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Resources contributing to gaining competitive advantage for open source software projects: An application of resource-based theory

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Abstract

Open Source Software (OSS) is an important asset in today's software-intensive society. The success of OSS projects is highly dependent on a number of factors. These factors must be understood and managed as an OSS project progresses. Thus, project management of an OSS project has a decisive role in ensuring the success of its software. The objective of the research is to increase the understanding of the resources affecting the competitiveness of OSS projects. Herewith, the responsiveness of OSS projects to users' needs is assessed via an investigation of the defect-fixing process. A Resource-Based View of the firm (RBV) is used to build theoretical justifications for a set of hypotheses proposed in this study. Data gathered from 427 OSS projects confirmed that developers' interest in and users' contribution to the project as well as frequently updating and releasing the software affect the project's ability to gain competitive advantage through effective defect-fixing. It is also shown that OSS projects that are more popular and have a higher level of organizational communication than others are more likely to gain competitive advantage through effective defect-fixing. Finally, implications of the results for practitioners and the research community are presented.

Keywords: Project resources; Open-source software project; Competitive advantage; Resource-based view of the firm

1. Introduction

Open source software (OSS) has changed the way that software is developed, deployed, and perceived. The spread of OSS was facilitated by commercial and government organizations, which adopted OSS widely (Carillo and Okoli, 2008). Nowadays, influential organizations of all sizes have adopted OSS products (Sen, 2007a) because OSS has been recognized as a cheap and reliable alternative to proprietary software (Paulson et al., 2004).

However, despite the increasing adoption of open source software, many OSS projects fail in the early stages of development (Aksulu and Wade, 2010; Chengalur-Smith and Sidorova, 2003) for various reasons such as inability to attract volunteer developers to join their development team or inability to attract voluntary contribution from user community (Subramaniam et al., 2009). Whereas Linux and Apache have been highly successful instances of OSS (Nelson et al., 2006; Sen, 2007b), the majority of OSS projects fail (Colazo and Fang, 2009) because of low responsiveness to user needs (Golden, 2004). According to Krishnamurthy (2002), 63% of OSS projects on Sourceforge.net, the world's largest OSS host, fail. This might be because a large majority of OSS projects cannot attract the interest of the user community (Stewart and Gosain, 2006a) for a number of reasons, such as low responsiveness to user needs (Golden, 2004) (e.g., in terms of fixing software defects).

Herein, the responsiveness of OSS projects to user needs is studied via an examination of the defect-fixing process. Previous research on OSS projects has suggested that effective defect-fixing is important for the success of OSS projects

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(Crowston et al., 2003, 2006; Garousi, 2009). Effective defect-fixing is tied to users' perceptions of the quality, value, and project development activity (e.g., number of line of codes) (Midha et al., 2010; Mockus and Weiss, 2008). In light of this, the objective of the study reported herein was to investigate the factors that drive the effectiveness of the defect-fixing process, because defect-fixing may well be a strong source of competitive advantage for OSS projects.

To achieve this objective, we developed and assessed a set of hypotheses regarding the influence of project resources on the effectiveness of the defect-fixing process. Previous studies have proposed a number of factors that might be useful when predicting OSS projects' positive outcomes. For example, certain decisions that project managers have to make before launching the project can influence success. Examples of this include decisions on programming language (Chandrasekar Subramaniam et al., 2009), sponsorship (Stewart et al., 2006), project audience, and project topic (Crowston and Scozzi, 2002). Our study complements this earlier work by focusing on a further factor, *project resources*, because identifying the project resources that have the potential to affect defect-fixing effectiveness might provide organizations that are interested in adopting OSS products with certain criteria for selecting OSS projects. Herein, defect-fixing effectiveness is defined as the extent to which the OSS project accomplishes to remove the defects existing in the software. On the assumption that a project's resources act as a source of added value for users by influencing the effectiveness of the defect-fixing process, we decided to address the following research question:

> RQ: What are OSS project resources that have the potential to affect defect-fixing effectiveness and, therefore, might provide organizations that are interested in adopting OSS products with certain criteria for selecting OSS projects?

The answer to this question has both theoretical and practical implications. In order to answer the research question, we used Resource-Based View (RBV) of the firm, according to which, in order to attain competitive advantage, projects need to have strategic resources that are valuable, rare, non-imitable, and non-substitutable (Jugdev et al., 2007).

Our study contributes to the existing literature by: (1) extracting the critical resources of OSS projects which are important for their defect-fixing process; (2) revealing the significant impact that the identified OSS projects' resources have on the effectiveness of their defect-fixing process; (3) applying the resource-based view of the firm to the context of OSS projects; and (4) studying a considerable number of OSS projects.

The remainder of the paper is structured as follows. In Section 2, the research background is discussed. The research model and theoretical justifications for the relationships proposed are presented in Section 3. In Section 4, the design of the study is described. In Section 5, the data analysis and the results of the study are presented. The implications for both research and practice are derived and discussed in Section 6. In Section 7, the limitations of the study are noted followed by concluding remarks in Section 8.

2. Research background

OSS projects seem to involve a never-ending process of defect fixing. During the defect-fixing process, defects that are observed in the software are handled and resolved to improve the quality of the software. However, this process should not be characterized as simple maintenance, because the software always evolves to fulfill new user requirements (Ghapanchi and Aurum, 2012). That is why previous research considers continuous defect fixing to be one of the processes that characterize OSS projects (Crowston et al., 2006).

The defect-fixing process has been addressed in only a few studies on OSS. Herbsleb and Mockus (2003) found that the progress in fixing defects influences the positive outcomes in OSS projects. Stewart and Gosain (2006a) used the percentage of defect reports completed as an indicator of the effectiveness of OSS projects and found that the quality of communication among team members and team effort affect the quantity of defect reports completed. They suggested that the success of an OSS project is a function of the extent to which a project receives input from the community, and the extent to which it creates an observable output, such as a defect fixed. Stewart and Gosain (2006b) also provided strong evidence that the percentage of defect reports completed affects the perceived effectiveness of OSS projects, where 'perceived effectiveness' is defined by how well an OSS project succeeds in accomplishing its goals.

An OSS project can be launched through the project website or using an existing portal that offers open source hosting services. Examples of the former are Open Office and Firefox. Examples of portals are Sourceforge.net, Freshmeat.net, OSDir.com, and BerliOS.com. Since 1996, a number of web portals have been launched that are dedicated to serving open source projects, providing a wide range of tools for such matters as development, defect fixing, enhancement, software release, communication, and coordination (Capiluppi et al., 2003). These portals typically provide a defect-tracking system for the purposes of providing quality assurance.

The study reported herein examined Sourceforge.net. Sourceforge does not clearly specify the process by which defects are fixed through its defect-tracking system, but defines the different statuses of a defect (See Fig. 1). When a defect is first reported, it is assigned the status Open. Subsequently, someone (e.g., a project administrator) either assigns the defect to a developer to be fixed, rejected if it is duplicate, out of date or not legitimate; the "pending" status is also used when the defect is legitimate but it is deemed better to be fixed. When a defect is resolved, the defect is assigned the status Fixed. Finally, when the defect report is completed, the status is changed to Closed.

3. Research model

3.1. Resource-based view of the firm

According to the resource-based view, competitive advantage and firm performance are influenced strongly by the firm's