Organizational Adoption of Open Source Software: An Empirical Investigation of the Human Capital, Institutional Pressures and Social Capital Perspectives

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SUMMARY

This dissertation proposes and validates three theoretical models of organizational adoption intention of OSS from human capital, social capital and institutional pressures perspectives respectively, which extends the established innovation adoption literature with new insights and provides researchers and managers with a better understanding of organizational innovation adoption behavior.

The OSS movement dictates that the source code be made public, modifiable, and re-distributable, which affords organizations with vast opportunities to acquire, customize, and upgrade software to meet their own circumstantial requirements at a much cheaper cost compared to proprietary software. While these obvious advantages of OSS suggest that it is fast becoming a major market force, the fact remains that proprietary software continues to dominate today's software market, which begs an interesting question: "What are the factors that inhibit the adoption and use of OSS in organizations?" Up till now, very few researches have been conducted on the organizational adoption of OSS. My dissertation proposes to study this topic from three perspectives based on the unique properties of OSS.

Perspective One: the unique development style of OSS is based on the informal networks of volunteer developers and hence, the service and support of the software are no longer guaranteed. This leads to high level of uncertainty and risk of adopting OSS and hence, many organizations continue to perceive OSS to be inaccessible. This lends credence to using

human capital perspective as a theoretical lens to examine organizational OSS adoption. It is contestable that if an organization possesses the necessary human capital either internally or externally, it can greatly reduce the perceived uncertainty and risk in OSS service and support, and thus increase the organizational intention to adopt OSS.

Perspective Two: OSS is unique as an innovation in that it has had great impact on people's mindset by challenging a lot of existing social norms. Thus, the adoption of OSS may be considered as unconventional, unprofessional, or even illegal in the software market which is still dominated by traditional proprietary software. Organizations may be under the pressures to conform to the software adoption norms in the industry. Hence, it is conceived that existence of the institutional pressures toward OSS adoption which consist of coercive pressures, mimetic pressures and normative pressures will help organizations overcome this adoption barrier and thus play an important role in organizations' OSS adoption.

Perspective Three: the unique properties of OSS which include low cost of acquisition, wide availability of the software and the freedom in changing the source code and customize software enables bottom-up approach (compared with the conventional top-down approach) of organizational innovation adoption. Engineers at the bottom level may install and use OSS by themselves without the knowledge or permission from the organization's managers. These early OSS adopters in the organization can leverage on their own social capital to influence other employees' perception on OSS through informal interaction with them, thus indirectly promotes the OSS adoption in the organization. Hence it is proposed that the differences in

the properties of an individual (OSS proponent)'s social capital/network such as centrality, direction of ties and strength of ties would have different influences on other employees' perception of OSS, and consequently affect the organizational adoption of OSS.

This will be the first study investigating the organizational adoption of OSS in an integrative fashion. Large scale cross-country surveys have been carried out to collect data from organizations in Singapore and China to verify the conceptual models proposed in each of the three studies. Evidence obtained can inform OSS proponents, potential OSS adopter organizations and governments, and provide new perspectives to innovation adoption literature. Insights gained may also inspire new theoretical and empirical advance.

CHAPTER 1

INTRODUCTION

Since its emergence in the early 1990s, open source software (OSS) has attracted widespread attention from academics and industry practitioners, partly because of its unique business paradigm and developmental approach. The definition of OSS can be complicated and multifaceted[1], however, the main theme is the emphasis on its being a public good, the use of which is non-rival and involves a copyright-based license to keep private intellectual property claims out of the way of both software innovators and software adopters—while at the same time preserving a commons of software code that everyone can access (O'Mahony 2003). Based on this unique property, unlike proprietary software vendors, the OSS movement dictates that the source code be made public, modifiable, and re-distributable, which affords organizations with vast opportunities to acquire, customize, and upgrade software to meet their own circumstantial requirements at a much cheaper cost compared to proprietary software (Feller and Fitzgerald 2000). In view of these compelling advantages, it is touted that OSS will challenge the dominance of the proprietary software in the $300 billion software market (Khalak 2000).

While these developments suggest that OSS is fast becoming a major market force, the fact remains that proprietary software continues to dominate today's market

[1] http://www.opensource.org/docs/osd last visited on 1st July, 2007

(Mears 2004), despite the numerous initiatives launched by technology leaders such as IBM, Sun Microsystems, JBoss and others to support the growth of OSS (Mishra et al. 2002; Watson et al. 2005). For example, the Linux server market share was only 28.3%[2] in 2004 and its desktop market share was even smaller at 2.8 %.[3] This begs some interesting and important research questions: "Why is OSS not widely accepted by organizations given so many advantages over proprietary software?" "What will be the factors that facilitate the adoption and use of OSS in organizations?" Based on the unique properties of OSS, this thesis pursues the answers to these research questions from three distinctive perspectives through rigorous theory and model development and empirical investigations in a cross-country setting.

1.1. The Emergence of OSS

A brief illustration of the origin of OSS is essential in facilitating the understanding of the uniqueness of OSS as an innovation and the huge impacts OSS movement has had on the whole society.

- **Emergence of OSS as a Challenge to Social and Moral Norms:** Since the term OSS was coined in late 1990s, open source advocates have heralded the era with the mantra: "The key formula for the coming age is this: "open good,

[2] http://www.alwayson-network.com/comments.php?id=P5013_0_6_0_C last visited on 31 August, 2005

[3] http://insight.zdnet.co.uk/software/linuxunix/0,39020472,39118695,00.htm last visited on 31 August, 2005

closed bad" (Schwartz and Leyden 1997). The origin of OSS, the Free Software movement, started in 1984, put much emphasis on the ***moral rightness*** and ***importance of granting users the freedom*** offered by both free and open source software (Hippel and Krogh 2003). Given the idealism of such initiatives, OSS has been deemed to be anti-conventional and anti-commercial in nature (Perens 1999).

- **Emergence of OSS as an Innovative Software Development Process:** From the development style perspective, OSS is written and supported by globally dispersed programmers, most of whom come from the "hacker culture" (Hippel and Krogh, 2003) Eric Raymond (1999), in his pioneering article "*The Cathedral and the Bazaar*", has depicted the development process of proprietary software as the construction of a splendid cathedral for which everything is based on a well-sketched blueprint while the development process of OSS seemed to resemble a great babbling bazaar of differing agendas and approaches, out of which a coherent and stable system could seemingly emerge only by a succession of miracles. This a fact that further adds to its anti-conventional flavor.

- **Emergence of OSS as a Challenge to Intellectual Property Rights:** What is more, the arrival of OSS has led to a new form of licensing called *"copyleft—all rights reversed"* in contrast to the conventional copyright license. It creates some turmoil in the intellectual property rights filed and

leads some IT managers or CIOs to conceive the adoption of OSS is a potential legal minefield.

In a nutshell, OSS is different from the proprietary software in term of its development style, its ownership, and its moral emphasis on openness, therefore it is not only a technological innovation, but also a social or philosophical innovation. Its impact on organizations is more complicated than pure technological innovations. Thus an organization's choice of adopting OSS may involve more than technological concerns.

1.2. Impacts of OSS on Organizations

OSS, as a unique innovation, has shown its deep impacts on different facets of our society from technological, economic, political and legal perspectives. This thesis will focus on its impacts on organizations from an innovation adoption's perspective. Organizational innovation adoption has two aspects: the adoption of an innovative process and the adoption of an innovative product.

From an innovative process point of view, while OSS may not represent a real paradigm shift in software development, the model is an extremely successful exemplar of globally distributed development. It is attracting considerable attention in the current climate of outsourcing and off-shoring. Organizations are seeking to emulate OSS success on traditional

development projects, through initiatives variously labeled as inner source, corporate source, or community source. Other open source principles—such as open sharing of source code, large-scale independent peer review, the community development model, and the expanded role of users—also have important implications and impacts for organizations which want to leverage on the OSS development process.

Whereas the OSS development process may have influenced the traditional way by which software was produced in organizations, the emergence of OSS as an innovative product, such as Linux and Apache, compared with proprietary software, has been touted to impact organizations by:

- Lowering software acquisition cost;
- Providing more choices of software adoption and lowering the risks of being dependent on a single proprietary software vender
- Providing more freedom in modification and customization of the software due to the availability of source code;
- Delivering higher software reliability owing to a wider pool of developers around the globe compared to proprietary software.
- Providing a different way of innovation adoption in organizations which is a bottom-up approach instead of a top-down approach due to its wide availability and almost zero cost.

Given the comparative advantages of OSS over proprietary software, there is growing consensus that OSS may challenge the dominance of proprietary software in the market (Khalak 2000). Indeed, many multinational organizations such as IBM, Apple, HP, Oracle and Intel have publicly announced various initiatives to support the growth of OSS (Mishra et al. 2002). Larger amount of early adopters have been reporting huge benefits reaped through their usage of OSS.

1.3. Limitation of Current Literature

While the unique emergence of OSS and its huge impacts on organizations both as an innovative process and as an innovative product have aroused the interests from both academia and industry, the current research on OSS has not given enough attention to the issue related to organizational adoption of OSS. This section identifies this gap in research by summarizing the extant literature on OSS and categorizing them into three streams. At the end of this part, we also point out one of the limitations in current innovation adoption literature, thus justify our research approach.

Since the turn of the century, a very impressive body of research on OSS has emerged based in different academic disciplines and drawing on a variety of methodological approaches. Much of the extant literature on OSS had centered on ***three*** streams pertaining to the development process of OSS such as the identification of an individual developer's motivation to contribute to an OSS project (e.g., Lakhani and

Wolf 2003; Hann et al. 2002), the organization and the coordination of activities in the OSS development community (e.g., Sharma et al., 2002; Jorgensen 2001; Koch and Schneider 2002), and the comparison between OSS and proprietary software, their different development styles and the impact of OSS development model on the traditional software industry (e.g., Comino and Manenti 2003), Table 1.1 summarizes the extant literature on OSS into these three major streams.

Authors	**Research Focus**
Stream 1: Individual Developers' Motivation to Contribute to OSS Development Bergquist and Ljungberg (2001) Franke and von Hippel (2003) Hann et al. (2002) Hars and Ou (2000) Lakhani and Wolf (2003) Lerner and Tirole (2002) von Hippel and von Krogh (2003) Zeitlyn (2003)	● Individual's incentives to contribute: both intrinsic and extrinsic motivations ● Relationship between OSS leaders' leadership style and the developers' motivation and contribution ● Impact of firms' participation on individual motives ● Impact of community participation on individual motives ● Relationship between incentives and technical design
Stream 2: Organization and coordination of activities in the OSS development community Kogut and Metiu (2001) O'Mahony (2003) Raymond (1999) Dempsey et al. (2002) Gallivan (2001) Koch and Schneider (2002) West and O'Mahony (2005) Feller and Fitzgerald (2000) Lanzara and Morner (2003) Lee and Cole (2003) Lin (2003) Mockus et al. (2002)	● Reconciliation of diverse and distributed contributor interests ● Governance of project architecture to prevent "forking" ● Governance of the public good ● Functioning and types of organizations in open source software projects ● Roles taken by contributors to open source software projects ● Coordination of innovation ● Processes of open source software maintenance and development ● Factors explaining the evolution

Sharma et al. (2002) Jorgensen (2001) Yamauchi et al. (2000)	of the open source software architecture
Stream 3: comparison between OSS and proprietary software, their different development styles and the impact of OSS development model on the traditional software industry Bonaccorsi and Rossi (2003) Comino and Manenti (2003) Cusumano and Gawer (2002) Dahlander and Magnusson (2005) Garud et al. (2002) Grand et al. (2004) Mustonen (2005) West (2003) Raymond (1999)	● Impact of open source software on competition in the software industry ● Hybrid strategies for melding commercial and open source platforms ● Firms' resource allocation to open source software projects ● Relationship between firms and open source software projects ● Free revealing amongst competitors of improvements to common software platforms

Table 1.1 Summary of Major Studies on OSS

While the current literature has contributed significantly to the understanding of OSS in both academic field and industry, it has largely neglected issues related to OSS adoption by organizations. One exception has been the case study conducted by Dedrick and West (2003). In that study, the authors empirically examined the organizational adoption of platform-based OSS using the general organizational innovation adoption framework: Technology Organization Environment (TOE), which categorizes all possible adoption factors into the three dimensions (DePietro et al. 1990)4. While the TOE framework has been widely used by Information Systems

[1] *Dedrick and West (2003) classified the OSS adoption factors according to TOE framework. Technology factors: hardware cost, software cost, reliability, availability of 3rd party applications, portability of own applications, skills of existing IT workers, fit to task, difficulty in administration, ease of experimenting; Organizations factors: IT capital budget, IT staff time, innovativeness of IT organizations, worker experience with new platform;*

(IS) researchers, it has been criticized for its underlying assumption that a universalistic theory of innovation adoption can be developed to predict the adoptions of all types of innovations (Dewar and Dutton 1986). The search for a universal innovation adoption theory may be inappropriate given that fundamental differences exist across innovations and dissimilar innovations create different barriers for organizations in their adoptions.

To help address the shortcomings of the existing research, this study approaches the issue of organizational adoption of OSS from a unique theoretical angle based on the distinctive characteristics of OSS and the specific barrier it creates for the adopting organizations.

1.4. Research Focus, Research Questions and Scope

Despite the obvious advantages of OSS and its rapid growth, market observers have noted that proprietary software continues to lead today's software market (Mears 2004). The situation is clearly worth examining. While the current literature on OSS has largely ignored the topic of organizational adoption of OSS, this dissertation focuses on identifying ***the key factors that will affect the organizational intention to***

Environment factors: industry maturity, availability of skilled IT workers, availability of external support services, platform long-term viability.

adopt OSS, based on the unique properties of OSS, from three distinctive theoretical perspectives.

Research Question 1

While the OSS unique business model and developmental process (*the bazaar model*) confer significant benefits on organizations *prima facie*, it also presents significant hurdles to organizations interested in its adoption because the services related to OSS, such as implementation, technical support, training, application administration, and consulting, are virtually non-existent, unlike proprietary software offered by profit-making entities (Dedrick and West 2003). According to the Gartner Group, 92% of the cost of software licenses charged by monopolistic vendors reflects the costs of installation, conversion, maintenance, management, and repairs after failure (Raymond 1999).

The un-guaranteed OSS service will give rise to the organizations' perceived uncertainty in its service and support which could lead to an increase in the organization's cost in switching from extant technology to OSS; In this light, it would seem that significant ***human capital*** in OSS would be of paramount importance for organizations keen to reap the benefits of effectively deploying the OSS. It is contestable that if an organization possesses the necessary OSS human capital - the OSS knowledge, skills, abilities and capacities possessed by people (Becker 1993) –

either internally (e.g., their own IT staff members) or externally (e.g., external consultants, programmers on the OSS forum and university students in the vicinity), it can greatly reduce the perceived uncertainty and risk in OSS service and support, and thus increase the organizational intention to adopt OSS directly or indirectly through the switching cost, which is a major concern for organizations when making decisions for innovation adoption (Rajagopalan 1999; Dedrick and West 2003).

However, to our best knowledge, very few studies have explicitly examined the role of human capital in influencing the adoption of an information system innovation at the organization-level. This leads to:

Research Question 1: How will an organization's OSS human capital affect its intention to adopt OSS? What is the difference between internally available OSS human capital and externally accessible OSS human capital in influencing the organization's adoption intention? What is the role of switching cost in this process?

Research Question 2

From the illustration of the emergence of OSS movement, we have explained why it is not only a technological innovation, but also a social or philosophical innovation. Its impact on organizations is more complicated than pure technological innovations.

Thus an organization's choice of adopting OSS may involve more than technological concerns. For example, organizations may have to withstand the pressure to conform to the software adoption norms in a market that has long been dominated by proprietary software where the adoption of OSS may be considered as unconventional, unprofessional, or even illegal if the copyright and license issues are taken into consideration.[5]

Concerning the second adoption barrier, we conceive that existence of the favorable ***institutional pressures*** toward OSS adoption which consist of coercive pressure, mimetic pressure and normative pressure will also help the organizations overcome the second barrier and thus play an important role in organizations' OSS adoption. This leads to:

Research Question 2: How will institutional pressures affect the organizations' intention to adopt OSS? What is the different role of mimetic pressure, normative pressure and coercive pressure in this process?

[7] *In a 2003 CIO survey on OSS adoption, (*http://www2.cio.com/research/surveyreport.cfm?id=51*, last visit on 31 August, 2005), the top reason for an organization not to use OSS is "lack of in-house skills or lack of funds to acquire skills to support OSS" (69%), followed by "switching cost—both hard and soft costs to move to a new platform" (59%) and "Lack of vendor support" (57%). 16% CIOs also mentioned "legal issue and license issue" as one of the reasons.*

Research Question 3

Another unique property of OSS is its zero cost and wide availability. This has enabled a different way of innovation adoption in organizations which is carried out without formal managerial decision.

This conjecture confirms with the result of a 2003 survey conducted by the CIO magazine[6]. This survey reveals that among the OSS adopter organizations, 37.8% of them reported the way how OSS was introduced to their organizations is through informal deployment, which means developers using the OSS on ad hoc basis without management commanding or pushing. Compared with the conventional top-down approach (formal) of how a technology innovation was introduced in and adopted by an organization (e.g. SAP), this relatively large portion of bottom-up (informal) cases of how OSS was introduced into organizations may be explained by the unique nature of OSS as an innovation: low cost or zero cost of acquisition, wide availability of the software and the freedom in changing the source code and customize software without the permission from the organization's managers.

Based on this result, we can depict a scenario which should be common to organizational introduction and adoption of OSS: some "key employee" who is an early OSS adopter and opinion leader in the organization, without being formally

[1] http://www2.cio.com/research/surveyreport.cfm?id=51

commanded by the managers, leverages on his own ***social capital*** to influence other employees' perception on OSS through interaction with them by face-to-face contact, email exchange or telephone talk, thus informally promotes the OSS adoption in the organization. We believe, for a special innovative product like OSS, the OSS opinion leaders' social capital will have an important effect on the organization's intention to adopt it. And as opinion leaders, their social network properties such as degree of centrality, betweenness and closeness will be different from those of Non OSS opinion leaders. Depicting the profile of OSS proponents, especially their social network properties will be interesting and important for OSS diffusion. We would therefore like to examine the properties of the OSS Opinion Leaders' social capital in this process. This leads to:

> ***Research Question 3: What are the social capital properties (such as degree of centrality, betweenness and closeness) like for OSS Opinion Leaders? Are they significantly different from those of Non OSS Opinion Leaders?***

After deciding on the research focus and research questions, we would like to define the scope of this study very clearly since OSS has developed into several different product lines and the adoption behavior could be very different among them. The OSS product line includes:

(1) Operating systems such as Linux and FreeBSD;

(2) Server applications such as Apache, MySQL, and Samba;

(3) Desktop applications such as Mozilla, OpenOffice, Evolution,

(4) Development tools such as Perl.

To avoid confounding effects arising from product differences (e.g., individual level and organizational adoption of OSS), our study focuses on the adoption of platform-based OSS (Dedrick and West 2003). Specifically, the platform-based OSS includes operating systems, such as Linux, and server applications, such as Apache. Compared with the adoption of desktop application OSS products, the adoption decision of operating systems and server applications has a more significant organizational impact and is likely to be an organizational decision, which is our study's focus.

1.5. Contributions

This dissertation seeks to benefit and contribute to both academic and industry arenas. By addressing the limitations in previous innovation adoption research, filling the gaps in current OSS research, answering the specific research questions proposed in the previous section and collecting data in a cross-country research setting, we aim to contribute to the extant innovation adoption and OSS literature and industrial understanding of OSS in the following aspects:

- First, we propose a new approach towards examining the issue of innovation adoption, focusing on finding key factors based on the innovation's unique properties. Explicitly, we contend that to study an innovation adoption phenomenon, one has to first understand the innovation's properties and identify the concerns that the practitioners have on its adoption, especially the prohibiting factors, or inhibitors (Cenfetelli 2004).

- Second, the human capital, institutional perspectives, and social capital perspectives, which we have undertaken in this research, will add to the extant literature on organizational adoption of innovation and call for more attention to be directed at understanding the influence of these three factors in an increasingly technologically complex environment.

- Third, we have extended the application of human capital theory originated from economic field, institutional theory and social capital theory originated from organizational theory field to the field of innovation adoption.

- Fourth, this study collected survey data from two countries in order to test the robustness of the conceptual model, as till now, no large scale empirical studies, particularly one that spans across more than one country, has yet been undertaken to examine the factors influencing organizational adoption of OSS. This study will thus be a pioneering research which will add on to people's

understanding of organization's innovation adoption behaviors in different cultural and institutional settings.

- Fifth, methodologically, the way we operationalize human capital construct which divides it into internally available human capital and externally accessible human capital will highlight the importance to human capital researchers that we should not simply view human capital as one single construct. The validated internal and external human capital constructs will facilitate future research on human capital.

- Sixth, practically, our findings also provide important lessons for potential OSS adopters, OSS proponent organizations or governments in both developing countries and developed countries.

More thorough discussion of the contribution from each of the three perspectives will be presented in the following sections of this dissertation.

1.6. Organization of Thesis

The opening chapter aims at providing an outline of this thesis by briefly describing the emergence of OSS to illustrate its uniqueness as an innovation and its strategic impacts on organizations. This is followed by a review of extant literature on OSS and

the identification of a research gap in the area of organizational adoption of OSS and an inappropriate assumption in innovation adoption research that a universalistic theory can be developed to explain all types of innovation adoption. Therefore, we propose to study organizational adoption of OSS based on its unique properties through three distinctive theoretical perspectives: Human Capital perspective, Institutional perspective and Social Capital perspective.

- Chapter 2 presents the detailed review of literature that is related to the three themes of this thesis: human capital theory, institutional theory and social capital theory.

- Chapter 3 reports the research model, research methodology, data analysis, the results of analysis, and discussion of theme one study on how an organization's human capital affects its intention to adopt OSS.

- Chapter 4 reports the research model, research methodology, data analysis, the results of analysis, and discussion of theme two study on how the institutional pressures in an organization's environment affect its intention to adopt OSS.

- Chapter 5 reports the research hypotheses, research methodology, data analysis, the results of analysis, and discussion of theme three study on how

an organization's key employees' social capital affect its intention to adopt OSS.

- Chapter 6 concludes this thesis by presenting a summary for the findings of the studies of the three themes, discussing the implications of this research for both theory and practice, and projecting possible directions for future research.

CHAPTER 2
LITERATURE REVIEW

Chapter 2 is a review of three major streams of literature that are relevant to this research: (1) Human capital theory; (2) Institutional theory; and (3) Social capital theory. By reviewing these three theories in the context of innovation adoption, we establish a theoretical foundation for research model development for the three studies in the following chapters.

2.1. Human Capital and Innovation Adoption

Human capital refers to the knowledge, skills, experience, abilities, and capacities possessed by people (Becker 1993). It can be accumulated in many ways, including education, on-the-job training, and work experience. Although the human capital theory was originally developed to examine the economic value of education[7], more recently, its application has been extended to organizational staff selection, training, compensation, human resource management, and innovation adoption practices in general (Wallace and Fay 1988). The concept has also been applied extensively at a macro level (e.g., Papageorgiou 2002) to explain the relationship between human capital and innovation adoption (Becker 1993).

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[7] *Higher investment in education (a major way to accumulate human capital) will lead to higher compensation in the future (Becker 1993)*

At the organizational level, human capital is considered a valuable and rare resource[8], which enables the owning organization to adopt innovations that its competitors are not able to (Goodwin and Schroeder 1994), thereby providing the basis for accruing competitive advantage (Amit and Schoemaker 1993; Barney 1991). In other words, according to the resource-based view of the firm, differences in innovation adoption behaviors across organizations can be attributed to the variance in their resources and capabilities. Compared with tangible resources such as physical and financial resources, intangible resources such as human capital (people's tacit knowledge and skills) are more likely to produce a competitive advantage in innovation adoption because intangible resources are often rare and socially complex, thereby making them difficult to imitate (Peteraf 1993). This observation is consistent with the view that considers knowledge to be a firm's most important resource (Grant 1988).

Particularly, organizational innovation adoption depends on enterprises having the pre-requisite skills for effective deployment or accessibility to external expertise (e.g., system integrators or expert consultants) to help overcome the knowledge barriers associated with adopting an innovation (Attewell 1992). In other words, an

[7] *For human capital to be termed as organizational resource, it must satisfy two criteria put forward by the Resource-based view of evaluating organization resources (Dierickx and Cool 1989): first, resources that are both rare (i.e., not widely held) and valuable (i.e., contribute to organization efficiency or effectiveness) can produce competitive advantage. Second, when such resources are also simultaneously not imitable (i.e. they cannot easily be replicated by competitors), not substitutable (i.e. other resources cannot fulfill the same function), and not transferable (i.e. they cannot be purchased in resources market); those resources may produce a competitive advantage that is long lived (sustainable).*

organization is unlikely to successfully adopt an innovation unless much of the required specialized expertise exists within the organization or such knowledge can be acquired easily or economically from the market (Fichman and Kemerer 1997).

While human capital has been well studied by economists to understand its relationship with technology adoption and economic growth *at the national level* (Dakhli and Clercq 2003; Teixeira and Fortuna 2003; Papageorgiou 2002). its application in innovation adoption *at the organizational level* by IS researchers is still in its nascence. Traditional investigations of the importance of human factor in innovation adoption at the organizational level include investigating the importance of possessing employees of innovative capability (e.g. Wozniak 1983), absorptive capacity (e.g. Cohen and Levinthal 1990), organizational expertise (e.g. Tornatzky and Fleischer 1990), organizational learning and acquisition of technical know-how (e.g. Attewell 1992). Despite the merits of these studies in contributing to the cumulative understanding of innovation adoption, none of them has *explicitly* investigated the relationship between human capital, a concept originated from economics, and the IS technology adoption intention of an organization in an integrative fashion. Given the increasing importance of intangible assets such as human capital in gaining competitive advantage for an organization through innovation adoption, it is imperative to understand the functions of human capital in this process. We contend that bridging this theoretical disconnect is key to the

development of a more coherent and cumulative theoretical framework for IS technology adoption.

2.1.1. Internal and External Human Capital in Innovation Adoption

As with other capital investments, the management of human capital can also be broken down into "make-or-buy" decisions (Miles and Snow 1984). On the one hand, organizations may internalize employment and build their human capital stock through training and development initiatives (Lepak and Snell 1999). On the other hand, organizations may externalize employment by contracting or outsourcing certain functions to market-based agents (Rousseau 1995).

Much of the previous research has focused on investigating the internal (i.e., within an organization) manpower capacity, very little research attention has been devoted to discriminating the different functions of human capital internally available to and externally accessible to an organization in influencing the organization's innovation adoption intention. Since these two types of human capital can be differentiated in nature through several aspects such as their reliability, timeliness and cost efficiency, it is imperative for researchers to examine their influences on organizational innovation adoption separately. Therefore, in this study, we extend the previous human capital studies by defining OSS human capital as the knowledge, skills,

abilities, capacities, and experience with OSS (specific to platform-based OSS in this study) possessed by people either ***internal*** or ***external*** to the organization.

Conceptually, an organization's OSS human capital can be divided into two parts: availability of internal OSS human capital, which refers to availability of the organization's staff members with the relevant skills and experience in OSS, and accessibility to external OSS human capital, which refers to the extent to which an organization has access to external consultants, programmers on OSS forums, or an information technology (IT) educational resources for supporting OSS adoption and use. For OSS products where there is no formal support system, the internal availability or external accessibility of human capital will be a more important consideration than it is with products where service and support are provided by profit-making enterprises (e.g., Windows and SAP).

2.1.2. Switching Costs and Human Capital in Innovation Adoption

Switching cost, which refers to the cost of replacing an existing technology with another, has been recognized as one of the most important factors in organizational innovation adoption (Rajagopalan 1999; Dedrick and West 2003). The existing literature on innovation adoption has suggested that organizations may be "trapped" in an old technology even though a newer, superior technology is available (Farrell and Saloner 1985) because the adoption of the innovative technology may require

substantial investment from the organization in hardware, software, and employee training (Iacovou et al.1995; Emmelhainz 1993) and its implementation may require organizations to develop special technical skills to cope with its complexity (Subramani 2004). Together, these factors may translate into *switching costs*, which in turn might inhibit organizations' migration to newer technologies (Klemperer 1987; Beggs and Klemperer 1992).

While strong human capital has long been argued to be an important antecedent of switching cost (Rajagopalan 1999; Heide and Weiss 1995; Williamson 1975) in organizational innovation adoption, the inner mechanism of how the two different types of human capital (internal and external to an organization) will influence an organization's technology adoption decision has not been unfolded till now: whether it is through an innovation-bias route (direct relationship) or it is through an efficiency route (indirect relationship) via switching cost. Given the importance of organizational decision on human capital investment to reduce the switching costs for innovation adoption, we posit that understanding of the above issues will significantly explicate the theoretical and practical implications of the human capital and switching cost perspective of IS innovation adoption.

2.2. Institutional Pressures and Innovation Adoption

Institutions, by definition, are composed of cultured-cognitive, normative, and regulative elements that, together with associated activities and resources, provide stability and meaning to social and business life (Scott 2001). In this conception, regulative systems, normative systems and cultured-cognitive systems have been identified as vital ingredients of institutions. The three elements form a continuum moving "from the conscious to the unconscious, from the legally enforced to the taken for granted" (Hoffman 1997). They have been coined as ***three pillars*** making up or supporting institutions through the mechanism of coercive, normative and mimetic pressures. The interactive functions of these three pressures have been the focus of attention for institutional theory researchers.

To illustrate the inner mechanism of how these three institutional pressures work, institutional theory argues that organizations require more than material resources and technical information if they are to survive and thrive in their social environment. They also need social acceptability and credibility (Scott et al, 2001). Sociologists employ the concept of ***legitimacy*** to refer to these conditions. In a resource-dependence or social exchange approach to organizations, legitimacy is typically treated as simply another kind of resource. However, from an institutional perspective, legitimacy is not a commodity to be processed or exchanged but a condition reflecting perceived consonance with relevant rules and laws (coercive),

normative supports (normative) or alignment with cultural-cognitive frameworks (mimetic).

