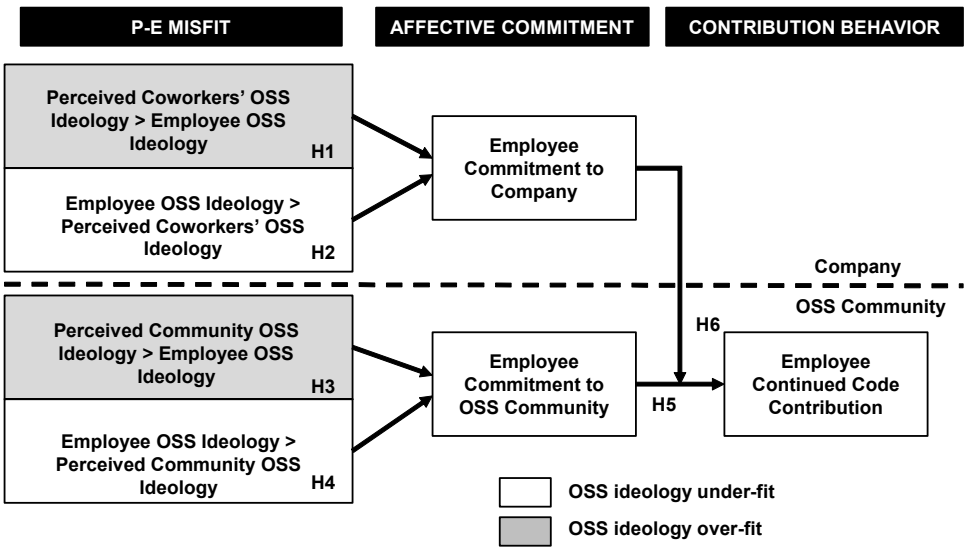

Figure 1. Research Model

find that met needs mediate the impact of fit on affective commitment. However, individuals do things for reasons other than being intrinsically motivated.

Motivations lie along a continuum running from intrinsic to extrinsic. Extrinsically motivated individuals complete a task for reasons other than performing the task itself. An OSS developer who codes for fun is intrinsically motivated and a developer who codes because a company pays him to do so is extrinsically motivated. An individual can experience multiple motivations at the same time (Roberts et al. 2006), so developers who receive payment for development can feel extrinsic and intrinsic motivations. In sum, the P–E fit perspective combined with SDT should provide theoretical insight into the relationship between employee OSS ideology, their commitment, and their contribution. Accordingly, we conceptualize our research model shown in Figure 1.

Hypothesis Development

OSS Ideology Misfit and Employee Commitment to the Company

The next two hypotheses consider the effects of two types of misfit between the employee and their coworkers. In the context of the employee and the company, we define *OSS ideology over-fit* as the situation in which an employee perceives that their coworkers embrace the OSS ideology more than the employee does. We define *OSS ideology under-fit* as the situation in which an employee embraces the OSS ideology more than they perceive their coworkers do. The employee's situated experience in working with coworkers shapes the perceptions of the coworkers' embrace of the OSS ideology.

Impact of OSS Ideology Over-Fit on the Company

OSS ideology embodies opportunities to meet an employee's need for autonomy, competence, and relatedness (Deci et al. 1989; Gagné and Deci 2005) and coworkers, in enacting the OSS ideology, create an environment conducive to psychological needs fulfillment. For instance, the OSS ideology encourages sharing and cooperation (Stewart and Gosain 2006) and, to the degree that coworkers take those actions, feelings of competence and relatedness emerge (Howison and Crowston 2014). When an employee embraces the OSS ideology they feel that working with others offers the best way to get the job done and working with others engenders relatedness and competence (Howison and Crowston 2014, Ke and Zhang 2010). Further the OSS ideology focuses on learning and reputation building through skill display (Stewart and Gosain 2006). These practices work well in meeting an employee's need for competence.

Embracing the ideology means the coworkers find value in appreciating and rewarding the skill of others (Stewart and Gosain 2006). For example, the coworkers who embrace the

OSS ideology sometimes offer positive feedback by recognizing the employee as a hacker or by keeping the employee's name as an author for code the employee wrote (Stewart and Gosain 2006). Positive feeback promotes a sense of competence when a person attributes responsibility for their performance to themself (Deci 1971) and it coincides with developing feelings of relatedness (Deci and Ryan 1987). Further when coworkers belive in cooperation, it could help the employee feel a sense of belonging. The coworkers believe they need the employee to do their work, making the employee feel as though they are a part of the development process and evoking a sense of relatedness. In an environment colored by OSS ideology, coworkers believe in helping each other. The employee benefits from the coworkers' help, delivers better quality code, and their need for competence is met. Further, given that the employee knows coworkers embrace the ideology and thus value technical knowledge, the employee may believe that receiving pay from those kinds of people indicates the employee's competence. Feeling competent leads to positive feelings of commitment toward the company (Ryan et al. 1983).

In terms of autonomy, an environment that supports feelings of autonomy embodies the freedom beliefs fundamental to the OSS ideology. Another principle that is common among OSS proponents is that a developer performs their best work when the developer chooses on what they will work (Howison and Crowston 2014). Environments that afford choice symbolize ones that offer individuals a sense of control (Deci and Ryan 1987). Coworkers who embrace the OSS ideology may allow an employee to pick the assignments on which they will work, giving the employee feelings of autonomy.

Given the employee's met needs, through coworker help, the employee feels positive emotion toward the company and is affectively committed. Feelings of competence, control, and relatedness give the employee a sense of well-being that spills over to the company. We expect that employees in situations of OSS ideology over-fit form a positive emotional attachment to their company because it provides a supportive software development environment. Extrinsic motivation, in the form of salary, can heighten the benefit of intrinsic motivation (Gagné and Deci 2005). In summary, an environment that embodies OSS ideology allows everyone in the environment to have their psychological needs met. Even the employee who does not embrace the OSS ideology benefits from this environment and thereby commits to the company. Indeed, anecdotal evidence suggests that companies that provide a supportive structure for contributing to OSS attract highly skilled developers (Gold 2015). For these reasons, we hypothesize the following:

H1: The more the employee's perception of their coworkers' OSS ideology exceeds the employee's OSS ideology, the higher the employee's commitment to the company.

Impact of OSS Ideology Under-Fit on the Company

A situation of OSS ideology under-fit indicates that the employee embraces the OSS ideology more strongly than the employee perceives coworkers as doing. We theorize that OSS ideology under-fit erodes an employee's commitment to the company. To the degree that an employee embraces the OSS ideology, but perceives coworkers do not, the employee operates in a context that does not allow the employee to have their psychological needs met. When an employee embraces the OSS ideology, it specifies the goals the employee feels attached to and the way to achieve those goals (i.e., through sharing and cooperation) (Stewart and Gosain 2006). However, coworkers may not share code and cooperate, leaving the employee feeling unable to do their best work and without a sense of well-being (Ryan and Deci 2000). Without a sense of well-being, the employee may not experience positive emotions toward the company and will have lower commitment.

Coworkers may not recognize the employee as a hacker or even keep the employee's name associated with his or her work. Without this peer recognition, the employee's sense of relatedness is compromised and the emotional attachment to the company is minimized (Deci et al. 1999). Finally, because the employee cannot choose what to work on or how, they may not feel in control. For instance, coworkers may enforce several layers of bureaucracy for using OSS code, limiting an employee's ability to leverage cutting-edge OSS code, and eventually causing the employee to fall short in reaching their own goals (Rolandsson et al. 2011). Without these feelings of control the employee may not feel committed to the company.

This logic coincides with other P–E research findings (Schuler 1980). P–E fit researchers generally find that employees hold less favorable views of their company when the work environment falls short in meeting their preferences (Schuler 1980). Employees are less likely to form an emotional attachment to their company if they perceive that it does not support their preferred work approach. Such arrangements may lead the employee to adopt and maintain two different work styles: one that they use when developing software within the company and one for OSS community contributions.

H2: The more employee OSS ideology exceeds the employee's perception of their coworkers' OSS ideology, the lower the employee's commitment to the company.

OSS Ideology Misfit and Employee Commitment to the OSS Community

Impact of OSS Ideology Over-Fit on the OSS Community

Howison and Crowston (2014) argue that developers are more motivated to complete OSS tasks when the task conditions favor autonomy, competence, and relatedness. We expect OSS ideology over-fit to increase employee commitment to an OSS community because it embodies an environment that supports an employee's feelings of competence, autonomy, and relatedness. First, the high level of helping, knowledge sharing, positive feedback, and cooperation reflected in OSS ideology and enacted by the OSS community enables the employee to learn coding skills. Such learning provides benefits to employees in their work for their company (Hann et al. 2013) and allows employees to feel competent. Competence is also developed when other community members provide positive feedback and value the reputation the employee has built by contributing to OSS projects (Deci et al. 1999). In addition to competence, feelings of relatedness form when a person feels appreciated by those around him.

The OSS community shares many of the same characteristics as virtual organizations that prevent attachment. However, such a generous and supportive environment can entice employees to form an affective attachment and generate norms of reciprocity (Faraj and Johnson 2011). Ke and Zhang (2010) find that developers who feel a sense of autonomy, competence, and relatedness are more motivated to increase their task effort in OSS projects.

Although the underlying logic parallels the case of over-fit in the company context, differences exist. As noted earlier in our discussion of the role of OSS ideology, such ideology facilitates certainty in how the community works. This carries significance because OSS developers face uncertainty about how to contribute to OSS communities and many newcomers find learning to engage in such communities daunting (Steinmacher et al. 2015). OSS ideology over-fit creates conditions in which employees know what community members expect from them and can anticipate the actions of other community members, offering a sense of competence and well-being. The ease leads to an emotional bond with the community (Meyer et al. 1993), promoting a positive emotional attachment in the form of commitment (Meyer et al. 2010; Yi 1990).

H3: The more the employee's perception of the OSS community's OSS ideology exceeds the employee's OSS ideology, the higher the employee's commitment to the OSS community.

