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Multi-level framework of open source software adoption

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ABSTRACT

Numerous studies examine potential facilitators and inhibitors of open source software (OSS) adoption at the firm level. This study represents the first attempt to propose and test a multi-level framework, examining the effects of five country-level variables and two under-explored firm-level factors on firm OSS adoption. The findings suggest that a country's uncertainty avoidance orientation has a positive impact on OSS adoption, whereas power distance orientation and economic development have a negative impact on OSS adoption. In addition, uncertainty avoidance at the country level sets boundaries for the effect of firm-level IT-based networks in a way that the impact of proprietary IT-based networks becomes stronger, but that of open IT-based networks becomes weaker when uncertainty avoidance is high rather than low. The study also develops public policy implications from these findings.

1. Introduction

Open source software (OSS) continues to gain increasing attention in the business world. Unlike proprietary software (e.g., Windows XP), OSS (e.g., Linux) development occurs in a public, collaborative manner with its source code accessible to the public. This open model permits users to use, change, improve, and redistribute the software. CIO Insight magazine (D'Agostino 2005) reports that 81% of firms deploy or are considering deploying some sort of open source systems or applications, with 60% replacing legacy systems with Linux, or planning to do so in the next two years. Even Microsoft, a giant in proprietary software, is starting to collaborate with such OSS vendors as Red Hat and Novell. Although early OSS users are themselves technologists and the distribution and the use of OSS is initially only among academia, today the development and design of OSS are often for mass consumption (Boulanger, 2005).

Studies that investigate potential facilitators and inhibitors of OSS adoption among firms find that factors such as low cost, high reliability, slack resources, and relevance to business encourage firms to adopt OSS, while the lack of internal skills or external support inhibits firms from adopting OSS (Dedrick and West, 2004; Goode, 2005; Ven and Verelst, 2008b). These studies provide intriguing findings; however, the focus is primarily at the firm level, whereas they largely neglect the effect of country-level factors. Among the rare exceptions, Mindel, Mui, and Verma (2007) compare OSS adoption levels across a few Southeast Asian countries and find that firms in economically disadvantaged countries are more likely to adopt OSS. Some other scholars (e.g., Tuomi, 2006; Ven, Verelst, and Mannaert, 2008) also notice that a country's cultural values, such as power distance orientation, might be influential to a firm's adoption of OSS.

Despite these advocates, no research to date theorizes the effects of country-level factors on OSS adoption and tests these effects using large-scale data from countries with a wide span of cultural orientations and economic development levels. In addition, previous studies in this area largely neglect the nested structure of the OSS adoption data. A common practice in most prior studies that investigates the effects of country-level factors on OSS adoption is to obtain information from multiple firms in each country and then researchers determine a country's OSS adoption level using aggregate measures across all firms. One of the problems with aggregation is that this method loses all firm-level information and the statistical analysis loses power. Assigning an aggregate value obscures the fact that OSS adoption is heterogeneous across firms.

To address the above issues, this paper develops a multi-level framework of firm OSS adoption that specifies the country-level, the firm-level, and the cross-level effects. At the country level, the study describes the impact of a country's cultural, technological, and economic factors on firm OSS adoption. At the firm level, the study examines the effects of proprietary and open IT-based networks on firm OSS adoption. Investigating OSS adoption simultaneously at both country- and firm-levels has important policy and managerial implications. Governments in many countries nowadays are setting up policies to promote the use of OSS. The Brazil government, for instance, proposes a bill to mandate

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that all software in the federal administration and public entities be OSS (Lewis, 2008). In the U.K., the government enacts a new policy to promote the use of open source software in the public sector (UK CIO Council, 2009). The United Nations also calls on economically disadvantaged countries to adopt OSS to bridge the digital divide with the rich, as the use of OSS can lower costs, increase security, stimulate local economies, and avoid proprietary lock-in (United Nations, 2003). By investigating how a country's characteristics influence firm decisions on OSS adoption, this study provides policy makers with useful guidance to set up relevant policies to promote OSS.

2. Research background

Numerous studies investigate facilitators and inhibitors of firm OSS adoption. Parallel with the structure in innovation adoption research, these factors are classifiable into three groups: organizational, technological, and environmental (DePietro, Wiarda, and Fleischer, 1990). Of these three categories, organizational factors gain the most research attention. Firms are more likely to adopt OSS when they have necessary technical skills (Dedrick and West, 2004; Goode, 2005; Morgan and Finnegan, 2007). By contrast, prior experience with proprietary software may reduce the propensity to adopt OSS due to switching costs (Goode, 2005; Ven and Verelst, 2008b; West and Dedrick, 2006). Managers' stance toward IT innovation (Dedrick and West, 2004; Paré, Wybo, and Delannoy, 2009), decision-makers' ideology (Ven and Verelst, 2008a), and the presence of boundary spanners (Ven and Verelst, 2008b) are other key factors affecting OSS adoption. Apart from the organizational factors, the characteristics of OSS itself also play a role. Low price seems to be the most important thrust of OSS adoption (Dedrick and West, 2004). Compatibility and trialability are the other two technical features that managers seriously take into account when making OSS adoption decisions (Morgan and Finnegan, 2007; Waring and Maddocks, 2005; West and Dedrick, 2006).

