Journal of Strategic Information Systems xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Strategic Information Systems

journal homepage: www.elsevier.com/locate/jsis

Sourcing knowledge in open source software projects: The impacts of internal and external social capital on project success

Sherae Daniel[a,*], Vishal Midha[b], Anol Bhattacherhjee[c], Shivendu Singh[d]

[a] University of Cincinnati, 2925 Campus Green Drive, Cincinnati, OH 45221, United States
[b] Illinois State University, Campus Box 5520, Normal, IL 31790-5500, United States
[c] University of South Florida, Muma College of Business, 4202 East Fowler, CIS 2083, Tampa, FL 33620-7800, United States
[d] University of Pittsburgh, Katz School of Business, Pittsburgh, PA 15222, United States

ARTICLE INFO

Keywords:
Open source projects
Diversity
Development difference
Participant difference
Connectedness
Success

ABSTRACT

Open source software (OSS) development has become an essential element of IT strategy: many firms seek OSS as a strategic means of unlocking the business value in external developer communities and internal knowledge sources. However, integrating external and internal sources of social capital is challenging and identifying appropriate integration strategies is crucial for the success of such endeavors. This study examines the simultaneous effects of external and internal sources of social capital, in the form of participant and project differences, and examines how they interact to influence OSS project success. We propose a taxonomy of participant differences (language, role, and contribution) and project differences (development environment and connectedness) and postulate their main and moderating effects on project success. Using a four-year panel data set of 329 SourceForge projects, we show that development environment difference has a curvilinear relationship with success and that connectedness reduces the positive impact of role and contribution diversity on project success. We also show that when development environment difference is moderate, the impact of role diversity is the most positive. We present the implications of these findings for theory and practice.

1. Introduction

In recent years, open and collaborative models of innovation, such as open source software (OSS) development, have attracted the attention of practitioners and researchers alike. Many technology firms traditionally known for closed organizational structures and propriety software development, such as IBM, Microsoft, and Facebook, have embraced the strategic opportunities that open source development models offer. They are actively pursuing open platforms and promoting hackathons inside and outside their organizational boundaries in order to source new knowledge, identify innovations, and create new business value (Santos et al., 2013). For the year 2016, revenue from OSS products is estimated to have exceeded 50 billion euros ($57 billion), up from under 8 billion euros in 2008 (Statistica, 2016). Five out of Fortune 10 firms and 40% of Fortune 50 firms are today developing next generation software solutions using open platforms such as GitHub. For instance, Microsoft and Facebook have the most active open source development communities on GitHub, with Microsoft boasting the highest number of contributors and more than 258 software projects under development (Octaverse, 2016).

While OSS development holds many interesting opportunities, not all OSS projects are successful (Ehls, 2017). To understand the success or failure of OSS projects, some researchers have used a social capital lens (Chou and He, 2011; Grewal et al., 2006; Singh

* Corresponding author.
E-mail addresses: daniesr@ucmail.uc.edu (S. Daniel), vmidha@illinoissatate.edu (V. Midha), abhatt@usf.edu (A. Bhattacherhjee), shs161@pitt.edu (S. Singh).

https://doi.org/10.1016/j.jsis.2018.04.002
Received 7 July 2016; Received in revised form 16 April 2018; Accepted 26 April 2018

et al., 2011; Wang, 2005; Xu and Jones, 2010) to examine how social relationships create resources for action (Coleman, 1988; Nahapiet and Ghoshal, 1998). Social capital theory has primarily considered how social capital, derived from an external network of suppliers, customers, vendors, and business partners, leads to the development of intellectual capital within organizations in the form of new or improved products or processes (Nahapiet and Ghoshal, 1998). This theory is applicable to OSS development because OSS is an intellectual resource developed via the social action of freelance developers.