Institutional Theory has been used extensively to explain significant variance in observed organizational innovation adoption behavior (Markus 1987). Particularly, it has been successfully applied to examine organizational IT decisions ranging from innovation adoptions, such as electronic data interchange technology (Teo et al. 2003), to outsourcing IT operations (Ang and Cummings 1987). According to Institutional Theory (DiMaggio and Powell 1983), one key reason for the observed homogeneity of organizational innovation adoption decisions is organizational isomorphism, which argues that organizations are more likely to adopt innovations that others have already adopted to gain organizational legitimacy and to reduce the uncertainty and risk of adopting new innovations (DiMaggio and Powell 1983). With respect to isomorphism, the literature has identified three specific types of institutional pressures facing an organization: mimetic, coercive and normative pressures (DiMaggio and Powell 1983).

2.2.1. Mimetic Pressure

Mimetic Pressures mean that an organization may change over time to become more like other organizations in its environment (DiMaggio and Powell 1983, Haveman 1993). Often referred to as bandwagon effects (Abrahamson and Rosenkopf 1993), in

an innovation adoption context, mimetic pressures manifest themselves in two ways: the prevalence of the adoption practice in the focal organization's industry and the perceived success or benefits of organizations within the focal organization's industry that have adopted an innovation (Haveman 1993).

When an organization faces problems with ambiguous causes or unclear solutions, it may model itself on other organizations that have adopted the innovation with positive outcomes. In this regard, an organization may pay special attention to the innovation adoption behavior of similar others within its industry (e.g., its competitors) and adjust its own decisions accordingly (Haveman 1993). By conforming to mimetic pressures, the organizational decision makers will be able to economize on search costs (Cyert and March 1963), minimize experimentation costs (e.g., Levitt and March 1988), and avoid risks that are borne by early adopters (Tolber 1985).

2.2.2. Coercive Pressure

Coercive Pressures result from both formal and informal pressures exerted on the focal organizations by other organizations upon whom they are dependent and by cultural expectations in the society within which organizations function (DiMaggio and Powell 1983). Institutional arguments on coercive pressures mainly take their roots in resource-dependency theory (Pfeffer and Salancik 1978), and empirical evidence (e.g., Palmer et al. 1993) suggests that coercive pressures may stem from a

variety of sources including resource-dominant organizations, regulatory bodies, and parent corporations, and are built into exchange relationships (Teo et al. 2003).

In the organizational innovation adoption scenario, a dominant actor that controls scarce and important resources may demand that organizations, which depend on it, adopt structures or technologies that serve the dominant party's interests. Due to resource-dependency reasons, these organizations may have to comply with the dominant actor's demands to secure their survival (Pfeffer and Salancik 1978). Coercive pressures may take several forms such as force, threats, persuasion, and invitations to join in collusion (DiMaggio and Powell 1983).

2.2.3. Normative Pressure

Normative Pressures, which are exerted primarily by professional relationships (Scott 1987), imply that strategic processes taken by organizations are subjected to values and norms shared among the members of their social networks (Scott 2001). Organizations are likely to behave based on their belief about what is expected of, and what is viewed as appropriate, among members in their social networks (Scott 2001).

The commonly accepted norm of technology adoption in the professional circle will thus play an important role in organization's decision of innovation adoption. Organizations tend to avoid adopting innovations that are against the normal practice

in the professional circle since such behaviour may cause them to be deemed as unprofessional or unconventional, which may in turn hurt their organizational "legitimacy". The variety of sources of normative pressures includes trade associations, professional associations, accreditation agencies, channel members, or professionals themselves (Grewal and Dharwadkar 2002).

2.3. Social Capital and Innovation Adoption

2.3.1. Social Capital Studied at Different Level and Scope

Social capital has been studied differently by sociologists, organization scientists, political scientists, and economists in examining its relationship with innovation adoption. Views are divided both on its definition, measurement possibilities and significance. In the past decade, social capital has received an increased attention in the innovation adoption literature and has been studied at multiple levels, including the individual (micro-level) (Burt 1992), organizational (meso-level) (Nahapiet and Ghoshal 1998), and societal (macro-level) (Putnam 1993).

First, at the individual level, social capital has been defined as the resources embedded in one's relationships with others. The emphasis in this case is on the actual or potential benefits that one accrues from his/her network of formal and informal ties with others (Burt 1992).

Second, at the organizational level, social capital has been defined as the value to an organization in terms of the relationships formed by its members for the purpose of engaging in collective action (Nahapiet and Ghoshal 1998, Freel 2000).

Third, the role of social capital has also been examined on a more macro-level in terms of its impact on the well-being of regions or societies (Coleman 1990, Putnam 1993). Similarly, Putnam (1993, 2000) conceptualized social capital as features of social organizations, such as network structures, norms, and trust that facilitate coordination and co-operation for mutual benefit within a society.

Since social capital is such a multi-dimensional and multi-level concept, we will firstly clarify with (1) the level of study; (2) level of analysis; (3) definition of social capital within this research scope:

- First, in this research, we study social capital at the individual level.

- Second, there are three levels of analysis: Dyad analysis which examines the relationship between a pair of players; Ego-centric analysis which examines the network of an individual as the center; Group analysis, which studies a group as a whole. Ego-centric method will be used in this study because it really focuses on the individual, rather than on the network as a whole. By collecting information on the connections among the actors connected to each

focal ego, we can get a pretty good picture of the "local" networks or "neighborhoods" of individuals. Such information is useful for understanding how networks affect individuals, and they also give a picture of the general texture of the network as a whole.

- Third, there are two routes in defining social capital at the individual level. The first describes a network as the player's access to people with specific resources, which creates a correlation between the player's and theirs (Lin, Ensel, and Vaughn 1981). The second route describes social structure as capital in its own right (Boxman, De Graaf, and Flap 1991). The first line describes the network as a conduit while the second line describes how the networks are themselves a form of social capital. Both lines of work are essential to a general definition of social capital. Here, social capital is defined as both the resources contacts hold and the structure of contacts in the network. The first term describes whom you reach. The second term describes how you reach (Burt 1992).

2.3.2. Importance of Opinion Leaders' Social Capital in Innovation Adoption

In the literature of innovation adoption and diffusion, opinion leaders have been identified to play important role. Opinion leaders are individuals who lead in influencing others' opinions about innovations (Rogers, 1995). The behavior of

opinion leaders is important in determining the rate of adoption of an innovation in a system. In fact, the S-shape of the diffusion curve occurs because once opinion leaders adopt and tell others about the innovation, the number of adopters per unit of time takes off (Rogers1995).

Earlier in the 1940s and 1950s, the mass media were perceived to be powerful in influencing mass audience's attitude toward an innovation and their consequent adoption behavior. The famous Hypodermic Needle Model (Katz and Lazarsfeld 1955) postulates that the mass media has direct, immediate, and powerful effects on a mass audience's innovation adoption tendency. However, later, more sophisticated studies by Lazarsfeld et al (1963) developed the Two-step Flow Model which depicts the process of mass communication of an innovation in two steps. The first step, from media sources to opinion leaders, is mainly a transfer of information, whereas the second step, from opinion leaders to their followers, also involves the spread of interpersonal influence. The two-step flow model helped focus attention upon the interface between mass media channels and interpersonal communication channels.

There are various stages in the innovation-decision process that the individuals need to pass: (1) knowledge of an innovation; (2) persuasion; (3) decision to adopt or reject; (4) implementation; (5) confirmation of this decision (Rogers 1995). Mass media channels are primarily knowledge-creators, whereas interpersonal networks are more important in persuading individuals to adopt or reject. Thus it is imperative to

examine the opinion leaders' characteristics in order to identify them and better encourage them.

We explore in this study the role of OSS opinion leaders' social capital in the OSS diffusion networks within their department, and how interpersonal communication drives the diffusion process through creating a "critical mass" of adopters. Based on this definition of social capital as both resources at contacts side and the structure of network itself, we will examine four properties of OSS opinion leaders' social capital, namely degree of centrality, betweenness, closeness and in-degree centrality in the network and how they will affect the organization's adoption of OSS.

2.3.3. Properties of Social Capital

Important properties of social capital within a social network have been operationalized and measured in a variety of ways. To clarify these measures conceptually, Freeman (1979) summarized four related measures of degree of centrality, closeness, betweenness and in-degree centrality which are the essential part of an individual's social capital

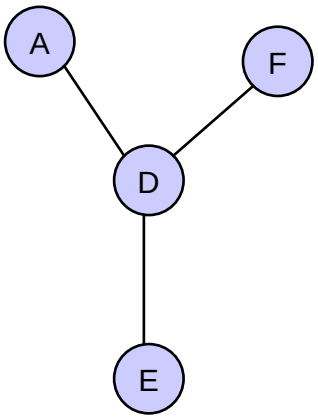

Figure 2.1

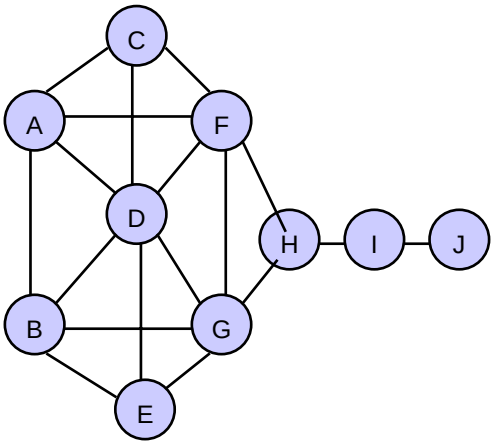

Figure 2.2

Degree: the number of direct links to or from an actor. Having more direct contacts means more referrals, access to resources, more exposure, access to information and influential power. To illustrate, D has the highest number of adjacent links in both the above diagrams

Closeness: summing the lengths of the shortest paths (geodesics) from a node to all other nodes; It indicates how "close" a person is to all other persons in the network; Assuming there is a limit to how many direct links a person can have, it is more efficient to have links to highly central people. In Figure 2.1, D can reach all others in a total of 3 links while the rest need 5 links. In Figure 2.1, G and F are the closest (not D any more)

Betweenness: The extent to which an actor falls between pairs of other actors on the shortest path (geodesics) connecting them (Freeman, 1979). It measures the potential control over others or the increasing dependence on others. Another measure is

brokerage based on structural holes which refer to the absence of relations in a network. These holes are opportunities for the actor to broker disconnected contacts or play them off against one another when they compete for the same resources or make conflicting demands. In Figure 2.1, D has the highest brokerage score.

In-degree Centrality: The degree of centrality is also broken down into two measures, in-degree centrality refers to the number of direct ties in which the actor is the object of the relation and out-degree centrality refers to number of direct ties from the actor (source) to others (objects). In-degree centrality reflects deference of popularity: the number of times an actor is chosen by others, thus it is also referred to as prestige by Knoke and Burt (1983).

CHAPTER 3

THE THEME 1 STUDY - PREDICTING ORGANIZATIONAL INTENTION TO ADOPT OPEN SOURCE SOFTWARE: A TALE OF HUMAN CAPITAL IN TWO COUNTRIES

This chapter addresses the research questions explored by theme one. Specifically, a conceptual research is established to explore how an organization's OSS human capital will affect its intention to adopt OSS, what is the difference in internally available OSS human capital and externally accessible OSS human capital in influencing the organization's adoption intention and what is the role of switching cost in this process.

To test the predictions of the theory in a robust manner, we collected data from 81 Singapore-based organizations and 212 China-based organizations that have yet to adopt platform OSS products. Platform OSS products such as Linux or Apache web server were chosen as the focus of interests because the decision to adopt such operating systems is likely to be an organizational-level decision, with long- and wide-ranging impact on the organization, and hence is a good test case for the study of the effects of human capital in fostering innovation adoption. Understanding what and how human capital influences OSS adoption in a developed economy (Singapore) and a developing economy (China) adds to the extant literature on information

technology (IT) innovation by providing a nuanced understanding of the role of human capital in shaping IT innovation for organizations embedded in different stages of economical and technological development.

3.1. The Research Model and Hypotheses

Based on preceding analysis, we posit that OSS human capital should be a determining factor for organizational adoption decision since it will help organizations reduce the switching costs by overcoming the barrier of perceived uncertainty in service and support of OSS if they decide to adopt it. And this barrier is created by the unique development process and business model of OSS.

Adopting a resource-based perspective of human capital theory (Becker 1993; Pfeffer 1994), this study contends that an organization's *availability of internal human capital* (i.e., the knowledge, skills, abilities and capacities possessed by employees to provide OSS-related services) and *accessibility to external human capital* (i.e., the knowledge, skills, abilities and capacities possessed by external parties such as freelance OSS programmers and consultants), can determine its propensity to adopt OSS. We posit that both forms of the human capital have a direct (innovation-bias route) and an indirect (efficiency route through reduction of switching cost) effect on organizational adoption intention toward OSS. To add to the collective knowledge on the resource-based view of organizations, we also examine the effects of the

availability of internal human capital on the accessibility to external human capital. Figure 3.1 depicts the conceptual model.

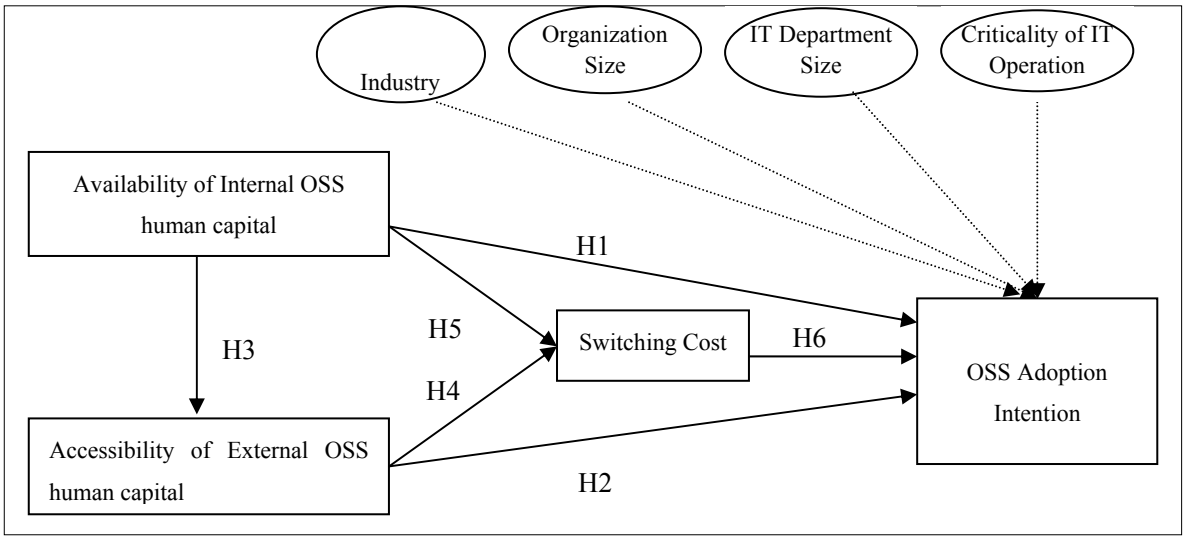

Figure 3.1. Conceptual Model of OSS Adoption Intention

3.1.1 Direct Effect of Human Capital on OSS Adoption: An Innovation-Bias Route

In order to deeply understand the inner mechanism of how OSS human capital functions in the process of influencing organizational intention to adopt OSS, we divide it into two parts: availability of internal OSS human capital, which refers to availability of the organization's staff members with the relevant skills and experience in OSS, and accessibility to external OSS human capital, which refers to the extent to which an organization has access to external consultants, programmers on OSS forums, or an information technology (IT) educational resources for supporting OSS adoption and use.

Based on the concept of technology-sensing capability, one of the two components of technological opportunism (Srinivasan, Lilien, and Rangaswamy 2002), organizations with a high availability of internal OSS human capital tend to be more active in technological environmental scanning for OSS development, more sensitive to technological changes in OSS in their organizational environments, and hence more receptive to the adoption of OSS. Leveraging on their internal OSS human capital, these organizations are likely to perceive less uncertainty and risk in the service and support of OSS when they adopt and deploy OSS innovations within their organizations.

Based on the concept of technology-responding capability, the other component of technological opportunism (Srinivasan, Lilien, and Rangaswamy 2002), these organizations are likely to be more capable of responding to technological trends in OSS development. Organizations that are sensitive to changes in their environment are likely to create enough momentum to change and innovate (Dutton and Duncan 1987). Furthermore, organizations with a greater response capability tend to consider an innovation as an opportunity rather than a threat since they perceive greater control over the outcome (Dutton and Jackson 1987). In a study of the demographic characteristics of employees in 61 manufacturing industries, Bartel and Lichtenberg (1987) confirm the positive relationship between internal human capital and innovation adoption. CIOs were often advised to consider the following two most important human capital related questions when deciding whether OSS is appropriate

for their organizations' IT strategy[1] : "*Is there adequate in-house expertise to manage open source deployment, modification and maintenance*? *How significant may limited support be for implementation and maintenance?"* We therefore propose:

H1. Availability of internal OSS human capital is positively associated with an organization's intention to adopt OSS.

Access to suppliers of technology-related services is one of the most efficient ways for an organization to accomplish the host of decision making, adoption, and implementation tasks associated with new technologies (Tornatzky and Fleischer 1990). Organizations with access to top-notch, low-cost suppliers of technology-related training and consulting have more choices and more flexibility in carrying out innovation adoption strategies (Tornatzky and Fleischer 1990). "Suppliers" in the OSS product context do not refer to the traditional software producers like Microsoft, but rather, they are third party IT consultants or developer groups on OSS forum that are externally accessible to the organizations.

Although, nowadays, external OSS human capital, in the form of OSS developers on a forum, OSS consultants, and freelance programmers (e.g., university students), is readily accessible, organizations may have different level of skills in accessing them. For example, although nearly all OSS projects have established an online mailing list, organizations that are not sensitive to the technology environment may experience

[1] http://www2.cio.com/analyst/report1489.html . Last visited: April 28, 2005

difficulty in locating the most relevant external human capital for help and support in their OSS deployment when needed. Similarly, university students' working as part-time freelance programmers is very popular nowadays. The Silicon Valley is near Stanford University, and Singapore's science park is located near the National University of Singapore. The proximity in geography allows them to better leverage the external human capital. This further explained that even though freelance OSS programmers external to an organization are abundant today, different organizations have different easiness accessing to and leveraging on them. An organization's ability to find such external resources and its skill to manage them remotely will make a difference in its accessibility to external OSS human capital.

Organizations that have high accessibility to external OSS human capital can conveniently tap this expertise to learn more about OSS innovations to reduce their own level of perceived uncertainty and risk associated with adopting and deploying OSS (Grant 1988). Specifically, external OSS human capital can be a reliable source of information concerning the risks and benefits of using OSS products, and an alternative source of expertise for OSS adopting organizations. Hence, we propose:

H2. Accessibility to external OSS human capital is positively associated with an organization's intention to adopt OSS.

Besides the two relationships between an organization's OSS human capital and its OSS adoption intention hypothesized previously, we also believe an organization's availability of internal OSS human capital will help create or enhance its accessibility to external OSS human capital. As we argued previously, an organization with high availability of internal OSS human capital tends to be more sensitive to technological changes and trends such as the emergence of new OSS products, and it also tends to be more active in technological environment scanning. Thus, facing the same technological environment, an organization with internal skills and experience in OSS is likely to be more interested in and pay closer attention to the OSS development situation and be better-informed of external OSS resources (e.g. be familiar with popular OSS forums) and it will also be easier for such an organization to discover and locate external OSS human capital such as OSS developers on the forum, OSS consultants, and freelance programmers, compared with organizations without such kind of internal knowledge. In another word, an organization's availability of internal OSS human capital can be an antecedent of its accessibility to external OSS human capital. Hence, we propose:

H3. Availability of internal OSS human capital of an organization is positively associated with its accessibility to external OSS human capital.

3.1.2 Indirect Effect of Human Capital on OSS Adoption: An Efficiency Route

In line with an efficiency perspective, we factor in switching cost, which refers to the cost of replacing an existing technology with another, because it has been recognized as one of the most important factors in organizational adoption (Rajagopalan 1999; Dedrick and West 2003). Klemperer (1995) categorized switching cost into three components: transitory transaction cost, learning cost, and contractual cost deliberately introduced by vendors to build barriers for competitors. Since the acquisition cost of OSS is negligible, and there is also negligible contractual cost per se given the nature of OSS development, learning cost becomes the most predominant component of switching cost when an organization considers OSS adoption. Thus, organizations must leverage human capital to offset the switching cost (learning cost) in their OSS adoption.

Strong human capital has long been argued to be an important antecedent of switching cost (Rajagopalan 1999; Heide and Weiss 1995; Williamson 1975). The skills of existing IT workers and the availability of external service and support have a significant impact on reducing switching cost for OSS adoption (Dedrick and West 2003). In this research, we define the learning cost to include time, effort, and money spent in retraining an organization's internal IT staff members to become competent in OSS deployment (i.e., implementation, maintenance, technical support

and customization), or the organization's time, effort and money spent in searching for, locating, and hiring external OSS expertise for OSS deployment.

The availability of internal OSS human capital is the result of an organization's deliberate investment through developing its own IT staffs in-house (Snell and Dean 1992). Such investment is justified only if the internal OSS human capital can produce future returns via increased productivity (Duncan and Hoffman 1981) or decreased switching cost. Organizations with an existing IT staff capable of and available to provide timely solutions for problems arising from the use of OSS will incur less learning cost in terms of time, effort, and money spent in retraining their IT staffs for OSS adoption (Dedrick and West 2003). Hence, we propose:

H4. Availability of internal OSS human capital is negatively associated with an organization's switching cost in adopting OSS.

Although leveraging on internal OSS human capital may have the potential benefits of greater stability, predictability (Pfeffer and Baron 1988), and better coordination and control (Jones and Hill 1988), many organizations are now increasingly depending on external OSS human capital (Lepak and Snell 1999), such as third party IT consultants, freelance programmers, or developer groups on OSS forum, for the potential benefits of externalization of the employment which enables the organizations to decrease overhead and administrative costs (Von Hippel, Mangum,

Greenberger, Heneman and Skoglind 1997), balance workforce requirements (Pfeffer 1994) and enhance organizational flexibility (Miles and Snow 1992). Organizations with greater accessibility to external human capital for OSS deployment, which means they have easier access to external resources for cost-efficient and timely service and support of OSS deployment within the organization, will spend less time, effort, and money in locating external OSS expertise. This accessibility should in turn result in lower perceived switching cost. We propose:

H5. Accessibility to external OSS human capital is negatively associated with an organization's switching cost in adopting OSS.

Switching cost is a major concern for organizations when making innovation adoption decisions (Rajagopalan 1999; Dedrick and West 2003). An organization's switch to OSS may be triggered by various reasons, which may include: moving to an infrastructure appropriate for changing business needs; lowering the cost of operating the IS unit; and reducing dependence on a single vendor. OSS confers benefits such as lower software acquisition cost; greater flexibility in modification and customization of the software due to the availability of source code; and delivery of higher software reliability owing to a large pool of global developers (Feller and Fitzgerald 2000; Plotkin 1998). Typically, an organization will be willing to switch if the perceived benefits outweigh the perceived costs of switching. Low switching costs are likely to tip the benefit-cost comparison in favor of adoption. Thus, we hypothesize:

H6. The perceived switching cost for adopting OSS is negatively associated with an organization's intention to adopt OSS.

3.1.3. Control Variables

Motivated by prior research on organizational innovation studies and feedback from informed participants, we control for four key factors because of their potential influence on organizational adoption intention:

- The first is organizational size which has been found to have a positive influence on adoption behavior (Rogers 1995).
- The second is IT department size which represents the technical resources of an organization and which has been found to be important in adoption of technological innovations (e.g., Zmud 1984).
- The third is criticality of IT operations which represents the degree of technological impact on the organization's business operations (e.g., Miller and Doyle 1987).
- The fourth is the industry in which the organizations function. Figure 1 depicts the conceptual model of OSS adoption intention.

3.2. Research Methodology

In order to test the proposed research model, survey methodology was adopted. Data were collected from two Web-based survey questionnaires administered to Chief Information Officers (CIOs) or IS managers in Singapore and China, during the six-month period from March to August 2004. Respondents were first asked to answer a question aimed at identifying whether or not their organizations had adopted OSS. Based on the answer provided, respondents were directed to answer questionnaire for pre-adoption period or post-adoption period depending on whether they were adopters or non-adopters. If their answer to the question is "Yes", they are directed to answer questionnaire for post-adoption, otherwise, they are directed to answer questionnaire for pre-adoption. To avoid confounding effects arising from product differences (e.g., individual level and organizational adoption of OSS), our survey focused only on the adoption of platform-based OSS (Dedrick and West 2003).

This part describes the process of operationalization of constructs, conceptual validation of measurement, and the field study which includes sample selection, survey administration and a report of respondents' profiles.

3.2.1. Development of Measures

The main constructs of interest in this study are human capital, switching costs and organizational intention to adoption OSS. Prior to developing measurement instruments for these constructs, literature is extensively searched for tests and scales that were already developed and evaluated in terms of validity and reliability. Where available, questionnaire items are drawn from previous research; otherwise, new items were created. Special care was taken to ensure that items adapted from prior studies were updated with terminology that is more current or revised to adhere more closely to general principles of item construction, such as avoiding double-barreled questions.

The two human capital constructs, availability of internal human capital and accessibility to external human capital, are mainly based on the extant conceptual definitions of the constructs found in Attewell (1992) and Fichman and Kemerer (1997).[10]

Availability of internal OSS human capital refers to availability of the organization's staff members with the relevant skills and experience in OSS. This construct taps the organization's internal staffs' capability and availability in providing timely solution for OSS implementation in the organization.

[10] We made it clear to our survey respondents that they are supposed to consider the OSS human capital of platform-based OSS specifically.

Item	Wording	Scale (Source)
AvailIntHc1	Our internal IT staff members will be available to solve any problem regarding the use of open source software within our organization.	7-point Likert scale (Self-developed)
AvailIntHc2	Our internal IT staff members will be contactable at any time to provide support on the use of open source software in our organization.	
AvailIntHc3	Our internal IT staff members will be capable of solving any problem regarding the use of open source software in our organization.	
AvailIntHc4	Our internal IT staff members will be capable of providing timely solution for any problem regarding the use of open source software in our organization.	

Table 3.1. Opeartionalization of Availability of Internal OSS Human Capital

Accessibility to external OSS human capital refers to the extent to which an organization has access to external consultants, programmers on OSS forums, or an information technology (IT) educational resources for supporting OSS adoption and use. This construct covers the different externally accessible sources of OSS human capital which organizations can rely on for timely and cost-efficient solution for their OSS implementation:

Item	Wording	Scale (Source)
AccExtHc1	Our organization has access to external vendors who can provide cost-efficient solutions for the problems in open source software deployment in our organization on an as-needed basis.	7-point Likert scale (Self-developed)

AccExtHc2	Our organization has access to external vendors who can provide timely solutions for the problems in open source software deployment in our organization on an as-needed basis.	
AccExtHc3	Our organization has access to external consultants who can provide cost-efficient solutions for the problems in open source software deployment in our organization on an as-needed basis.	
AccExtHc4	Our organization has access to external consultants who can provide timely solutions for the problems in open source software deployment in our organization on an as-needed basis.	
AccExtHc5	Our organization has access to external online open source forum for timely solution for the problems we encounter in open source software deployment in our organization.	
AccExtHc6	Our organization has access to external freelance IT people with specialized expertise in open source software who can provide timely support for the open source software deployment in our organization on an as-needed basis.	
AccExtHc7	Our organization has access to external freelance IT people with specialized expertise in open source software who can provide cost-efficient support for the open source software deployment in our organization on an as-needed basis.	
AccExtHc8	Our organization has access to external IT educational force like university students who can work part-time or work on the project-based style in assisting our organization in open source software deployment.	
AccExtHc9	Overall, our organization can access to external human capital (e.g., consultants, vendors, developers in online OSS forum, freelance IT professionals, university students) to assist us in supporting open source software adoption.	

Table 3.2. Operationalization of Accessibility to External OSS Human Capital

The switching costs refer to the cost of replacing an existing technology with another, (Rajagopalan 1999; Dedrick and West 2003). The operationalization of this constructs

are based on Heide and Weiss (1995) which mainly taps on the staff costs when switching from existing software to OSS.

Item	Wording	Scale (Source)
SwitchCost1	Acquiring open source software would incur a significant cost in retraining a large number of our employees.	7-point Likert scale (Heide and Weiss 1995)
SwitchCost2	Our belief was that the drafting of procedures to deal effectively with open source software would take a lot of time and effort.	
SwitchCost3	Abandoning the existing software to acquire open source software would be too costly for the organization.	
SwitchCost4	Generally speaking, the cost in time, money, effort and employees' dissatisfaction to switch to open source would be high.	
SwitchCost5	Considering everything, the costs to stop using the existing software would be high.	
SwitchCost6	Overall, I would spend a lot and lose a lot if I switch to open source software.	

Table 3.3. Operationalization of Switching Costs

Based on Teo et al. (2003), the dependent variable -- adoption intention is measured by asking respondents to indicate whether they are seriously contemplating OSS adoption. These questions should lead to better prediction of behavior since they incorporate actions (contemplating to adopt, will adopt, will prefer to use), target (OSS), context (my organization), and time (in the near future, within one year) which are essential elements of intention and behavior:

Item	Wording	Scale (Source)
Intention1	Our organization will adopt open source software whenever it is possible.	7-point Likert Scale (Teo et al.

Intention2	Given a choice, my organization will prefer to use open source software in the near future (i.e., within 1 year).	2003)
Intention3	Our organization is seriously contemplating to adopt open source software in the near future (i.e., within 1 year).	

Table 3.4. Operationalization of Organizational Intention to Adopt OSS

IT criticality represents the degree of technological impact on the organization's business operations (Profitability and viability, smooth running of day-to-day operation, and strategic plan and vision.). Its operationalization follows the construct description in Miller and Doyle (1987).

Item	Wording	Scale (Source)
TechCri1	Information Technology is very critical to my organizations' profitability and viability.	7-point Likert scale (Miller and Doyle 1987)
TechCri2	Information Technology is very critical to my organizations' smooth running of day-to-day operation.	
TechCri3	Information Technology is very critical to my organizations' strategic plan and vision.	