Impact of OSS Ideology Under-Fit on the OSS Community

When OSS ideology under-fit exists in the OSS community, we expect lower commitment to the OSS community. An employee who embraces the OSS ideology believes that software development practices embodied in the OSS ideology yield the best outcomes (Stewart and Gosain 2006). If the other developers do not believe this, the employee likely believes the community developers do not interact with the employee in a way that produces the best work. The missing interaction leaves the employee feeling less in control with respect to the experience, less competent, and socially isolated from the community. This is especially problematic because developers do not meet face-to-face, potentially exacerbating feelings of isolation (Ke and Zhang 2010) and, along with the other factors, driving lowered well-being (Deci et al. 1999). Because of the employee's lowered sense of well-being, derived from interactions with OSS community members, the employee experiences less positive feelings toward the community. That is, the employee does not feel positive emotions toward the community because the OSS community is not fulfilling the employee's fundamental needs (i.e., competence, autonomy, and relatedness). Without these emotions the employee does not feel committed to the OSS community.

H4: The more employee OSS ideology exceeds the employee's perception of the OSS community's OSS ideology, the lower the employee's commitment to the OSS community.

Commitment drives an employees' willingness to expend effort in contributing their intellectual capital toward achieving organizational goals (Hoffman and Woehr 2006; Kristof 1996). When an individual commits to an organization, that individual wants to see the organization succeed and puts in the effort to make that possible. Consequently, an employee who commits to an OSS community likely makes the community's goal of producing a quality software application their own goal. In order to achieve the goal, the employee committed to the OSS community makes more code contributions than an employee who is less committed to the OSS community. Code contribution increases the quality of

the application and allows the employee to take on a leadership role in the community (Eseryel and Eseryel 2013). The leadership role may allow the employee to influence others to contribute code to improve OSS community outcomes.

Commitment acts as a critical mechanism because employees working on an OSS project typically work from geographically distributed locations and rely on technology-mediated communication (Yamauchi et al. 2000). This distance creates a lack of shared context that can result in shirking behavior, whereby individuals exert less effort in contributing to a collective endeavor than they otherwise would (Alnuaimi et al. 2010). The psychological bond that underlies commitment ensures that employees contribute to community success even though they can shirk. Further, development work (e.g., coding, debugging, testing) requires significant cognitive effort and the psychological bond reflected in commitment enables employees to persist in making the effort to contribute, absent monetary enticements from the OSS community. Commitment, therefore, becomes an essential driver of employee continued contributions (Ahuja et al. 2006; Bateman et al. 2011) and affective commitment, in particular, drives continuance intention in online communities (Jin et al. 2010). We expect affective commitment to promote continued contribution to the OSS community.

H5: OSS commitment positively impacts employee continued contribution to the OSS community.

For employees who are active in OSS communities, contributing code to the community may reflect a response to commitment to both entities. Beyond the extra amount of contribution that we attribute to employee commitment to the OSS community (as set forth in H5), if such an employee is also committed to the company, their commitment to the community is likely to play a stronger role in motivating their continued code contribution compared to an employee without both commitments. One reason the employee contributes additional code is because commitment to the company prepares the employee to make contributions to the OSS community. Researchers consistently link commitment to one's company with prosocial behaviors even without compensation for such behaviors (Mathieu and Zajac 1990; Morrow 2011). To the extent that an employee views contribution to the OSS community as benefitting the company, an employee committed to their company feels motivated to refine their programming skills, so that they can improve company outcomes. These same programming skills enable an employee committed to the OSS community to increase code contributions to the OSS community. Thus, company commitment crosses over into the OSS community domain and enhances the influence of community commitment on continued contributions to the OSS development.

Further, writing source code aligns well with the goals of an employee with dual commitments because it aids the company and the OSS community in meeting their goals. A company's goals for participating in OSS communities include ensuring the application's popularity (Capra et al. 2011), sharing costs to develop and maintain code (Schaarschmidt et al. 2015), enabling compatibility with applications the company sells, and increasing demand for complementary services and products (Andersen-Gott et al. 2012). For example, the 2009 GNOME annual report mentions that "Cody said that he had been working with Nokia to ensure that Qt's approach would be similar, to avoid compatibility issues between Qt and GTK + applications that provide their own CSD (client side decorations)."[3] He was making sure that software Nokia developed worked well with software GNOME developed. By contributing code, the employee modifies the code to meet the company's goals. In fact, code writing is the most common task firm employees perform in OSS communities (Capra et al. 2011) and for some companies, such as Red Hat, the business model requires maintaining the OSS (Dahlander 2007). At the same time, coding enables the OSS community to meet its goals. Writing code helps the OSS community to increase market share by creating a quality product (Capra et al. 2011).

Writing code also creates future benefits for the company. Companies often desire to influence code development; they may want to influence timelines and the degree to which the software works for their customers (Capra et al. 2011). According to the do-ocracy principle, contributing code is the best way for an employee to influence code development (Capra et al. 2011; Schaarschmidt et al. 2015). Active coding ensures the employee receives respect from the community, and thereby allows the employee to influence community decisions (e.g., what features to add and when) (Schaarschmidt et al. 2015). Further, respect from peers, developed through coding, enables an employee to easily commit code to the main branch of the OSS application in the future, further increasing the company's OSS community influence (Schaarschmidt et al. 2015). Because both the company and the OSS community benefit from the employee's code contributions, the employee may have two sets of motivations driving them if the employee feels committed to both. Employees committed to both entities will be motivated from two different sources and thus feel an acute need to contribute code to the OSS community. In essence, the commitment to the company crosses over to efforts directed toward the OSS community and amplifies the impact of the OSS commitment on continued code contribution by focusing the employee on this type of contribution.

[3]https://www.gnome.org/wp-content/uploads/2011/11/gnome-annual-report-2009.pdf

H6: The positive relationship between OSS commitment and employee continued contribution to the OSS community is moderated by company commitment such that the positive relationship will be stronger with increasing company commitment.

Method

In order to test the research model, we collected data from the GNOME OSS community. Comprised of a globally distributed network of paid and volunteer developers who work jointly to produce software (www.gnome.org), GNOME exemplifies the type of entanglement between employees, their company, and an OSS community that is the focus of this research. For example, employees from Red Hat, Google, Cisco, and Novell, among others, make contributions to GNOME and the number of contributors continues to grow (Dahlander and Wallin 2006). Companies, such as Motorola and Supersonic Image, use GNOME technologies in their products and thus have reason to pay developers to make sure GNOME technologies work well with their own. A list of commercial companies that work with GNOME and the capacity in which GNOME works with them is provided in Appendix A. Formed in 1997, the GNOME community creates a graphical user interface platform for Unix operating systems such as Linux. GNOME is a community-founded OSS project that creates and distributes the application under the GNU Public license (GPL), a license supported by the Free Software Foundation. GNOME developers utilize two tools to support their work. Mailing lists represent the main mechanism for communication. Source code repositories enable developers to make application changes and to access the history of the development activities.

Sample and Procedure

Survey and archival data were used to test the model. The GNOME source code repositories were used to identify the contributors as well as to extract GNOME activity and control variables. In January 2011, the survey was administered to collect data on OSS ideology, commitment to the company, and commitment to the OSS community. From its inception in 1997, developers started numerous GNOME projects. As of August 2010, the GNOME community included 734 projects. We used criteria set forth by Crowston et al. (2006), only considering active projects that demonstrated continuity of development activity (at least one year), with a sufficient amount of development activity (at least 100 commits), that attracted developers (at least 10 committers), and that exhibited user interest to participate (at least one community hosted mailing list). Ninety-one projects satisfied these criteria. We identified 2,341 developers who made contributions to these 91 projects between 1998 and August 2010. Developers frequently make a single code contribution to an OSS project (Pham et al. 2013; Pinto et al. 2016; Zhou and Mockus 2012) and, consistent with this contribution pattern, 553 developers did not make any contributions after 2005. In order to minimize the impact of recall problems, we did not consider them in our analyses. The remaining 1,788 developers contributed 91.6% of the commits to the 91 projects in our sampling frame.

Before inviting contributors to complete the survey, we had multiple discussions with GNOME leadership and allowed them to pretest the survey to ensure our survey measures (especially OSS ideology) resonated with them and their membership. We then invited the 1,788 contributors to complete our survey through an email request. We sent a reminder email after one week and three weeks later a final reminder was sent. As an incentive, each developer who completed the survey was entered into a drawing for a monetary prize. Two developers, randomly selected through the drawing, received $200.00 each. In all 562 individuals responded to the survey and 330 of them were employed by a company. One respondent explained that he was blind and we surveyed him over the phone. Of the 330 employed respondents, 186 provided usable responses for this study.[4] Hence, all subsequent analyses were based on these 186 developers. The mean age of this final sample of participants was 30 years with a standard deviation of 8.08 years; 95% of these participants were men.

[4]Our analysis showed that our sample of 186 participants did not differ significantly in their patterns of contribution activity in terms of the number of projects in which the individuals participated, the number of commits made, the number of lines of software code contributed, the number of messages contributed to the mailing lists , and the number of messages posted on the defect tracking system of the GNOME community from the other 144 individuals who were employed but did not provide complete responses to the survey. In addition, analysis showed that our sample of 186 participants did not differ significantly from the 1,226 developers who did not participate in the survey in terms of the number of projects in which the individuals participated, the number of commits made, the number of lines of software code contributed, and the number of messages contributed to the mailing lists. The two groups differed in terms of the number of messages posted on the defect tracking system of the GNOME community.

Measurement

Employee Continued Contribution to OSS Community

For each respondent, we counted the number of files changed on all GNOME projects over the 9-month period after the survey was administered (between January 2011 and September 2011). We use this measure of contribution because software development is one of the core community activities. The number of commits and the number of lines of code added/deleted are two other commonly used measures of developer contribution (Cataldo and Herbsleb 2013; Espinosa et al. 2007). We collected data on these two other measures of employee contribution over the same time frame as our measure of number of files changed. The software engineering literature has shown that those measures of development are highly correlated (Briand et al. 2000; Cataldo et al. 2006; Nagappan and Ball 2007) and we also find a high correlation among them (range: $r = .97$ to $r = .99$, $p < .001$), underscoring their interchangeability.