Environmental factors influence firm decisions on whether or not to adopt OSS. For example, the availability of third-party technical support facilitates OSS adoption (Paré et al., 2009; West and Dedrick, 2006). More importantly, a number of country-level factors are likely to influence a firm's adoption of OSS. When political pressures on the use of commercial software exist, firms are less likely to adopt OSS, especially for those whose businesses are dependent on the government (Paré et al., 2009). A country's economic development level may also exert a great influence on firm OSS adoption, as Mindel et al. (2007) find that the OSS adoption levels vary across a few Southeast Asian countries, with poorer ones having a higher motivation to pursue technology independence through low-cost technologies such as OSS. The cultural orientation of a country is likely to affect firm OSS adoption as well. Tuomi (2006) advocates that high power distance may be a barrier for OSS adoption.

These observations provide strong evidence to justify the important role of country-level factors in a firm's adoption of OSS. Building upon previous studies, this study develops a multi-level model of firm OSS adoption and specifies five factors at the country level, namely, uncertainty avoidance, power distance, individualism, IT competence, and economic development. The first three are the key Hofstede's cultural dimensions. Although recent publications in the psychology literature further advance the studies of Hofstede, Hofstede's cultural dimensions remain wide acceptance in marketing and are the most popular measures to study cultural effects on innovation adoption across different nations (De Jong, Steenkamp, Fox, and Baumgartner, 2008; Franke and Nadler, 2008). This study investigates IT competence and economic development because prior research implies that they may influence OSS adoption (Mindel et al., 2007; West and Dedrick, 2006).

The study also examines two variables at the firm level, namely, proprietary IT-based networks and open IT-based networks. IT-based networks are important communication channels for firms. Although communication channels are a key to innovation adoption (Gurbaxani, 1990; Loh and Venkatraman, 1992), little research thus far associates IT-based networks with OSS adoption. This study fills the gap by examining not only the main effects of the two types of IT-based networks on OSS adoption, but also their interactions with uncertainty avoidance to advance the understanding of how the country-level factor sets the boundary for the effects of IT-based networks at the firm level.

3. Research framework and hypotheses

3.1. Country-level hypotheses

3.1.1. Effect of uncertainty avoidance on OSS adoption

Uncertainty avoidance refers to the extent to which people feel comfortable in novel, unknown, surprising, and unusual situations (Hofstede, 1991). People in countries with high uncertainty avoidance feel great stress and anxiety when facing uncertain situations; as a result, they usually try to minimize uncertainty by enacting strict laws and rules, as well as safety and security measures (Hofstede, 1991). In contrast, people in countries with low uncertainty avoidance are more tolerant of opinions that are different from their own.

The uncertainty avoidance of a country likely relates positively to firm OSS adoption. Popular OSS applications such as Linux often have the benefit of high reliability and superior security over proprietary software (Raymond, 1999). A report by Reasoning Inc (2003) shows that the defect rate for the Internet protocol code in Linux is 0.1 defects per 1000 lines of code (KLOC), while that for the proprietary implementation is 0.55 defects per KLOC. Similarly, a study by Bloor Research (1999) pits Windows NT against GNU/Linux in a head-to-head comparison and finds that GNU/Linux is more reliable to Windows NT in seven of nine categories. In the Operating System Availability category, the GNU/Linux system does not experience a single outage due to software during the year of testing, while Windows NT system suffers a total of 68 failures. The high reliability and superior security of OSS is probably due to its unique development approach, that is, in a public, collaborative manner. Just as Raymond (1999, p. 29) points out, “given enough eyeballs, all bugs are shallow.”

Because OSS often has a higher reliability and superior security than the proprietary software, firms in countries with higher uncertainty avoidance should be more likely to adopt OSS than those in countries with lower uncertainty avoidance, ceteris paribus.

H1. The uncertainty avoidance orientation of a country associates positively with a firm's OSS adoption.

3.1.2. Effect of power distance on OSS adoption

Power distance refers to the extent to which less powerful members expect and accept that the distribution of power is unequal (Hofstede, 1991). In countries with low power distance, people accept consultative or democratic power relations. The less powerful are more comfortable with, and demand the right to contribute to and critique, the decisions made by those in power. On the contrary, in countries with high power distance, people usually accept the power of others according to certain formal positions. The less powerful are usually comfortable with more autocratic and paternalistic power relations (Hofstede, 2001).

A country's power distance orientation may impede a firm's adoption of OSS for three reasons. First, the ideology underlying open source movement does not fit with a culture of high power distance. People usually develop OSS in a public, collaborative manner, which may be in conflict with the values of a culture of high power distance, such as the acceptance of autocratic and paternalistic power relations (Hofstede 2001). Second, a firm's adoption of OSS is a bottom-up initiative; initiators often are technical employees who are adherents to the open source movement (Ven and Verelst, 2008a). In countries with low power distance, technological staff talking to top managers about the advantages of OSS and making recommendation of OSS