Table 3.5. Operationalization of IT Criticality

Other constructs, industry, organization size, and IT department size are all objective measures with only one item per construct. Respondents reported the industry in which their organizations operated. Also, respondents recorded the number of employees and IT staff members in their organizations.

Construct	Wording	Scale (Source)
Industry (Ind)	Which industry does your organization belong to?	
Organization Size (OrgSize)	What is the number of employees in your organization?	Interval (Yasai-Ardekani

		and Nystrom 1996)
IT Department Size (ITSize)	What is the number of IT professionals in your organization?	Interval (Zmud 1984)

Table 3.6. Operationalization of Single-item Control Variables

All latent constructs are measured with multiple items on 7-point Likert scales, ranging from 1 (strongly disagree) to 7 (strongly agree).

3.2.2. Content Validity of Measurement

Content validity refers to the extent to which a measurement represents all facets of a given construct. Content validity of all items, and especially new items, was carefully assessed:

- First, all items were scrutinized by three faculty members (in Department of Information Systems, School of Computing, National University of Singapore) with expertise in measurement theory and questionnaire design to identify and rectify potential problems due to framing and wording of questions. Based on their feedback, we rewrote some of the items with obscure meaning which may cause confusion to survey subjects.

- Second, all items were tested by conducting one unlabeled sorting session. Each question was printed on a piece of paper. Six identical sets of items were created. Six judges who were postgraduate students majoring in IS participated in the unlabelled sorting session. All the items in each set were shuffled and each was

presented to the judge for sorting. The judges sorted the items into independent constructs and provided their own labels and definitions for each of the constructs. This procedure minimized the potential of "interpretational confounding" which is defined as the "assignment of empirical meaning to an unobserved variable other than the meaning assigned to it by a researcher a priori to estimating unknown parameters" (Burt, 1976). Based on the results of the unlabeled sorting session, ambiguous items were reworded.

- Third, subsequent to the unlabeled sorting session, one labeled sorting session was carried out with six judges (postgraduate students majoring IS) different from the ones in the previous session. In this session, each judge sorted a shuffled set of items according to given constructs. The hit rate for this session was one hundred percentage so that no further modifications were made based on the sorting results.

- Fourth, three Chief Information Officers (CIO) were invited to comment on the questionnaires. One of them suggested adding "This question is not applicable to my organization" as an alternative answer to most of the multi-item questions; another suggested adding two more industries in the organization demographics part. We followed their advice and added in the information to the questionnaire accordingly. The three of them all had a concern that the questionnaire was a little bit too lengthy for people like CIO, IT managers whose time schedules were

usually very tight. However, they all agreed that all the questions were relevant. For the sake of completeness, we decided to keep all the constructs and take all possible steps to induce a high response rate.

- Fifth, we followed a double translation method to assure the content validity was not lost in the translation process since this is a cross-cultural survey study and the English and Chinese versions of the questionnaire were used in Singapore and China respectively. In the case of the Chinese version, the questionnaire was first translated into Chinese by a technical writer from the culture. Next, the translated questionnaire was back-translated into English by another technical writer from the same culture. Based on this double translation process, minor corrections were made to the Chinese version of the questionnaire to ensure that the equivalence of meanings of all items across the two versions. Several academics, bilingual in both languages, were invited to review the survey questionnaires for both languages for clarity of instructions, content validity, and semantic consistencies. Based on this feedback, the survey instrument was deemed acceptable.

- Sixth, after all problems are dutifully addressed through the conceptual validation processes, the questionnaire were put on online hosted by a server of School of Computing, National University of Singapore. Three IT professionals from our school were invited to comment on the layout of questions for the Web survey

and highlight problems of the arrangement of the questions that may arouse confusion from the subjects. Subsequent revisions of the web survey layout were made and again verified by the three IT professionals before the survey was administered.

3.2.3. Sample Selection and Survey Administration Procedure

The online survey was administered to 500 organizations, randomly sampled from the 17,000 member database of a national computer society in Singapore, and 5,000 organizations, randomly sampled from the 80,000 member database of an IT association in China. Members from the two associations are mainly CIOs or IS managers in multiple industrial sectors. We excluded any organizations with an OSS-related business (e.g., RedHat) as this study is concerned with the potential adopters of OSS but not OSS proponents. The survey was addressed to the CIOs or IS managers of each organization to ensure high respondent validity (i.e., the person answering the questionnaire has the knowledge, or access to it, to respond accurately).

The survey consisting of a cover letter, survey instructions, and the survey was hosted on Web servers at National university of Singapore and at a programming community portal[11] in China. The URL of the survey was sent through email with a password for access authentication. To increase the response rate, follow-up email reminders or

[11] http://www.csdn.net

telephone calls were made to organizations that had not responded one week after the URL was sent. Also, potential respondents were offered the option of replying via fax, postal system, or email attachment.

A total of 11 and 245 emails in Singapore and China, respectively, were returned as undeliverable. Among the remaining 489 and 4755 organizations in Singapore and China respectively, 138 and 1181 responses were received, yielding response rates of 28.22% and 24.84%. These response rates are considered reasonable because the survey was unsolicited and it involved senior management. Given that the respondents were from more than 12 industries and the survey was solicited from members of two established associations, we believe that the survey sample was good representative of the population of CIOs and IS managers.

Respondents were asked whether they were aware of the availability of OSS that their organizations could adopt. Only respondents of OSS non-adopting organizations indicating 'yes' were considered in this data analysis. Respondents were also asked whether they had sufficient knowledge and played an influential role in adoption decisions for their organizations. This allowed us to ascertain whether a respondent was capable of assessing the adoption strategy of the organizations within which he resided. We only included those responses in which respondents indicated 'yes' to both questions in the analysis to ensure high data integrity. After further discarding unusable questionnaires with missing data, we obtained 81 and 212 responses from

organizations in Singapore and China respectively that had not yet adopted OSS and 46 and 597 responses from organizations in Singapore and China respectively that had adopted OSS. Only responses from non-adopting organizations were used to predict adoption intention, and to avoid the problems of respondent-recall and correlating today's variables with that of yesterday's innovativeness (Teo et al. 2003). Table 3.7 depicts the demographic information of the organizations and Table 3.8 depicts the descriptive statistics of variables under investigation.

	Singapore (N = 81)		**China (N = 212)**		**Pooled (N = 293)**	
	Freq	**Percent**	**Freq**	**Percent**	**Freq**	**Percent**
Industry/Group						
Advertising/Marketing/ Public Relation	1	1.2	8	3.8	9	3.1
Aerospace	1	1.2	7	3.3	8	2.7
Construction	4	4.9	8	3.8	12	4.1
Consumer Goods	2	2.5	5	2.4	7	2.4
Computer/Electronics	24	29.6	90	42.5	114	38.9
Education	7	8.6	15	7.1	22	7.5
Finance/Insurance/Property	10	12.3	12	5.7	22	7.5
Government-related bodies	8	9.9	10	4.7	18	6.1
Media/Publishing/ Entertainment	4	4.9	3	1.4	7	2.4
Medical/Health Services	2	2.5	2	.9	4	1.4
Travel/Transportation	6	7.4	6	2.8	12	4.1
Telecommunication/ Networking	5	6.2	20	9.4	25	8.5
Others	7	8.6	26	12.3	33	11.3
Number of Employees						
9 and below	3	3.7	19	9.0	22	7.5
10 – 49	16	19.8	69	32.5	85	29.0
50 – 99	10	12.3	30	14.2	40	13.7
100 – 499	19	23.5	53	25.0	72	24.6
500 – 999	18	22.2	10	4.7	28	9.6
1000 and above	15	18.5	31	14.6	46	15.7
Number of IT Employees						

9 and below	24	29.6	79	37.3	103	35.2
10 – 49	19	23.5	76	35.8	95	32.4
50 – 99	8	9.9	26	12.3	34	11.6
100 – 499	13	16.0	15	7.1	28	9.6
500 – 999	17	21.0	16	7.5	33	11.3

Table 3.7. Profile of Potential Adopting Organizations that Responded

	Singapore Sample (N=81)		**China Sample (N=212)**	
	Mean	SD	Mean	SD
Independent Variables				
AvailInHc	3.48	1.39	3.39	1.16
AccExtHc	3.92	1.37	3.73	1.13
SwitchCost	4.88	1.24	4.11	1.04
Dependent Varialbe				
Intention	3.55	1.50	4.10	1.13
Control Variables				
Industry	9.32	0.48	8.14	4.37
OrgSize	3.96	1.50	3.28	1.54
ITSize	2.75	1.55	2.12	1.20
TechCri	5.52	1.59	4.90	1.25

Table 3.8. Descriptive Statistics of Variables

3.3. Data Analyses

This section describes the results of testing the research model proposed for theme 1 study. Structural Equation Modeling technique is used for data analysis. It is a powerful second generation multivariate analysis technique that allows an estimation of multiple and interrelated dependence relationships, and has the ability to represent unobserved concept in these relationships and account for measurement error in the estimation process (Hair *et al,* 1998). In simple terms, structural equation modeling is composed of two models: the measurement model and the structural model. The

measurement model specifies the indicators for each construct, and assesses the reliability of each construct for estimating the dependence relationships. The structural model is a set of dependence relationships linking the model constructs.

Structural Equation Modeling is superior to traditional regression analysis and factor analysis because the measurement model is assessed within the context of the structural model. It addresses both models at the same time, compared to factor analysis that assesses the measurement model only and path analysis that addresses the structural model alone. While superior to other multivariate techniques, structural equation modeling requires strong theoretical justifications for the specifications of dependence relationships. A theory-based approach to structural equation modeling is an absolute necessity because the technique, being completely specified by the researcher, increases the risks of "overfitting" the model or developing a model with little generalizability (Hair *et al.* 1998). The need for a theory-based model to guide the estimation process becomes especially critical when model modifications are made. The use of theoretical based model can also reduce the chances of specification error. Drawing comprehensively upon human capital and innovation adoption theories, this study is also to address these concerns.

Partial Least Square (PLS) and Linear Structural Equations (LISREL) are the most widely used implementations of Structural Equation Modeling. PLS was developed by Wold (1982) while LISREL was developed by Joreskog and Sorborn (1981). The

choice of either LISREL and PLS depends on certain conditions. LISREL demands some rather restrictive assumptions, including strong theoretical knowledge, multivariate normal distribution, interval scales, and fairly large sample sizes (Fornell and Bookstein 1982). PLS, on the other hand, has less restrictive assumptions. It does not depend on having multivariate normal distributions, interval scales, or a large sample size. While LISREL's emphasis is on overall model fit, making it "closer to the model, more confirmatory, and more model analytic", PLS seeks to maximize the variance explained in constructs, thus making it "closer to data, more exploratory, and more data analytic" (Barclay, Higgins, and Thompson 1996).

For the measurement model testing, this study uses LISREL version 8.51 for confirmatory factor analyses to facilitate a more rigorous assessment of the fit between collected data and the theoretical factor structure, and to satisfy the minimum requirements of assessing the measurement properties of unidimensionality, convergent validity, and discriminant validity (Byrne 1998).

After assessing the measurement model, PLS, as implemented in PLS Graph version 3.0, was used for assessing the structural model and hypotheses testing, given the prediction-oriented nature of this study.

3.3.1. Evaluating Measurement Model

The validity of the five multi-items constructs —availability of internal OSS human capital, accessibility to external OSS human capital, switching cost, IT criticality and intention to adopt—were assessed in terms of unidimensionality, convergent validity, internal consistency, and discriminant validity (see Byrne 1998). All other constructs in the model were operationalized through single item.

The initial model structure of the five multiple-items constructs comprised of 25 items. Seven indicator loadings were below the criterion of .707 (Hair et al. 1998) and were subsequently removed from the revised model (AvailIntHc02, AccExtHc01, AccExtHc09, SwitchCost01, SwitchCost02, SwitchCost06, Intent01). The revised model fit indices provide adequate evidence of the unidimensionality of the items (see Table 3.9 and Table 3.10). Although the Goodness-of-Fit (GFI) did not satisfy the recommended threshold by Hu and Bentler (1999), the index is relatively close to the threshold and the model is deemed to be sufficiently "fit" (Marsh et al. 2004).

Goodness of Fit Indices	**Initial Model**	**Revised Model**	**Desired Levels**
χ^2	1008.76	413.70	Smaller
Df	265	125	-
GFI	.78	.86	> .90
AGFI	.73	.81	> .80
Standardized RMR	.049	.035	< .05
NFI	.86	.97	> .90
CFI	.90	.97	> .90
Number of Latent Variables	5	5	-
Total Number of Items	25	18	-

Table 3. 9. Goodness of Fit Indices for the Measurement Model

Construct Items	Standardized Parameter Estimate	t-value
Availability of Internal OSS Human Capital (AvailIntHc)		
AvailIntHc01	.77	15.09
AvailIntHc03	.89	18.81
AvailIntHc04	.91	19.57
Accessibility to External OSS Human Capital (AccExtHc)		
AccExtHc02	.80	16.21
AccExtHc03	.85	17.79
AccExtHc04	.88	19.11
AccExtHc05	.86	18.11
AccExtHc06	.86	18.30
AccExtHc07	.87	18.45
AccExtHc08	.77	15.30
Switching Cost (SwitchCost)		
SwitchCost03	.83	16.59
SwitchCost04	.88	17.91
SwitchCost05	.83	16.62
Criticality of IT Operations (TechCri)		
TechCri01	.89	18.05
TechCri02	.83	16.39
TechCri03	.80	15.69
Intention to Adopt (Intent)		
Intent02	.88	16.20
Intent03	.93	17.12

Table 3.10. Operationalization of Multi-Item Subconstructs:

Evidence of Unidimensionality

The internal consistency reliability refers to the extent to which the items used to measure a construct reflect a true common score for the construct (Kerlinger 1986) and convergent validity is the degree to which two or more items measuring the same construct agree (Cook and Campbell 1979). The internal consistency reliability and the convergent validity of each construct was assessed by computing the Cronbach's

alpha, composite reliability of the constructs[12], and variance extracted by the constructs (AVE)[13] (Hair et al. 1998; Fornell and Larcker 1981). Table 3.11 presents the results along these constructs. All Cronbach's alpha and composite reliabilities exceed Nunnally's (1978) criterion of .70 while the AVE for each of these constructs is above the recommended threshold of .50 (Hair et al. 1998), indicating the constructs have sufficient internal consistency reliability and convergent validity.

Dimensions	**No. of Items**	**Cronbach's Alpha**	**Composite Reliability**	**Average Variance Extracted**
Availability of Internal OSS Human Capital (AvailIntHc)	3	.890	.894	.738
Accessibility to External OSS Human Capital (AccExtHc)	7	.943	.945	.709
Switching Cost (SwitchCost)	3	.883	.884	.717
Criticality of IT Operations (TechCri)	3	.876	.878	.707
Intention	2	.900	.901	.820

Table 3.11. Assessment of Internal Consistency and Convergent Validity

Discriminant validity refers to the degree to which items differentiate between constructs, or measure different constructs (Cook and Campbell 1979). It is assessed by testing whether the (unconstrained) correlations between pairs of constructs are significantly different from unity (Anderson 1987). Discriminant validity is

[12] *Composite reliability of a construct is calculated as* $(\Sigma (\lambda_i))^2 / (((\Sigma (\lambda_i))^2 + \Sigma (1 - \lambda_i^2))$ *where* λ_i *denotes loading of question* ***i*** *on the construct.*

[13] *Average variance extracted is computed as* $\Sigma \lambda_i^2 / (\Sigma \lambda_i^2 + \Sigma (1 - \lambda_i^2))$ *where* λ_i *denotes loading of question* ***i*** *on the construct.*

established if the χ^2-value of the unconstrained model is significantly lower than that of the constrained model. Table 3.12 provides strong evidence of discriminant validity. Additionally as indicated in Table 3.13 the correlations between all pairs of constructs are also below the threshold of value of .90 (Bagozzi et al. 1991) reflecting that the constructs are distinct.

Dimensions	Constrained Model X^2 (df)	Unconstrained Model X^2 (df)	ΔX^2
Availability of Internal OSS Human Capital (AvailIntHc)			
Accessibility to External OSS Human Capital (AccExtHc)	629.69 (36)	274.27 (34)	355.42*
Switching Cost (SwitchCost)	456.99 (9)	17.27 (8)	439.72*
Criticality of IT Operations (TechCri)	478.12 (9)	12.05 (8)	466.07*
Intention to Adopt (Intent)	191.80 (5)	2.95 (4)	188.85*
Accessibility to External OSS Human Capital (AccExtHc)			
Switching Cost (SwitchCost)	725.64 (35)	301.10 (34)	359.90*
Criticality of IT Operations (TechCri)	713.39 (35)	287.71 (34)	425.68*
Intention to Adopt (Intent)	471.49 (27)	283.21 (26)	188.28*
Switching Cost (SwitchCost)			
Criticality of IT Operations (TechCri)	430.27 (9)	11.57 (8)	418.70*
Intention to Adopt (Intent)	196.57 (5)	5.47 (4)	191.10*
Criticality of IT Operations (TechCri)			
Intention to Adopt (Intent)	196.30 (5)	7.93 (4)	188.37*

-All χ^2 differences in are significant at $p < .01$

Table 3.12. Assessment of Discriminant Validity

	AvailIntHc	AccExtHc	SwitchCost	Intention	Industry	OrgSize	ITSize	TechCri
AvailIntHc	**(0.859)**							
AccExtHc	0.614	**(0.842)**						
SwitchCost	-0.142	-0.138	**(0.847)**					
Intention	0.341	0.400	-0.223	**(0.906)**				
Industry	-0.001	-0.007	0.092	-0.012	**(1.000)**			
OrgSize	-0.043	0.027	0.070	-0.037	0.101	**(1.000)**		
ITSize	-0.004	-0.037	0.075	-0.063	-0.031	0.530	**(1.000)**	
TechCri	0.031	0.104	0.203	0.175	0.116	0.261	0.310	**(0.841)**

Table 3.13. Shared Variance (Variance Extracted) Among Constructs

3.3.2. Evaluating the Structural Model

Following the confirmation of good psychometric properties in the measurement model, PLS was used to assess the structural model. A bootstrapping procedure generating 250 random samples of size 200 was used to estimate the significance of the path coefficients and the weights of the dimensions of constructs. Table 3.14 depicts the structural models. The cells contain the path coefficients produced by PLS; these are identical to the standardized beta coefficients produced by the OLS regression. After computing the path coefficient estimates, PLS used a bootstrap procedure to obtain the corresponding t-values. Support for each hypothesis could be determined by examining the sign (positive or negative) and the statistical significance of the t-value for its corresponding path coefficients. All statistical tests were conducted at 0.05 significant levels. Table 3.15 summarizes the results of hypothesis testing.

Model / Construct	China Sample (N = 212)			Singapore Sample (N = 81)		
	M1	M2	M3	M1	M2	M3
Dependent variable – Switching cost						
AvailIntHc	-.152		-.152	-.457**		-.457**
AccExtHc	-.160		-.160	-.045		-.045
R^2	.020		.020	.238		.238
Dependent variable – AccExtHc						
AvailIntHc	.584**		.584**	.676**		.676**
R^2	.34		.034	.457		.457
Dependent variable – OSS adoption intention						
AvailIntHc	.150*		.117*	.059		.086
AccExtHc	.254**		.337**	.276*		.304**
SwitchCost	-.028		-.018	-.311**		-.376**
Industry	-.106*	-.139**		.090	.094	
OrgSize	-.036	-.024		-.084	-.084	
ITSize	.030	.015		-.034	-.044	
ITCriticality	.354**	.405**		-.099	-.157	
R^2	.285	.155	.173	.322	.050	.294

- M1: full model; M2: control model; M3: theoretical model;
- * p < .05; ** p < .01

Table 3.14. Structural Model Comparisons

The explanatory power of a structural model can be evaluated by examining the R^2 (variance accounted for) in the final dependent construct. In this study, the final dependent construct (intention to adopt OSS) had R^2 values of .285 for China sample and .322 for Singapore sample. Comparing the full models (M1) and the control models (M2) shows that the full models explain incremental variances of 13.0% (28.5% - 15.5%) for China sample and 27.2% (32.2% - 5.0%) for Singapore sample. Including the control variables on top of the independent variables, by contrast, only explains for 11.2% (28.5% - 17.3%) for China sample and 2.8% (32.2% - 29.4%) for Singapore sample.

Hypotheses	China Sample	Singapore Sample
H1. Availability of internal OSS human capital is positively associated with an organization's intention to adopt OSS.	Supported	Not Supported
H2. Accessibility to external OSS human capital is positively associated with an organization's intention to adopt OSS.	Supported	Supported
H3. Availability of internal OSS human capital of an organization is positively associated with its accessibility to external OSS human capital.	Supported	Supported
H4. Availability of internal OSS human capital is negatively associated with an organization's switching cost in adopting OSS.	Not Supported	Supported
H5. Accessibility to external OSS human capital is negatively associated with an organization's switching cost in adopting OSS.	Not Supported	Not Supported
H6. Switching cost in adopting OSS is negatively associated with an organization's intention to adopt OSS.	Not Supported	Supported

Table 3.15. Summary of Hypotheses Testing Results

3.4. Discussions and Implications

3.4.1. Discussion of Results

This study constitutes one of the first cross-country tests of a fundamental linkage between an organization's human capital and its intention to adopt OSS, an area that has yet to be comprehensively examined by prior studies of IT innovation adoption in an integrative fashion. Our evidence indicates that human capital constructs – availability of internal OSS human capital and accessibility to external OSS human capital – can be clearly distinguished conceptually and empirically in terms of their

influence on OSS organizational adoption intention. Overall, there is strong empirical support for the human capital constructs (Becker 1993) as predictors of OSS organizational adoption intention. Our results further suggest that there might be differentiated effects of human capital constructs on adoption intention, depending on whether the human capital is available within or without the organization and whether the organization is in a developing or a developed country.

The Singapore sample suggests that the higher availability of internal OSS human capital can reduce the switching cost, which in turn leads to a higher intention to adopt OSS. However, there is insufficient evidence indicating that availability of internal OSS human capital will directly influence adoption intention. This may suggest that the mere availability of internal OSS human capital will not precipitate IS leaders to be positively disposed to OSS and to adopt OSS for their organizations even if there is a need to switch from the software that is presently used. This contradicts an oft-held conventional wisdom that IS or technology leaders tend to be more pro-innovation bias (Rogers 1995). When considering the adoption of OSS, IS leaders in our Singapore sample clearly value the availability of the internal OSS human capital only to the extent that it helps reduce the switching cost involved in migrating from proprietary platforms to OSS platforms. This also reflects the trend that IS leaders are becoming more rational in IT innovation adoption decision making after the first round of frenetic IT investment at the end of last century and collapse of the dot com bubble at the beginning of this century.

The Singapore sample also suggests that external OSS human capital has a different effect on organizational adoption intention compared to internal OSS human capital. Higher accessibility of external OSS human capital does not help reduce switching cost. One plausible explanation is that the reliability of the external OSS human capital may be of a concern. Because external OSS human capital is outside their boundaries, organizations may find it difficult to assess and trust the quality and the commitment of the external human capital. *"Who do you call when things go wrong (with OSS)? You can't wring a vendor's neck when there's no vendor,"* said Gary Hein, an analyst with technology consultancy Burton Group[14] stated in *CIO Magazine*, *"Although most open-source projects have a large corps of developers, Internet mailing lists, archives and support databases—all available at no cost, there's no single source of information. A simple question may result in multiple, conflicting answers with no authoritative source."* With less than absolute control over this source of human capital, organizations may not feel secured to rely on it and may not perceive it to be helpful in lowering the switching cost, should they decide to adopt OSS.

In contrast, the result from the China sample indicates that both the organizational availability of internal OSS human capital and its accessibility to external OSS human capital will directly affect the intention to adopt OSS, indicating that Chinese IS

[14] The myths of Open Source (http://www.cio.com/archive/030104/open.html, last visited *on 31 August, 2005*)

leaders perceive OSS human capital, either internally available or externally accessible as important prerequisite for their organizations to adopt OSS. However, neither the availability of internal OSS human capital and the accessibility to external OSS human capital has a significant influence on switching cost, which does not seem to affect an organization's OSS adoption intention significantly in China. The different roles played by switching cost in influencing an organization's OSS adoption intention in these two countries might be explained by their difference in IT adoption history.

Singapore is a city-state famous for its advanced IT infrastructure. There was an early recognition that IT would be needed to leverage Singapore's intellectual capital in order for it to move into the ranks of developed nations. Singapore's IT initiatives began in the early 1980s and evolved in three phases, each framed by a national plan that clearly articulated goals, policies, resources, and projects (Choo 1997). The long history of IT infrastructure development and technology adoption created many legacy systems for Singaporean organizations and, consequently, raises their perceived switching cost relative to organizations in a developing country like China, which has a much shorter technology adoption history and a less advanced IT infrastructure. In this aspect, OSS provides a "leapfrogging" chance for countries that have under-developed technology or economic bases, such as China, to move forward rapidly through the adoption of cutting-edge technology like OSS because they have

minimal investment in prior technology. Switching cost may not be an issue when you are not switching but rather installing for the first time.

We believe it is this distinct difference in the IT adoption history between these two countries that explains the considerably different role played by switching cost in the OSS adoption model in these two countries. This observation also highlights the importance of examining the contextual or background situation when investigating how switching cost functions in a specific country or area.

Despite the variation of the relationships among the two OSS human capital constructs, switching cost and an organization's OSS adoption intention in the two samples as discussed previously, we have observed a strong and consistent positive effect of an organization's availability of internal OSS human capital on its accessibility to external OSS human capital across the two samples. This is an interesting finding which implies that the internal OSS human capital seems to be a necessary pre-requisite to access external OSS human capital. Without internal OSS human capital, organizations would find it difficult to leverage external expertise to exploit the use of OSS.

3.4.2. Limitations

Before discussing the implications of this study, it is important to consider the study's limitations. The primary limitation relates to issue that only one respondent is surveyed for each organization, and that person might not best represent the organization's actual opinions. However, to the extent that the questionnaire was administered to the organization's IS leader, who was likely to be the most cognizant of their environment, we believe that the use of a single respondent should not present a significant problem.

Another limitation concerns external validity. Sampling was limited to organizations in two Asia-Pacific countries. Although this limitation may limit generalizability to other countries or areas, we believe our findings may still be applicable to OSS adoption in similar environments such as other developed countries with well-established IT infrastructure or newly industrializing and developing countries. Notwithstanding the applicability of the present results, we believe further research is needed to assess the extent to which the findings can be generalized in diverse organizational and environmental settings.

It is also important to note that both independent and dependent measures were gathered through self-reports at a single point in time. This gives rise to the possibility of common method bias in this study. When all measures were collected at the same time, respondents may give the answers that they believe the survey researchers expect to receive. We minimized these effects in two ways: we implemented the

online web-based survey questionnaire in such a way to prevent respondents from back-trekking to change their answers, and we presented the pages of the survey items in a random manner to discourage respondents from figuring out the relationship between the independent and dependent variables that we were trying to establish. A telephone-based follow-up survey on randomly selected 25 OSS non-adopting organizations from Singapore and 65 non-adopting organizations from China was also conducted. A comparison of response answers collected at the main survey and follow-up survey revealed a high degree of consistency between the two. Hence, we believe that this potential limitation may not significantly affect the results.

3.4.3. Implications

This study has implications for theory, methods, and practice. From the human capital theory perspective, this study extends its applicability to the technological innovation adoption, and this extension will also add to the extant literature on IS innovation adoption and serves as a call for more attention to be directed at understanding the influence of human capital in an increasingly technologically complex business environment. By operationalizing the human capital construct from both internal and external perspectives and demonstrating that these two dimensions are conceptually and empirically distinguishable in terms of their influence on OSS organizational adoption intention, we also enhance the human capital theory and highlight to future researchers the necessity of considering this separation in order to understand how

human capital functions. Moreover, by examining the direct and indirect effects of the human capital constructs in the OSS adoption context, we were able to delineate the mechanisms by which they influence OSS adoption intention, and this provides a more nuanced understanding of human capital effects in IS innovation adoption. From a resource-based perspective, our findings also show that an internal organizational critical resource may be required to enable the capture of external resources in order to increase its innovation propensity. This linkage between the availability of internal human capital and accessibility to external human capital has profound importance and is worthy of further investigation.

Methodologically, this paper also focuses on the validation of the two constructs of internal and external human capital. The results indicate that different types of human capital have differential effects on adoption intention. Hence, it is imperative that we should not simply view human capital as one single construct. The validated internal and external human capital constructs will facilitate research on human capital. This study also adopts a cross-country survey methodology that collected data from two countries with different IT adoption histories and shed light on how the influences of human capital and switching cost may vary between organizations in a developed country and a developing country. This cross-country approach has proved to be valuable in revealing the universal and the particular effects of certain variables in different contexts.

Our findings also have implications for organizations promoting OSS that are eager to learn about what it takes to increase the OSS adoption and diffusion in different countries. Particularly, human capital is a crucial factor in determining the propensity of technology adoption. This provides a basis for more targeted marketing and promotion of OSS. Taking into consideration that external OSS human capital are consistently significant in affecting an organization's adoption intention in both samples, OSS proponents should put effort into providing service and support that are readily accessible to potential adopters so as to reduce the perceived uncertainty and risk in OSS deployment. The recent emergence of new OSS business models such as Professional OSS (POSS) or Commercialized OSS companies like JBoss, Redhat, MySQL (Watson, Wynn and Boudreau 2005) can be explained by our model as an effort toward providing more reliable external OSS human capital. Our results indicate that an organization's availability of internal OSS human capital is a significant antecedent of its accessibility to external OSS human capital. This may remind OSS proponents that more effort is needed in helping organizations build their internal OSS human capital, which will then help the firm to take more advantage of external OSS capital. Possible approaches include providing regular communication, training, seminars, conferences, and workshops about OSS for potential adopting organizations. Particularly, marketers can also actively promote the use of OSS in educational institutions (e.g., schools and universities). With proper encouragement, support and training, students should be able to learn how to develop and use OSS effectively. This generates the "alumni effect" and increases both the internal OSS

human capital via recruitment and external OSS human capital via contracting freelancing professionals and students for adopting organizations (Lerner and Tirole 2002).