Commitment

We measured commitment using a five-item scale from Ahuja et al. (2006). The scale captures the extent to which an individual is psychologically attached to an organizational entity. In light of our focus on employees' commitment to the OSS community and their companies, we adapted the scale items to each referent in our study. Specifically, for company commitment, we changed the wording of the questions to refer to the respondent's company, and for OSS commitment, we changed the wording of the questions to refer to the specific OSS community: GNOME. The reliability (Cronbach's α) was 0.88 for company commitment and 0.94 for OSS community commitment. We averaged the ratings for each scale to compute a single score each for company commitment and OSS commitment.

OSS Ideology

We measured OSS ideology using Stewart and Gosain's (2006) 14-item scale. The scale captures the extent to which an entity is perceived to adhere to the OSS ideology. The measurement scale is made up of three subscales encompassing values, beliefs, and norms. Given our focus on employees, OSS community, and companies, we modified the scale items to include each of these entities as the referent. In the case of the subscale for norms, we were not aware of any norms pertaining to forking, code distribution, and named credit for companies' in-house software projects. Consequently, we omitted this subscale when using the company as the referent.

Following the guidance of Polities et al. (2012), we were primarily interested in the influence of OSS ideology as a superordinate construct and, therefore, treat it as a unitary concept. Such treatment allows researchers to "advance IS research by enabling the capture of complex concepts in comparatively simple abstractions" (Polities et al. 2012, p. 23). This treatment is further bolstered by the conceptualization of OSS ideology as a set of interrelated values, beliefs, and norms (Stewart and Gosain 2006). These underlying facets are reflective of the overarching OSS ideology, which is an important aspect of treating it as a unitary concept (Polities et al. 2012). The reliability (Cronbach's α) for employee, company, and OSS community OSS ideology was 0.80, 0.86, and 0.88 respectively.[5] Table 3 summarizes variable measurement.[6]

Control Variables

Using data collected through the survey, we controlled for the gender, age, education, organizational tenure, and volunteer status (paid versus unpaid contributor) of each participant because these factors impact commitment (Brierley and Cowton 2000). Social identity influences developers' contributions to OSS (Henkel 2008), therefore we measured participants' social identification with OSS using a four-item scale from Randel and Jaussi (2003). The reliability of the scale was .72. In addition, in order to account for the potential influence of their activities within the community, we controlled for the number of GNOME files changed by each participant and the number of projects to which each participant contributed during the period *before* the survey was administered (pre-survey). We log-transformed the number of files changed and the number of projects because they were left skewed. Finally, although participants in our sample represented a variety of nationalities, we dummy coded the three most highly represented nationalities in our sample. All models include these control variables.

Analysis and Results

In order to assess the validity of the measurement scales, we conducted a factor analysis using direct oblimin rotation (Fornell and Larcker 1981). With a few exceptions, all items had loadings above .60 on their expected constructs and cross-

[5]A list of all items for each of the measurement scales is presented in Appendix B.

[6]Appendix C includes a description of an alternative operationalization of OSS ideology.

Table 3. Variable Measurement

Variable	Referent	Description of Measurement	Reliability
Commitment	Company	Five-item scale used by Ahuja et al. (2006).	.88
	OSS community	Modified five-item scale used by Ahuja et al. (2006) to make GNOME the referent by substituting the word GNOME for organization.	.94
OSS Ideology	Employee	Fourteen-item scale developed by Stewart and Gosain (2006).	.80
	Company	Modified ten-item scale developed by Stewart and Gosain (2006) to reference coworkers in the company. Norms were omitted from this scale as it was difficult to conceptualize the ideas of forking and distribution norms in an company-based project environment.	.86
	OSS community	Modified fourteen-item scale developed by Stewart and Gosain (2006) to reference the OSS community.	.88

loadings lower than .40, thus demonstrating adequate convergent validity and discriminant validity. One item each for employee values, employee norms, perceived OSS community values, and perceived OSS beliefs had loadings that were less than .60. One item for perceived OSS norms had a loading of .60 on its intended factor, but it also had a cross-loading of .49 on another factor. These items were dropped from subsequent analyses. The results of the factor analysis are presented in Appendix D. The average variance extracted for each of the constructs was greater than the suggested threshold of .50 and the square root of the average variance extracted for each construct was higher than the correlation between that construct and all other constructs, further demonstrating the convergent validity of the measures (Fornell and Larcker 1981).[7]

The employees in our sample were nested in 91 projects. A consequence of this is that some of the variability in commitment could be attributable to the specific project on which an employee worked. We were able to link each employee in our sample to a specific project in GNOME. Therefore, we tested the hypotheses using regression analysis with project fixed effects to account for unobserved project heterogeneity (Greene 2003).

To test our hypotheses, we use polynomial regression because it is a more robust approach than difference scores to test the effects of misfit in that it permits a higher degree of precision (Edwards 2002; Klein et al. 2009; Meilich 2006). The use of difference scores to test the effect of misfit on a criterion variable has several well-recognized limitations (Klein et al. 2009; Meilich 2006), including discarded information and unrealistically restrictive constraints that make the use of difference scores less robust for detecting the effects of misfit (Meilich 2006). For instance, difference score analysis mathematically considers OSS ideology under-fit and over-fit as the same. Polynomial regression analysis allows us to analyze differences in these types of misfit. The results of the polynomial regression analysis are shown in Table 4.

Before proceeding to test our hypotheses regarding the effects of misfit on employee commitment, we sought to also test the implicit assumptions from prior research that only developer OSS ideology should be considered or only OSS community ideology should be considered.

The equation used to test these models is given by

$$Z = b_0 + b_1 + b_2 + e \quad (1)$$

where b_0 is the intercept term, b_1 is the coefficient on employee OSS ideology and b_2 is the coefficient on community OSS ideology. The implicit assumption that only developers' OSS ideology should be considered would find support if $|b_1| > 0$ and $|b_2| = 0$. Similarly, the implicit assumption that only the community OSS ideology should be considered would be supported if $|b_1| = 0$ and $|b_2| > 0$. The results in Table 4 (Models 2b and 3b) indicate that both developer and OSS community ideology are statistically significant in predicting developer commitment. These results challenge the assumptions in the literature and indicate that research should consider both developer and OSS community ideology.

In order to more precisely test the effects of misfit in the polynomial regression model, we examined the slope of the response surface (the shaded squares in Figure 2) along the first and second principal axes (Edwards 2002). The first principal axis is the line along which the value of commitment is maximized (i.e., greater fit results in higher levels of employee commitment). The second principal axis is the line along which the value of commitment decreases and can be used to test the effects of misfit. Along this line, greater misfit can lead to lower levels of employee commitment. For

[7]Descriptive statistics and correlations are shown in Appendix E.

Table 4. Results of Tests of Misfit Using Polynomial Regression Analysis with Project Fixed Effects

	Company Commitment					OSS Community Commitment				
Predictors	**1a**	**2a**	**3a**	**4a**	**VIF**	**1b**	**2b**	**3b**	**4b**	**VIF**
U.S.A.	.04	.00	.03	.03	1.20	-.03	-.02	-.05	-.04	1.15
Germany	.07	.06	.04	.04	1.11	.07	.09	.10	.08	1.09
Spain	.06	-.01	-.03	-.03	1.16	.07	-.03	-.02	-.02	1.16
Age	-.03	-.14*	-.10	-.10	1.54	.02	.02	.05	.06	1.51
Gender	.02	-.05	-.06	-.06	1.11	.02	-.02	-.01	-.02	1.10
Education	.06	.07	.06	.06	1.11	-.12*	-.14*	-.14*	-.13*	1.11
Paid volunteer	-.44***	-.18**	-.16*	-.16*	1.43	-.31***	-.24**	-.23**	-.22**	1.18
Organizational tenure	-.07	-.05	-.01	-.01	1.79	-.16*	-.09	-.04	-.02	1.73
Pre-survey commits	.06	.08	.06	.06	1.10	.06	.09	.12*	.10†	1.10
Pre-survey number of projects	.01	.00	.01	.01	1.19	.03	.01	.01	.01	1.17
Social identity	.04	.01	.00	.00	1.15	.12*	.04	.04	.05	1.14
Employee ideology		.05	.03	.03	1.36		.17*	.15*	.20**	1.68
Perceived OSS community ideology							.35***	.40***	.38***	1.87
Perceived company ideology		.63***	.60***	.61***	1.86					
Employee ideology × perceived company ideology			.17**	.17**	1.91					
Employee ideology × perceived OSS community ideology								.15*	.17*	3.59
Employee ideology^2				.01	1.79				-.05	2.73
Perceived company ideology^2				.01	1.48					
Perceived OSS community ideology^2									-.06	1.58
Adjusted R^2	.23***	.49***	.54***	.54***		.19***	.34***	.37***	.40***	
ΔR^2		.26	.05	.00			.15	.03	.03	

Notes: n = 186; †p < .10, *p < .05, **p < .01, ***p < .001.

(a) Employee Commitment to the Company **(b) Employee Commitment to the OSS Community**

Figure 2. Response Surfaces from Polynomial Regression Analysis

a given response surface, tests of the effect of misfit are conducted by examining the position of the first and second principal axes.[8] Graphical depictions of the response surfaces are shown in Figure 2.

Tests of the Effects of OSS Ideology Misfit on Employee Commitment to the Company

H1 predicted that employee OSS ideology over-fit would be associated with higher commitment to the company. In contrast, H2 posited that employee OSS under-fit would be associated with lower commitment to the company. Support for these hypotheses is found when the second principal axis is parallel to the line of misfit and the coefficient on the slope of the surface along the second principal axis is negative. A negative slope of the response surface along the second principal axis essentially indicates that commitment decreases as employees' embrace of OSS ideology exceeds perceptions of their coworkers' embrace of the ideology and that commitment increases as perception of their coworkers' embrace of the OSS ideology exceeds their own.

The second principal axis is not statistically significantly different from -1 (Equation: $Y = -3.37 - 1X$). This suggests that the second principal axis runs parallel to the line of misfit (i.e., the line along which $X = -Y$). This result indicates that employee commitment to the company decreases along the line where there is misfit between employee ideology and perceived coworker ideology. Consistent with our hypotheses, a test of the slope of the response surface along the second principal axis showed a negative slope ($a_x = -1.09$, $p < .05$). This indicates that employee commitment to the company increases as the employee perceives that their coworkers embrace the OSS ideology more than they themselves do (OSS ideology over-fit). This also indicates that misfit results in lower employee commitment to the company as the employee embraces the OSS ideology more than the employee perceives their coworkers do (OSS ideology under-fit). These results provide support for H1 and H2.