While social capital theory has traditionally focused on external sources of social capital, such as those acquired by an organization's network of suppliers, customers, vendors and business partners, an organization's internal resources, such as its employees, can also be valuable sources of social capital. In particular, the external and internal social capital can complement each other by interacting in ways to create business value (Adler and Kwon, 2002; Cuevas-Rodríguez et al., 2014; Stam and Elfring, 2008; Walter et al., 2007). In the OSS context, internal social capital relates to an OSS project's team of software developers, testers, and active users, while external social capital relates to contributors from other OSS projects who may be interested in and can contribute to the target project by virtue of their connectedness and the similarity in their project development environments. Several OSS projects use the same OSS platform and developers often work concurrently on multiple projects, transferring ideas, knowledge, interfaces, and software code from one project to another (Fershtman and Gandal, 2011; Grewal et al., 2006; Méndez-Durón and García, 2009; Peng and Mu, 2011; Peng et al., 2013). Unlike traditional organizations, OSS project boundaries are permeable, impermanent, and somewhat ill-defined, allowing for easy flow of people and resources within and across project boundaries (Seidel and Stewart, 2011). Further, OSS projects differ from traditional projects in this way: key stakeholders do not define their success in terms of financial outcomes. Because OSS projects differ from traditional projects in the ways described, we must develop unique theories for OSS projects.

In this study, we contend that (1) both internal *and* external social capital contribute to OSS success, and (2) internal and external social capital may *interact* in unique ways to influence OSS success. We define OSS success in terms of developer contributions to OSS source code. This definition is consistent with examinations of technical success and we use it because code contributions represent the lifeblood of OSS projects (Daniel and Stewart, 2016). We define internal social capital as differences among participants (developers, etc.) in an OSS project, and external social capital as differences among OSS projects on OSS platforms. We propose a taxonomy of internal and external social capital in terms of *participant differences* (language, role, and contribution differences across participants) and *project differences* (differences in development environments of OSS projects and their connectedness to other OSS projects). We postulate the main and moderating effects of these two types of social capital on project success and test these effects using four years of data on 329 SourceForge projects. The research question of interest is: *Does internal and external social capital influence OSS project success, and if so, how*?

Our study makes several contributions to social capital and open source research. First, it bridges the gap between internal and external sources of social capital, offering a more nuanced and holistic view of the interaction between the two sources in OSS projects. This holds significance because prior OSS research has considered either internal social capital (e.g., Chou and He, 2011) or external social capital (e.g., Grewal et al., 2006), but not both at the same time. Our study examines the simultaneous effects of and interaction between these two sources of social capital on OSS project success and shows that the "more-is-better" approach may not be the right strategy for firms. We also provide tentative explanations for some of the inconsistent findings reported in the prior OSS literature. For example, Chou and He (2011) found that two out of three types of social capital (relational and cognitive capital) did not impact OSS project outcomes, while studies in face-to-face settings report the importance of relational social capital (Putnam, 1995; Shumaker and Brownell, 1984) and cognitive social capital in electronic networks of practice (Constant et al., 1996). Similarly, internal social capital (measured as team homogeneity or closeness in internal networks), is linked to higher efficiency and lower administrative overhead in one study (Zenger and Lawrence, 1989), but others report negative effects on creativity and knowledge assimilation capabilities of the team (Pelled et al., 1999). We explain these mixed findings by suggesting that external social capital must be examined to understand the impact of the internal social capital.

2. Conceptual development

Social capital is defined as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit" (Nahapiet and Ghoshal, 1998). The central tenet in social capital theory is that networks of relationships constitute a valuable resource (a collectivity owned capital called "social capital") that facilitates the creation of intellectual capital (e.g., new knowledge) through the processes of knowledge exchange and combination. Social capital consists of three dimensions: structural capital, cognitive capital, and relational capital. "Structural capital" relates to the configuration of linkages and ties that provides access to network resources such as knowledge embedded within network members. "Cognitive capital" refers to shared language, codes, and narratives that enable effective communication and interpretation of knowledge among knowledge sources and recipients. "Relational capital" is the trust, norms, and obligations that facilitate frictionless sharing and acceptance of knowledge.

We distinguish between the social capital that is internal to an OSS project and the social capital that is external to it. We consider internal social capital in terms of participant diversity within the project team. The notion of diversity as a resource is well-researched in the management, sociology, and political science literatures (Cheong et al., 2007). Diversity embedded in institutional structures can manifest as social capital (Arneil, 2006; Reagans and Zuckerman, 2001). In particular, similar people can share cognitive schemas and relate easily to each other. Nahapiet and Ghoshal's (1998) study of cognitive and relational dimensions can explain the impact of internal social capital.

External social capital refers to a project's relationship with the broader social structure of the OSS network through which the