For the potential OSS adopters, as they recognize the importance of building internal OSS human capital and having access to external OSS human capital, more effort could be devoted to increase both forms of human capital. For instance, potential adopters contemplating OSS adoption might turn to external sources for advice and assistance to supplement the internal human capital (e.g., through workshops and short-term trainings). However, based on our findings, they should observe that the availability of internal OSS human capital is more crucial for a successful OSS adoption because it will also enhance their accessibility to external OSS human capital. Potential adopters should consider recruiting and selecting OSS-competent project leaders and programmers from the market. Given that many IS managers have continued to look askance at staff members involved in external OSS projects, potential adopters may need to modify their human-resource practices to heavily encourage and support their staff members to learn OSS by creating a supportive atmosphere. Cultivating OSS human capital is increasingly important given the increasing availability of OSS as an alternative technological solution.

3.4.4. Future Research

We see several directions for further research:

- First, based on our discussion of the different impacts that switching cost has on OSS adoption intention in the two countries, we speculate that IT adoption history and legacy systems might be important factors affecting innovation adoption intention. Thus, the conceptual model can be refined to take into account these factors extent the innovation adoption literature by adding a national dimension. Moving beyond parochial explanations of phenomenon is necessary if we are to have theories that are applicable to a global economy.

- Second, an examination of the antecedents of human capital (e.g., education, on-the-job training, and organizational culture) should enable IS leaders to effectively prepare the organization for OSS adoption.

- Third, following the argument by Barker and Mueller (2002) that certain characteristics, such as age, of a Chief-Executive-Officer (CEO), decision-maker of an organization, may be associated with an organization's research and development budget, it would be interesting to see whether organizations with IS leaders of certain psychological characteristics are more likely to adopt OSS.

- Fourth, future research can be conducted to examine OSS adoption by expanding this study to other countries that have very dissimilar cultural, economic, political and legal systems from Singapore and China. We conjecture that culture might be an influential factor affecting an organization's propensity toward OSS adoption.

The history of human civilization is closely linked to technological adoption. Societies that learn how to innovate and adopt innovations advance economically, politically, and socially. Those that never acquire these skills, or lose them, become stalled in poverty. Businesses, the major modern instrument of technological progress, are critical to economic success, and in the era of globalization, information technology is the critical technology. Thus, we need a globally robust theory of organizational innovation adoption that assists us to understand how information technology adoption occurs. This study, with its focus on human capital, the ultimate driver of innovation and adoption, opens a new vein for the exploration of a critical societal dimension.

CHAPTER 4
AN INSTITUTIONAL PERSPECTIVE OF OPEN SOURCE SOFTWARE ADOPTION IN ORGANIZATIONS: A CROSS-COUNTRY INVESTIGATION

This chapter addresses the research questions explored by theme two. Specifically, a conceptual model is established to explore how institutional pressures will affect the organizations' intention to adopt OSS and what is the different role of mimetic pressure, normative pressure and coercive pressure in this process. A cross-cultural survey study is carried out to validate the proposed research model. Based on the findings obtained from the empirical study, important theoretical and practical implications are identified.

4.1. The Research Model and Hypotheses

Pressure to conform to the existing software adoption practice in the industry, one of the barriers to organizational OSS adoption, has been found common in IS business and has been demonstrated to be significant in influencing organizations' innovation adoption intention (Teo, Wei and Benbasat 2003). This pressure creates a hurdle for OSS adoption primarily because:

- The software market is still dominated by traditional proprietary software, and corporate IT managers and decision makers have traditionally depended on either internally developed systems or commercially purchased systems that have been mostly closed source and proprietary (Madey, Freeh and Tynan, 2002);

- OSS, from its emergence as a unique innovation, has also challenged some existing social norms, ethics, and morals, has brought forward new intellectual property questions and has had great impact on people's mindset—which make OSS not only a technical innovation, but also a social/cultural/institutional innovation and thus differentiate it other purely technical innovations.

OSS is different from the proprietary software in term of its development style, its ownership, and its moral emphasis, an organization's choice of adopting OSS may be perceived as an unconventional decision, and it may have to withstand the institutional consequences.

According to Institutional theory, besides competing for resources and customers, organizations also compete for political, economic, and social fitness (Carroll and Delacroix 1982). Hence, although in IS, innovation can often lead to competitive advantages, organizations face pressures to conform to certain shared notions of appropriate forms and behaviors, such as avoiding adopting innovations that are perceived to be unconventional, unprofessional, or even illegal since violating

accepted norms may call into questions the organization's legitimacy and thus affect its ability to secure resources and social support (DiMaggio and Powell 1983; Tolbert 1985). Therefore, organizations are subject to pressures to be isomorphic with their counterparts in the environment. Three pressures have been identified to affect organizations' institutional decision and behavior: mimetic, coercive and normative pressures. We believe these three pressures are particularly relevant in organizations' decision making on whether to adopt OSS because this may be one of the most unique innovations in the technological history in terms of its influences on different facets of the whole society.

Based on the preceding analysis, our main proposition is that the existence of the institutional pressures, which includes coercive, mimetic and normative pressure, will significantly affect organizations' intention to adopt OSS. Figure 4.1 depicts the conceptual research model. This study focuses on the intention toward OSS adoption rather than the actual adoption behavior for two reasons. First, the relationship between intention to adopt and the actual adoption behavior has been established by previous research, indicating that a strong intention to adopt should lead to actual adoption behavior (Teo et al. 2003). Second, by focusing on intention, we will be able to understand the dynamics of decision-making of the potential OSS adopters and provide some potentially useful prescriptive guidelines to encourage adoption and diffusion of OSS innovations. Figure 4.1. depicts the conceptual model.

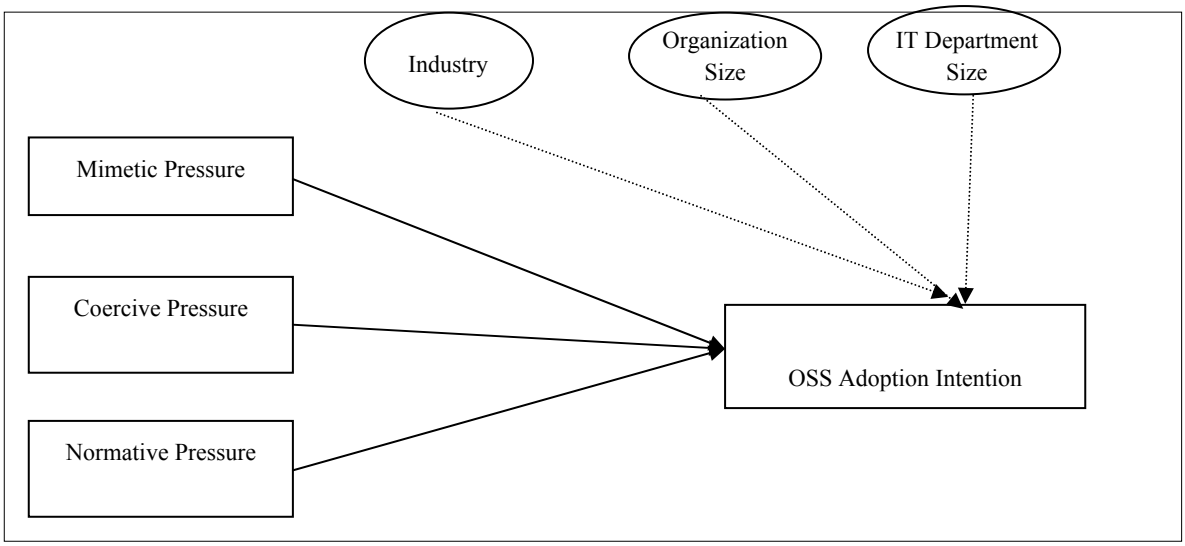

Figure 4.1. Conceptual Model of OSS Adoption Intention

4.1.1. Mimetic Pressure and OSS Adoption Intention

Mimetic pressure may cause an organization to change over time to become more like the organizations in its environment (Dimaggio an Powell 1983). In the decision of OSS adoption, where the software market is still dominated by proprietary software, there is a high uncertainty and risk to adopt OSS given its unique characteristics (i.e. unconventional development style, ownership issue and the anti-commercial nature). In this light, an organization may first observe in its industry whether the number of OSS adopters among its peers is large and whether these adopters have benefited (e.g., cost-savings, efficiency and productivity increases) from adopting OSS. The prevalence and perceived benefits of OSS adoption among its peers will form the mimetic pressures on the organization's intention to adopt OSS and, to a certain extent, help it overcome the adoption barrier posed by the dominance of proprietary

software in the market. For example, IBM's early embracing of OSS in mid 1998[15] would have created such kind of mimetic pressures for its counterparts like HP, Apple, and Sun MicroSystems who supported OSS later. Hence, we hypothesize that:

H1. Mimetic pressures will have a positive impact on an organization's intention to adopt OSS.

4.1.2. Coercive Pressure and OSS Adoption Intention

Coercive pressure refers to the formal or informal pressures exerted on organizations by other organizations upon which they are dependent (Dimaggio and Powell 1983). With increased software interoperability, the concern of system compatibility and interchangeability if one organization adopts OSS while its alliances, suppliers, customers, subsidiaries or parent corporations do not adopt diminishes. However the coercive pressures from government authorities may still play an important role in an organization's decision making on OSS adoption. That is, whether the local government promotes and encourages the use of OSS will affect an organization's intention to adopt. For example, the joint agreement and effort by Chinese, South Korean and Japanese governments on the co-development of a Linux-based

[15] In mid-June 1998, **IBM** chose the open-source Apache Web server to support and bundle with its WebSphere suite. Later, IBM also made **Linux** the primary operating system on all their high end mainframe servers. (http://www.opensource.org/docs/products.php (last visited on 25th April, 2006)

alternative to Windows[16] may significantly reduce the OSS adoption barrier and increase OSS adoption intentions in these countries. We thus hypothesize that:

H2. Coercive pressures will have a positive impact on an organization's intention to adopt OSS.

4.1.3. Normative Pressure and OSS Adoption Intention

Normative Pressures, which are exerted primarily by professional relationships (Scott 1987), imply that strategic processes taken by organizations are subjected to values and norms shared among the members of their social networks (Scott 2001). Organizations are likely to behave based on their belief about what is expected of, and what is viewed as appropriate, among members in their social networks (Scott 2001). The variety of sources of normative pressures includes trade associations, professional associations, accreditation agencies, channel members, or professionals themselves (Grewal and Dharwadkar 2002).

As previously stated, this OSS adoption barrier exists because organizations may consider the OSS movement is anti-conventional by nature and the present software market is still dominated by proprietary software. There are still "myths" about OSS, such as OSS is not for mission-critical applications due to its development style

[16]Source: http://www.ossi-news.org/archives/000384.html (last visited on 25th April, 2006)

(Bazaar vs. Cathedral, see Raymand, 1996), OSS is not ready for the desktop due to unfriendly user-interfaces, and OSS may be a legal minefield due to its special way of licensing.[17] Based on these perceptions/misperceptions of OSS, organizations may be viewed as unprofessional by their peers if they adopt OSS. Thus, when making OSS adoption decisions, an organization, under normative pressures, may attempt to conform to the conventions and professionalism of their industry so as to build a good image. For example, suppose in an industrial environment where using OSS is the usual practice and is considered to be professional by the social network members of the organization, an organizational decision-maker's intention to adopt OSS may be increased. We thus hypothesize that:

H3. Normative pressures will have a positive impact on an organization's intention to adopt OSS.

4.1.4. Control Variables

Motivated by prior research on organizational innovation studies and feedback from informed participants, we control three key factors because of their potential influence on organizational adoption intention:

[17] The myths of Open Source (http://www.cio.com/archive/030104/open.html) (last visited on 25th April, 2006)

- The first is organizational size, which has been found to have a positive influence on adoption behavior (Rogers 1995).
- The second is IT department size, which represents the technical resources of an organization and which has been found to be important in adoption of technological innovations (e.g., Zmud 1984).
- We also control for the industry in which the organizations function. Figure 4.1 depicts the conceptual model of OSS adoption intention.

4.2. Research Methodology

In order to test the proposed research model, survey methodology was adopted. Data were collected from two Web-based survey questionnaires administered to Chief Information Officers (CIOs) or IS managers in Singapore and China, during the six-month period from March to August 2004. Respondents were first asked to answer a question aimed at identifying whether or not their organizations had adopted OSS. Based on the answer provided, respondents were directed to answer questionnaire for pre-adoption period or post-adoption period depending on whether they were adopters or non-adopters. To avoiding confounding effects arising from product differences (e.g., individual level and organizational adoption of OSS), our survey focused only on the adoption of platform-based OSS (Dedrick and West 2003).

This part describes the process of operationalization of constructs, conceptual validation of measurement, and the field study which includes sample selection, survey administration and a report of respondents' profiles.

4.2.1. Development of Measures

The main constructs of interest in this study are mimetic pressure, coercive pressure, normative pressure and organizational intention to adoption OSS. Prior to developing measurement instruments for these constructs, literature is extensively searched for tests and scales that were already developed and evaluated in terms of validity and reliability. Where available, questionnaire items are drawn from previous research; otherwise, new items were created. Special care was taken to ensure that items adapted from prior studies were updated with terminology that is more current or revised to adhere more closely to general principles of item construction, such as avoiding double-barreled questions.

Mimetic pressure is operationalized in terms of the perceived extent and benefit of OSS adoption by competitors:

Item	Wording	Scale (Source)
MimePres1	Quite a number of our competitors benefit through great cost-saving from adopting open source software.	7-point Likert scale (Adapted from Teo et al. 2003)
MimePres2	Quite a number of our competitors significantly increase their employees' job efficiency through adopting reliable open source software.	
MimePres3	Quite a number of our competitors improve their productivity through adopting reliable open source software.	
MimePres4	Quite a number of our competitors benefit a lot from the use of open source software since it allow easy and flexible customization.	

Table 4.1. Opeartionalization of Availability of Mimetic Pressure

Coercive pressure is operationalized in terms of local government's attitude or policy toward OSS adoption:

Item	Wording	Scale (Source)
CorcPres1	The local government promotes the use of open source software.	7-point Likert scale (Adapted from Teo et al. 2003)
CorcPres2	The local government encourages organizations to use open source software.	
CorcPres3	The local government endorses the use of open source software.	

Table 4.2. Operationalization of Coercive Pressure

Normative pressure is operationalized in terms of the widely accepted practice of software adoption in the industry where the organization operates in:

Items	Wording	Scale (Source)
NormPres1	It is perceived to be a usual practice to use open source software in my industry.	7-point Likert scale (Adapted from Teo et al. 2003)
NormPres2	It is perceived to be professional to use open source software in my industry.	
NormPres3	In general, organizations in my industry still prefer software that is open source.	

Table 4.3. Operationalization of Normative Pressure

Based on Teo et al. (2003), the dependent variable -- adoption intention is measured by asking respondents to indicate whether they are seriously contemplating OSS adoption. These questions should lead to better prediction of behavior since they incorporate actions (contemplating to adopt, will adopt, will prefer to use), target (OSS), context (my organization), and time (in the near future, within one year) which are essential elements of intention and behavior:

Item	Wording	Scale (Source)
Intention1	Our organization will adopt open source software whenever it is possible.	7-point Likert scale (Adapted from Teo et al. 2003)
Intention2	Given a choice, my organization will prefer to use open source software in the near future (i.e., within 1 year).	
Intention3	Our organization is seriously contemplating to adopt open source software in the near future (i.e., within 1 year).	

Table 4.4. Operationalization of Organizational Intention to Adopt OSS

Other constructs, industry, organization size, and IT department size are all objective measures with only one item per construct. Respondents reported the industry in

which their organizations operated. Also, respondents recorded the number of employees and IT staff members in their organizations.

Construct	Wording	Scale (Source)
Industry (Ind)	Which industry does your organization belong to?	
Organization Size (OrgSize)	What is the number of employees in your organization?	Interval (Yasai-Ardekani and Nystrom 1996)
IT Department Size (ITSize)	What is the number of IT professionals in your organization?	Interval (Zmud 1984)

Table 4.5. Operationalization of Single-item Control Variables

All latent constructs are measured with multiple items on 7-point Likert scales, ranging from 1 (strongly disagree) to 7 (strongly agree).

4.2.2. Content Validity of Measurement

The cross-country survey for theme one study was a joint field research for theme two study. Thus content validity of measurement was assessed following the same procedure as it was described in theme one study. For detailed steps and procedures, please refer to the reports in Chapter 3.

4.2.3. Sample Selection and Survey Administration Procedure

The cross-country survey for theme one study was a joint field research for theme two study. For the details of sample selection, survey administration procedure and profiles of respondent organizations, please refer to the reports in Chapter 3.

Table 4.6 depicts the descriptive statistics of variables under investigation:

	Singapore Sample (N=81)		**China Sample (N=212)**	
	Mean	SD	Mean	SD
Independent Variables				
MimePres	3.74	1.26	3.71	1.10
CorcPres	3.62	1.36	4.02	1.22
NormPres	4.87	1.35	4.31	1.08
Dependent Variable				
Intention	3.55	1.50	4.10	1.13
Control Variables				
Industry	9.32	0.48	8.14	4.37
OrgSize	3.96	1.50	3.28	1.54
ITSize	2.75	1.55	2.12	1.20

Table 4.6 Descriptive Statistics of Variables

4.3. Data Analyses

The primary method for data analysis was structural equation modeling (SEM). In this study, MPLUS version 4 was used to perform confirmatory factor analyses of the measurement items that were used to capture the dimensions of the sub-constructs, assessing the structural model, and hypotheses testing. Using MPLUS for

confirmatory factor analyses facilitates a rigorous assessment of the fit between collected data and the theoretical factor structure, and satisfies the minimum requirements of assessing the measurement properties of unidimensionality, convergent validity, and discriminant validity.

4.3.1. Evaluating Measurement Model

Four multi-items constructs – mimetic pressure, coercive pressure, normative pressure, and intention to adopt – were subjected to confirmatory factor analyses using LISREL 8.51. The validity of the constructs was assessed in terms of unidimensionality, convergent validity, internal consistency, and discriminant validity (see Byrne 1998). All other constructs in the model were operationalized through single items.

The model structure of the four multiple-items constructs comprised of 12 items.[18] All indicator loadings were above the criterion of .707 (Hair et al. 1998) and, hence, all indicators were retained. The model fit indices provide adequate evidence of the unidimensionality of the items (see Table 4.7 and 4.8). All the indices satisfied the recommended threshold by Hu and Bentler (1999) and hence the model was deemed sufficiently "fit" (Marsh et al. 2004).

[18] The original Intent01 was removed from this data analysis based on the results of theme one study.

Goodness of Fit Indices	Model	Desired Levels
χ^2	110.618***	-
Df	48	-
GFI	.94	> .90
AGFI	.91	> .80
Standardized RMR	.042	< .05
NFI	.95	> .90
CFI	.97	> .90
Number of Latent Variables	4	-
Total Number of Items	12	-

Table 4.7. Goodness of Fit Indices for the Measurement Model

Construct Items	Standardized Parameter Estimate	t-value
Mimetic Pressure (MimePres)		
MimePres01	.888	33.777
MimePres02	.909	54.592
MimePres03	.915	65.730
MimePres04	.802	18.697
Coercive Pressure (CorcPres)		
CorcPres01	.914	46.257
CorcPres02	.911	29.463
CorcPres03	.928	73.977
Normative Pressure (NormPres)		
NormPres01	.835	3.855
NormPres02	.970	5.503
NormPres03	.735	2.595
Intention to Adopt (Intent)		
Intent02	.956	94.549
Intent03	.950	98.792

Table 4.8. Operationalization of Multi-Item Subconstructs:

Evidence of Unidimensionality

The internal consistency of each dimension was assessed by computing Cronbach's alpha, composite reliability of constructs,[19] and variance extracted by constructs[20] (AVE) (Hair et al. 1998; Fornell and Larcker 1981). Table 4.9 presents the results along these dimensions. All Cronbach's alpha and composite reliabilities exceeded Nunnally's (1978) criterion of .70 while the AVE for these constructs are all above the recommended threshold of .50 (Hair et al. 1998).

Dimensions	**No. of Items**	**Cronbach's Alpha**	**Composite Reliability**	**Average Variance Extracted**
Mimetic Pressure (MimePres)	4	.903	.932	.774
Coercive Pressure (CorcPres)	3	.908	.941	.842
Normative Pressure (MormPres)	3	.855	.887	.727
Intention	2	.900	.952	.909

Table 4.9. Assessment of Internal Consistency and Convergent Validity

Discriminant validity is assessed by using the indice Rhovc (Fornell and Larcker 1981). According to Fornell and Larcker (1981), the requirement for discriminant validity can be established for two constructs if the Rhovc values for the two constructs are each greater than the shared variance of two constructs. The Rhovc reflects the amount of average variance captured by a construct. It is formulated as:

Rhovc *(construct) =* *(sum of all squared loadings of all indicators for the construct) / [(sum of the squared loadings of all indicators for the construct) + (sum of the all residual variances of indicators for both constructs)]*

---

[19] Composite reliability of a construct is calculated as $(\Sigma (\lambda_i))^2 / (((\Sigma (\lambda_i))^2 + \Sigma (1 - \lambda_i^2))$ where λ_i denotes loading of question ***i*** on the construct.

[20] Average variance extracted is computed as $\Sigma \lambda_i^2 / (\Sigma \lambda_i^2 + \Sigma (1 - \lambda_i^2))$ where λ_i denotes loading of question ***i*** on the construct.

Table 4.10 provides strong evidence of discriminant validity. Additionally, as indicated in Table 4.10, the correlations between all pairs of constructs are also below the threshold of value of .90 (Bagozzi et al. 1991) reflecting that the constructs are distinct.

Dimensions	**Rhovc (A)**	**Rhovc (B)**	**Shared variance of constructs A and B**
Mimetic Pressure (MimePres = A)			
Coercive Pressure (CorcPres = B)	.645	.516	.138
Normative Pressure (NormPres = B)	.563	.477	.045
Intention to Adopt (Intent = B)	.645	.323	.152
Coercive Pressure (CrcPres = A)			
Normative Pressure (NormPres = B)	.576	.540	.045
Intention to Adopt (Intent = B)	.686	.608	.066
Normative Pressure (NormPres = A)			
Intention to Adopt (Intent = B)	.858	.890	.011

* A denotes the construct in bold and B denotes the construct without being bold. For instance, the Rhovc–value for mimetic pressure (MimePres = A) is Rhovc (A), which is .645, and for coercive pressure (CorcPres = B) is Rhovc (B), which is .561.

Table 4.10. Assessment of Discriminant Validity

	MimePres	CorcPres	NormPres	Intention	Industry	OrgSize	ITSize	TechCri
MimePres	**(.774)**							
CorcPres	-.375	**(.842)**						
NormPres	.142	-.240	**(.727)**					
Intention	.357	.274	.181	**(.909)**				
Industry	-.028	.042	.082	-.012	**(1.000)**			
OrgSize	-.015	-.104	.118	-.038	.101	**(1.000)**		
ITSize	.058	-.129	.003	-.064	-.031	.530	**(1.000)**	

Table 4.11. Correlation (Variance Extracted) Among Constructs

4.3.2. Evaluating Structural Model

Following confirmation of good psychometric properties in the measurement model, MPLUS was used to assess the structural model (see Table 4.12). All statistical tests were conducted at 0.05 significant levels (see Table 4.13)

Model / Construct	**China Sample (N = 212)**			**Singapore Sample (N = 81)**		
	M1	M2	M3	M1	M2	M3
MimePres	.295**		.296**	.631**		.580**
CorcPres	.142*		.146*	.024		.041
NormPres	.087		.089	-.167		-.156
Industry	-.012	-.005		.065*	.027	
OrgSize	.016	.014		.089	-.020	
ITSize	.006	.030		-.106	-.106	
R^2	.161	.005	.159	.268	.031	.219

- M1: full model; M2: control model; M3: theoretical model;
- * p < .05; ** p < .01

Table 4.12. Structural Model Comparisons

The explanatory power of a structural model can be evaluated by examining the R^2 (variance accounted for) in the final dependent construct. In this study, the final dependent construct (intention to adopt OSS) has R^2 values of .178, .161, and .268 for the pooled, Chinese, and Singaporean samples, respectively. Comparing the full models (M1) and the control models (M2), we observe that the full models explain incremental variances of 17.3% (17.8% - 0.50%), 15.6% (16.1% - 0.50%), and 23.7% (26.8% - 3.10%) for the pooled, Chinese, and Singaporean samples, respectively.

Hypotheses	China Sample	Singapore Sample
H1. Mimetic→Intention	Supported	Supported
H2. Coercive → Intention	Supported	Not supported
H3. Normative → Intention	Not supported	Not supported

Table 4.13. Summary of Hypotheses Testing Results

4.4. Discussions and Implications

This study constitutes one of the first cross-country tests of a fundamental linkage between institutional pressures and organizational intention to adopt OSS. Our evidence indicates that institutional pressure constructs – mimetic, coercive and normative pressures – can be clearly distinguished conceptually and empirically in terms of their influence on organizational adoption intention toward OSS. Examining the results of institutional pressures shows that both mimetic and coercive pressure have a significant impact on an organization's intention to adopt OSS in the Chinese sample while only mimetic pressure is significant in the Singaporean sample, and normative pressure is consistently insignificant in both samples.

4.4.1. Discussion of Results

Interestingly, mimetic pressure is significant in both samples. In our view, organizational imitation is often a chosen response to uncertainty. Faced with problems with unclear solutions, organizations adopt the solutions used by others. Such imitation represents an efficient mode or "problemistic" search (Cybert & March

1963; DiMaggio & Powell 1983). To conform to mimetic pressures, organizations aim to minimize the risks of innovation adoption. OSS, a unique innovation with unconventional development style, different ownership, and a special moral emphasis, has created high uncertainty and adoption risk, especially in a software market that is still dominated by proprietary software. Organizations in Singapore, a developed country whose business environment is characterized by a mature economy and conservative and uncertainty-avoidance culture[21], may put a lot of emphasis on minimizing risks in innovation adoption by imitating early adopters. The long history of IT adoption in Singapore has likely resulted in establishment of a recognized cadre of early adopters whom the majority follows. This effect is likely to be particularly prevalent in a city state confined to a small geographic area. This potentially explains the significance of mimetic pressure in Singapore. Similarly, organizations in China, a developing country with a long traditional and conservative business culture and less organizational resources, may also pay close attention to competitors' OSS adoption behavior in order to minimize the risks. It might also be that the newness of IT makes Chinese decision makers cautious and doubt their expertise in making independent judgments on IT investments. Thus, they tend to ape the decisions of others.

Coercive pressure, however, is significant only in the Chinese sample. Since its economic reform in 1979, China has undergone a dramatic transformation from a centrally-planned to market economy. The Chinese government considers that a

[21] http://www.educationnz.org.nz/eeidf/resources/E3.pdf (refer to page 84) (last visited on 25th April, 2006)

developing economy should maintain a balance among reform, development, and stability (Jacobs 2002). On the one hand, it admits that market forces can serve as the basic means of regulating the allocation of resources, and they should be fully exerted for the development of socialist market economy; otherwise economic development will lose its dynamism. On the other hand, it also feels that markets have limitations that need administration and guidance through macroeconomic control by the government, otherwise the economy will descend into chaos. Thus, the Chinese government's interference and influence in the country's business is still fairly evident, and Chinese organizational decision-makers are more sensitive to the government's attitude and propensity when considering innovation adoption compared with their Singapore peers who operate their business in an open and free market economy. What is more, China is one of the most aggressive countries in promoting OSS in Asia.[22] This could well serve as an explanation for the different effects of *coercive pressure* on organizations' adoption intention in these two countries.

The normative pressure is insignificant in both samples. This may be explained by the different tangibility of benefits or resources related to the three forms of institutional pressures. Organizations conform to mimetic pressure in order to gain benefits by minimizing potential losses due to uncertainty and risk; they conform to coercive pressure because they need to secure scarce resources that are controlled by the authoritative parties (e.g., the government). While to conform to the normative

[22] http://www.redhat.com/truthhappens/public_policy/osa/ (last visited on 25th April, 2006).

pressures, an organization's major concern is its image among its social network members. It does not want to appear to be unusual, unprofessional, or strange in its professional circle or industry. Compared with mimetic and coercive pressure, the benefits and resources related to normative pressure are more intangible. This suggests that, when making a software adoption decision, organizations in our samples care more about the tangible benefits (e.g., cost-savings, efficiency, and productivity increases) and resources (e.g., government support and subsidy) than the intangible benefits, such as peer group image. In other words, they do not care whether they would look strange or unusual to their peers if the adoption of OSS will create tangible benefits. They only want to conform to the software adoption norms in their industry to the extent that it will be beneficial to them. This contradicts the notion that organizations are overly concerned with in-group image (Dennis, Majken and Kevin 2000) and are even willing to sacrifice benefits in order to build or keep their images. This may not hold true in the context of OSS adoption, even in the Chinese sample, where organizations have a deep-rooted business tradition emphasizing "relationship" ("Guan Xi").

4.4.2. Limitations

The primary limitation relates to issue that only one respondent was surveyed for each organization. One respondent might not best represent an organization's actual opinions. However, to the extent that the questionnaire was administered to a CIO or

IS manager, who was likely to be the most cognizant of their environment, we believe that the single respondent problem should not be a significant flaw in this study. Another limitation concerns external validity. Sampling was limited to organizations in two Asian countries. Therefore, the results might have limited generalizability in other countries or areas. Further research is needed to assess the extent to which this study's results are applicable in diverse organizational and environmental settings.

It is also important to note that both independent and dependent measures were gathered through self-reports at a single point in time. When all measures are collected at the same time, respondents may give the answers that they believe the survey researchers expect to receive. One way to address this problem is to gather data on just the dependent variable from the same respondent at a later time (Fichman and Kemerer 1997). A telephone-based follow-up survey of a randomly selected 25 OSS non-adopting organizations from Singapore and 65 non-adopting organizations from China was conducted. A comparison of responses collected by the main survey and follow-up survey reveals a high degree of consistency between the two. Hence, we believe that this potential limitation did not materially affect the results.

