2

EMPIRICAL ANALYSIS OF HYBRID OPEN SOURCE SOFTWARE MODEL: DETERMINATION OF EFFICIENCY AND GOVERNANCE

by

Mohamed A. Sidahmed

B.S. (honors), University of Khartoum, 1998

M.S., Cleveland State University, 2001

A thesis submitted to the

University of Colorado Denver

in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

Computer Science and Information Systems

2009

INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.
In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

This thesis for the Doctor of Philosophy

degree by

Mohamed A. Sidahmed

has been approved

by

James H. Gerlach

Clifford E. Young

Ronald V. Ramirez

E. Woodrow Eckard

Tom Altman

7-13-2009

Date

Sidahmed, Mohamed A. (Ph.D., Computer Science and Information Systems)

Empirical Analysis of Hybrid Open Source Software Model: Determination of Efficiency and Governance.

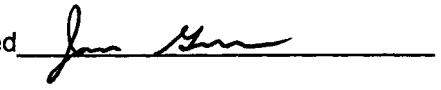
Thesis directed by Professor James H. Gerlach

ABSTRACT

Over the past decade, open source software (OSS) projects underwent significant changes and restructuring, symbolizing venture from the original approach of producing open source code by volunteer contributors. The latest trend, which is fueled by commercial organizations, systems integrators, and IT vendors' interest in OSS, involves the joint collaboration between open and proprietary concerns. This study investigates the implications of a collaborative hybrid OSS development model from the perspective of the OSS project. By extending transaction cost economics and interorganizational cooperation frameworks to the OSS domain, the research investigates factors affecting network governance structure of this hybrid alliance. Theory predicts that efficient forms of collaborative transaction leads to perceived satisfaction with an alliance. The study examines factors that contribute to satisfactory institutional governance and underlying principles that influence OSS projects to engage in hybrid relationships with commercial partners. Moreover, the research identifies the necessary dimensions of interorganizational cooperation and safeguards, which minimize project's vulnerability to detrimental behavior by commercial partners. Data was collected across OSS projects to analyze the impact of commercial partners' involvement on project efficiency and governance. Results demonstrate that OSS projects seek to establish arrangements that give rise to atypical structure for efficient management of the development process. Results reveal that the

formation of institutional establishment based on streamlined information flow, flexible non-formal relationship, collective collaboration responsibility, and moderation of influence effect give rise to a favorable form for governing transactions. The study also found that trust and branding play significant roles in reinforcing a thriving governance structure. Findings support the notion that hybrid projects achieve gains in product distinctiveness, yet collaboration is fragile to commercial parties' behavior of seeking self-interest. The emerging structure yields a perceived meritorious outcome for the OSS project; strongly suggesting that transaction cost efficiencies are realized. Practical implications for the study include identifying significant factors that contribute to OSS project efficiency and optimal governance, in addition to, establishing brand identity as a mutual benefit that binds the alliance. Hybrid OSS project success is largely dependent upon how well these factors are managed. The research fills a gap in empirical analysis of both OSS hybrid development model and OSS business model research.

This abstract accurately represents the content of the candidate's thesis. I recommend its publication.

Signed 

James H. Gerlach

DEDICATION

I dedicate this thesis to my parents and dearly loved grandparents, who taught me the essences of life. Their teaching always enlightens my path. Also, I dedicate this dissertation to my wife, thank you for the tremendous support and patience throughout the program.

ACKNOWLEDGMENT

I would like to express my gratitude to several people, who provided me with tremendous help and support either directly or indirectly. I owe a great credit to my advisor and mentor James Gerlach. His support extends beyond research, as one of his valuable life and a career counsels was "opportunities are made!"

When it comes to research, Jim's mentoring approach stimulates talented ideas and always challenges one to go an extra step. I also, want to thank my committee members, professors, Cliff Young, Ron Ramirez, Woody Eckard, and Tom Altman for their generous time and efforts. It has been a privilege to have such diverse and supportive cohort of scholars. Their collective intelligence and constructive feedback helped improving the quality of this research.