Tests of the Effects of OSS Ideology Misfit on Employee Commitment to the OSS Community

H3 predicted that employee OSS ideology over-fit would result in higher commitment to the community, and H4 posited that employee OSS ideology under-fit would result in lower commitment to the community. These hypotheses are supported when the second principal axis of the response surface is parallel to the line of misfit and the coefficient on the slope of the surface along the second principal axis is negative. As noted earlier, a negative slope of the response surface along the second principal axis essentially indicates that commitment increases as perception of the community's embrace of the OSS ideology exceeds the employees' embrace of the ideology and that commitment decreases as employees' embrace of OSS ideology exceeds perceptions of the community's embrace of the ideology.

The second principal axis of the response surface shown in Figure 2b runs parallel to the line of misfit (Equation: $Y = -9.82 - 1.06X$), providing preliminary support for the hypotheses. Contrary to expectations, the slope of the response surface along the second principal axis is an inverted-U shape ($a_x = -3.12$, $p < .05$, $a_{x2} = -.30$, $p < .05$), suggesting that employee commitment to the OSS community decreases both as their perception of the community's embrace of the ideology exceeds their own and as their embrace of the OSS ideology exceeds the community's perceived embrace of the ideology. This shows that commitment to the OSS community decreases with increasing misfit, both for OSS ideology over-fit and under-fit. H3 is not supported because, counter to expectations, employee commitment to the OSS community decreases with greater OSS ideology over-fit. We discuss this unexpected finding in the "Discussion" section. Based on the findings, H4 is supported in that employee commitment to the OSS community decreases as there is greater OSS ideology under-fit.

Tests of Effects of Commitment on Developer Continued Contributions

H5 and H6 focus on the influence of commitment on employee continued contributions to the OSS community. As noted earlier, the dependent variable is operationalized as the number of files changed by an employee over the 9-month observation period *after* the survey was administered. Consequently, we conducted a moderated negative binomial regression analysis to test the hypotheses (Cameron and Trivedi 2005; Cameron and Trivedi 2013). The negative binomial approach to estimation is a special case of the Poisson regression that is robust to over-dispersion. The results of the moderated negative binomial regression analysis are shown in Table 5.

H5 predicted that employee commitment to the OSS community would be positively related to continued code contribution activity. Model 1 in Table 5 shows the model with only the control variables. In Model 2, we added commitment. The model with commitment was a better fit to the data com-

[8] A full discussion of the tests of slopes along the lines of interest is provided in Appendix F and Appendix G. Appendix F explains the examination of key features of the response surface and Appendix G shows the equations for response surface key equations..

Table 5. Results of Negative Binomial Regression Predicting Number of Files Changed

	Number of Files Changed		
Predictors	**1**	**2**	**3**
Intercept	1.121	-2.034	-3.645*
U.S.A	-1.038*	-.986*	-1.140**
Germany	1.168	1.107	.430
Spain	-1.180	-1.360	-1.358*
Age	.056	.096	.127†
Gender	1.626*	1.621*	1.781*
Education	-.095	-.104	-.110
Organizational tenure	-.013	-.046	-.044
Paid volunteer	-1.347*	-.548	-.137
Pre-survey number of files changed	.008	.006	.006
Pre-survey number of projects	.200**	.19**	.181**
Social identity	.160	.136	.100
OSS commitment		.561*	.559*
Company commitment		.246	.342
OSS commitment × company commitment			.384*
AIC	1209.51	1088.86	1042.07
BIC	1241.77	1124.34	1084.01
Deviance	735.30	612.65	561.87

Notes: n = 186; *p < .05, **p < .01.

pared to Model 1 (Model 2: AIC = 1088.86 versus Model 1: AIC = 1209.51). The results show that commitment to the OSS community has a positive relationship with number of files changed ($\beta = .561$, $p < .05$), thus providing support for H5.

H6 predicted that employee commitment to the company would moderate the relationship between employee commitment to the OSS community and continued contribution activity such that the relationship would be stronger with increasing levels of commitment to the company. Commitment to the company and commitment to the OSS community were mean-centered before computing an interaction term. This helped minimize non-essential multicollinearity. In Model 3, we entered the interaction term. As the results show, the interaction model was a better fit to the data compared to the main effects model (Model 3: AIC = 1042.07 versus Model 2: AIC = 1088.86). Additionally, the interaction effect between employee commitment to the company and commitment to the OSS community was positive and significant ($\beta = .384$, $p < .05$), suggesting complementarities between the two. To better understand the form of the interaction, we plotted the relationship between commitment to the OSS community and number of files changed at low (1 standard deviation below the mean), moderate (mean), and high (1 standard deviation above the mean) levels of employee commitment to the company. The interaction plot is shown in Figure 3. As Figure 3 shows, at low levels of employee commitment to the company, commitment to the OSS community has no significant effect on number of files changed. In contrast, at high levels of employee commitment to the company, commitment to the OSS community has a positive effect on number of files changed, providing further support for H6.

Robustness Tests

Common method variance is a threat to our results as employee, perceived coworker, and perceived OSS community ideology as well as commitment to the company and OSS community were measured using a single method: surveys (Podsakoff et al. 2003). In the interest of robustness, we conducted the marker variable test suggested by Lindell and Whitney (2001). We identified a marker variable that was theoretically expected to be unrelated to the substantive variables in the model. We then examined the observed correlations between the marker and the substantive variables in

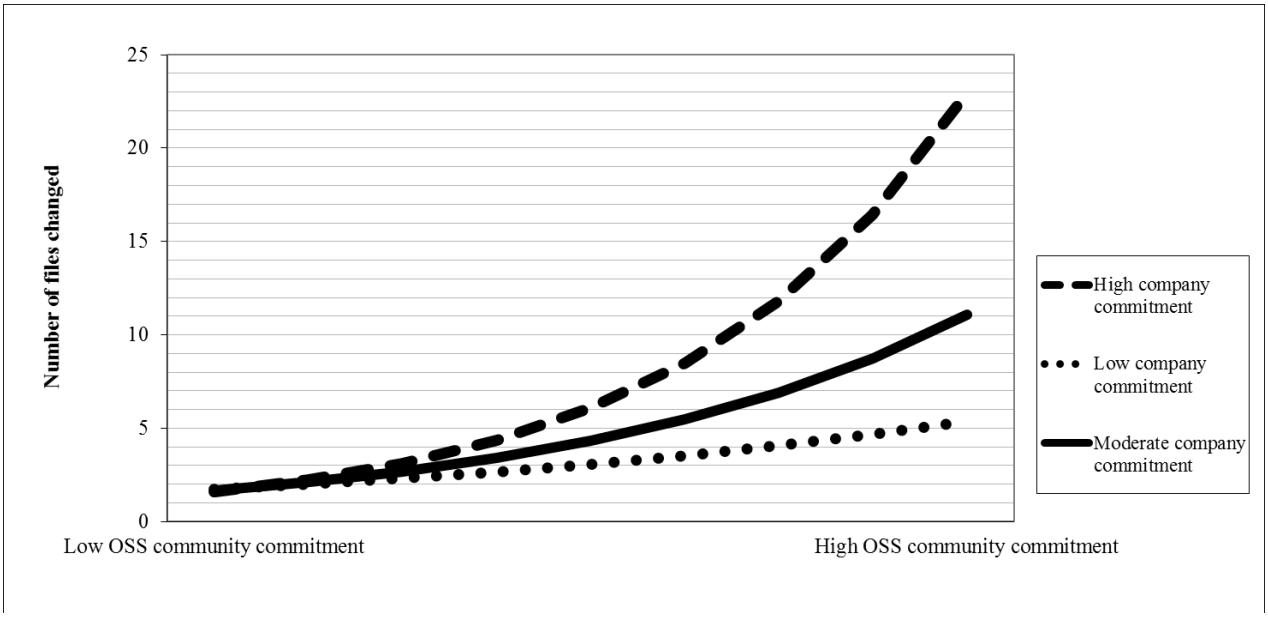

Figure 3. Plot of Interaction Between Commitment to the OSS Community and Commitment to the Company

the model. The lowest observed correlation was used as a basis for partialing out the shared variance between the marker variable and the substantive variables (Richardson et al. 2009). The corrected correlations did not differ substantially from the uncorrected correlations as shown in Appendix H, suggesting that common method variance is not a major concern in our results.

Finally, in order to account for the possibility of selection bias in our sample, we conducted a Heckman two-step selection procedure (Heckman 1979). As noted earlier, we compared the contributions (e.g., the number of commits made, the number of lines of software code contributed, number of projects in which the individuals participated) and communication activity (e.g., the number of messages contributed to the mailing lists and the number of messages posted on the defect tracking system of the GNOME community) of the 186 respondents in our final sample to the 144 employed developers who did not participate in the survey as well as to the 1,226 and found no significant differences. Nevertheless, we wanted to ensure that our findings were robust. We used the pre-survey contributions and communication activity as the selection predictors in the first stage. The results of the model estimation were similar to those of our main model.

Discussion

This research sought to advance the literature in two key ways. The first was by providing a holistic treatment of OSS ideology as pertaining to developers and their environment separately. The second was to gain an understanding of the role of OSS ideology in affecting the continued contributions of an increasingly prominent yet understudied OSS community participant: company employees. We proposed that OSS ideology misfit—between employees and their companies (as represented by their coworkers), and between employees and the OSS community—affect commitment to the company and the OSS community. Further we proposed that the positive impact of OSS community commitment on employee continued contribution to the OSS community would be stronger when the employee was committed to their company. To accomplish this, we integrated P–E fit theory, SDT, and the OSS ideology literature. We tested the proposed model and found support for most of the hypotheses as summarized in Table 6.