4.4.3. Implications

This study has implications for theory and practice. With regard to theory, first, we propose approaching the study of innovation adoption by examining the technology properties and identifying the concerns, especially the inhibiting factors, that

practitioners must address when adopting an innovation. This approach also confronts the appropriateness of the search for a universal innovation adoption theory, which has been frequently sought in previous innovation adoption research. Second, this study extends the applicability of institutional theory to the technically and socially complex context of organizational OSS adoption. We further demonstrate that institutional theory can be successfully applied to OSS adoption to determine organizations' propensity to adopt OSS. We found strong support for the influence of institutional pressures on OSS adoption intention, with about 21.9% and 15.9 % of its variance explained in Singaporean and Chinese samples, respectively. We also surveyed two countries that differ in stability and maturity in their economic, political and legal systems and shed light on how the influences of institutional pressures may vary between organizations in a developed country and those in a developing country. The perspective of institutional pressure on OSS adoption intention in a cross-country setting adds to the extant literature on innovation adoption and serves as a call for more attention to be directed at understanding the influence of this factor in an increasingly technologically complex business environment.

Practically, our findings also have significant implications for organizations promoting OSS. Particularly, as evident in the survey results, institutional pressure is a crucial factor in determining the propensity for technology adoption. This provides a basis for more targeted promotion of OSS. Taking into consideration that mimetic pressure is significant in affecting an organization's OSS adoption intention in both

countries, OSS proponents should put more effort into creating incentives for large organizations (e.g., ITMA) or firms (e.g. HP, IBM) to support OSS in order to create mimetic pressure for other organizations to follow. Proponents should also actively promote the use of OSS in educational institutions (e.g., schools and universities). With proper encouragement, support and training, students should be able to learn how to develop and use OSS effectively. This generates an "alumni effect" and should directly or indirectly create mimetic pressure in the future when the graduates become influential in organizational software adoption decisions. OSS proponents should also notice the different roles that institutional pressures play in different countries. For example, in a country like China, where coercive pressure also has a significant impact on organizations' intention to adopt OSS, advocates might seek the government's support in promoting OSS adoption. While in a country like Singapore where only the mimetic pressure is important, OSS supporters might first focus on the most probable early adopters in each industry because their adoption will create the mimetic pressures on other organizations in the same industry.

Governments wanting to promote OSS can exert their influence directly by relying on the power of coercive pressure. For example, China's government has been developing its version of Linux for many years in order to remain self-sufficient and to protect national security. The government is also strongly promoting the use of OSS in China.[23] Another good example is the Linux city and Linux university plan

[23] http://www.redhat.com/truthhappens/public_policy/osa/ (last visited on 25th April, 2006).

by the Korean government [24]. The Korean Ministry of Information and Communication (MIC) has revealed a scheme for building a city and university that will operate as test beds for OSS. The Korean government also provides subsidies for organizations that use Linux or other OSS products.[25] Not surprisingly, there has been a surge of OSS adoption in these two countries. The governments of the world are among the key players in building the momentum of OSS.[26] As an increasing number of governments propound the benefits of OSS, they become driving forces in removing impediments to its deployment.

4.4.4. Future Research

We see several directions for further research:

- First, the present study only looks at how the three forms of institutional pressures influence the organizational OSS adoption intention without examining their inner mechanisms. We believe further investigation of potential mediators or moderators on the relationship between institutional pressures and organizational OSS adoption intention will help open up this black box and contribute to the institutional theory and innovation adoption literature;

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[24] http://times.hankooki.com/lpage/tech/200602/kt2006021517494311780.htm (last visited on 25th April, 2006).

[25] http://times.hankooki.com/lpage/tech/200602/kt2006021517494311780.htm (last visited on 25th April, 2006).

[26] http://www.redhat.com/truthhappens/public_policy/osa/ (last visited on 25th April, 2006).

- Second, organizational OSS adoption can be studied from other perspectives. For example, following the argument by Barket and Mueller (2002) that certain characteristics, such as age, of a Chief-Executive-Officer (CEO), decision-maker of an organization, may be associated with an organization's research and development budget, it would be interesting to see whether organizations with CIOs and the IS managers of certain psychological characteristics are more likely to adopt OSS.

- Lastly, future research can be conducted to examine OSS adoption by expanding this study to other countries which have very dissimilar cultural, economic, political and legal systems from those of Singapore and China. We conjecture that national cultural might be an influential factor affecting an organization's propensity for OSS adoption.

In conclusion, the notion that software adoption in general is often dictated by how many others have adopted it raises the question of whether institutional pressure influences the propensity for OSS adoption. From the institutional perspective, whether an organization adopts OSS depends on the presence and degree of mimetic, coercive, and normative pressure. This study adds to the institutional literature by suggesting that the influence of these pressures could vary across countries. For instance, we observe that both the mimetic and coercive pressure could be affect Chinese organizations, while those in Singapore are more likely to be influenced by

mimetic pressure. In a globalizing world economy with nations at differing stage of economic, legal, political, and social maturity, it is imperative that we test theories in diverse situations. In particular, theories of technology adoption need careful evaluation and testing because the speed with which a nation can adopt a new technology often has a telling influence on its international competitiveness. If we can determine how to accelerate organizational technology acceptance in some of the less developed nations, IS scholars might be able to influence the rate of poverty reduction, surely a goal well worth pursuing. Thus, while this study had rather modest goals, it does provide some thoughts and ideas on how to further investigate an important economic development issue.

CHAPTER 5

A SOCIAL CAPITAL PERSPECTIVE OF OPEN SOURCE SOFTWARE ADOPTION IN ORGANIZATIONS: AN EXPLORATORY STUDY OF OSS OPINION LEADERS' NETWORK PROFILES

This chapter addresses the research questions explored by theme three. Specifically, we posit that within an organization's IT department, OSS opinion leaders should have different social network profiles in terms of degree of centrality, betweenness, closeness and in-degree centrality from their peers who are not OSS opinion leaders. We also postulate the differences in their demographic characteristics such as age, educational level, tenure in organization, position in organization, and personality profiles such as openness and extraversion. A filed survey using Social Network Analysis technique was carried out to test the hypotheses. Based on the findings obtained from the empirical study, important theoretical and practical implications are identified.

5.1. The Research Hypotheses

Another unique property of OSS is its zero cost and wide availability which has enabled a different way of innovation adoption in organizations which will be thoroughly investigated in this study. During the theme one and theme two studies of

the organizational intention of adopting OSS from the human capital and institutional perspectives, we had an interesting observation through our formal and informal interactions with employees of OSS adopter organizations in the two countries: in quite a number of cases, OSS was not firstly introduced into the organizations by the IS management team (e.g. CIO) with any formal decisions of adoption; instead, employees simply installed the software on their computers and used it in their work all by themselves. Through time, their individual pioneering behaviors in OSS adoption would influence other employees and even caught the attention of the management team, which may then formally introduce OSS to the whole organization.

This observation confirms with the result of a 2003 survey conducted by the CIO magazine[27]. This survey reveals that among the OSS adopter organizations, 37.8% of them reported the way how OSS was introduced to their organizations is through informal deployment, which means developers using the OSS on ad hoc basis without management commanding or pushing. Compared with the conventional top-down approach (formal) of how a technology innovation was introduced in and adopted by an organization (e.g. SAP), this relatively large portion of bottom-up (informal) cases of how OSS was introduced into organizations may be explained by the unique nature of OSS as an innovation: low cost or zero cost of acquisition, wide availability of the software and the freedom in changing the source code and customize software without

[27] http://www2.cio.com/research/surveyreport.cfm?id=51

the permission from the organization's managers. Based on this result, we can depict a scenario which should be common to organizational introduction and adoption of OSS: some "key employee" who is an OSS opinion leader in the organization, without being formally commanded by the managers, leverages on his own social capital to influence other employees' perception on OSS through interaction with them by face-to-face contact, email exchange or telephone talk, thus informally promotes the OSS adoption in the organization.

Based on the above analysis, leveraging on the strength of social network analysis method, we set out to investigate the differences of OSS opinion leaders' social network profiles in terms of degree of centrality, in-degree centrality, betweenness, and closeness from those of their peers who are not OSS opinion leaders.

In this study, we will diagram three types of relationship networks proposed by Krackhardt and Hanson (1993): the advice network, the communication network and the trust network:

The Advice network: It shows the prominent players in an organization on whom others depend to solve problems and provide technical information related to work (Krackhardt and Hanson 1993). Mapping advice network will reveal the most influential players in the day-to-day operations of a company and it is useful to examine such networks when a company is considering some changes.

The communication network: It reveals the employees who talk to each other about work-related or non-work related matters on a regular basis (Krackhardt and Hanson 1993). Mapping communication networks will help identify gaps in information flow, the inefficient use of resources, and the failure to generate new ideas. The communication networks should be examined when the organization's productivity is low.

The trust network: It tells which employees share delicate potential information and back on another in a crisis (Krackhardt and Hanson 1993). Mapping trust network often reveals the causes of non-routine problems such as poor performance by temporary teams. Companies should examine trust network when implementing a major or experiencing a crisis.

5.1.1. Degree of Centrality of OSS Opinion Leaders

The degree of centrality is defined as the number of direct links to or from a member in the network (Brass 1992). Based solely on direct connections, degree of centrality has been conceptualized as a measure of a member's activeness (Freeman 1979) or the ***size*** of a member's social network (Burt 1982). Having more direct contacts (i.e. being more active within the network and having a larger social network size) can mean more referrals, more access to resources, more exposure, and earlier exposure to valuable information (Burt 1982). A member with more direct contacts is more likely

to be connected with other powerful actors in the network, potentially receiving information of higher quantity and quality than individuals with less direct contacts (Burt 1982). Based upon the exchange perspective on power, increasing a person's alternatives in contacts increases his or her power. An employee with many direct contacts may be perceived by others as powerful and influential because having many contacts is intuitively associated with power and resources (Brass 1992). Being perceived as having power may be a necessary, and sometimes sufficient, condition for implementing a person's preference.

For OSS opinion leaders, who have the power to lead in influencing others' attitude toward OSS adoption, they should be those who are more active or have larger social networks in the system, thus able to implement their own ***preference***, in this case, the adoption of OSS, within their department. An individual's measure of degree of centrality in a social network has been empirically associated with several important variables that might lead to superior performance. One of the most important ones is ***influence*** (Burkhardt and Brass 1990). OSS opinion leaders are more likely to be in a central position in his network which will allow him to exert more influence on others' perception of OSS by virtue of being linked with a large number of people in the network (Burt 1982). We thus posit a higher degree of centrality will be the characteristics of OSS opinion leaders compared with non OSS opinion leaders no matter it is in the advice network (more active in giving/enquiring advice for solving work-related or technical problems), communication network (more active in routine

communication be it work-related or non work-related) or trust network (have a larger number strong ties which can be utilized to back one in crisis). We thus hypothesize:

***H1a**. Degree of centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the advice network.*

***H1b**. Degree of centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the communication network.*

***H1c**. Degree of centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the trust network.*

5.1.2. In-degree Centrality of Opinion Leaders

In measuring degree of centrality of an employee, we assume all the ties among the members are symmetric and the direction of ties among them is not under consideration. However, in reality, ties can also be distinguished by examining whether a member is the source or the object of a relationship. For example, member A is the object of friendship from member B. If member B is also the object of friendship from member A, then this tie/relationship can be classified as symmetric. However, if member A did not reciprocate the friendship of member B, the relationship would be considered asymmetric. Therefore, the degree of centrality is also broken down into two measures, in-degree centrality refers to the number of direct ties in which the actor is the object of the relation and out-degree centrality

refers to number of direct ties from the actor (source) to others (objects). While degree of centrality emphasizes more on quantity of ties, in-degree centrality is a more accurate indicator for quality of ties. In-degree centrality reflects deference of popularity: the number of times an actor is chosen by others, thus it is also referred to as ***prestige*** by Knoke and Burt (1983). From a cognitive attribution perspective, initiating contact may connote dependence (Murnighan and Brass 1991).

For an OSS opinion leader who is highly influential on people's attitude toward OSS, he may achieve his status through different routes: (1) he can be an expert in technical knowledge upon whom others will be dependent on for technical advice (center of the advice network); Others may also trust his choices of an innovative technology due to his prestige as a technical authority; (2) or he may be a popular figure in the communication network who are welcomed by most of the people so that he can spread the news of OSS to influence others through this less formal relational network[28]; (3) he may also be the center of trust network whom is considered to be reliable and whom is often recruited to share someone's concerns of work-related issues or to back someone in a crisis. Thus, the OSS opinion leaders' in-degree centrality should be higher than Non OSS opinion leaders in their department:

[28] The distinction between formal and informal sources of influence is that the latter arises from a member's position in the actual patterns of interaction rather than a formally defined position in the organizational hierarchy (Monge and Eisenberg 1987). In-degree centrality can also be viewed as a source of informal power. Like formal authority, it can translate into a high level of access to various resources (Burt 1982).

***H2a**. In-degree centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the advice network.*

***H2b**. In-degree centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the communication network.*

***H2c**. In-degree centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the trust network.*

5.1.3. Betweenness of OSS Opinion Leaders

Betweenness (Freeman, 1979) examines the extent to which a member is between all other members within the network. If member A and member C are connected only through member B, B would then fall "between" A and C and would mediate the flow of any information or resources between A and C. This property of social network has also been conceptualized as ***Brokerage*** (Burt 1982) or ***Structural Hole*** (White 1970). It measures the individual's potential control over others. Freeman (1979) suggests that betweenness is particularly appropriate for assessing power in communication networks: a mediating person may withhold or distort information in transition. A member with higher betweenness score is the one who are highly depended by others in the system and being depended is a vital source of power.

OSS opinion leaders who are powerful in influencing others' attitude toward OSS are more likely to have higher betweenness score in the advice network (with tacit expert

knowledge that not possessed by others), in the communication network (holding more brokerage positions that will facilitate or block information flow in the system), and in the trust network (being perceived as reliable and trustworthy and irreplaceable by other members). We therefore hypothesize:

***H3a**. Betweenness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the advice network.*

***H3b**. Betweenness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the communication network.*

***H3c**. Betweenness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the trust network.*

5.1.4. Closeness of OSS Opinion Leaders

Closeness of an individual's social network is generally calculated by summing the lengths of the ***shortest*** paths from a node to all other nodes, indicating how "close" an individual is to all other members in the network. Conceptually, the closeness measure has been interpreted as efficiency (extent to which a member can reach all other members in the shortest number of steps) and independence (being close to all other members, an individual is less dependent on any of them as intermediaries). It indicates the extent to which an individual can avoid the control of others. While some overlap between the two measures of betweenness and closeness would be

expected, it is advisable to consider them as complementary rather than competing or repeating. Closeness and betweenness represent the two necessary resource-dependency conditions for acquiring power (Brass 1985): decreasing or avoiding your dependence on others (closeness) and increasing or controlling others' dependence on yourself (betweenness).

OSS opinion leaders who can have significant effect on other members' perception on OSS within the department are more likely to be more efficient than non OSS opinion leaders in reaching all other members in the advice network (have smaller number of steps to reach technical experts), in the communication network (less dependent on any of the other members in communication within the network), and in the trust network (faster and easier in reaching someone who are perceived to be reliable). We thus hypothesize:

> ***H4a***. *Closeness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the advice network.*
>
> ***H4b***. *Closeness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the communication network.*
>
> ***H4c***. *Closeness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the trust network.*

5.1.5. Demographic and Personality Variables

Besides investigating the main social network properties of an IT department's employees, we also include measurements of their major demographic and personality traits in our study in order to have a more holistic profile of OSS opinion leaders versus non OSS opinion leaders. The argument for factoring the following variables is mainly based on an individual's innovation adoption tendency (being an OSS adopter is the pre-request for being an OSS opinion leader) instead of on his social network properties.

Age. Previous studies indicate that older people tend to be more conservative than younger ones (Hambrick and Mason 1984) in terms of innovation adoption since they have greater difficulty grasping new ideas and learning new behaviors due to diminished cognitive ability (Burke and Light 1981), relatively outdated education and technical knowledge (Bantel and Jackson 1989), and more emphasis on stability and security in life and career (Hambrick and Mason 1984). We therefore factor in Age as a demographic variable in the OSS opinion leaders versus non OSS opinion leaders profiling, in the belief that OSS opinion leaders should be younger than non OSS opinion leaders.

Tenure in organization. Previous researches advocate that years of inside service of employees are negatively related to their choice involving new terrain (Hambrick and

Manson 1984). This is because as the years of tenure increase, employees may have more psychological commitment to the organizational status quo (Staw and Ross 1980) and inertia to new technology (Hambrick and Fukutomi 1991). We therefore take into consideration tenure as a demographic variable in the OSS opinion leaders versus non OSS opinion leaders profiling, in the belief that OSS opinion leaders should have shorter tenure than non OSS opinion leaders

Educational level. Prior studies show that the amounts of formal education an employee has had are positively associated with their attitude toward innovation (Hambrick and Manson 1984). This is because higher levels of education are associated with an employee's ability to absorb new ideas and thus increases his tendency toward using and promoting an innovative technology. We posit that OSS opinion leaders should have higher educational level than non OSS opinion leaders. Therefore this variable is included in the profile.

Position in organization. The focus of this study is to examine the influence of individuals' informal networks behind the organizational chart. However, a formally defined position in the organizational hierarchy (Monge and Eisenberg 1987) comes naturally with power, resources and influence. For example, CIO or IT managers in an IT department should be more influential in terms of innovation adoption decision compared with employees on lower position. We posit that OSS opinion leaders

should hold higher position in the organization compared with non OSS opinion leaders.

Openness. Openness describes a person who is imaginative, creative, original, curious, sensitive, unconventional, flexible, broad-minded and adventurous (Costa and MaCrae 1992). Previous studies suggest that employees with high openness would seek out new information and emphasize reacting and adapting to changing conditions through innovation. This kind of people are more sensitive to changes and more willing to accept innovations. We therefore include this personality variable in OSS opinion leaders' profile and we believe they should have a higher degree of openness compared with non OSS opinion leaders.

Extraversion. Extraversion is the degree to which a person is ambitious, active, assertive, gregarious and sociable (Costa and MaCrae 1992). People high in extraversion tend to take actions to influence environmental change by scanning for opportunities, showing initiatives, taking action and persuading people (Bateman and Grant 1993). For OSS opinion leaders, proactiveness and persuasiveness are necessary characteristics in order for them to promote OSS and influence others' opinion about it. We thus include extraversion in OSS opinion leaders' profile and we believe they should have a higher degree of extraversion compared with non OSS opinion leaders.

5.2. Research Methodology

In order to test the hypotheses, field survey methodology was adopted. Data were collected from a paper-based survey questionnaires administered to employees of IT departments in fifty companies in China, during the six-month period from August 2006 to January 2007. Social Network Analysis (SNA) is the main methodology applied in the field survey. Social network analysis is "a method of research for identifying the communication structure in a system, in which relational data about communication flows are analyzed by some type of interpersonal relationships as the unit of analysis" (Rogers and Kincaid 1981, p. 24). A communication network consists of interconnected nodes (individuals) linked by ties (communication flows), representing informal communication patterns that crystallize over time.

In contrast to the first and second study which collected data at the organizational level, this study collects data at the individual level. Besides answering basic demographic questions, each respondent was required to fill up a social network analysis matrix which will reveal the communication network, advice network and trust network within the department. Each respondent was also asked to answer a question aimed at identifying whether or not he is an OSS opinion leader. We defined OSS opinion leaders as individuals who lead in influencing others' opinions about OSS adoption by actively advocating OSS and encouraging other colleagues to use it.

This part describes the process of operationalization of constructs, conceptual validation of measurement, and the field study which includes sample selection, survey administration and a report of respondents' profiles.

5.2.1. Development of Measures

Prior to developing measurement instruments for the main constructs of interest, literature is extensively searched for tests and scales that were already developed and evaluated in terms of validity and reliability. Where available, questionnaire items are drawn from previous research; otherwise, new items were created. Special care was taken to ensure that items adapted from prior studies were updated with terminology that is more current or revised to adhere more closely to general principles of item construction, such as avoiding double-barreled questions.

Employees' communication network, advice network and trust network are measured by asking subjects to fill up the social network matrix of his department based on the following questions used by Krackhardt and Hanson (1993). We adopt a "Roaster Technique" (Rogers 1995) in which each respondent is presented with a list of all the other members in their department, and asked whether he or she talks with each of them, seeks advice from each of them or trusts each of them. The roaster technique captures a holistic social network within a system and has the advantage of measuring weak as well as strong links (Rogers 1995). To answer each of these questions, a

respondent is asked to go through the complete list of member in their department and tick those who satisfy the requirement of the question. The detailed questionnaire is shown in Appendix C:

Network	Wording	Scale (Source)
Communication Network	Within your Department, whom do you talk to everyday for work-related or non work-related issues?	Social Network Matrix by Roaster Checking (Krackhardt and Hanson 1993)
Advice Network	Within your Department, whom do you often go for help or advice for work-related problems?	
Trust Network	Within your Department, whom would you trust to keep in confidence your concerns about a work-related issue?	

Table 5.1. Operationalization of Network Questions

Personality variables. We adapted personality variables mainly from International Personality Item Pool[29]. Because the pool of personality constructs (*openness, and extraversion*) contained too many items (about 30; see Appendix C for the full scale and selected items), and using all of them would make our questionnaire unbearably long, we collected data from 150 Management of Information Systems (MIS) undergraduates to trim the instruments for each of the personality constructs. Factor analysis based on responses was performed to identify and select four items with the highest factor loadings in each construct (see Appendix A). We anchored all personality items on a 1-to-7 Likert scale (1=strongly disagree; 7=strongly agree).

[29] Source: http://ipip.ori.org/ipip/ ; last visited: September 20, 2004.

Openness is operationalized in terms of how creative, original, curious, unconventional, flexible, broad-minded and adventurous a person is:

Item	Wording	Scale (Source)
Open01	I love to read challenging material.	7-point Likert scale (Adapted from Li et al. 2006)
Open02	I am quick to understand things.	
Open03	I love to think up new ways of doing things.	
Open04	I like to challenge the norms.	

Table 5.2. Operationalization of Openness

Extraversion is operationalized in the degree to which a person is ambitious, active, assertive, gregarious, sociable and excitement-seeking (Costa and MaCrae 1992).

Items	Wording	Scale (Source)
Extra01	I feel comfortable around people.	7-point Likert scale (Adapted from Li et al. 2006)
Extra02	I talk to a lot of different people at parties.	
Extra03	I know how to captivate people.	
Extra04	I am skilled in handling social situations.	

Table 5.3. Operationalization of Extraversion

Demographic variables. We adapted the operationalization of demographic variables mainly from Barker III and Mueller (2002). We measured *age* by asking respondents to indicate their exact age. Although this may arouse discomfort from respondents, we deem it necessary since the age range within IT departments tends to be small. Thus letting respondents choose an age range to which they belong may show no variance

in the results of their ages in the end. (see Appendix D). We took this approach to minimize the discomfort respondents might experience when responding to sensitive questions such as about age. We measured *educational level* by asking respondents to provide the highest degree they had obtained (1= Diploma; 2= Bachelor; 3=Master; 4=PhD; and 5=others). We measured position by asking respondents to indicate which position they held in the department (1= Engineer, 2= Project Manager, 3= IT/IS manager/director, 4= CIO). We measured *tenure* by asking how many years the respondent had been in the position in his current organization of affiliation.

5.2.2. Content Validity of Measurement

Content validity refers to the extent to which a measurement represents all facets of a given construct. Content validity of all items, and especially new items, was carefully assessed:

- First, all items were scrutinized by three faculty members (in Department of Information Systems, School of Computing, National University of Singapore) with expertise in measurement theory and questionnaire design to identify and rectify potential problems due to framing and wording of questions. Based on their feedback, we rewrote some of the items with obscure meaning which may cause confusion to survey subjects.

- Second, we followed a double translation method to assure the content validity was not lost in the translation process since this is a cross-cultural survey study and the English and Chinese versions of the questionnaire were used in Singapore and China respectively. In the case of the Chinese version, the questionnaire was first translated into Chinese by a technical writer from the culture. Next, the translated questionnaire was back-translated into English by another technical writer from the same culture. Based on this double translation process, minor corrections were made to the Chinese version of the questionnaire to ensure that the equivalence of meanings of all items across the two versions. Several academics, bilingual in both languages, were invited to review the survey questionnaires for both languages for clarity of instructions, content validity, and semantic consistencies. Based on this feedback, the survey instrument was deemed acceptable.

5.2.3. Sample Selection and Survey Administration Procedure

Organizations are very different in their tolerance for disclosure of information about various social relations (Cross, Borgatti and Oarker 2002). So we were very careful about the way we approached them. The field survey was administered to organizations in China, following a snow ball sampling scheme. We were referred to some companies' IT departments through our contacts in China. We would proceed with them after making sure that they were non OSS adopter organizations. The first

step was to convince the IT department head that this survey would be valuable to reveal the informal relational network behind the company's formal organizational chart. However, most of them felt the questions were too sensitive for the employees to answer especially when there was no way for us to ensure ***anonymity*** for them. In the end, among the 102 companies we contacted, 41 of them which satisfied our criteria agreed to conduct the survey for us in their IT departments.

A total of 615 questionnaires were administered to IT department employees through their department heads. Some of them distributed the questionnaires to employees and make it as an administrative command for them to fill it up, while most of them distributed the questionnaires and encouraged their employees to fill it up, but left the final decision to themselves. In order to increase response rate, follow-up phone calls were made to the department heads and emails were sent.

During the six-month period from August 2006 to January 2007, 138 completed questionnaires from 32 companies were returned, yielding a response rate of 22.4% which is considered reasonably high because the survey was unsolicited and it involved sensitive information about human relationships (Guan Xi). However, only 87 data sets from 5 companies included responses from all the employees in their IT department. A tricky part of Social Network Analysis is that every member within the system needs to respond to the survey because social capital, unlike human capital or financial capital, is a thing owned ***jointly*** by the parties to a relationship (Brass 1985).

No one player has exclusive rights to social capital. If you or your partner in a relationship withdraws, the connection, with whatever social capital it contained, dissolves. So that for Social Network Analysis, if some members in the system do not respond to the survey, with a high possibility that they are "key members" who sit at the center of the network and who have the power to be indifferent to such surveys, the social network map drawn for this system will be severely distorted. Therefore, only 87 completed data sets from 5 companies whose IT departments' employees all participated in the survey were used for data analysis.

5.3. Data Analyses

The primary method for data analysis was Social Network Analysis (SNA). In this study, UCINET 6 version 6.152[30] was used to perform the network analysis. It is a comprehensive package for the analysis of social network data. Matrices of the relationships among the individuals can be developed with data collected through the network survey. UCINET 6 can then convert these matrices into individual network scores for degree of centrality, betweenness, closeness and in-degree centrality (See Appendix F for individual's network scores in three types of networks in the five companies). Visualized network of relationships can also be produced by the NetDraw Module of UCINET 6 (See Appendix G for visualized networks of three types in the five companies.).

[30] Available at http://www.analytictech.com/ucinet/ucinet.htm (last visited on June 20th, 2007)

Table 5.4 gives the means of the network variables in three types of networks and also the means of demographic and personality variables for both OSS opinion leaders and non OSS opinion leaders in the 5 companies. Table 5.4 also reports the results of *t*-tests of the differences in means of the network variables, demographic variables and personality variables. As predicted, the two types of employees differ significantly on a large number of social network characteristics and some of the demographic and personality variables.

		OSS Opinion Leaders (N=29)		Non OSS Opinion Leaders (N=58)		
	Variable	Mean	s.d.	Mean	s.d.	*t**
Communication Network	Degree	6.83	1.93	4.31	1.76	5.91*
	Betweenness	12.42	10.05	6.44	8.59	2.74*
	Closeness	48.45	17.98	55.69	19.23	1.73
	In-degree	6.10	1.95	3.19	1.46	7.11*
Advice Network	Degree	10.83	2.70	5.86	2.52	8.27*
	Betweenness	11.44	9.65	2.28	4.20	4.88*
	Closeness	42.03	13.38	49.55	14.91	2.38
	In-degree	9.24	2.85	1.62	2.92	11.64*
Trust Network	Degree	5.17	1.95	2.93	1.31	5.59*
	Betweenness	18.46	16.51	8.79	11.46	2.75*
	Closeness	53.72	20.56	63.40	22.80	1.99
	In-degree	4.79	2.62	1.67	1.28	6.06*
Demographic and Personality Variables	Age	28.31	3.17	28.78	2.80	0.67
	Degree	2.48	0.51	2.43	0.50	0.45
	Position	1.79	0.49	1.19	0.40	5.75*
	Tenure	3.38	2.14	3.16	1.94	0.47
	Openness	4.90	1.14	4.84	1.30	0.19
	Extraversion	4.14	0.99	2.52	1.30	6.46*

* $P < 0.005$

Table 5.4 Comparison of Means for OSS opinion leaders and non OSS opinion leaders

Table 5.5 summarizes the hypothesis testing results. More detailed discussion of the results will be presented in the following section.

Hypotheses	
H1a. Degree of centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the advice network.	Supported
H1b. Degree of centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the communication network.	Supported
H1c. Degree of centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the trust network.	Supported
H2a. In-degree centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the advice network.	Supported
H2b. In-degree centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the communication network.	Supported
H2c. In-degree centrality of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the trust network.	Supported
H3a. Betweenness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the advice network.	Supported
H3b. Betweenness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the communication network.	Supported
H3c. Betweenness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the trust network.	Supported
H4a. Closeness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the advice network.	Not Supported
H4b. Closeness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the communication network.	Not Supported
H4c. Closeness of the OSS opinion leaders' social network would be higher than that of Non OSS opinion leaders in the trust network.	Not Supported

Table 5.5. Summary of Hypothesis Testing Results

5.4. Discussions and Implications

This study constitutes one of the first exploratory researches that profile the individual's social capital characteristics in three different types of networks and their tendency or capability to promote OSS within an organization. Interestingly, our evidence indicates that the scores for social capital variables such as *degree of centrality, in-degree centrality* and *betweenness* are significantly different between OSS opinion leaders and non OSS opinion leaders across all the three types of network under investigation, namely the advice network, the communication network and the trust network. However, *closeness* is consistently insignificant in differentiating OSS opinion leaders and non OSS opinion leaders in these three types of network. For demographic variables and personality variables, these two groups of people have significantly different scores in *position in organization* and *extraversion.* There is no difference found in their *age*, *educational level, tenure in organization,* or *openness*.