My deepest gratitude to professor Adam Fadlalla. Adam is a life-long friend, mentor, and an advisor. He is one of the remarkable teachers, who had big impact on my academic career. His influence taught me that achievement, to a large extent, is a function of articulated goals, persistence, and perseverance.

I want to extend my appreciation to professor Peter Bryant for his teaching, generosity and encouragement. I will always miss our discussion sessions and extraordinary class experience. My thanks go to professor Dawn Gregg for her collaboration and career advice. It has always been a pleasure working together. Last but not least, I would like to extend my appreciation to the many people, I did not explicitly mentioned, and without their support this would not be achievable. I deeply appreciate it and always grateful.

TABLE OF CONTENTS

FIGURES

Figure

TABLES

Table

1. Introduction

1.1 Study Framework

Accelerated technological advancements and continuous demands for new solutions to fulfill users and businesses' needs impose extra challenges on the traditional model of software and applications development. The constrained closed software development approach, often ascribed as rigid structure, is criticized for failing to exploit open innovation artifacts beyond institutional boundaries. In general the proprietary scheme is increasingly imposing supplementary licensing structure and additional fees to match overhead structuring costs and associated development expenditures.

The open source software (OSS) development model emerged as a contender to closed proprietary software development controlled by commercial vendors. The OSS approach is characterized as a transparent decentralized volunteer-based collaboration for developing software products that fulfill both authors' personal needs and made available for free or a nominal fee to a wide user base. The growth of OSS as a viable low-cost alternative to proprietary software total cost of ownership (TCO) and licensing fees, appealed to a broad capacity of commercial organizations, systems integrators, and IT vendors. Yet, full adoption of open source software by individuals and particularly within the enterprise is undermined by several risk factors. According to Dixon (2007), some of these impediments include:

- Unclear or imprecise roadmap
- Functional gaps

- Lack of formal support and services
- Project's rate of change
- Lack of endorsement by independent software vendors
- Software license types

Recognizing the fact that risk-related elements sometimes supersede cost attributes and in seeking to overcome some of the above obstacles, a growing number of volunteer community-based projects attracted attention and direct involvement of large corporations that recognized the value of either supporting the open source development approach, or embracing OSS business models.

A well-known example of collaboration between commercial organization and open source community started more than a decade ago by Netscape Communications endeavors to create network externalities via open source code of their flagship browser, Netscape Communicator, and initiated efforts for building a sound community around the project. A renowned pattern of established collaboration between OSS and commercial partners is revealed by the level of investment in OSS projects. Currently, several different-size organizations and giant IT vendors such as Intel, Google, Oracle, and Sun Microsystems are participating and endorsing multiple open source projects. A variety of support measures include: contributing physical assets and manpower resources, releasing patents and proprietary code, and announcing platform certification and endorsement of open source products. In addition, monetary donations are also among common forms of endorsement. The significant investment and collaboration between the two parties mark an emerging pattern of software development model that leverages organizations' economies of scale and community's pool of talent and resources. Research indicated that joint collaboration between open source software project community and commercial

partners establishes synergy that contributes positively to OSS ecosystems (Capek, Frank, Gerdt, & Shields, 2005).

The open source software community is a heterogeneous group of individuals, which include members with diverse backgrounds and domains of expertise involved in the process of creating and maintaining OSS production model. The dimension of cooperation and contribution of commercial organizations and IT vendors in open source projects is regarded as an effort to augment value and resource utilization (Clemons & Row, 1992). Also, the commercial partners' involvement is regarded as an attempt to support commoditized OSS products that complement organization's proprietary products (Deek & McHugh, 2008). An example of explicit coordination and contribution made by these organizations to one of the prominent open source software projects, Linux operating system kernel, shows that commercial and proprietary vendors' strategy recognized the significance of open source software development approach.