We found that OSS ideology over-fit resulted in increased employee commitment to the company, while conditions of under-fit undermined employees' commitment to their com-

Table 6. Summary of Hypotheses and Results

	Hypotheses	Result
H1	*The more the employee's perception of their coworkers' OSS ideology exceeds the employee's OSS ideology, the higher the employee's commitment to the company.*	Supported
H2	*The more employee OSS ideology exceeds the employee's perception of their coworkers' OSS ideology, the lower the employee's commitment to the company.*	Supported
H3	*The more the employee's perception of the OSS community's OSS ideology exceeds the employee's OSS ideology, the higher the employee's commitment to the OSS community.*	Not Supported
H4	*The more employee OSS ideology exceeds the employee's perception of the OSS community's OSS ideology, the lower the employee's commitment to the OSS community.*	Supported
H5	*OSS commitment positively impacts employee continued contribution to the OSS community.*	Supported
H6	*The positive relationship between OSS commitment and employee continued contribution to the OSS community is moderated by company commitment such that the positive relationship will be stronger with increasing company commitment.*	Supported

pany. Contrary to expectations, H3—which posited that employee commitment to the OSS community would increase with increasing OSS ideology over-fit—did not receive support. Instead, we found that employee commitment to the OSS community decreases under this condition. Our rationale for H3 was rooted in SDT; namely, being embedded in an environment where the employee perceives participants to more strongly embrace the OSS ideology than the employee would allow for the employee's psyschological needs to be met and create an emotional attachment to the community. Possibly, an OSS community filled with ideological participants demands more from the employee than the employee wishes to provide. Consequently, as OSS ideology over-fit increases, the OSS community pulls the employee farther out of their comfort zone in terms of how to approach code development and drains their resources (Alexy et al. 2013). The employee may receive requests to help others or share their expertise much more often or intensively than they prefer. The OSS community may ask the employee to drastically change how they go about the coding process. Alexy et al. (2013) find that employees are less likely to support their company's adoption of an OSS development approach if it entails a large technical change in the job role. The additional fact that the OSS community does not pay the employee obstructs the development of an emotional attachment to the community.

Our finding also provides evidence for extrinsic motivation (e.g., pay), increasing the benefit of an intrinsic motivation on commitment. Extrinsic motivations can amplify intrinsic motivations when the individual experiences extrinsic rewards as equitable and based on performance. While the employee feels the OSS community members embrace the ideology, and we argue that leads the members to act in a way that supports the employee's needs, it is not enough without the extrinsic motivation of pay directly from the community to lead to commitment to the community. Further empirical research is needed to verify whether or not this is indeed the underlying reason for this finding. Nonetheless, this finding underscores the differences between employee experiences in, and views of, the company versus the OSS community. Below we discuss the theoretical and practical implications of our research while also acknowledging some limitations and outlining directions for future research.

Theoretical Contributions

This research contributes to the OSS literature in several key ways. First, a fundamental motivating factor for this research was that, increasingly, companies seek to tap into the intellectual capital embedded in OSS communities (Agerfalk and Fitzgerald 2008; Colombo et al. 2012; Dahlander and Wallin 2006; Stam 2009) and that in this pursuit, companies face challenges in interacting with OSS communities (Rolandsson et al. 2011; Stam 2009). Yet the literature lacked theoretical and empirical insight into the implications of OSS ideology for companies. We contribute to the OSS literature by showing that companies face no penalty, in terms of employees' commitment, when the employee perceives coworkers to embrace the OSS ideology more than the employee does. Thus, companies accrue a net benefit (in terms of employee commitment) from efforts to support OSS ideology.

In contrast, we find that employee commitment to their company decreases when the employee perceives that coworkers adhere less to OSS ideology than the employee does. The two types of misfit—OSS ideology over-fit and under-fit—yield different impacts on employee commitment

to the company. Recent anecdotal evidence that employees find companies that support OSS to be "more attractive to potentially valuable developers" supports this finding (Gold 2015). By teasing out the unique effects of each type of misfit through SDT, we uncovered this interesting relationship. This constitutes a key first step into understanding the issues that companies face as they engage OSS communities and reiterates Fitzgerald's (2006) statement that companies "must still satisfy certain criteria in relation to acceptable community values" (p. 596). It also demonstrates why companies such as IBM and Google experience some success in engaging with the OSS community by supporting the OSS ideology through their policies and initiatives (Gold 2015).

Second, we noted the missing theoretical explanation for the inconsistent pattern of findings linking developer OSS ideology to beneficial attitudes and behaviors relating to the OSS community and we observed that most research overlooked the environment in which the developer is embedded (exceptions are Ke and Zhang 2009, 2010). Consistent with prior research, we found that the employee's OSS ideology impacts commitment to the community. However, our results add to this research by showing that the relationship between employee OSS ideology and commitment depends on the perceived ideology of the OSS community members *and* coworkers. When we include the misfit between employee and members of the OSS community into the model, the model explains more variance than including only the employee ideology. This finding provides insight on the inconsistent findings in prior research. For example, we offer a potential explanation for studies finding a negative relationship between OSS ideology and prosocial outcomes; the negative effect could occur when the employee perceives the OSS community does not adhere to the OSS ideology as much as the employee does. In contrast, increasing employee OSS ideology yields a positive effect on commitment when the OSS community also embraces OSS ideology to a similar degree. Our research demonstrates that, in order to have a complete understanding of the relationship between OSS ideology and employee commitment, research should consider both the employee and the environment.

The research presented here also constitutes an essential contribution to the P–E fit literature by demonstrating how context (OSS community versus company) affects the consequences of misfit for commitment (Johns 2006). In the OSS community, the impact of misfit on commitment was the same no matter which type of misfit occurred; however, for companies, the two types of misfit yielded distinct outcomes. In our study, OSS ideology over-fit increased employee commitment to the company, but decreased employee commitment to the OSS community. The lack of a financial or contractual relationship between the employee and the OSS community could lead to the universal negative impact of misfit on OSS community commitment and not the company. For instance, one developer stated "small projects get lots of, well, basically useless people who need tons of hand-holding to get anything accomplished. I see the upside for them, but I don't see the upside for me" (Willis 2007). In this case, the developer feels a sense of misfit with this OSS community related to the OSS ideology values around sharing, making it difficult to form an affective commitment. In contrast, employees who receive payment from their company appear to value support for OSS ideology. Future research is necessary to understand why employees find companies that support OSS ideology endearing.

In using SDT to explain the impacts of misfit on commitment, we depart from much of the SDT literature that concentrates on individuals and children in particular (Deci and Ryan 1985) or focus on fit impacts on employee organizational commitment (Greguras and Diefendorff 2009). In particular, using SDT, we build theoretical reasoning to explain that, in addition to fit, some types of misfit can also embody a situation that allows an individual to get their psychological needs met and yield prosocial outcomes. Exploring the prosocial impacts of misfit causes us to rethink attraction–selection–attrition theory, which posits that misfit separates individuals from organizations (Schneider 1987).

Finally, our work responds to the call to explore commitment to multiple organizations at once and how they interact (Vandenberg and Scarpello 1994). In doing so, we are one of the first to examine the impact of the employee's commitment to their company on the employee's OSS community continued code contribution. Exploring commitment to multiple organizations at once carries significance in the OSS context because developers often work for a company and also contribute to OSS communities (Gamalielsson and Lundell 2014). Because companies sometimes use the application that the OSS community develops, or develops complementary applications, it benefits the company to have common developers and a collaborative relationship. For instance, it can be useful to establish coordinated release schedules between the OSS community's application and the company's own products (Michlmayr et al. 2015). However, the company and the OSS community may differ in their goals and ideologies (O'Mahony and Bechky 2008), making it unclear the degree to which employees can commit to both. For example, OSS communities often include two developers from two companies who compete with each other working on the same OSS project. This is likely at Eclipse, where contributors come from IBM and Oracle (Schaarschmidt et al. 2015). Another complication could occur when the company's ideology differs significantly from that of the OSS community.

Given the many players and associated goals in this environment, understanding whether developer commitment to the company and the OSS community exists and is complementary provides value to companies and the OSS community.

Our work suggests that commitment to the company and the OSS community are complementary in augmenting employees' continued code contributions. Gamalielsson and Lundell (2014) find that several contributors experience congruence between the professional and volunteer activities in the OSS project, LibreOffice. Gamalielsson and Lundell documented one developer describing the relationship between his contribution to LibreOffice and his day job as follows: "it is not related, but it is in harmony basically" (p. 139). This comment points to the fact that, from the position of an OSS project manager, developer commitment to their company does not represent a threat and employees committed to their companies should be encouraged to participate in OSS communities.

Managerial Implications

The results of this research hold important implications for managers. Prior work identified the company and the OSS community obligations (Agerfalk and Fitzgerald 2008), leaving psychological impacts on individual employees unclear. Managers can facilitate successful experiences for employees encouraged to contribute to OSS projects while also keeping them committed to the company. For instance, managers can act deliberately in their staffing decisions. Our results suggest that companies are most negatively impacted when the employee embraces the OSS ideology and the company does not. Managers may be able to counteract this negative consequence by assigning employees who adhere to OSS ideology to OSS communities that also strongly adhere to OSS ideology as this will provide an avenue for self-actualization for the employee while also providing the company with access to knowledge and influence within the OSS community.

Finally, the results of this study should attract the interest of OSS community leaders, who seek to keep skilled developers committed to their projects. While many studies attempt to understand why developers participate in OSS development (Hars and Ou 2002; Lerner and Tirole 2002; Roberts et al. 2006; Ye and Kishida 2003), few studies consider the factors that lead a developer to commit to a particular OSS project. This study represents one of the first to begin to answer this question. Our results suggest that commitment is highest when both the developer and the OSS community embrace the OSS ideology. Further, the positive impact of OSS commitment on continued code contribution is strongest among employees who are committed to their companies.

Limitations and Directions for Future Research

As with any research, the results require interpretation in light of some limitations. One limitation is that the sample of employees comes from a single OSS community: GNOME. As one of the largest OSS communities at the forefront of leveraging this new hybrid form of OSS development, GNOME has many of the same features (high level of corporate relationships, not hosted on a platform with other projects, associated foundation, large number of contributors) as other large OSS communities (e.g., Apache and Linux). This similarity offers the reader confidence that our results generalize to employees who contribute to projects like Apache and Linux. However, OSS projects take on a great variety of sizes, use various platforms and governance styles (Di Tullio and Staples 2013), and originate in different ways, making it difficult to generalize to all OSS projects. For example, an OSS community like Firefox may embrace the OSS ideology less than GNOME does because Firefox started from within Netscape, while GNOME originated in the OSS community. Another interesting way to consider the impact of ideology misfit would be to explore its impact on employees working on shared platforms such as GitHub. The projects on shared platforms typically receive contributions from a smaller set of employees compared to the projects on GNOME and may not receive as much support from companies, so the employees may be more impacted by misfit with their small teams. It remains unclear the degree to which our results generalize to projects hosted on shared platforms. We also wish to note that the purpose of research is to generalize to theory rather than to other contexts. Nonetheless there would be theoretical value in research that replicates tests of our hypotheses in other communities.