5.4.1. Discussion of Results

5.4.1.1. Social Network Variables

As it is indicated by Table 5.4, the differences in in-degree centrality between OSS opinion leaders and non OSS opinion leaders are the most significantly throughout

different types of networks, while the differences in degree of centrality between these two groups are less significant. This further confirms with our hypothesis that the quantity does not equate to quality. While degree of centrality emphasizes more on quantity of ties, in-degree centrality is a more accurate measurement for quality of ties. In-degree centrality reflects deference of ***popularity***: the number of times an actor is chosen by others (Knoke and Burt 1983). From a cognitive attribution perspective, initiating contact may connote dependence (Murnighan and Brass 1991). Our evidence highlights the importance of ***prestige*** of an individual's social network position for him to become an opinion leader in the system.

Differences in betweenness are even less significant between OSS opinion leaders and non OSS opinion leaders. While in-degree centrality focuses on the measure of popularity and prestige of an individual, betweenness emphasizes more on an individual's ***control*** over others as brokerage or bridge in the systems. Our results indicate that while such control may be the vital source of power, it may not be an equally important source of ***influence*** which is the most distinctive characteristics of an opinion leader.

Closeness is the only network variable which is consistently insignificant in differentiating OSS opinion leaders from non OSS opinion leaders in all types of the three networks. While betweenness measures the extent to which an individual increases his control over others, closeness measures the extent to which an individual

decreases his dependences on others. The data in our survey shows that being less dependent on others does not equate to being influential to others. This may explain why the differences in closeness are insignificant between these two types of employees in all types of networks.

The results of social network variables imply that in-degree centrality is the most important characteristics that distinguishes OSS opinion leaders from non OSS opinion leaders, followed by degree of centrality and betweenness. Closeness is not a good indicator to differentiate these two groups of people.

5.4.1.2. Three Types of Networks

Another interesting discovery we made is that the differences in all the four social network variables between OSS opinion leaders and non OSS opinion leaders are most significant in the advice network. This can be explained by the nature of the IT department which is technical-oriented so that the advice network may be the dominant one among the three. And OSS opinion leaders may accumulate their power of influence mainly through the advice network in which they are technical experts who are the sources of advice and solutions for work-related problems. Due to their authoritative position in the domain of technical knowledge, others tend to trust and follow their choice of innovative technology, in this case, OSS

As it is shown in Figure 5.7. Figure 5.8, and Figure 5.9 (three types of networks in company 3), the advice network is the most intensive one while the trust network is the sparsest one in the department. This is reasonable since an employee may communicate and seek/give advice to a lot of other members in the system, but he may trust much fewer of them.

Blue nodes represent OSS opinion leaders and red nodes represent non OSS opinion leaders in the following figures. We can see most of OSS opinion leaders are having a dominantly central position in the advice network although there are non OSS opinion leaders who are also central in this network (e.g Player P). In the communication network, OSS opinion leaders' dominant position is weakened while in the trust network it is the weakest among all types of network (e.g. Player B and H are more central than most of the OSS opinion leaders in the trust network). This implies that technical experts upon whom people depend for solutions to work-related problems may not be the one who others can trust for concerns of company politics-related issues and recruit to back oneself up in a crisis.

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Based on this analysis, we can claim compared with the communication network and the trust network, the advice network should be more important for investigation when an organization is considering of the adoption of an innovative technology such as OSS. And technology opinion leaders' influence on others is mainly established through their central position in the advice network.

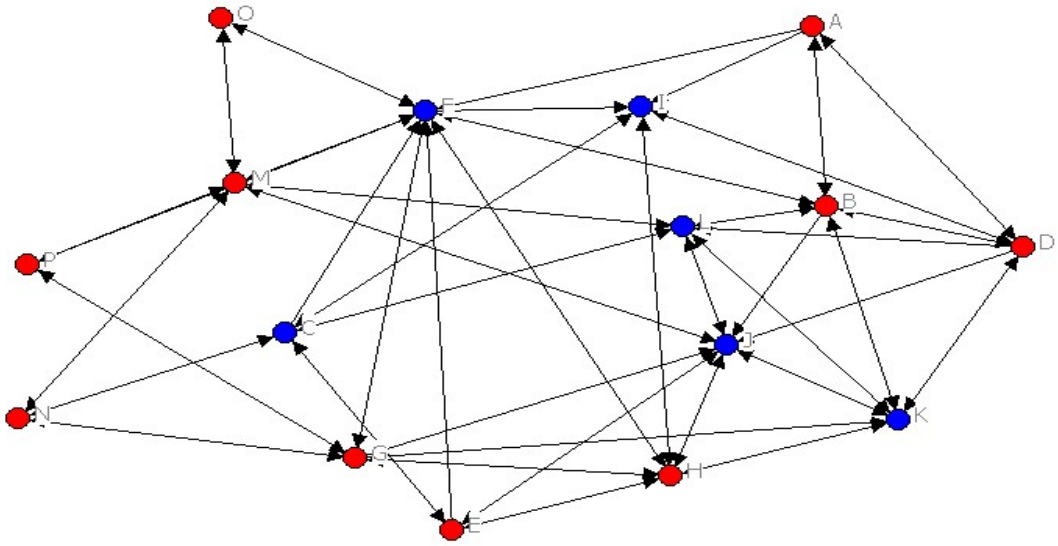

Figure 5.7 Communication Network in Company 3

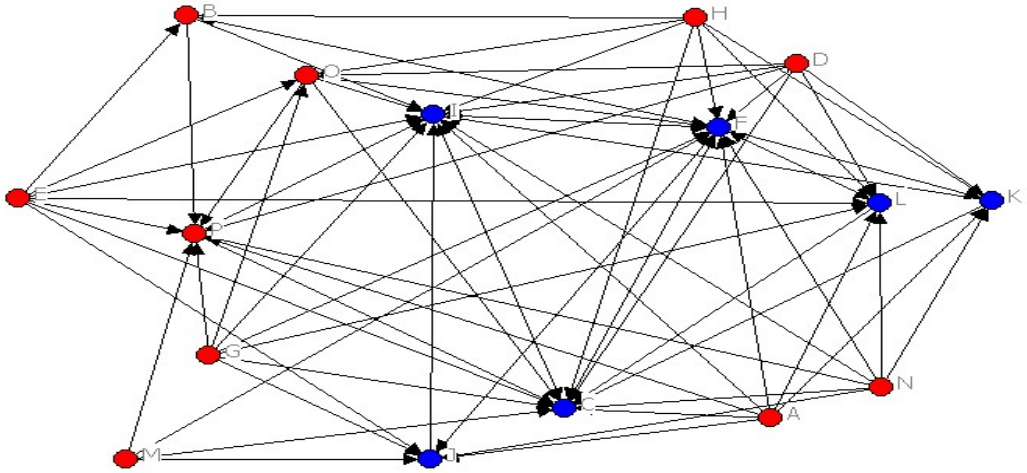

Figure 5.8 Advice Network in Company 3

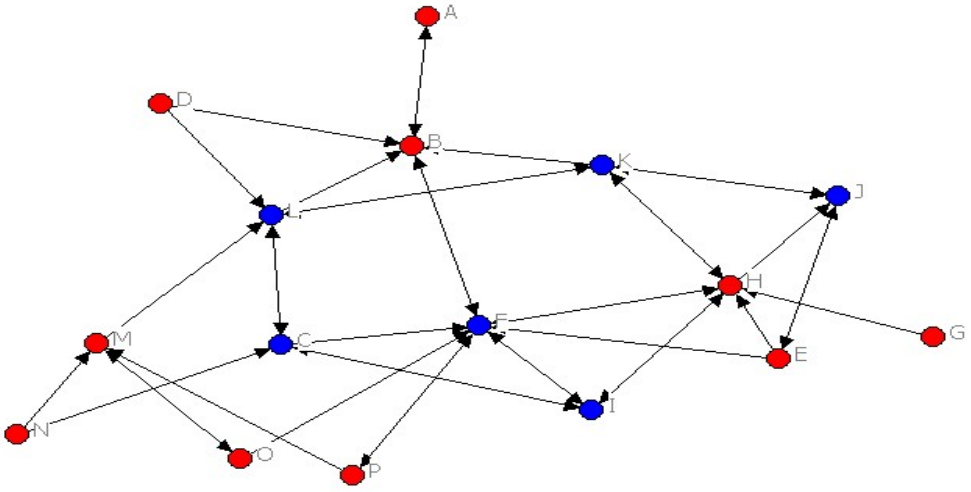

Figure 5.9 Trust Network in Company 3

5.4.1.3. Demographic and Personality Variables

In the four demographic variables under investigation, no differences were found in *age*, *educational level* and *tenure in organization* between OSS opinion leaders and non OSS opinion leaders. However, these two groups are significantly different in *position in organization* which indicates that formally defined leading position (e.g. IT managers) is a natural source of power that will contribute to the individual's status as an OSS opinion leader.

Actually, by highlighting this thought-provoking discovery and the influence an OSS opinion leader employee can exert on other employees through informal infleunce, we do not intend to overlook the role managers (e.g. IT managers or CIO) play in promoting OSS adoption in the organizations. On the contrary, we believe IT managers or CIOs should have a more advantageous position to promote OSS, however they behave differently by applying different strategies to cope OSS whose adoption mechanism is unique.

Earlier in the organizational study of leadership, there has been a debate on managers' actual working style. The classical view of the manager emphasizes his decision-making role in an organizational hierarchy of authority (Barnard 1938). Because responsibility for the well-being of the organization increases as one moves up this hierarchy, the image of the managers that emerges from this perspective is one

consistent with those activities often thought to produce successful firm-performance: long-range planning, efficient organizing, and issuing goal–oriented directives. Later, however, Mintzberg's (1973) analysis demonstrates that this classical view is misleading. His analysis emphasizes the socially interactive dimension of a manager's work. Managers not only communicate regularly with superiors and subordinates but also interact extensively with individuals outside the formal chain of command. Most of this communication is informal and is done orally. Managers rely heavily on unscheduled meetings and telephone calls to receive and transmit information. Many of a manager's interactions are brief and, in terms of content, they are dispersed. When viewed as an aggregated set, the interactions and contacts of a manager on the job reflected his social capital. When it comes to the tasks like promoting OSS adoption within organizations, instead of pushing it down through authority channel, IT managers or CIOs may simply rely on their social capital to influence other members who are within his social network.

For the two personality variables under investigation, there is significant difference found in extraversion between OSS opinion leaders and non OSS opinion leaders while no significant difference is found in openness between these two groups. While openness has been an important characteristics or even a necessary condition for early adopters of an innovation, it is not sufficient for an innovation opinion leader. An employee with high degree of openness can adopt OSS and use it silently without influencing others. In this way, he is an early adopter of OSS but is far from being an

OSS opinion leader. Here is where extraversion comes in play: OSS early adopters who are active, sociable, ambitious and eager to captivate others are more likely to become OSS opinion leaders rather than silent OSS users.

5.4.2. Limitations and Future Study

Before we discuss the implications of this research, we will first admit several limitations of present study:

The primary limitation relates to issue of small sample size. As we have reported in the survey administration section, social network questionnaires involve very sensitive information such as interpersonal relationships among employees which may be perceived by the respondents as being related to company politics and should be avoided as much as possible. Asking such questions may thus arouse defensive attitude from them. During our survey procedure, in those organizations where the IT department head did not make it an administrative command that everyone must fill up the form, the response rates were very poor. Although we extended the survey period from 3 months to 6 months and made phone calls to the IT department heads to follow up, most of them promised us that they would encourage their employees to respond, but felt no incentives to push their employees to much for this. A better solution for future study which involves social network data collection would be to approach government organizations or industry associations for endorsement of the

survey. With the coercive pressure from authorities, organizations will be more motivated to push their employees to respond.

Due to the small sample size, it is either impossible for us to further investigate the relationship between OSS opinion leaders' social network characteristics and the organization's intention to adopt OSS since this will be an analysis at the organizational level and we only have 5 data points at this level. This relationship is hard to be established until large sample of organizational level data can be collected. This will be our of our future research direction.

It is also important to notice there are other properties of social network that are interesting to investigate. For example, we did not measure ties in terms of frequency and intensity. Frequent, intense ties, or ties between two nodes which are present across different types of networks, are considered to be strong ties. For example, close friendship is strong ties while acquaintances are weak ties. Granovetter (1982) argues that strong ties are more likely to be formed between persons with similar attitudes, values, and so forth. Two people with a strong tie tend to have access to the same information while weak ties can sometimes provide novel, different, or even contradictory information by extending beyond a person's immediate circle of friends to less similar others. Due to this reason, weak ties have been found to be advantageous than strong ties in providing employment opportunities and information about innovation. We will also include this interesting topic in our future research.

5.4.3. Implications

This study has implications for both theory and practice. With regard to theory, first, we are among the first to profile individuals' social capital characteristics as innovation opinion leaders in three different types of networks, namely, the advice network, the communication network and the trust network. Our findings have shown that these three types of networks can be clearly distinguished in terms of its nature, characteristics and importance in determining an individual's position as an OSS opinion leader. This highlights the necessity for examining different types of networks separately rather than lump them together. Our results also indicate that different social capital characteristics such a degree of centrality, in-degree centrality, betweenness and closeness vary in their significance in differentiating OSS opinion leaders from non OSS opinion leaders and their distinctive roles should be given enough attention by innovation adoption researcher or social network researchers. By doing so, this study extends the applicability of social capital theory to the technically and socially complex context of organizational OSS adoption and adds to the extant literature on innovation adoption and serves as a call for more attention to be directed at understanding the influence of this factor in an increasingly technologically complex business environment.

Second, similar as previous two studies, approached the study of innovation adoption by examining the technology properties and the unique way of its adoption. In this

case, it is the bottom-up approach instead of top-down approach for OSS adoption in organizations due to its unique property of zero cost and wide availability. Based on this uniqueness, we identify social capital perspective to be the focus of this study. This approach also confronts the appropriateness of the search for a universal innovation adoption theory, which has been frequently sought in previous innovation adoption research.

Practically, our findings also have significant implications for organizations promoting OSS. Particularly, as evident in the results, social capital characteristics are important discriminant factors between OSS opinion leaders and non OSS opinion leaders. Among the four social capital variables under examination, in-degree centrality is most significant, which implies that organizations should pay close attention to the direction of ties among employees instead of focusing only on the number of ties when trying to identifying an OSS opinion leaders to promote OSS within the organization. Among the three types of networks examined, the advice network appeared to be most important for OSS opinion leaders to exert their influence, followed by the communication network and the trust network. This set priorities for mapping networks when an organization is considering promoting OSS. While examining the demographic and personality variables of OSS opinion leaders, extraversion is found to be more essential than openness. Thus, it is more advisable to identify and rely on outgoing, active and ambitious members in the organization to promote OSS rather than to count on early OSS adopters who are introverts.

We also find that a higher position in the organizational hierarchy is a crucial factor contributing to one's opinion leader status although the focus of this study is to target the informal networks behind the organizational chart. OSS proponent organizations should still target IT/IS leaders in organizations despite the widely reported bottom-up approach in organizational OSS adoption since these people tend to have richer social capital compared with employees in lower ranks.

In conclusion, we studied the differences in social capital characteristics between OSS opinion leaders and non OSS opinion leaders in three different types of networks. Drawing out the profiles of OSS opinion leaders in terms social capital properties, demographic and personality characteristic is our first step toward a cross-level mapping of the individuals' characteristics and the organizational OSS adoption behavior. We believe this is a promising area for research that will shed light on both innovation adoption literature and organizational theories on social capital.

CHAPTER 6

CONCLUSION

The OSS movement dictates that the source code be made public, modifiable, and re-distributable, which affords organizations with vast opportunities to acquire, customize, and upgrade software to meet their own circumstantial requirements at a much cheaper cost compared to proprietary software. While these obvious advantages of OSS suggest that it is fast becoming a major market force, the fact remains that proprietary software continues to dominate today's software market, which begs an interesting question: "What are the factors that inhibit the adoption and use of OSS in organizations?" Up till now, very few researches have been conducted on the organizational adoption of OSS. My dissertation studied this topic from three perspectives based on the unique properties of OSS.

Theme One: The unique development style of OSS is based on the informal networks of volunteer developers and hence, the service and support of the software are no longer guaranteed. This leads to high level of uncertainty and risk of adopting OSS and hence, many organizations continue to perceive OSS to be inaccessible. This lends credence to using human capital perspective as a theoretical lens to examine organizational OSS adoption. It is contestable that if an organization possesses the necessary human capital either internally or externally, it can greatly reduce the

perceived uncertainty and risk in OSS service and support, and thus increase the organizational intention to adopt OSS.

Our research evidence indicates that human capital constructs – availability of internal OSS human capital and accessibility to external OSS human capital – can be clearly distinguished conceptually and empirically in terms of their influence on OSS organizational adoption intention. Overall, there is strong empirical support for the human capital constructs (Becker 1993) as predictors of OSS organizational adoption intention. Our results further suggest that there might be differentiated effects of human capital constructs on adoption intention, depending on whether the human capital is available within or without the organization and whether the organization is in a developing or a developed country.

Theme Two: OSS is unique as an innovation in that it has had great impact on people's mindset by challenging a lot of existing social norms. Thus, the adoption of OSS may be considered as unconventional, unprofessional, or even illegal in the software market which is still dominated by traditional proprietary software. Organizations may be under the pressures to conform to the software adoption norms in the industry. Hence, it is conceived that existence of the institutional pressures toward OSS adoption which consist of coercive pressures, mimetic pressures and normative pressures will help organizations overcome this adoption barrier and thus play an important role in organizations' OSS adoption.

Our survey evidence indicates that institutional pressure constructs – mimetic, coercive and normative pressures – can be clearly distinguished conceptually and empirically in terms of their influence on organizational adoption intention toward OSS. Examining the results of institutional pressures shows that both mimetic and coercive pressure have a significant impact on an organization's intention to adopt OSS in the Chinese sample while only mimetic pressure is significant in the Singaporean sample, and normative pressure is consistently insignificant in both samples. And such differences can be explained by the differences in cultural, economical, legal, and business tradition aspects between these two countries.

Theme Three: The unique properties of OSS which include low cost of acquisition, wide availability of the software and the freedom in changing the source code and customize software enables bottom-up approach (compared with the conventional top-down approach) of organizational innovation adoption. Engineers at the bottom level may install and use OSS by themselves without the knowledge or permission from the organization's managers. Among these early OSS adopters in the organization, some will become OSS opinion leaders who can leverage on their own social capital to influence other employees' perception on OSS through informal interaction with them, thus indirectly promotes the OSS adoption in the organization. This study set out to examine the differences in the properties of an individual's social capital/network between OSS opinion leaders and non OSS opinion leaders, such as degree of centrality, in-degree of centrality, betweenness and closeness. We also

examine the differences in major personality and demographic characteristics between these two groups of people in order to come up with a more comprehensive profile of OSS opinion leaders v.s. non OSS opinion leaders.

The results from our social network survey indicate that the scores for social capital variables such as *degree of centrality, in-degree centrality* and *betweenness* are significantly different between OSS opinion leaders and non OSS opinion leaders across all the three types of network under investigation, namely the advice network, the communication network and the trust network. However, *closeness* is consistently insignificant in differentiating OSS opinion leaders and non OSS opinion leaders in these three types of network. For demographic variables and personality variables, these two groups of people have significantly different scores in *position in organization* and *extraversion.* There is no difference found in their *age*, *educational level, tenure in organization,* or *openness*.

This is the first study investigating the organizational adoption of OSS through three different theoretical perspectives based on the unique properties of the innovation under study. This approach of studying innovation adoption addresses the shortcoming of the previous literature which emphasizes on the search of a universalistic theory to explain all types of innovation adoption. The three theoretical perspectives adopted in this research, namely, the human capital perspective, the

institutional perspective and the social capital perspective also add in new angles for researchers to look at innovation adoption.

This is also among the first studies that investigate organizational OSS adoption in an integrative fashion through large scale cross-country surveys and social network survey in Singapore and China. Evidence obtained can inform OSS proponents, potential OSS adopter organizations and governments, and provide new perspectives to innovation adoption literature. Insights gained may also inspire new theoretical and empirical advance.

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APPENDIX

Appendix A: Survey on Open Source Software Adoption

Dear Sir/Madam,

Open Source software (OSS) is an emerging technology that permits an organization to acquire software at almost zero cost and have access to the source code. It is expected to play an increasingly important role in organization's drive to lower the operating cost of Information Technology (IT).

OSS's growing importance underscores an urgent need to understand the factors affecting its adoption by corporate businesses. Hence, this research survey is targeted at collecting your organization's views on using OSS as well as assessing the status of OSS adoption in Singapore.

This questionnaire is being administered to important organizations operating in Singapore. Each set of questionnaire would take approximately **20 minutes** to complete. Please do complete in **ONE** sitting. Being the likely decision-makers on OSS adoption, your views on OSS are extremely important. We assure you that all responses will be kept strictly confidential. Only group statistics will be published.

From your response, we will be able to formulate an understanding of the factors that affect OSS adoption in Singapore. The success of this research therefore depends on your firm's participation and cooperation. As a token of our appreciation, a copy of our research findings report will be given to all respondents and we will donate S$2 to the community chest for every respondent. Thank you for your cooperation. We wish you every success in all your future endeavors.

Professor Alex Siow
Adjunct Professor of NUS
Vice President, Strategic Relations
StarHub Pte Ltd

Dr. Teo Hock Hai
Department of Information Systems
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What is this survey about?

Open source software (OSS) such as Apache and Linux has gained increasingly widespread popularity in recent years. Open source software refers to software which is developed by hundreds of developers dispersed all over the world collaboratively, with an aim toward providing users ready access to executable and source codes at negligible acquisition cost.

In this research, we are interested in examining the adoption of platform-based OSS (such as operating systems like Linux or server applications like Apache and **NOT** desktop applications like OpenOffice and development tools like Perl). In particular, we are interested in identifying the key factors influencing the adoption of these platform-based OSS.

Please note that OSS is **NOT** freeware, shareware or trialware.

Open Source Software (OSS) has several features:
1. The source code is open and available. No one can claim ownership.
2. The acquisition cost of OSS is lower compared to that of the proprietary software.
3. The maintenance and technical support for OSS would normally have to be sourced by the adopting organizations.

This section solicits your organization's demographic information

1. Which industry does your organization belong to (Tick one only)?

	Advertising/Marketing/PR		Aerospace		Agriculture		Construction
	Consumer Goods		Computer/Electronics		Education		Energy
	Finance/Insurance/Property		Government		Hospital/Recreation		Media/Publishing/Entertainment
	Medical/Health Services		Retail		Travel/Transportation		Telecommunication/Networking
	Others (please state):						

2. What is the estimated number of employees in your organization?_____

3. What is the estimated number of Information Technology (IT) professionals in your organization? _____

4. What is the estimated distribution of IT staff members' education levels in IT-related areas (e.g., computer science, electronic commerce, information systems, computer engineering, multimedia)?

Education	**Percentage**
National ITE certificate/Higher National ITE certificate	_____%
Diploma and/or Advanced Diploma	_____%
Bachelor and/or Honours degree	_____%
Postgraduate degree (e.g., Master and PhD)	_____%
Total	*100%*

5. Overall, IT staff members in our organization have a strong educational background in IT-related areas (e.g., computer science, electronic commerce, information systems, computer engineering, and multimedia).

Strongly disagree			Neutral			Strongly agree
1	2	3	4	5	6	7
( )	( )	( )	( )	( )	( )	( )

6. Information Technology is very critical to…

Strongly disagree			Neutral			Strongly agree
1	2	3	4	5	6	7

a. my organization's profitability and viability.	( )	( )	( )	( )	( )	( )
b. my organization's smooth running of day-to-day operations.	( )	( )	( )	( )	( )	( )
c. my organization's strategic plan and vision.	( )	( )	( )	( )	( )	( )

7. Has your organization outsourced your IT operation?

____Yes

____No

If you answer for question 7 is YES, please answer question 8.

	Website functions		Application development		Application maintenance		PC support
	Network Operations Support		Technical support		System installation		
	Others (Please state):						

If you answer for question 7 is NO, please answer question 9.

9. Is your organization considering outsourcing your IT operation? (___)Yes (_____)No

10. Has your organization adopted any platform-based Open Source Software (e.g., Apache, Linux, and NOT Mozilla)?(____)Yes (____)No

If your answer for question 10 is YES, please answer question 11.

11. Is your firm still using open source software? (__)Yes (____)No

If you answer for question 11 is YES, please answer question 12.

12. What are the open source software that your organization have adopted? Please tick (you can tick more than one)

	Linux		Samba		KDE		Apache
	GNOME		PostgreSQL		MySQL		PHP
	Mailman		XFree86		bind		Perl
	OpenOffice		FreeBSD, OpenBSD, NetBSD		GNU compiler collection		
	Others (please state):						

If you answer for question 11 is NO, please answer question 13.

13. When did your organization stop using open source software? Year (_____)

If your answer for question 10 is NO, please answer question 14.

14.	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. Our organization will adopt open source software whenever it is possible..	( )	( )	( )	( )	( )	( )	( )
b. Given a choice, my organization will prefer to use open source software in the near future (i.e. within 1 year).	( )	( )	( )	( )	( )	( )	( )
c. Our organization is seriously contemplating to adopt open source software in the near future (i.e. within 1 year).	( )	( )	( )	( )	( )	( )	( )

This section solicits your perceptions of level of training of your IT staff members.

15. IT staff members in our organization...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. receive professional IT training related to proprietary software (e.g., .NET, Oracle Database, CISCO networking) regularly.	( )	( )	( )	( )	( )	( )	( )
b. are provided with opportunities to attend external trainings on proprietary software.	( )	( )	( )	( )	( )	( )	( )
c. are provided with opportunities to attend workshops on proprietary software.	( )	( )	( )	( )	( )	( )	( )
d. generally have sufficient IT training on	( )	( )	( )	( )	( )	( )	( )

proprietary software.

16. IT staff members in our organization...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. receive training on open source software (e.g., Linux, Apache).	( )	( )	( )	( )	( )	( )	( )
b. are provided with opportunities to attend external trainings on open source software.	( )	( )	( )	( )	( )	( )	( )
c. are provided with opportunities to attend workshops on open source software.	( )	( )	( )	( )	( )	( )	( )
d. generally have sufficient IT training on open source software.	( )	( )	( )	( )	( )	( )	( )

<u>This section solicits your perceptions on how your IT staff members monitor the technological changes in the environment.</u>

17. IT staff members in our organization...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. constantly scan the technological environment to keep themselves updated with the new technological trend.	( )	( )	( )	( )	( )	( )	( )
b. actively seek intelligence on technological changes that are likely to affect the organization.	( )	( )	( )	( )	( )	( )	( )
c. regularly read IT-related periodicals, magazines and journals (e.g., PC magazine and online CIO newsletter).	( )	( )	( )	( )	( )	( )	( )
d. actively participate in activities such as IT-related roadshows and exhibitions.	( )	( )	( )	( )	( )	( )	( )

This section solicits your perceptions on your IT staff members' willingness to change.

18. IT staff members in our organization...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. are open to new software.	( )	( )	( )	( )	( )	( )	( )
b. are willing to try new software.	( )	( )	( )	( )	( )	( )	( )
c. are enthusiastic toward experimenting new software.	( )	( )	( )	( )	( )	( )	( )
d. tend to be excited when new software is available.	( )	( )	( )	( )	( )	( )	( )

This section solicits your perceptions on your IT staff members' experiences with OSS.

19. IT staff members in our organization...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. have sufficient experience in using open source software.	( )	( )	( )	( )	( )	( )	( )
b. have sufficient experience in implementing open source software in business areas.	( )	( )	( )	( )	( )	( )	( )
c. have sufficient experience in supporting open source software usage in the organization.	( )	( )	( )	( )	( )	( )	( )

This section solicits your perceptions on your IT staff members' willingness to change.

20. IT staff members in our organization...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. are enthusiastic on acquiring knowledge on open source software.	( )	( )	( )	( )	( )	( )	( )
b. are keen to explore open source software.	( )	( )	( )	( )	( )	( )	( )
c. are passionate toward introducing open source	( )	( )	( )	( )	( )	( )	( )

software to the organization.

d. are fervent over the use of open source software.	( )	( )	( )	( )	( )	( )	( )

<u>This section solicits your perceptions on the availability of internal IT human capital for OSS support in your organization.</u>

21. Our organization can depend on our internal IT staff members for open source software...	Strongly disagree 1	2	3	Neutral 4	5	6	Strongly agree 7
a. training.	( )	( )	( )	( )	( )	( )	( )
b. implementation.	( )	( )	( )	( )	( )	( )	( )
c. technical support.	( )	( )	( )	( )	( )	( )	( )
d. maintenance.	( )	( )	( )	( )	( )	( )	( )
e. customization to the needs of the organization.	( )	( )	( )	( )	( )	( )	( )

22. Our internal IT staff members will be...	Strongly disagree 1	2	3	Neutral 4	5	6	Strongly agree 7
a. available to solve any problem regarding the use of open source software within our organization.	( )	( )	( )	( )	( )	( )	( )
b. contactable any time to provide support on the use of open source software in our organization.	( )	( )	( )	( )	( )	( )	( )
c. capable of solving any problem regarding the use of open source software in our organization.	( )	( )	( )	( )	( )	( )	( )
d. capable of providing timely solution for any problem regarding the use of open source software in our organization.	( )	( )	( )	( )	( )	( )	( )

This section solicits your perceptions on your organization's accessibility to external IT human capital for OSS support.