In opposition to what is commonly believed, the majority of contributions to successful and well-established open source software projects are made by commercial partners and IT vendors' paid contributors. The case studies chapter of the dissertation (Chapter 6) discloses details about volunteer vs. commercial companies paid employees' contribution ratio.

A recent study investigating major contributors to the Linux kernel project found that more than twenty nine organizations and IT vendors are making significant contributions to the development of the open source project (Kroah-Hartman, Corbet, & McPherson, 2008). This revealing information evidently substantiate the fact that open source paradigm is undertaking remarkable amendment to the conventional pure volunteer-based model. The OSS community is welcoming collaboration with IT vendors and commercial partners, who

contribute considerable amount of code development and perform mundane maintenance, support, and documentation tasks through paid employees. This study investigates outcomes of established relationships between OSS projects and commercial partners. Specifically, the research assesses cooperation efficiency and optimal ways for governing the relationship between an open source software project and commercial partners.

1.2 Statement of the Problem

The study embarks upon the application of transaction cost economics to open source software (OSS) development organizations. Latest trend in OSS witnessed significant involvement of commercial IT vendors and proprietary software development shops by 'embracing the bazaar'. Until recently, commercial vendors considered open source software as a low-profile hobbyist activity with insignificant impact on their product market share. As OSS continues to develop into a mainstream IT and become part of the enterprise domain mix, commercial IT vendors shift strategy to accept the movement.

The value of collaboration and IT vendors' sponsorship of OSS projects requires rigorous research to determine the prospect of such alliance. As parties of the alliance hold dissimilar and sometimes contradictory goals and missions, it becomes important to take into consideration special characteristics of non conventional transaction established between the two parties. Open source software project perspective has been adopted in this study to examine the outcome of the hybrid partnership. The study extends TCE vertical integration decision, by adopting the principal-agent metaphor to OSS project and commercial associate partnership. The partnership ascribes OSS project as the client (principal) making the decision whether to adhere to the typical pure volunteer contribution mode (vertical integration), or establishing a hybrid structure, through alliance with

commercial partners (agents). OSS project has the option of completely relying on the open source standard mode mechanisms, fueled by community volunteers for developing the product, or accepting the involvement of sponsoring and/or collaborating commercial organizations. Economic rationale predicts that open source software projects will continue to carry out those talent-oriented tasks that appeal to volunteers and leverage commercial partners' competences for other activities. The strategic alliance between the parties positions itself to take advantage of opportunities arising in a sustained relationship. Such values include advancement of product and service offerings and utilization of talent to accommodate relationship revolution (Subramani, 2004).

The OSS community develops software as a public good. Unlike other proprietary vendors, OSS volunteers are not concerned about disclosing innovation in product design or algorithm development. Quite the opposite, the latest move by proprietary software vendors calls for protecting claimed intellectual property even before identifying the potential role in the final commercial product. This contradicting nature between the parties of the relationship is unique in a sense. Although they share some incentives of traditional inter-organization alliance, yet OSS project community and commercial partners represent divergent forms of structures that are involved in the OSS hybrid model of collaboration. Open source software development is regarded as a mode of governance structure that differs from the classical profit maximization firm model. Development in TCE suggests that hybrid models for alliance organizing are more likely to take place when each party realizes the added value of the relationship. The study attempts to empirically validate the assumption that forming a relationship between open source software project and commercial partners will result in favorable outcomes for the project. The study embraces the open source software project point of view to assess the causal structure of the hybrid model efficiency and governance.

1.3 Thesis Statement

Structural changes in the open source software governance model and increased involvement of commercial companies and proprietary IT vendors represent a departure from the classical 'pure' open source software model to acceptance of a 'hybrid' commercialization approach for organizing. The open source software project should embrace commercial organizations collaboration and sponsorship, if the governed alliance yields increased efficiency and recognized brand entity.