A second limitation is that when examining the misfit between employee and company OSS ideology, we did not consider OSS ideology norms. The norms pertaining to forking, code distribution, and named credit laid out by Stewart and Gosain (2006) were uncommon for companies. Future research can explore what OSS ideology norms are relevant to companies. However, it does not diminish the value of the insights gained by understanding how OSS ideology misfit affects commitment. Like ideology, our study emphasizes a single type of commitment. While we opted to study affective commitment based on prior research (Bateman et al. 2011; Jin et al. 2010), future research may usefully study other forms of commitment.

Although we controlled for the number of projects to which participants contributed within the GNOME community, we did not control for projects to which they contributed outside of GNOME. This limitation is not unique to our study and represents a challenge for much OSS research. Like many

studies, we are unable to control for all antecedents of commitment and code contributions. Future studies should include antecedents that impact commitment and continued code contributions. In particular, companies such as IBM, in addition to paying employees to contribute, support or sponsor OSS projects in other ways that impact an employee's interest in contributing to OSS projects (AlMarzouq et al. 2005; Capra et al. 2011). Further exploration of other motivations may be useful to consider as antecedents to continued code contribution and commitment.

A final limitation is associated with the research design. Specifically, some variables were measured using a survey method, thus raising concerns about common method bias and social desirability. We sought to minimize concerns related to common method bias and social desirability in several ways suggested by Podsakoff et al. (2003). We randomized the order of the questions pertaining to OSS ideology and commitment and informed participants that we would share only aggregated results with the GNOME community. Also, as with studies of moderation relationships, the complexity of the relationships examined in this research (which included interaction and quadratic effects as well as examinations of misfit) are such that it would minimize concerns of common method bias. Additionally, our marker variable test showed that common method variance was not a major concern in affecting the results. Further, we used archival data as the dependent variable.

These limitations notwithstanding, this research opens up several directions for research on the topic of OSS ideology and OSS community commitment and contribution. We observed an unexpected, yet interesting, difference in the effects of misfit on commitment to the company versus commitment to the OSS community. Researchers can delve more deeply into the reasons underlying this discrepancy in effects on employees who do not adhere to OSS ideology.

This research examined a small set of the ways misfit exists (Vogel and Feldman 2009) and future research can explore others. We focused on the effects of supplementary fit—that is, the extent to which the environment (company or OSS community) possessed the same OSS ideology as the employee. As stated earlier, some companies encourage their employees to contribute to OSS communities to gain knowledge that the company can use to foster innovation (Colombo et al. 2012; Stam and Elfring 2008). Complementary fit (the extent to which what the employee needs matches with what the OSS community provides or vice versa) could influence the effort that employees exert to become more embedded within the OSS community and maximize their knowledge access. Therefore, important insights could arise from research that examines complementary fit (Schilling et al. 2011, 2012). Perhaps while supplementary fit facilitates alignment in the coordination activities necessary to complete OSS project tasks, complementary fit aids access to knowledge.

Further, future research may usefully consider misfit with GNOME subprojects instead of with GNOME (as we did here). Similarly, for large organizations such as IBM, future research could consider departments. In addition to main effect relationships between GNOME subproject misfit and outcomes, prior research suggests that there is an interplay between the impacts of misfit at different levels of analysis (Vogel and Feldman 2009). That is, person–group fit moderates the impact of person–job fit.

Researchers seeking to understand employee participation in OSS projects may find recognizing the differing nature of company–OSS community collaborations useful. This study does not include several factors associated with the relationship between the company and the OSS community (Agerfalk and Fitzgerald 2008; Colombo et al. 2012; Dahlander and Wallin 2006; Stam 2009). For instance, some companies started application development internally and then released it under an OSS license (e.g., IBM and Eclipse) (Munga et al. 2009). In other cases, the company contributes to a project that started with an OSS license (e.g., IBM contributing to Linux). GNOME is more similar to Linux than to Eclipse in this regard. If the company pays an employee to maintain an application developed internally, the employee's fit with the OSS ideology may not matter as much as it does in other contexts. Another differentiator may be the company's business strategy. A company that primarily sells hardware, compared to software, involves a different set of employees and strategies. Similarly, a company whose total strategy revolves around OSS, such as RedHat, may be distinctly impacted by misfit compared to a company such as IBM that encompasses a broad set of business areas. Future research should carefully consider company characteristics.

Conclusion

The symbiotic relationship between companies and OSS communities presents both challenges and benefits to the OSS communities and companies involved (Chan and Husted 2010; Gamalielsson and Lundell 2014; Wagstrom et al. 2010). This research takes preliminary steps to understand how companies impact OSS communities. As these software development models merge, the employees who cross environments experience situations where the software development ideologies may not be aligned. Our work suggests that OSS ideology misfit impacts the way employees feel about their company and the OSS community.

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RESEARCH ARTICLE

THE IMPACT OF IDEOLOGY MISFIT ON OPEN SOURCE SOFTWARE COMMUNITIES AND COMPANIES

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Appendix A

Examples of Companies Working with GNOME

Table A1. GNOME's Corporate Interactions

Company	Commercial Company Interaction Type	Illustrative Quote
Supersonic Image	Technology working together	"Supersonic Image makes a scanner that detects breast cancer using GNOME technologies" Annual Report 2008
Motorola	Technology working together, Advisory board	"Motorola is a member of GNOME Mobile and uses GNOME technologies in their cell phones" Annual Report 2008
Google	Pay developers, Match employee donations to GNOME	"Google has been a long time GNOME supporter through projects like Google Summer of Code, GNOME Accessibility Outrech and GUADEC sponsorship" Annual Report 2008
Nokia	Advisory board	"Cody said that he had been working with Nokia to ensure that Qt's approach would be similar, to avoid compatibility issues between Qt and GTK + applications that provide their own CSD (client side decorations)" Annual Report 2009
Hewlett Packard	Pay developers, Adopt GNOME as standard	"The Sun/HP announcement that they will be adopting GNOME as their desktop standard" KDE announcement (https://www.kde.org/announcements/gfresponse.php)

Table A1. GNOME's Corporate Interactions (Continued)

Company	Commercial Company Interaction Type	Illustrative Quote
Sun	Paid developers to work on GNOME	"Sun will be assigning developers (the figure "50 developers" seems to be in vogue) to work on GNOME" KDE announcement "Sun's existing GNOME hackers will continue down the path they have been following for months, building and maintaining the core accessibility modules (atk, at-spi, gail) and contributing to various GNOME components such as ORBit2 and gnome-core" Mark McLoughlin post to GNOME listserve
Dell	Give hardware to GNOME developers	"provided me with a free laptop for Gnome development/conferences" (https://people.gnome.org/~michael/blog/copyright-assignment.html)
Wipro	Paid developers to work on GNOME	"Sun is partnering with Wipro and Ximian to commit a large team of full-time hackers to help drive GNOME 2.0 forward" Mark McLoughlin post to GNOME listserve (https://mail.gnome.org/archives/gnome-hackers/2002-February/msg00199.html)
RedHat	Paid developers to work on GNOME	RedHat, Sun or Novell, decided to sponsor developer teams and monetary resources to support the platform (Lee 2012)
IBM	Advisory board	N/A
Intel	Advisory board	N/A
Novell	Paid developers to work on GNOME	N/A
Apple	Match employee donations to GNOME	N/A
Microsoft	Match employee donations to GNOME	N/A

Appendix B

Items for Measurement Scales Used in Study

Table B1. Items for Measurement Scales Used in Study

Items (Source: Stewart and Gosain 2006)
As a software developer…
Employee values 1: I value sharing knowledge.
Employee values 2: I believe in helping others.
Employee values 3: I place great value on technical knowledge.
Employee values 4: I am driven by a desire to learn new things.
Employee values 5: I think cooperation is important.
Employee values 6: I value the reputation I gain by participating in open source projects.
Employee beliefs 1: I believe that the best code wins out in the end.
Employee beliefs 2: I believe free software is better than commercial software.
Employee beliefs 3: I think information should be free.
Employee beliefs 4: I believe that with enough people working on a project, any bug can be quickly found and fixed.
Employee beliefs 5: I believe that you only become a hacker when others call you a hacker.
Employee norm 1: I think that it is wrong to fork a project.
Employee norm 2: I believe it is inappropriate to distribute code changes without going through the proper channels.
Employee norm 3: I think it is OK to remove someone's name from a project without that person's consent.
Members of this organization…
Coworker values 1: value sharing knowledge.
Coworker values 2: believe in helping others.
Coworker values 3: place great value on technical knowledge.
Coworker values 4: are driven by a desire to learn new things.
Coworker values 5: think cooperation is important.
Coworker values 6: value the reputation gained by participating in open source projects.
Coworker beliefs 1:* believe that the best code wins out in the end.
Coworker beliefs 2: believe free software is better than commercial software.
Coworker beliefs 3: think information should be free.
Coworker beliefs 4: believe that with enough people working on a project, any bug can be quickly found and fixed.
Coworker beliefs 5: believe that you only become a hacker when others call you a hacker. (dropped)

*Some questions were inappropriate to ask in reference to the company. We did not measure this item and also did not measure behavioral norms with reference to the company.