23. Our organization can access to...	Strongly disagree 1	2	3	Neutral 4	5	6	Strongly agree 7
a. external vendors who can provide cost-efficient solutions for the problems in open source software deployment in our organization on an as-needed basis.	( )	( )	( )	( )	( )	( )	( )
b. external vendors who can provide timely solutions for the problems in open source software deployment in our organization on an as-needed basis.	( )	( )	( )	( )	( )	( )	( )
c. external consultants who can provide cost-efficient solutions for the problems in open source software deployment in our organization on an as-needed basis.	( )	( )	( )	( )	( )	( )	( )
d. external consultants who can provide timely solutions for the problems in open source software deployment in our organization on an as-needed basis.	( )	( )	( )	( )	( )	( )	( )
e. external online open source software forum for timely solution for the problems we meet in open source software deployment in our organization.	( )	( )	( )	( )	( )	( )	( )
f. external free lance IT people with specialized expertise in open source software who can provide timely support for the open source software deployment in our organization on an as-needed basis.	( )	( )	( )	( )	( )	( )	( )
g. external free lance IT people with specialized expertise in open source software who can provide cost-efficient support for the open source software deployment in our organization on an as-needed basis.	( )	( )	( )	( )	( )	( )	( )
h. external human resources like university students who can work part-time or work on the project-based style in assisting our organization in open source software deployment.	( )	( )	( )	( )	( )	( )	( )
i. Overall, our organization can access to external human resources (e.g. consultants,	( )	( )	( )	( )	( )	( )	( )

vendors, developers in online OSS forum, freelance IT professionals, university students) to assist us in support for open source software adoption.

This section solicits your perceptions on the degree of OSS adoption among your competitors and the results of their adoption.

24. Quite a number of our competitors...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. benefit through great cost-saving from adopting open source software.	( )	( )	( )	( )	( )	( )	( )
b. significantly increase their employees' job efficiency through adopting reliable open source software.	( )	( )	( )	( )	( )	( )	( )
c. improve their productivity through adopting reliable open source software.	( )	( )	( )	( )	( )	( )	( )
d. benefit a lot from the use of open source software since it allows easy and flexible customization.	( )	( )	( )	( )	( )	( )	( )

This section solicits your perception on how others' attitude towards OSS and the normal practice of software selection in your industry.

25. The local government...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. promotes the use of open source software.	( )	( )	( )	( )	( )	( )	( )
b. encourages organizations to use open source software.	( )	( )	( )	( )	( )	( )	( )
c. endorses the use of open source software.	( )	( )	( )	( )	( )	( )	( )

26. It is perceived to be...	Strongly disagree			Neutral			Strongly agree

	1	2	3	4	5	6	7
a. a usual practice to use proprietary software.	( )	( )	( )	( )	( )	( )	( )
b. professional to use proprietary practice.	( )	( )	( )	( )	( )	( )	( )
c. In general, organizations in my industry still prefer software that is open source.	( )	( )	( )	( )	( )	( )	( )

27.	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. In general, organizations still prefer software that is proprietary.	( )	( )	( )	( )	( )	( )	( )
b. There are few organizations (excluding your competitors) that have adopted open source software.	( )	( )	( )	( )	( )	( )	( )

<u>This section solicits your perceptions on your organization's ability to detect new technology changes in the environment.</u>

28. Our organization is...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. often one of the first in our industry to detect technological developments that may potentially affect the business.	( )	( )	( )	( )	( )	( )	( )
b. capable of acquiring knowledge on new technology.	( )	( )	( )	( )	( )	( )	( )
c. competent in assimilating knowledge on new technology.	( )	( )	( )	( )	( )	( )	( )
d. sensitive to technological trend in the industry.	( )	( )	( )	( )	( )	( )	( )

<u>This section solicits your perceptions on your organization's ability to respond to technological changes in the environment.</u>

29. Our organization has...	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. sufficient knowledge to respond to new	( )	( )	( )	( )	( )	( )	( )

technology.

b. sufficient expertise to respond to new technology.	( )	( )	( )	( )	( )	( )	( )
c. slack resources to respond to new technology.	( )	( )	( )	( )	( )	( )	( )
d. competent IT staff members to respond to new technology.	( )	( )	( )	( )	( )	( )	( )
e. Generally, our organization has responded very quickly to technological changes in the environment.	( )	( )	( )	( )	( )	( )	( )
f. For one reason or another, our organization is slow to respond to new technology.	( )	( )	( )	( )	( )	( )	( )

<u>This section solicits your perceptions on the switching cost for your organization to adopt OSS.</u>

30.	Strongly disagree			Neutral			Strongly agree
	1	2	3	4	5	6	7
a. Acquiring open source software would incur a significant cost in retraining a large number of our employees.	( )	( )	( )	( )	( )	( )	( )
b. Our belief was that the drafting of procedures to deal effectively with open source software would take a lot of time and effort.	( )	( )	( )	( )	( )	( )	( )
c. Abandoning the existing software to acquire open source software would be too costly for the organization.	( )	( )	( )	( )	( )	( )	( )
d. Generally speaking, the cost in time, money, effort and grief to switch to open source software would be high.	( )	( )	( )	( )	( )	( )	( )
e. Considering everything, the costs to stop using the existing software and change to open source software would be high.	( )	( )	( )	( )	( )	( )	( )
f. Overall, I would spend a lot and lose a lot if I switch to open source software.							

THANK YOU FOR YOUR COOPERATION

Appendix B: 关于中国公司对开放源代码软件采用情况的调研

尊敬的先生/女士

开放源代码软件是一项正在崛起的技术。公司能够以几乎为零的代价获得这样的软件，并且有权使用其源代码。开放源代码软件在公司降低信息技术运行成本的过程中将起到越来越重要的作用。

开放源代码软件日益增长的重要性促使公司迫切需要了解影响他们采用开放源代码软件的重要因素。针对这个需要，这项调研旨在收集您所在的公司对使用开放源代码软件的看法，并试图评定开放源代码软件目前在中国被采用的情况。

这份问卷正被分发给在中国运营的重要企业。填写这份问卷预计将花费您 20 分钟的时间。恳请您一次性完成在线填写。作为一个有可能对您所在公司的开放源代码软件采用做出决策的人，您对开放源代码软件的看法将对我们的研究非常重要。我们确保您的所有回答将被严格地保密。我们将只发表群体统计数据。

根据您的回答，我们将能够明确地了解到影响中国公司采用开放源代码软件的重要因素。因此，这项研究的成功与否取决于贵公司的参与和合作。出于感激，我们将把我们的研究报告反馈给每一家参与的公司，并将代表每一个参与的公司向中国的希望工程捐款 10 元人民币。谢谢您的合作。祝贵公司事业蒸蒸日上。

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调研概述
近年来，开放源代码软件如 Apache，Linux 已经越来越广泛地被接受。开放源代码软件是由遍布在世界各地的成千上万的软件开发者共同开发的软件， 旨在使用户以可以忽略不计的代价便捷地获得可执行软件及其源代码。 在这项研究中，我们感兴趣的是公司对基于平台的开放源代码软件的采用。（例如 Linux 那样的操作系统软件或 Apache 那样的服务器端软件。我们目前不研究桌面应用程序，如 OpenOffice，或开发工具，如 Perl）。我们尤其感兴趣确定那些影响公司采用这些基于平台的开放源代码软件的关键因素。 请您注意，开放源代码软件不同于免费软件，共享软件或试用软件。

开放源代码软件的特点
1. 其源代码公开供所有人使用。没有人可以要求其所有权。
2. 与商业软件（如微软产品）相比，获取开放源代码软件的花费要少很多。
3. 开放源代码软件在使用过程中的维护及技术支持通常由采用其的公司自己解决。

这个部分反映您所在的公司的基本信息

1. 您所在的企业组织属于哪一个行业？（请选择一个）

	广告/市场营销/公关		航空航天		农业		建筑
	生活消费品制造		计算机/电子业		教育		能源
	金融/保险/地产		政府		医院/疗养		传媒/出版/娱乐
	医疗/健康服务		零售业		旅游/交通		电讯/网络
	其他 （请注明）：						

2. 您所在的企业组织的估计员工数目是？_____

3. 您所在的企业组织信息技术部门的专业人员的估计数目是多少？_____

4. 您所在的企业组织的信息技术部门的专业人员的在信息技术相关领域的受教育水平的估计分布是怎样的？（计算机科学，电子商务，信息系统，计算机工程，多媒体等等领域）

教育	**百分比**
中专	_____%
大专	_____%
本科	_____%
研究生及以上	_____%
总共	*100%*

5.总体来说，我们的企业组织信息技术部门的专业人员的在信息技术相关领域的有相当强的受教育背景（计算机科学，电子商务，信息系统，计算机工程，多媒体等等领域）

强烈不同意			**中立**			**强烈同意**
1	2	3	4	5	6	7
( )	( )	( )	( )	( )	( )	( )

6. 信息技术在以下方面非常关键…

	强烈不同意			**中立**			**强烈同意**
	1	2	3	4	5	6	7
a. 我们的企业组织的生存和盈利	( )	( )	( )	( )	( )	( )	( )
b. 我们的企业组织日常的正常运营	( )	( )	( )	( )	( )	( )	( )
c. 我们的企业组织的战略性计划和视野	( )	( )	( )	( )	( )	( )	( )

7. 您所在的企业组织已经外包了其信息技术的实施运行业务吗？
_____是的　　____不是的

假如您对第 7 题的回答是“是的”， 请回答第 8 题。（您可以选择多项）

	网站功能		应用程序的开发		应用程序的维护		个人店号支持
	网络运行支持		技术支持		系统安装		
	其他（请注明）：						

假如您对其 7 题的回答是“不是的”，请回答第 9 题。

9. 您所在的企业组织正在考虑外包其信息技术的运行业务吗？
_____是的　　_____ 不是的

10. 您所在的企业组织曾经采用过基于平台的开放源代码软件吗？（如 Apache, Linux）
____是的　　_____ 不是的

假如您对第 10 题的回答是“是的”，请回答第 11 题。

11. 您所在的企业组织依旧在使用开放源代码软件吗？

____是的　　_____ 不是的

假如您对第 11 题的答案是“是的”， 请回答第 12 题。

12.您所在的企业组织已经采用的开放源代码软件有哪些？请选择 （可选择多项）

	Linux		Samba		KDE		Apache
	GNOME		PostgreSQL		MySQL		PHP
	Mailman		XFree86		Bind		Perl
	OpenOffice		FreeBSD, OpenBSD, NetBSD		GNU compiler collection		
	Others (please state):						

假如您对第 11 题的回答是“不是的”，请回答第 13 题。

13.您所在的企业组织什么时候停止使用开放源代码软件的？ ____年

假如您对第 10 题的回答是“不是的”，请回答第 14 题。

14.	**强烈不同意**			**中立**			**强烈同意**
	1	2	3	4	5	6	7
a. 可能的话,我们的企业组织会采用开放源代码软件。	( )	( )	( )	( )	( )	( )	( )
b. 可以选择的话,我们的企业组织在不久的将来（比如一年之内）将更加愿意使用开放源代码软件。	( )	( )	( )	( )	( )	( )	( )
c. 我们的企业组织正认真考虑在不久的将来(比如 1 年内)采用开放源代码软件。	( )	( )	( )	( )	( )	( )	( )

本题不适用于我所在的企业组织

开放源代码软件的采用者，请基于您所在的企业组织在决定采用开放源代码之前的情况回答以下的问题。

这部分问题旨在反映您对您的企业组织的信息技术部门员工关于培训水平的识

15. 我们的企业组织信息技术部门的员工	**强烈不同意**			**中立**			**强烈同意**
	1	2	3	4	5	6	7
a. 定期接受商业软件的专门培训(比如, .NET, Oracle 数据库, CISCO 网络)。	( )	( )	( )	( )	( )	( )	( )
b. 被给予机会参加外界的商业软件的培训。	( )	( )	( )	( )	( )	( )	( )
c. 被给予机会参加关于商业软件的研讨会。	( )	( )	( )	( )	( )	( )	( )
d. 通常得到足够的关于商业软件的信息技术培训。	( )	( )	( )	( )	( )	( )	( )

本题不适用于我所在的企业组织

16. 我们的企业组织信息技术部门的员工	**强烈不同意**			**中立**			**强烈同意**
	1	2	3	4	5	6	7
a. 接受了关于开放源代码软件的培训（如 Linux, Apache）。	( )	( )	( )	( )	( )	( )	( )
b. 被给予机会参加外界的关于开放源代	( )	( )	( )	( )	( )	( )	( )

码软件的培训。

c. 被给予机会参加关于开放源代码软件的研讨会。 ( ) ( ) ( ) ( ) ( ) ( ) ( )

d. 通常得到了足够的关于开放源代码软件的信息技术培训。 ( ) ( ) ( ) ( ) ( ) ( ) ( )

本题不适用于我所在的企业组织

这部分旨在反映您对于您所在的企业组织的文化的认识

17. 我们的企业组织非常:

	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. 个人化，亲切。 它象一个大家庭, 大家分享很多东西。	( )	( )	( )	( )	( )	( )	( )
b. 有生气, 企业化。员工都热衷于冒险。	( )	( )	( )	( )	( )	( )	( )
c. 以生产为导向。大家关心的重点是做完工作。 个人和组织的关系并不是很密切。	( )	( )	( )	( )	( )	( )	( )

18. 我们的企业组织的领导象是一个

	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. 良师, 德高望重, 或像父/母亲那样。	( )	( )	( )	( )	( )	( )	( )
b. 企业家, 改革者, 或冒险者。	( )	( )	( )	( )	( )	( )	( )
c. 协调者,组织者或者行政管理者。	( )	( )	( )	( )	( )	( )	( )
d. 生产者,技术员或者严厉的监工	( )	( )	( )	( )	( )	( )	( )

19. 把我们的企业组织紧密团结在一起的是

	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. 忠诚和传统. 对这间公司的承诺增加了	( )	( )	( )	( )	( )	( )	( )
b. 对改革和发展的承诺, 这是首要强调的.	( )	( )	( )	( )	( )	( )	( )
c. 公司的制度和政策. 维持一个运行良好的制度是很重要的	( )	( )	( )	( )	( )	( )	( )
d. 强调完成任务和目标.面向于产品	( )	( )	( )	( )	( )	( )	( )

20. 我们的企业组织强调	**强烈不同意**				**中立**		**强烈同意**
	1	2	3	4	5	6	7
a. 人力资源. 强大的凝聚力和高昂的士气很重要	( )	( )	( )	( )	( )	( )	( )
b. 增长和获取新资源. 胜任迎接新的调整很重要	( )	( )	( )	( )	( )	( )	( )
c. 稳定和持久. 有效的,平稳的运行很重要	( )	( )	( )	( )	( )	( )	( )
d. 稳定和持久.,有效的,平稳的运行很重要	( )	( )	( )	( )	( )	( )	( )

<u>本部分旨在反映您对信息技术部门员工如何应对周围环境的技术变革的认知。</u>

21. 本机构的信息技术部门员工……	**强烈不同意**				**中立**		**强烈同意**
	1	2	3	4	5	6	7
a. 坚持关注技术性环境以保持与新技术发展趋势同步。	( )	( )	( )	( )	( )	( )	( )
b. 积极探索可能影响机构发展的技术变革知识。	( )	( )	( )	( )	( )	( )	( )
c. 经常性地阅读信息技术相关地期刊、杂志和刊物(如个人电脑杂志和在线 CIO 时事通讯)。	( )	( )	( )	( )	( )	( )	( )
d. 积极参与如信息技术相关的路演和展览等活动。	( )	( )	( )	( )	( )	( )	( )
本题不适用于我所在的企业组织							

<u>本部分旨在反映您对信息技术部门员工参与变革的愿望的认知。</u>

22. 本机构的信息技术部门员工……	**强烈不同意**				**中立**		**强烈同意**
	1	2	3	4	5	6	7
a. 对新软件持开放态度。	( )	( )	( )	( )	( )	( )	( )
b. 愿意尝试使用新软件。	( )	( )	( )	( )	( )	( )	( )
c. 热衷于测试使用新软件。	( )	( )	( )	( )	( )	( )	( )
d. 当新软件可以应用时感到兴奋。	( )	( )	( )	( )	( )	( )	( )
本题不适用于我所在的企业组织							

23. 本机构的信息技术部门员工……	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. 热心于搜集关于开放源代码软件的知识。	( )	( )	( )	( )	( )	( )	( )
b. 热衷于探索研究开放源代码软件。	( )	( )	( )	( )	( )	( )	( )
c. 对将开放源代码软件介绍推荐给机构充满热情。	( )	( )	( )	( )	( )	( )	( )
d. 对开放源代码软件的使用十分兴奋。	( )	( )	( )	( )	( )	( )	( )

本题不适用于我所在的企业组织

<u>本部分旨在反映您对信息技术部门员工关于开放源代码软件的经验的认知。</u>

24. 本机构的信息技术部门员工……	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. 有足够的使用开放源代码软件的经验。	( )	( )	( )	( )	( )	( )	( )
b. 有足够的在商业领域应用开放源代码软件的经验。	( )	( )	( )	( )	( )	( )	( )
c. 有足够的在机构支持开放源代码软件使用的经验。	( )	( )	( )	( )	( )	( )	( )

本题不适用于我所在的企业组织

<u>本部分旨在反映您对内部信息技术人力资源支持您所在机构使用开放源代码软件的能力的认知。</u>

25 本机构可依靠内部信息技术部门员工进行开放源代码软件的……	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. 培训。	( )	( )	( )	( )	( )	( )	(
b. 实施。	( )	( )	( )	( )	( )	( )	( )
c. 技术支持。	( )	( )	( )	( )	( )	( )	( )
d. 维护。	( )	( )	( )	( )	( )	( )	( )
e. 基于机构需要的用户化。	( )	( )	( )	( )	( )	( )	( )

本题不适用于我所在的企业组织

26. 本机构内部信息技术部门员工将……	强烈不同意			中立			强烈同意

	1	2	3	4	5	6	7
a. 可以解决本机构开放源代码软件使用的任何问题。	( )	( )	( )	( )	( )	( )	( )
b. 随时能被联络以向本机构开放源代码软件使用提供支持。	( )	( )	( )	( )	( )	( )	( )
c. 有能力解决本机构开放源代码软件使用的任何问题。	( )	( )	( )	( )	( )	( )	( )
d. 有能力及时为本机构开放源代码软件使用中的问题提供解决方案。	( )	( )	( )	( )	( )	( )	( )

本题不适用于我所在的企业组织

本部分旨在反映您对您所在机构获得外部信息技术人力资源对开放源代码软件支持的能力的认知。

27. 本机构能接触到……	**强烈不同意** 1	2	3	**中立** 4	5	6	**强烈同意** 7
a. 基于需要为本机构配置的开放源代码软件问题提供经济有效的解决方案的外部卖家。	( )	( )	( )	( )	( )	( )	( )
b. 基于需要为本机构配置的开放源代码软件问题提供及时的解决方案的外部卖家。	( )	( )	( )	( )	( )	( )	( )
c. 基于需要为本机构配置的开放源代码软件问题提供经济有效的解决方案的外部卖家。	( )	( )	( )	( )	( )	( )	( )
d. 基于需要为本机构配置的开放源代码软件问题提供及时的解决方案的外部顾问。	( )	( )	( )	( )	( )	( )	( )
e. 外部在线开放源代码论坛以获得解决本机构配置的开放源代码软件问题的及时性方案。	( )	( )	( )	( )	( )	( )	( )
f. 有关于开放源代码软件专业技能的外部自由信息技术人员，以获得解决本机构配置的开放源代码软件问题的及时性方案。	( )	( )	( )	( )	( )	( )	( )
g. 有关于开放源代码软件专业技能的外部自由信息技术人员，以获得解决本机构配置的开放源代码软件问题的经济有效的方案。	( )	( )	( )	( )	( )	( )	( )
h. 外部人力资源如能参与兼职或基于项目的工作以辅助本机构开放源代码软件配	( )	( )	( )	( )	( )	( )	( )

置的大学学生。

i. 总体来说，本机构能接触到外部人力资源（如顾问，卖家，在线开放源代码论坛开发员，自由信息技术专家，大学学生）以辅助支持开放源代码软件使用。 ( ) ( ) ( ) ( ) ( ) ( ) ( )

本题不适用于我所在的企业组织

本部分旨在反映您对竞争者中开放源代码软件使用的程度以及采用结果的知。

28.	Low			Moderate			High
	1	2	3	4	5	6	7
在本机构的竞争者之间采用的程度……	( )	( )	( )	( )	( )	( )	( )

29. 本机构的竞争者中，有相当数量……	**强烈不同意**			**中立**			**强烈同意**
	1	2	3	4	5	6	7
a. 从开放源代码软件的采用中获得极大的成本节约收益。	( )	( )	( )	( )	( )	( )	( )
b. 通过采用开放源代码软件显著提高了员工的工作效率。	( )	( )	( )	( )	( )	( )	( )
c. 通过采用可靠的开放源代码软件提高了生产力。	( )	( )	( )	( )	( )	( )	( )
d. 因为开放源代码软件允许简单灵活的用户化儿从中获益。	( )	( )	( )	( )	( )	( )	( )

本题不适用于我所在的企业组织

本部分旨在反映您对其他人对开放源代码软件的态度以及您所在行业选择软件的普遍惯例的认知。

30. 本地政府……	**强烈不同意**			**中立**			**强烈同意**
	1	2	3	4	5	6	7
a. 推广开放源代码软件的使用。	( )	( )	( )	( )	( )	( )	( )
b. 鼓励各机构使用开放源代码软件。	( )	( )	( )	( )	( )	( )	( )
c. 认可开放源代码软件的使用。	( )	( )	( )	( )	( )	( )	( )

31. 业内普遍认为……	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. 使用商业软件是正常的行为。	( )	( )	( )	( )	( )	( )	( )
b. 使用商业软件是专业的行为。	( )	( )	( )	( )	( )	( )	( )
c. 总体说来，本组织所在的行业倾向于使用开源软件。	( )	( )	( )	( )	( )	( )	( )

32.	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. .总体上，机构仍倾向于使用私人所用的软件。	( )	( )	( )	( )	( )	( )	( )
b. 很少机构（包括你们的竞争者）已经采用开放源代码软件。	( )	( )	( )	( )	( )	( )	( )

<u>本部分旨在反映您对如何为机构转变成本结构来采用开放源代码软件的认知。</u>

33.	强烈不同意			中立			强烈同意
	1	2	3	4	5	6	7
a. 使用开放源代码软件将花费极大成本来保留大量机构员工。	( )	( )	( )	( )	( )	( )	( )
b. 使用开放源代码软件将花费极大成本来获得开放源代码软件专家。	( )	( )	( )	( )	( )	( )	( )
c. 使用开放源代码软件将花费极大成本来修正维护合同。	( )	( )	( )	( )	( )	( )	( )
d. 使用开放源代码软件将花费极大成本来保留大量信息技术部门员工。	( )	( )	( )	( )	( )	( )	( )
e. 使用开放源代码软件将花费极大成本来重新制定机构的信息技术政策和计划。	( )	( )	( )	( )	( )	( )	( )
f. 我们认为规定程序以有效使用开放源代码软件将消耗大量时间和精力。	( )	( )	( )	( )	( )	( )	( )
g. 采用开放源代码程序对机构来说代价太高。	( )	( )	( )	( )	( )	( )	( )
c. 弃用现有的软件而改用开放源代码软件对机构来说代价太高。	( )	( )	( )	( )	( )	( )	( )

d. 总得来说，改用开放源代码软件的时间、金钱、精力和风险代价会很高。	( )	( )	( )	( )	( )	( )	( )
e. 总体考虑，停用现有软件改用开放源代码软件的代价很高。	( )	( )	( )	( )	( )	( )	( )
f. 总得来说，如果改用开放源代码软件，我将花费和损失巨大。	( )	( )	( )	( )	( )	( )	( )
d. 总得来说，对机构来说使用开放源代码软件的风险太大。	( )	( )	( )	( )	( )	( )	( )

本题不适用于我所在的企业组织

谢谢您的合作！

Appendix C: Full scale for Personality and items selected for survey

The **bold items** indicate the questions chosen for assessing personality traits in the study.

Items for Openness

I like to challenge the norms.

I seldom have difficulty understanding abstract ideas.

I have a vivid imagination.

I am interested in abstract ideas.

I always have excellent ideas.

I have a good imagination.

I am quick to understand things.

I love to read challenging material.

I spend time reflecting on things.

I love to think up new ways of doing things.

Items for Extraversion

I am the life of the party.

I don't talk a lot.

I feel comfortable around people.

I know how to captivate people.

I always start conversations.

I am skilled in handling social situations.

I talk to a lot of different people at parties.

I don't like to draw attention to myself.

I don't mind being the center of attention.

I am quiet around strangers.

Appendix D: Questionnaire for OSS Opinion Leaders' Profiles

Demographic Information

1. Age (as at 1st August, 2006):

_____

2. The highest degree of education I have received till 1 August 2006 is:

(1) Diploma and below
(2) Bachelor
(3) Master
(4) PhD
(5) Others (please specify):

3. My position in the department is:

(1) Engineer
(2) Project Manager
(3) IT/IS manager/director
(4) CIO

4. I have been in this position within this organization for ___ years.

Personality Traits

5. Openness (Open):

1 – Strongly Disagree; 7- Strongly Agree;

I love to read challenging material **(Open01).**
I am quick to understand things **(Open02)**.
I love to think up new ways of doing things **(Open03)**.
I like to challenge the norms **(Open04)**.

6. Extraversion (Extra):

1 – Strongly Disagree; 7- Strongly Agree;

I feel comfortable around people **(Extra01)**.
I talk to a lot of different people at parties **(Extra02)**.
I know how to captivate people **(Extra03)**.
I am skilled in handling social situations **(Extra04)**.

OSS Opinion Leadership

In my department, I am an influential figure in recommending and promoting OSS to my colleagues.
Yes____ No____

Employees' Social Network Properties

Please fill up the table line by line instead of column by column.
Please tick all the names (A, B,…M) in each line that satisfy the criteria of the question.
If not specified, "often" refers to "at least once per week" in the following questions.

Within your Department:	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
Whom do you talk to everyday for work-related or non work-related issues?													
Whom do you often go for help or advice for work-related problems?													
Whom would you trust to keep in confidence your concerns about a work-related issue?													

Appendix E: 个人情况问卷调查

个人信息

1. 年龄 (到 1st August, 2006):

_____

2. 最高学历（到 1 August 2006）:

(1) 大专或以下
(2) 学士学位
(3) 硕士学位
(4) 博士学位
(5) 其它 (请注明):_____

3. 我在部门的职位是:

(1) 工程师
(2) 项目经理
(3) 技术总监
(4) 首席信息官

4. 我在本公司的担任以上这个职位已经___年了。

个性特征

5. 开放性 (Open):

1 – 强烈不同意; 7- 强烈同意;
我喜欢阅读有挑战性的资料 **(Open01).**
我领悟事情很快 **(Open02)**.
我做事情喜欢尝试新方法 **(Open03)**.
我喜欢挑战常规 **(Open04)**.

6. 外向性 (Extra):

1 – 强烈不同意; 7- 强烈同意;
我和人打交道很自在 **(Extra01)**.
我在聚会上和很多不同的人说话**(Extra02)**.
我知道如何让人对我的想法着迷 **(Extra03)**.
我有很好的社交技能 **(Extra04)**.