1.4 Motivation of the Study

Open source software development is a dynamic fuzzy organization structure that proved to be effective in producing high quality software products by volunteer communities. Yet, OSS development is experiencing mutation as a consequence of increasingly significant involvement of commercial IT vendors and other proprietary software development companies. It could be argued that OSS will gain momentum due to the combined efforts and support from both volunteers and commercial partners, but at the cost of transforming its bazaar process for development. Therefore, analyzing the consequences of this adaptation on the project becomes one of the goals of the study.

Open source's extraordinary method of organization should give rise to a new collaborative structure that engages competing resources. Given recognition of the special form of collaboration between open source community and commercial partners, it is expected that a new form of interorganizational cooperation would emerge to account for two-party differences since governance is recognized as the fundamental function of control and administration that takes place when a group of people come together to legally

incorporate under the laws of a state for a nonprofit organizational purpose (Gies, Ott, & Shafritz, 1990, p. 178). In addition, it is likely that the role of transaction cost will presume another level of importance and allow for alternative interpretations within the open source context. From a transaction cost point of view, various forms of interorganizational relationship, such as joint ventures or network structures, are considered alternative forms of governance and departures from the generic organizational hierarchy (Barringer & Harrison, 2000). Some examples of typical businesses relationships include: marketing distribution partnerships, sales partnerships, and R&D partnerships.

This research is unique in a sense that emphasizes organizational interdependency that involves the establishment of joint cooperative activities between open source project community, a casual non-profit volunteer-based organization, and hierarchical-oriented commercial partners (e.g. OSS companies, IT vendors). Moreover, as participants in the hybrid alliance maintain potentially conflicting goals and missions, it is imperative to take into consideration special characteristics of the transaction.

This research adopts a multidimensional view for examining the hybrid form of OSS development. It applies the premise of transaction cost economics and interorganizational collaboration theory of adopting cost-minimizing governance structure for open source project community and commercial (for-profit) organization partner(s), designed for software development transaction. Attempts to understand the implications of such relationships is conducted on the basis that both parties agreed to form an out-of-band association in the form of 'cooperative adaptation' (Williamson, 2002), which is a departure from the classical form of alliance, in order to achieve mutual benefits and cost savings. While it is expected that both parties have relative dependency on the other, nevertheless adoption of safeguard mechanisms and low perception of opportunistic behavior likely

enable launching successful institutional establishments. The research objective is to identify a meritocratic governance structure for managing the hybrid partnership and interorganizational cooperation. The study adopts open source software project level of analysis and community perspective to examine cooperation patterns and antecedents of efficiency and bilateral governance structure of hybrid OSS projects. The research presumes novel vision to help understand open source software phenomenon. It contributes to the OSS literature and leads the way for future research directions. Moreover, results of the study are of interest for practice, by offering insights on factors contributing to developing successful alliance between the open source software community and commercial partners.

1.5 Thesis Organization

The dissertation is organized into seven chapters. Following the introductory chapter, the remainder of the thesis structure is presented next. Chapter two provides an overview of open source software in general and relevant issues to the focus of the study. Significant background work in OSS is also presented in this chapter. Chapter three presents the theoretical foundation and the underlying guiding theories adopted for the study. Comparative theory assessment is incorporated in this chapter; a summary of alternative competing theories and their relevancy for the study is offered. The fourth chapter introduces the first empirical study. The efficiency of the hybrid OSS model is examined in this chapter. Chapter five includes the second analytical model that analyzes dimensions of governance and other influential factors for achieving meritorious relationship outcome. The sixth chapter investigates practical implementations of the hybrid open source software model across several projects. Finally, chapter seven presents the summary of research findings, study limitations, and future research directions.

2. Open Source Software Overview

2.1 Background

Traditionally, free or open source software (OSS) development is a distributed coordinated process and highly successful innovative mode of producing free software by large volunteer-base contributors (von Hippel & von Krogh, 2003; Osterloh & Rota, 2007). The volunteer contributors are typically working without promise of direct monetary reimbursement or indirect reward compensation. Therefore, open source software is habitually ascribed as a voluntary nonprofit community organized around a vast number of software projects supported by the community. Free Software Foundation[1] (FSF) distinguishes free software as being a matter of liberty, not price. The metaphor of "free speech" rather than "free beer" is commonly used to help understand the concept.