Table B1. Items for Measurement Scales Used in Study (Continued)
In my view, members of the OSS community…
OSS community values 1: value sharing knowledge.
OSS community values 2: believe in helping others.
OSS community values 3: place great value on technical knowledge.
OSS community values 4: are driven by a desire to learn new things.
OSS community values 5: think cooperation is important.
OSS community values 6: value the reputation gained by participating in open source projects.
OSS community beliefs 1: believe that the best code wins out in the end.
OSS community beliefs 2: believe free software is better than commercial software.
OSS community beliefs 3: think information should be free.
OSS community beliefs 4: believe that with enough people working on a project, any bug can be quickly found and fixed.
OSS community beliefs 5: believe that you only become a hacker when others call you a hacker.
OSS community norm 1: think that it is wrong to fork a project.
OSS community norm 2: believe it is inappropriate to distribute code changes without going through the proper channels.
OSS community norm 3: think it is OK to remove someone's name from a project without that person's consent.
Source: Ahuja et al. (2007)
Company commitment 1: I am willing to put in effort beyond the norm for the success of my primary employer.
Company commitment 2: For me, this is the best of all possible organizations for which to work
Company commitment 3: I am extremely glad to have chosen my primary employer to work for over other organizations.
Company commitment 4: This organization inspires the very best in the way of job performance.
Company commitment 5: I show by my actions that I really care about the fate of this organization.
OSS community Commitment 1: I am willing to put in effort beyond the norm for the success of GNOME.
OSS community Commitment 2: For me, this is the best of all possible OSS projects for which to work.
OSS community Commitment 3: I am extremely glad to have chosen GNOME to work for over other projects.
OSS community Commitment 4: GNOME inspires me to do my best technical work.
OSS community Commitment 5: I show by my actions that I really care about the fate of GNOME.
Source: Randel and Jaussi (2003)
OSS social identification1: In general my role as an OSS developer is an important part of my self-image.
OSS social identification2: My role as an OSS developer is an important reflection of who I am.
OSS social identification3: My role as an OSS developer is important to my sense of what kind of person I am.
OSS social identification4: Overall, my role as an OSS developer has little to do with how I feel about myself. (reverse coded)

Appendix C

Alternative Operationalization of OSS Ideology

For the main analysis, we operationalized OSS ideology as a second-order reflective construct. However, as Stewart and Gosain's (2006) found that the underlying dimensions of OSS ideology (i.e., values, beliefs, and norms) had different effects on OSS team trust and effectiveness; we also conducted an analysis where we specified ideology as a formative construct. Specifically, given the already established support for first-order reflective specification for values, beliefs and norms, we specified OSS ideology as a second-order formative construct. Although formative measures are not required to exhibit reliability (Petter et al. 2007) they can be checked for stability by assessing multicollinearity. Multicollinearity may suggest that items are tapping into the same dimension of the construct and can result in model instability (Diamantopoulos and Winklhofer 2001). The VIFs were less than 3.0, indicating that multicollinearity was not a concern. Following the

guidelines of Petter et al. (2007), we also examined the item weights. Although there is no recommended cut-off value, significant weights provide insight into the importance of each indicator. The weights of the first-order constructs on the second-order formative ideology construct were: .50 (developer beliefs), .69 (developer values), -.60 (developer forking norms), .65 (developer distribution norms) and .65 (developer named credit norms). The weights of the first-order constructs for OSS community ideology were .61 (perceived OSS beliefs), .78 (perceived OSS values), -.58 (perceived OSS forking norms), .70 (perceived OSS distribution norms), and .77 (perceived OSS named credit norms). Finally, the weights for second-order company ideology were: .50 (organizational beliefs) and .50 (organizational values). Since polynomial regression analysis does not use latent constructs, we computed linear composite scores for ideology based on the weights of the first-order factors. The results of the analysis involving this formative second-order specification did not differ from those of our initial reflective specification. This is to be expected since our variables are linear composites of highly correlated first-order factors (Rozeboom 1979). Rai et al. (2006) note that when first-order factors are highly correlated the linear composites based on different weighting schemes will also tend to be correlated. Moreover, the coefficient estimates based on these different weighting schemes will tend to be quite similar (Rai et al. 2006).

Appendix D

Results of Confirmatory Factor Analysis

	1	2	3	4	5	6	7	8	9	10	11
DV_VAL1	**.78**	.08	.04	.19	.09	.05	.23	.18	.18	.18	.05
DV_VAL2	**.70**	.03	.08	.29	.01	.02	.15	.12	.11	.21	.03
DV_VAL3	**.78**	.10	.08	.03	.01	.11	.06	.00	.02	.09	.06
DV_VAL4	**.74**	.06	.05	.17	.07	.04	.15	.07	.11	.11	.10
DV_VAL5	**.66**	.09	.22	.19	.01	.24	.21	.08	.22	.16	.32
DV_VAL6	**.28**	.12	.10	.22	.04	.03	.09	.09	.08	.05	.19
DV_BEL1	.17	**.67**	.14	.17	.08	.04	.00	.06	.01	.20	.13
DV_BEL2	.18	**.62**	.07	.18	.04	.12	.07	.04	.05	.33	.00
DV_BEL3	.22	**.68**	.02	.22	.17	.11	.18	.09	.14	.26	.13
DV_BEL4	.22	**.84**	.11	.22	.18	.08	.02	.37	.06	.05	.05
DV_BEL5	.07	**.82**	.01	.07	.06	.11	.06	.08	.02	.07	.14
DV_NOR1	.11	.00	**.79**	.12	.10	.01	.05	.12	.11	.06	.00
DV_NOR2	.21	.03	**.74**	.02	.01	.10	.05	.04	.05	.12	.10
DV_NOR3	.24	.11	**.59**	.12	.18	.08	.05	.09	.02	.06	.13
OSS_VAL1	.23	.09	.06	**.83**	.07	.01	.18	.03	.16	.14	.13
OSS_VAL2	.22	.06	.01	**.83**	.09	.05	.17	.04	.14	.08	.14
OSS_VAL3	.16	.07	.02	**.77**	.16	.13	.12	.10	.07	.19	.06
OSS_VAL4	.18	.05	.13	**.74**	.07	.00	.14	.18	.08	.19	.00
OSS_VAL5	.09	.04	.16	**.81**	.02	.12	.13	.01	.13	.13	.09
OSS_VAL6	.10	.08	.07	**.67**	.31	.09	.03	.17	.02	.18	.13
OSS_BEL1	.06	.48	.12	.53	**.57**	.01	.00	.05	.01	.28	.12
OSS_BEL2	.04	.13	.03	.27	**.68**	.03	.16	.05	.14	.23	.03
OSS_BEL3	.02	.21	.07	.36	**.66**	.02	.17	.03	.18	.24	.09
OSS_BEL4	.05	.12	.01	.20	**.71**	.09	.09	.09	.05	.23	.08
OSS_BEL5	.19	.02	.08	.19	**.74**	.02	.03	.19	.01	.01	.00
OSS_NOR1	.05	.03	.10	.21	.01	**.75**	.07	.06	.06	.07	.12
OSS_NOR2	.10	.04	.08	.33	.03	**.71**	.06	.13	.03	.11	.49
OSS_NOR3	.09	.49	.05	.17	.02	**.60**	.06	.00	.08	.06	.37
ORG_VAL1	.26	.02	.08	.09	.01	.09	**.75**	.04	.10	.09	.02
ORG_VAL2	.27	.13	.09	.17	.02	.09	**.75**	.07	.17	.07	.12
ORG_VAL3	.17	.09	.10	.20	.11	.10	**.73**	.01	.17	.06	.06
ORG_VAL4	.20	.01	.07	.15	.05	.07	**.82**	.03	.13	.09	.10
ORG_VAL5	.14	.04	.12	.16	.05	.12	**.83**	.01	.16	.17	.08
ORG_VAL6	.00	.02	.06	.02	.05	.08	**.68**	.06	.14	.06	.05
ORG_BEL1	.02	.05	.01	.02	.16	.01	.37	**.87**	.14	.20	.08
ORG_BEL2	.02	.11	.05	.09	.10	.07	.27	**.79**	.04	.02	.06
ORG_BEL3	.00	.12	.04	.13	.06	.05	.35	**.71**	.05	.05	.01
ORG_BEL4	.00	.08	.05	.01	.06	.05	.03	**.90**	.03	.03	.05
ORG_COM1	.03	.06	.08	.01	.03	.05	.06	.06	**.67**	.02	.08

ORG_COM2	.03	.20	.11	.10	.04	.03	.14	.12	**.73**	.01	.11
ORG_COM3	.06	.17	.12	.06	.04	.09	.13	.05	**.76**	.04	.12
ORG_COM4	.00	.16	.07	.06	.03	.01	.16	.02	**.74**	.00	.07
ORG_COM5	.10	.10	.03	.09	.08	.07	.12	.12	**.66**	.14	.03
OSS_COM1	.16	.02	.28	.23	.03	.07	.04	.04	.07	**.75**	.11
OSS_COM2	.04	.01	.01	.17	.09	.17	.04	.08	.04	**.84**	.06
OSS_COM3	.12	.04	.07	.23	.13	.11	.07	.10	.03	**.84**	.09
OSS_COM4	.12	.00	.02	.28	.05	.05	.04	.03	.03	**.83**	.07
OSS_COM5	.11	.14	.07	.32	.03	.02	.06	.00	.03	**.72**	.06
OSS_ID1	.16	.13	.12	.10	.16	.05	.14	.23	.17	.12	**.80**
OSS_ID2	.07	.00	.14	.18	.17	.03	.18	.24	.16	.07	**.81**
OSS_ID3	.22	.17	.11	.18	.09	.14	.17	.09	.10	.20	**.83**
OSS_ID4	.22	.18	.08	.02	.37	.06	.20	.01	.07	.15	**.81**

Appendix E

Descriptive Statistics and Correlations

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Company commitment	5.06	1.22																
2. OSS commitment	4.96	1.20	.07															
3. Employee ideology	4.74	0.87	.10	.37***														
4. Perceived coworker ideology	5.21	1.36	.67***	.21***	.25**													
5. Perceived OSS community ideology	6.41	0.61	.08	.49***	.49***	.27***												
6. USA	n/a	n/a	.03	.07	.17*	-.02	.03											
7. Germany	n/a	n/a	.01	.01	.09	.08	.08	-.15*										
8. Spain	n/a	n/a	.12†	.14†	-.27***	-.20**	-.24**	-.14†	-.09									
9. Age	30.00	8.08	-.07	-.06	-.05	-.06	.02	.00	.03	.05								
10. Gender	n/a	n/a	.11	.06	.06	-.19*	-.11	.04	-.07	-.06	-.08							
11. Education	n/a	n/a	.05	-.08	-.14†	-.02	-.01	-.18*	.15*	.03	.15*	.09						
12. Organizational tenure	3.70	3.92	-.08	-.18*	.21**	.13†	.12†	.05	.05	-.04	.45***	.00	.08					
13. Paid volunteer	n/a	n/a	-.46***	-.31***	.11	.47***	.22**	-.06	.10	-.16*	-.08	-.18*	.01	-.02				
14. Pre-survey activity	80.61	360.88	.15*	.16*	.00	-.07	.01	.01	-.01	.05	-.02	-.04	-.04	-.05	-.19**			
15. Pre-survey number of projects	2.35	5.53	.09	.18*	-.08	-.11	-.13†	-.08	.04	.07	-.07	.01	-.08	-.01	-.07	.24**		
16. Social identity	3.20	1.60	-.09	.19*	.26***	.15*	.15*	.09	.04	-.07	.11	-.03	-.02	.25**	.06	-.11	-.09	
17. Post-survey activity	27.59	121.63	.14*	.16*	.01	-.08	.06	.00	.02	.02	-.01	-.01	.04	-.03	-.23**	.65***	.18*	-.03

Notes: N = 186

1. Pre-survey activity = log-transformed number of files changed. Mean and standard deviation of non-transformed number of files changed shown for descriptive purposes only.
2. †p < .10, *p < .05, **p < .01, ***p < .001.