开源软件的意见领袖

在我的部门里面，我是在开源软件推广方面很有影响力的人物。
是_____不是_____

人际网络情况

请您逐行填写下表，而不是逐列填写。
请在每个符合问题要求的名字下面打勾。
假如没有特殊说明，下表中的“经常”指“至少一个星期一次”。

在您的部门里:	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
您每天都要和哪些人说话，不管是说工作相关还是不相关的？													
您经常要向哪些人请教工作相关的问题？													
您经常和哪些人分享一些关于工作的忧虑，并相信他们会帮您保守秘密？													

Appendix F: Individual's network scores in three types of networks in the five companies

	Communication Network				Advice Network				Trust Network			
	Degree	Between-Ness	Closeness	In-degree	Degree	Between-ness	Closeness	In-degree	Degree	Between-ness	Closeness	In-degree
A	10	6.73	33	10	10	6.2	33	9	9	14.44	34	9
B	6	1.06	37	3	7	0.87	36	0	4	0.73	39	0
C	5	1.28	38	2	5	1.92	38	0	4	1.07	39	0
D	10	5.1	33	10	11	7.37	32	10	7	4.62	36	7
E	9	3.37	34	8	11	5.3	32	11	8	7.77.	35	7
F	6	0.93	37	2	7	1.85	36	0	4	0.87	40	1
G	8	1.79	35	3	8	1.57	35	1	5	1.52	38	2
H	8	4.95	35	8	9	5.67	34	8	7	10.33	36	7
I	9	4.71	34	4	7	1.62	36	1	3	0.83	41	1
J	5	1.23	38	1	4	0.53	39	0	5	3.48	38	1
K	11	5.69	32	8	11	6.03	32	6	9	11.15	34	6
L	6	2.39	37	0	6	2.4	37	0	4	1.85	39	0
M	7	3.48	36	4	6	1.48	37	4	3	0.25	42	1
N	4	0.67	39	3	5	1.48	38	4	4	2.53	41	3
O	8	5.62	35	7	7	4.45	36	5	6	5.68	37	3

Table 5.6 Network Properties of Company 1

	Communication Network				Advice Network				Trust Network			
	Degree	Between-Ness	Closeness	In-degree	Degree	Between-ness	Closeness	In-degree	Degree	Between-ness	Closeness	In-degree
A	4	2	29	3	4	0.55	27	0	2	1	34	2
B	4	2.92	27	4	9	5.67	22	8	3	5.25	31	2
C	3	2.83	30	3	6	1.21	25	0	2	2.83	33	2
D	5	7.4	26	3	9	4.91	22	8	4	12.83	27	2
E	5	5.07	27	4	4	0	27	0	4	10.25	28	4
F	3	2.66	28	3	3	0	29	0	2	1.58	32	2
G	4	1.37	28	4	9	5.67	22	8	2	1.5	33	2
H	4	2.58	28	4	5	0.96	26	0	3	6.59	29	2
I	2	0.7	32	2	5	0.55	26	5	2	2	34	2
J	3	1.75	28	1	5	1.2	27	5	2	1.5	31	1
K	5	9.73	26	4	7	2.26	24	6	4	9.67	29	2

Table 5.7 Network Properties of Company 2

	Communication Network				Advice Network				Trust Network			
	Degree	Between-ness	Closeness	In-degree	Degree	Between-ness	Closeness	In-degree	Degree	Between-ness	Closeness	In-degree
A	4	1.01	43	2	7	1.53	39	0	1	0	57	1
B	6	3.24	41	5	5	0.73	41	3	5	21.75	43	5
C	5	5.58	41	4	13	9.1	33	13	4	11.38	45	3
D	6	3.33	43	4	7	1.14	39	0	2	0	53	0
E	4	1.03	42	3	7	2.29	39	0	3	1.95	48	1
F	10	26.67	36	9	13	11.48	33	13	7	37.4	39	7
G	6	7.31	40	4	7	1.33	39	0	1	0	58	0
H	6	3.4	40	6	7	1.72	39	0	6	20.82	44	5
I	5	3.26	41	5	13	9.18	33	12	3	2.45	46	3
J	8	9.19	38	8	7	2.54	39	6	3	0.75	51	3
K	6	2.94	41	6	7	1.04	39	5	4	12.15	45	3
L	6	5.29	40	6	8	2.88	38	7	5	17.23	43	4
M	6	9.41	40	6	4	0.42	42	0	4	8.53	49	3
N	3	1.08	46	3	7	1.53	39	0	2	0.75	55	0
O	2	0	46	2	8	1.63	38	4	2	1.917	49	1
P	3	0.25	44	3	10	6.48	36	8	2	1.917	49	1

Table 5.8 Network Properties of Company 3

	Communication Network				Advice Network				Trust Network			
	Degree	Between-ness	Closeness	In-degree	Degree	Between-ness	Closeness	In-degree	Degree	Between-ness	Closeness	In-degree
A	7	44.84	52	5	8	4.13	50	4	4	36.08	61	2
B	8	29.96	52	7	2	0	59	0	2	18	77	2
C	4	0.58	60	3	4	0.14	54	0	4	34	61	1
D	3	3.89	60	3	12	24.88	46	10	2	3.77	68	1
E	2	0.53	66	2	4	0.78	55	0	2	2.42	70	1
F	7	17.34	53	7	12	28.6	46	12	7	48.2	53	7
G	1	0	70	1	3	0.68	56	0	1	0	95	0
H	8	20.61	51	8	15	36.43	43	13	6	29.85	55	6
I	1	0	86	1	4	0.29	54	0	1	0	95	1
J	2	18	68	2	7	2.75	51	0	2	18	77	2
K	8	21.81	53	7	10	16.44	48	9	6	31.67	58	6
L	5	7.63	57	2	3	0	55	0	5	18.53	62	2
M	4	1.92	59	4	5	1.82	56	3	3	2.08	64	3
N	4	4.1	61	2	8	2.81	50	4	3	4.08	75	1
O	6	12.02	57	6	9	4.51	49	6	5	12.25	65	5
P	4	5.61	58	3	2	0.13	60	0	2	1.33	74	0
Q	2	0	66	1	2	0	58	0	1	0	76	0
R	7	13.16	54	6	9	6.69	49	7	5	11.92	60	5
S	4	2.64	62	2	3	0.14	57	0	3	6.45	64	1
T	5	6.36	57	5	6	3.79	54	5	4	17.37	62	3

Table 5.9 Network Properties of Company 4

	Communication Network				Advice Network				Trust Network			
	Degree	**Between-ness**	**Closeness**	**In-degree**	**Degree**	**Between-ness**	**Closeness**	**In-degree**	**Degree**	**Between-ness**	**Closeness**	**In-degree**
A	8	39.82	69	5	13	28.57	60	12	4	24.49	80	13
B	4	8	76	4	5	0.59	69	0	1	0	101	1
C	4	9.22	82	4	13	15.88	60	11	3	12.55	93	3
D	6	11.86	74	5	14	19.12	59	13	3	2.4	89	3
E	3	2.59	85	3	4	0.97	69	0	3	9.95	89	3
F	5	10.51	77	5	9	1.77	64	0	4	27.37	82	4
G	5	10.1	75	3	6	0.22	68	0	3	9.94	85	1
H	4	12.02	79	4	6	1.27	68	0	4	28.55	85	2
I	3	3.54	80	2	6	1.24	67	0	2	8.24	85	1
J	5	10.58	74	4	14	24.4	59	12	4	17.31	85	2
K	4	9.39	76	4	14	11.7	59	12	3	2.2	88	0
L	5	17.63	76	4	8	2.39	65	0	2	1.82	95	2
M	7	27.39	73	7	16	18.2	57	10	7	53.74	79	5
N	3	2.62	84	3	8	2.94	65	0	2	3.44	93	1
O	3	7.32	82	3	3	0.13	72	0	2	3.325	92	2
P	3	6.84	80	3	9	4.74	66	7	3	13.31	87	3
Q	6	33.67	74	5	2	0	77	0	5	47.68	79	4
R	5	15.87	75	4	11	18.47	62	9	4	38.73	79	3
S	3	8.75	81	3	3	0.29	72	0	3	18.95	84	3
T	4	14.68	77	3	6	0.6	68	0	3	26.69	87	2
U	2	0	88	2	3	0	73	0	1	0	110	1

V	7	33.51	72	7	11	8.91	62	8	7	52.84	75	7
W	6	15.74	74	5	10	8.78	64	7	5	16.98	82	5
X	5	16.87	74	4	7	2.48	66	4	2	5.42	97	1
Y	6	23.49	72	5	15	28.36	58	14	6	51.3	78	4

Table 5.10 Network Properties of Company 5

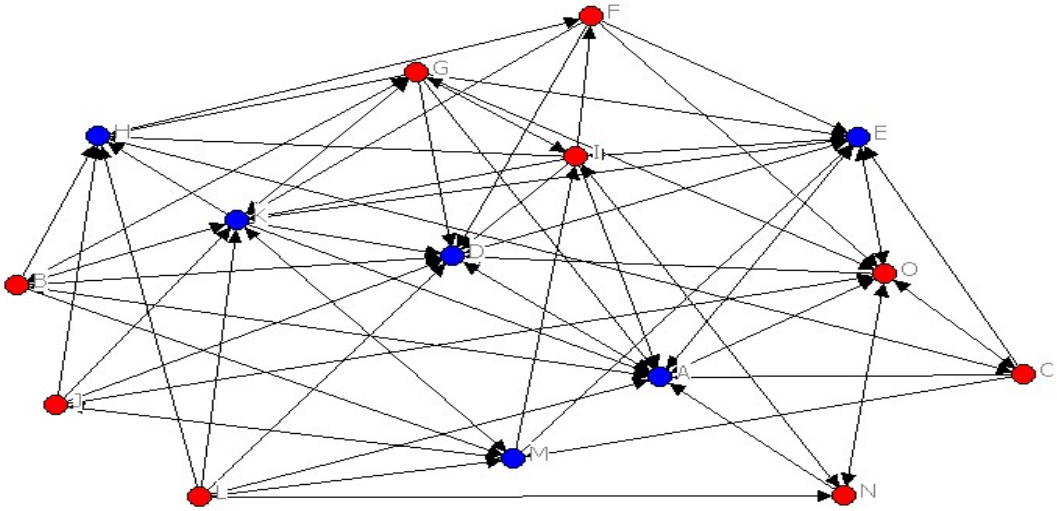

Figure 5.1 Communication Network in Company 1

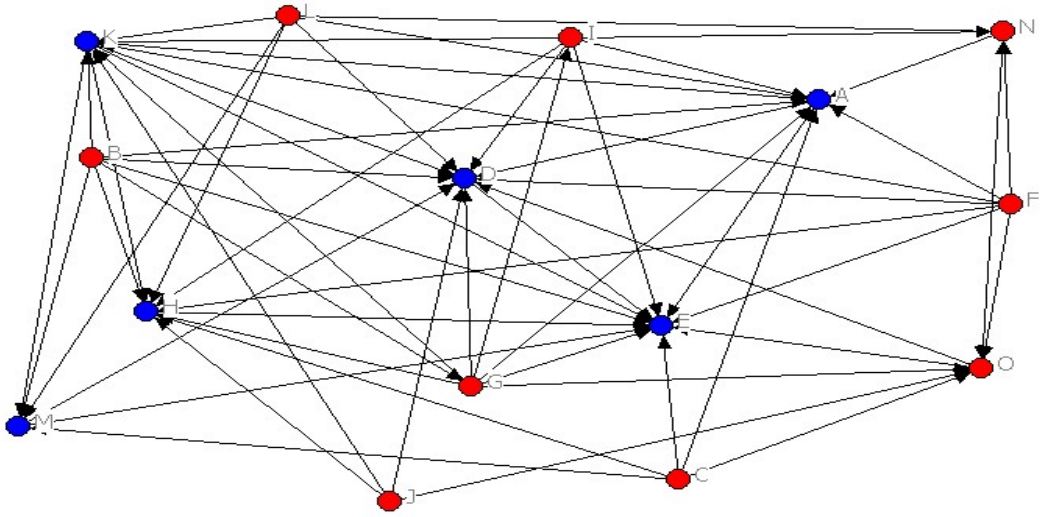

Figure 5.2 Advice Network in Company 1

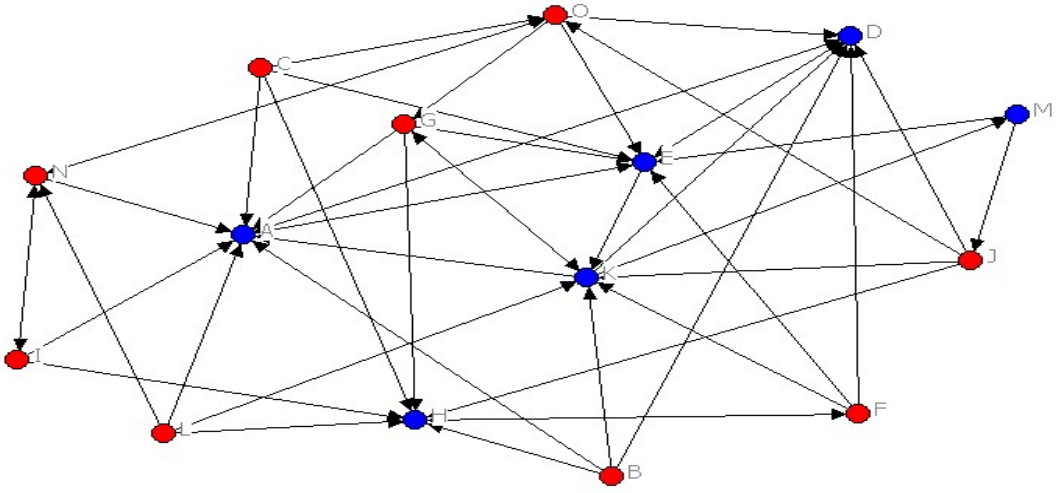

Figure 5.3 Trust Network in Company 1

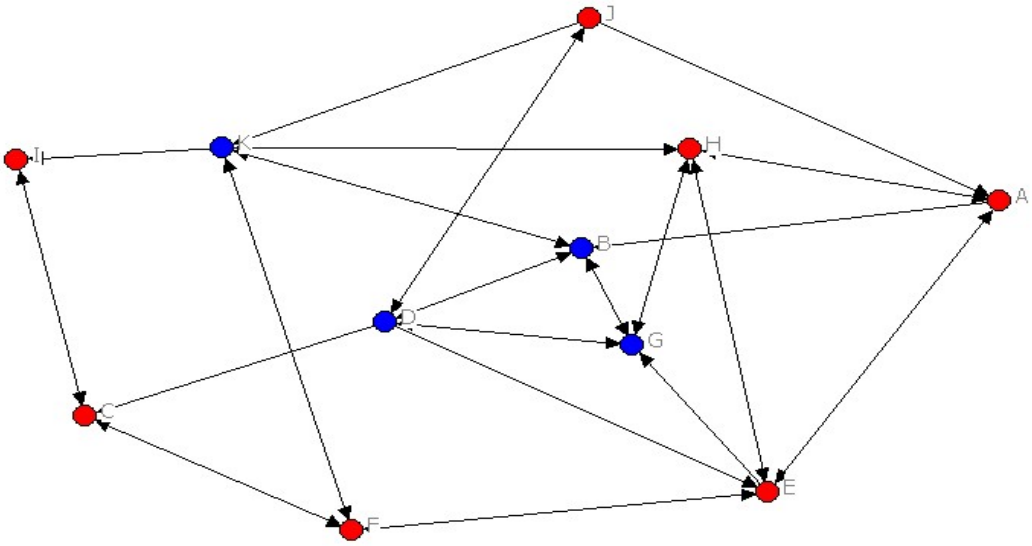

Figure 5.4 Communication Network in Company 2

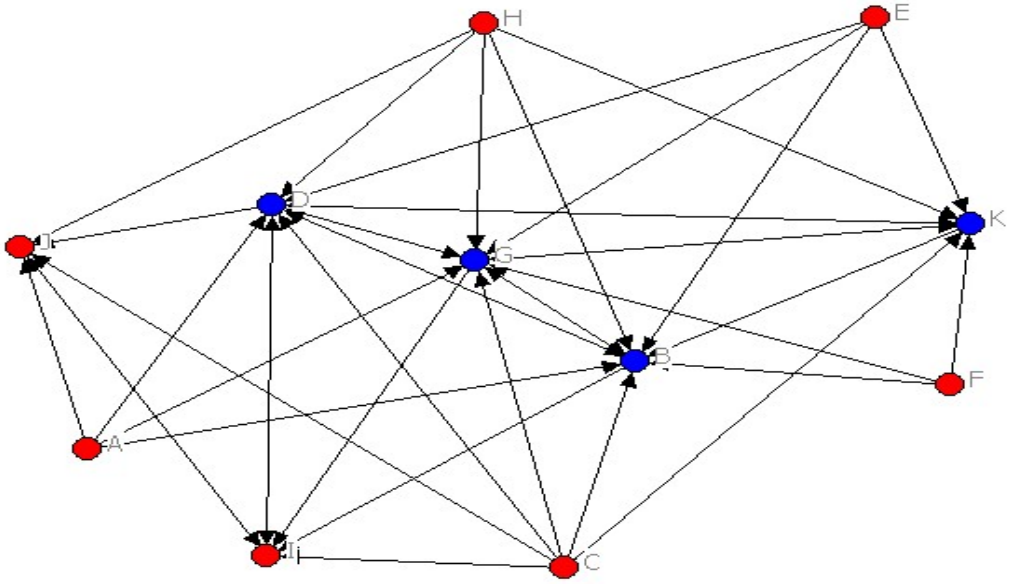

Figure 5.5 Advice Network in Company 2

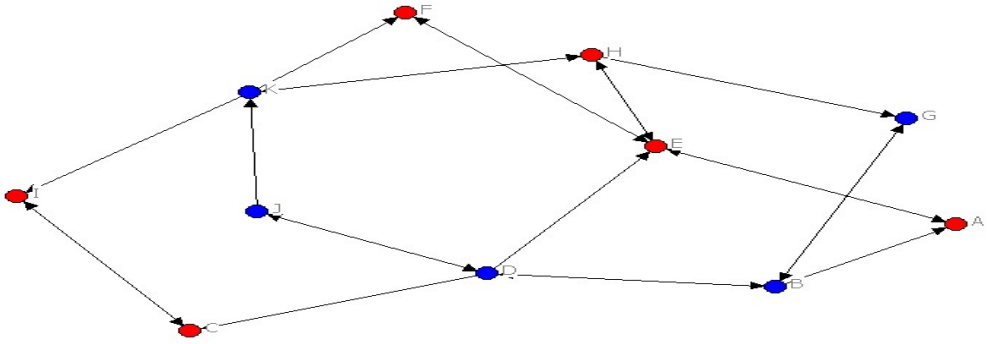

Figure 5.6 Trust network in Company 2

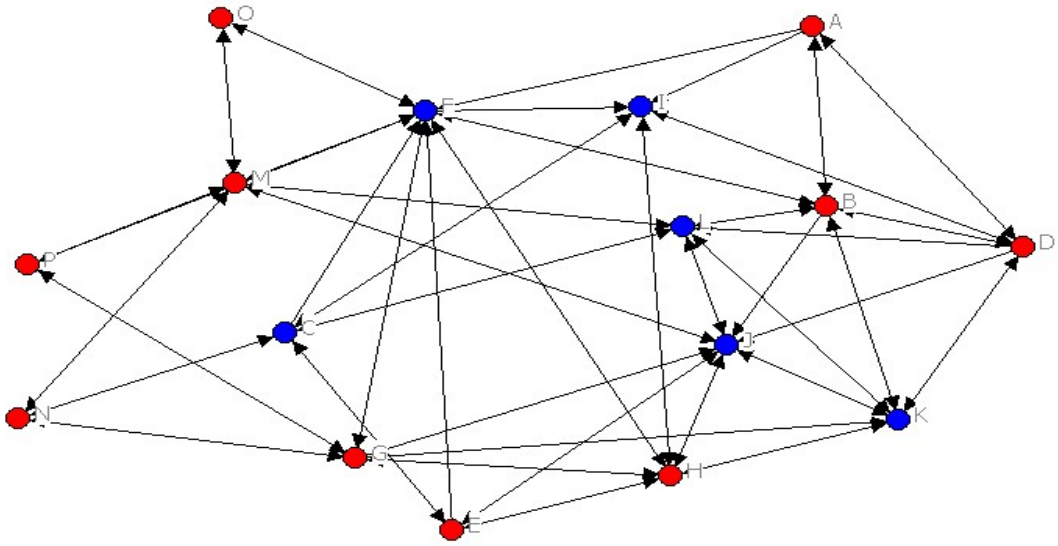

Figure 5.7 Communication Network in Company 3

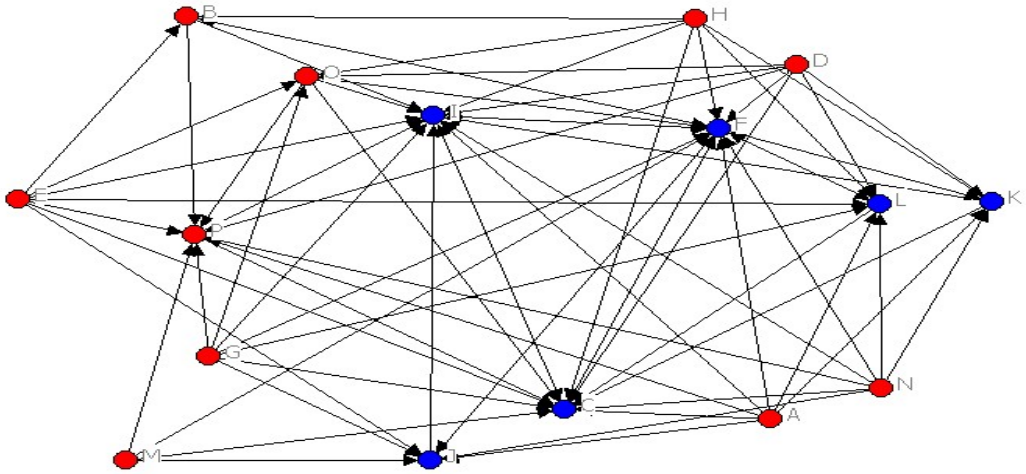

Figure 5.8 Advice Network in Company 3

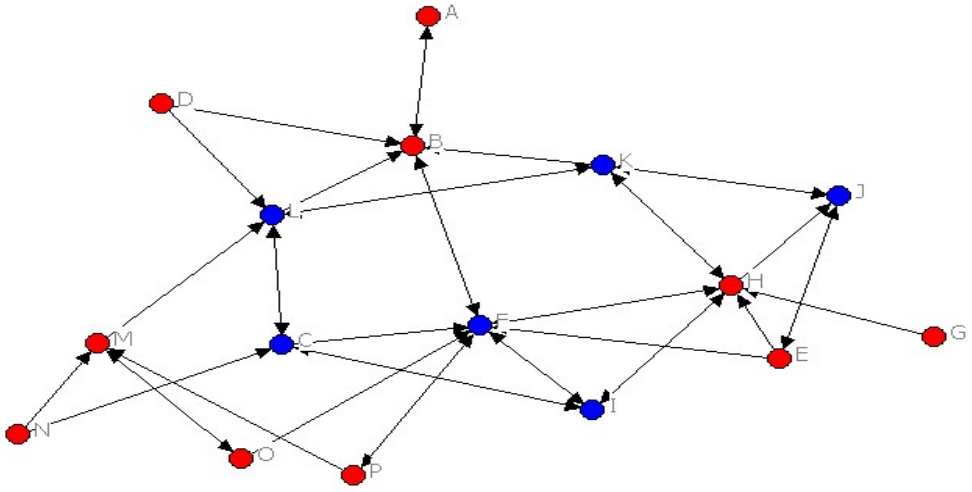

Figure 5.9 Trust Network in Company 3

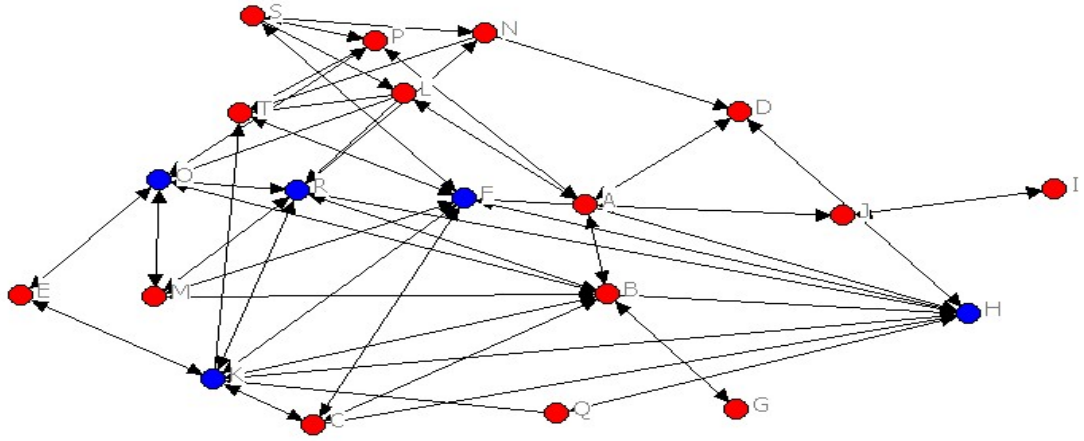

Figure 5.10 Communication Network in Company 4

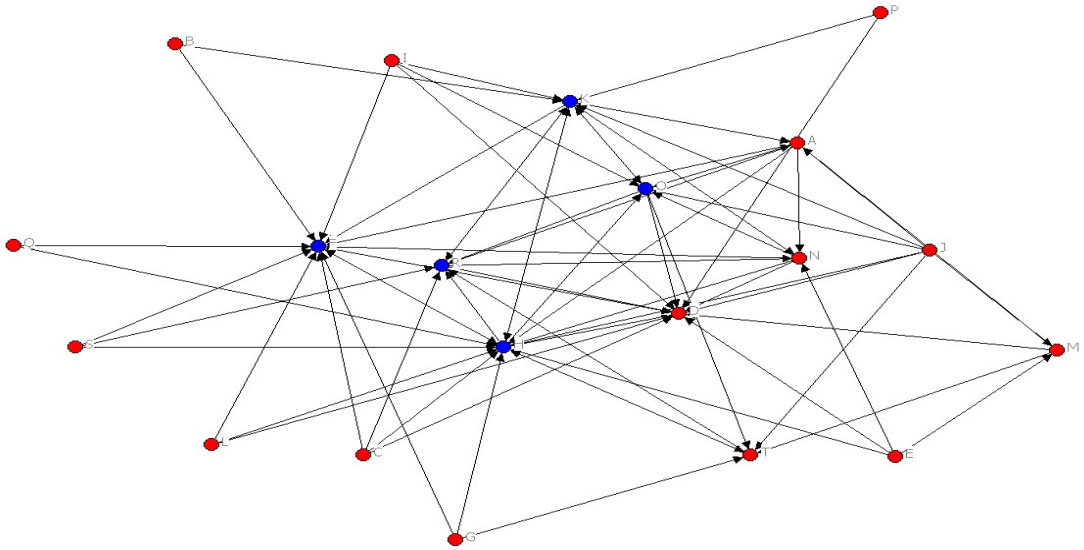

Figure 5.11 Advice Network in Company 4

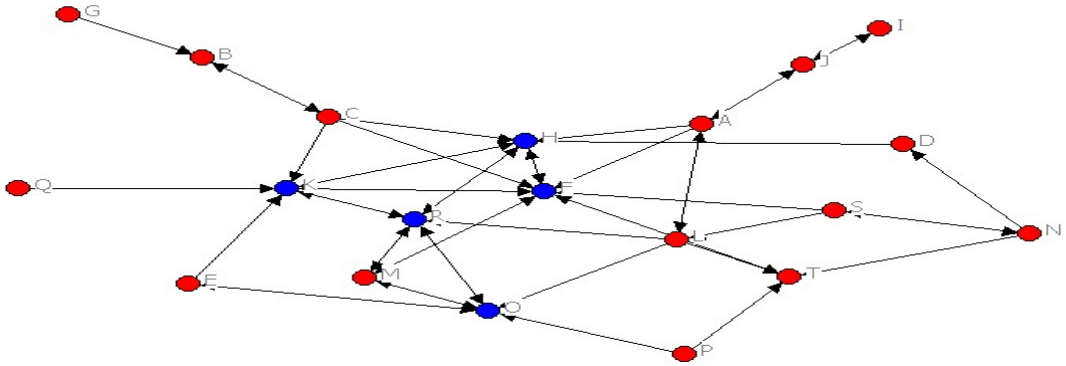

Figure 5.12 Trust Network in Company 4

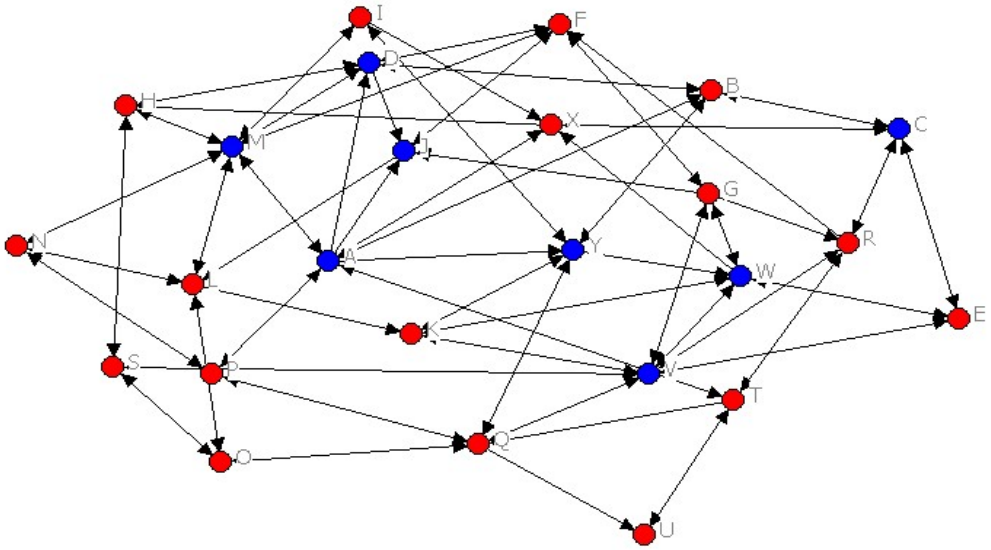

Figure 5.13 Communication Network in Company 5

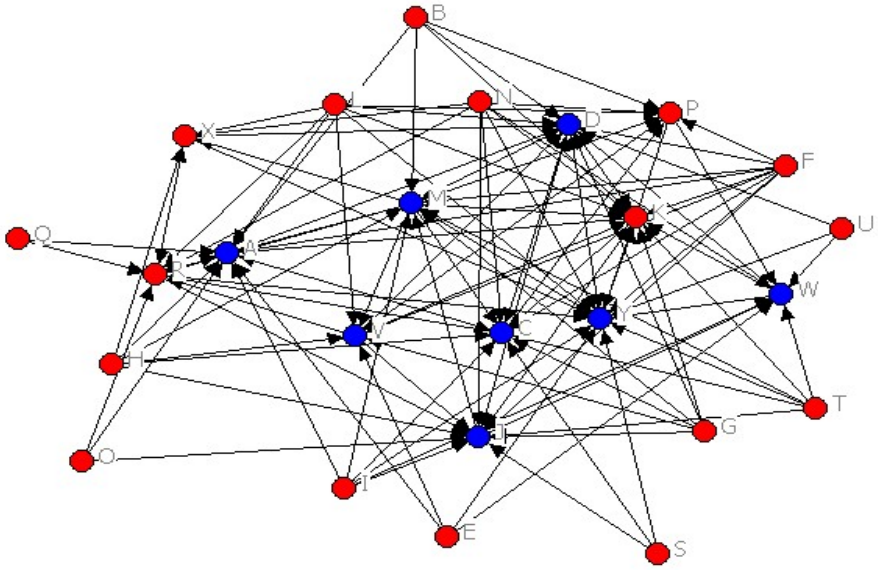

Figure 5.14 Advice Network in Company 5

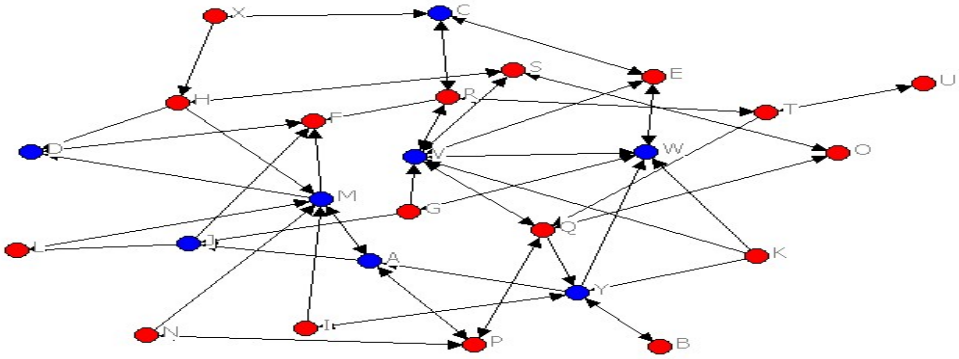

Figure 5.15 Trust Network in Company 5