Appendix F

Examination of Key Features of the Response Software

The principal axes of a response surface reflect the overall orientation of the response surface relative to the X,Y plane (Edwards 2002). The first and second principal axes are perpendicular to one another. In our model the first principal axis represents the line along which employee commitment is maximized. This would be represented along the line of fit, where X = Y. On the X, Y plane, the line of fit runs at a 45-degree angle from the origin (where X = 0 and Y = 0) and has a slope of 1. Therefore, it is useful to know if the first principal axis of the surface runs parallel to the line of fit. This can be accomplished by determining whether the slope of the first principal axis along the X, Y plane is significantly different from 1. A first principal axis whose slope is not significantly different from 1, likely runs parallel to the line of fit (Edwards 2002). The second principal axis is the line along which employee commitment decreases. Per our hypotheses H1 and H3, commitment is expected to increase with increasing OSS ideology over-fit. In contrast, as indicated by our hypotheses H2 and H4, commitment is expected to decrease as OSS ideology under-fit increases. The effect of these forms of misfit would be reflected along the line of misfit, where X = -Y. The slope of the line of misfit along the X, Y plane is -1. Hence, we can determine if the second principal axis runs parallel to the line of misfit by examining whether its slope differs significantly from -1 (Edwards 2002).

Another feature of interest is the slope of the response surface along the principal axes. It can be informative to know if the response surface is upward sloping, downward sloping, curvilinear, or flat along these axes. This is particularly important for testing our hypotheses because the slope is expected to have a negative overall orientation. A negative slope would indicate that commitment increases with increasing OSS ideology over-fit (region to the left of the line of fit) and decreases with increasing OSS ideology under-fit (region to the right of the line of fit).

Testing the significance of these key features requires non-parametric techniques. Following the recommendation of Edwards (2002), we used a bootstrapping procedure to test the significance of the key response surface features (i.e., stationary point, slopes along lines of interest, and first and second principal axes) (Efron and Tibshirani 1993). Bootstrapping is generally preferred over jackknifing, especially when sample sizes are smaller as in this study (Efron and Tibshirani 1993). Using the bootstrapping approach, we constructed bias-corrected confidence intervals around the estimates of these key features of the response surface (Edwards 2002). The results are shown in Table F1.

Table F1. Results of Tests of Key Features Response Surface Predicting OSS Commitment

			Fit Tests						Misfit Tests (H1, H2, H3, H4)					
	Stationary point		First principal axis		Slopes along first principal axis		Slopes along fit axis (X = Y)		Second principal axis		Slopes along second principal axis		Slopes along misfit axis (X = -Y)	
Dependent variable	X_0	Y_0	p_{10}	p_{11}	a_x	a_x^2	a_x	a_x^2	p_{20}	p_{21}	a_x	a_x^2	a_x	a_x^2
Company commitment	-3.62	.25*	3.87	1.00*	1.37**	.19	.64***	.19	-3.37	-1.00*	-1.09*	-.15	-.58*	-.15
OSS commitment	-5.24	-4.26	.68*	.94*	.60*	.06	.58**	.06	-9.82	-1.06*	-3.12	-.30*	-.18	-.28*

Notes:
1. N = 186.
2. Significance levels are based on bias-corrected confidence intervals constructed from coefficients from 10,000 bootstrap samples.
3. For the first principal axis, significance levels for p_{10} are based on bias-corrected confidence intervals around 0 and significance levels for p_{11} are based on bias-corrected confidence intervals around 1.
4. For the second principal axis, significance levels for p_{20} are based on bias-corrected confidence intervals around 0 and significance levels for p_{21} are based on bias-corrected confidence intervals around -1.
5. For a_x and a_x^2, significance levels are based on bias-correct confidence intervals around 0.

*p < .05, **p < .01, ***p < .001.

Test of H1 and H2

The results for company commitment in Table F1 show that the slope of the second principal axis (p_{21}) does not differ significantly from -1 ($p < .05$) (i.e., the bias-corrected confidence interval around p_{21} includes -1). This suggests that the second principal axis is parallel to the line

of misfit (i.e., the line along which X = -Y). We can conclude from this result that somewhere along this line, employee commitment to the company is minimized as OSS ideology misfit increases. In examining the slope of the response surface along this second principal axis, we find a negative linear slope (a_x = -1.09, $p < .05$). This suggests that employee commitment increases with increasing OSS ideology over-fit (i.e., the region to the left of the line of fit). Thus, H1 is supported. In contrast, the negative linear slope suggests that the negative effect of misfit in ideology occurs only in the region of the response surface representing OSS ideology under-fit (i.e., the region to the right of the line of fit, where an employee embraces the OSS ideology more than they perceive their coworkers do). This supports H2.

Test of H3 and H4

The results show that the slope of the second principal axis (p_{21}) is not significantly different from -1 ($p < .05$) (i.e., the bias-corrected confidence interval around p_{21} includes -1). This suggests that the second principal axis is parallel to the line of misfit and that OSS commitment is minimized along this line. An examination of the slope of the response surface along the second principal axis indicates an inverted U-shape slope (a_x^2 = -.30, $p < .05$). This shows that employee commitment to the community decreases both with increasing OSS ideology under-fit and with increasing OSS ideology over-fit. This supports H4 but is counter to H3.

In sum, the results suggests some potential theoretical differences between the company context and the OSS community context with respect to the impact of misfit.

Appendix G

Equations for Response Surface Key Equations (Edwards 2002)

1. Stationary Point

$$X_0 = \frac{b_2 b_4 - 2b_1 b_5}{4b_3 b_5 - b_4^2}$$

$$Y_0 = \frac{b_1 b_4 - 2b_2 b_3}{4b_3 b_5 - b_4^2}$$

2. First Principal Axis

$$Y = p_{10} + p_{11} X$$

where p_{11} is the slope of the first principal axis and is given by

$$p_{11} = \frac{b_5 - b_3 + \sqrt{(b_3 - b_5)^2 + b_4^2}}{b_4}$$

and p_{10} is the intercept of the first principal axis and is given by

$$p_{11} = Y_0 - p_{11} X$$

3. Second Principal Axis

$$Y = p_{20} + p_{21} X$$

where p_{21} is the slope of the second principal axis and is given by

$$p_{21} = \frac{b_5 - b_3 - \sqrt{(b_3 - b_5)^2 + b_4^2}}{b_4}$$

and p_{20} is the intercept of the second principal axis and is given by

$$p_{20} = Y_0 - p_{21} X_0$$

4. Slope of Surface along Line of Fit (Y = X)

$$Z = b_0 + (b_1 + b_2) X + (b_3 + b_4 + b_5) X^2 + e$$

where $(b_1 + b_2)$ represents the linear slope of the surface along the line of fit and $(b_3 + b_4 + b_5)$ represents the curvature of the surface along the line of fit.

5. Slope of Surface along Line of Misfit (Y = -X)

$$Z = b_0 + (b_1 - b_2) X + (b_3 - b_4 + b_5) X^2 + e$$

where $(b_1 - b_2)$ represents the linear slope of the surface along the line of misfit and $(b_3 - b_4 + b_5)$ represents the curvature of the surface along the line of misfit.

6. Slope of Surface along First Principal Axis

$$Z = b_0 + b_1 p_{10} + b_5 p_{10}^2 + (b_1 + b_2 p_{11} + b_4 p_{10} + 2 b_5 p_{10} p_{11}) X + (b_3 + b_4 p_{11} + b_5 p_{11}^2) X^2 + e$$

where $(b_1 + b_2 p_{11} + b_4 p_{10} + 2 b_5 p_{10} p_{11})$ represents the linear slope of the surface along the first principal axis and $(b_3 + b_4 p_{11} + b_5 p_{11}^2)$ represents the curvature of the surface along the first principal axis.

7. Slope of Surface along Second Principal Axis

$$Z = b_0 + b_2 p_{20} + b_5 p_{20}^2 + (b_1 + b_2 p_{21} + b_4 p_{20} + 2 b_5 p_{20} p_{21}) X + (b_3 + b_4 p_{21} + b_5 p_{21}^2) X^2 + e$$

where $(b_1 + b_2 p_{21} + b_4 p_{20} + 2 b_5 p_{20} p_{21})$ represents the linear slope of the surface along the first principal axis and $(b_3 + b_4 p_{21} + b_5 p_{21}^2)$ represents the curvature of the surface along the first principal axis.

Appendix H

Results of Marker Variable Test

	Correlation with Employee Commitment to the Company		Correlation with Employee Commitment to the OSS Community	
	Without Marker	**With Marker**	**Without Marker**	**With Marker**
Employee ideology	.10	.05	.37***	.34***
Perceived OSS community ideology	.07	.02	.49***	.46***
Perceived coworker ideology	.67***	.65***	.21**	.17*

Notes: *p < .05, **p < .01, ***p < .001.

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