The OSS project is recognized as the coordination entity that receives significant support from unpaid developers and adheres to the community's values and norms of organizing. The shared norms value system is fundamental in strengthening the community internal relations and protecting against 'outsiders' intrusion (Söderberg, 2007, p. 28). Unlike firm or market coordination mechanisms, the OSS production process orchestrates composite entity contribution efforts in an unconventional mode to produce functional products. The small group of core developers is reportedly accountable for about 80% of source code contributed (Crowston & Howison, 2005). Moving further away from the center of the OSS community, a larger group of seasonal developers with supporting roles to the core

commonly exists. A much bigger set of users represent a third layer surrounding the previous two.

The produced source code is freely available for download, modification, and redistribution, under a precise licensing scheme. One of the most widely used licensing schemes is GNU General Public License (GPL). Contrary to proprietary software, where development is executed in a closed-organization setting, OSS society adopts a globally distributed and transparent process of developing software products that span across languages, cultures, and geographic regions. The free and open model of collaboration is ascribed as a self-organizing society that fosters rapid knowledge creation and innovation diffusion (von Hippel & von Krogh, 2003; Lee & Cole, 2003).

The loosely structured open source model enables large scale collaboration and requires an agile, incremental development approach. The internal classical network organization structure and hierarchy is based on reputation, contacts, and demonstrated technical skills. Yet, the project's dynamic hierarchy and unrestricted shift of power is not based on economic, legal, or architectural dependencies (Söderberg, 2007).

The OSS paradigm positions itself as a revolutionary organization structure (Lerner & Tirole, 2002). This form of organization is distinct from the classical hierarchical structure with a chain of command and decision authority. Situated as a lean formation, open source organization is configured to reflect community's impulse and stimulate improvement and restructuring for efficiency. The community is a superset of all developers, users, and other

[1] www.fsf.org

supporters of OSS, who carry out fundamental activities of product design, implementation, defects reporting, and bug fixing.

Deeply rooted in 'Hackerdom' (AlMarzouq, Zheng, Rong, & Grover, 2005), the primary concern of open source hackers' (real programmers) culture is the assurance of public access to the source code. Members demand lifting all restrictions on obtaining, modifying, and freely redistributing source code and binaries. Adherence to this unwritten agreement is what establishes membership in the open source software community.

Intrigued by the freedom to express themselves (such as the freedom of speech) through the code, OSS developers elect for themselves what they want to work on and what fits their interests and capabilities. As collaborative activities continue, more developers join the efforts and eventually a social network structure emerges as a result.

Presently, there are two main campaigns, the Free Software Foundation lobby group and the Open Source Initiative[2], that steer OSS. The two merely differ on principles and agree in terms of practicalities. They resemble political parties with different views and stands on certain issues. Yet, the relationship between the two camps is more synergetic rather than being acrimonious to each other. Both contest a common opponent represented by proprietary software. The two camps reflect philosophical differences and endeavor to maintain their separate identities. For the Free Software camp, this reflects their claim to their original establishment of the community.

2.2 Motivation to Contribute

OSS developers' motivation to contribute to open source software has been a rich topic for research. Several studies investigate factors driving voluntary participants to contribute valuable resources such as time and effort without being directly compensated (Lakhani & von Hippel, 2003; Shah, 2006; Hertel, Niedner, & Herrmann, 2003). Essentially most of the developers possess skillful human capital (Hars & Qu, 2002), and could be economically rewarded in a free market. The OSS human capital encompasses knowledge, capabilities and skills acquired through participation and learning by doing.

Moreover, other studies embark upon determining factors driving sustained participation and contribution to open source (Fang & Neufeld, 2009). Results showed that some of the key reasons for contribution include an OSS gift driven culture (Bergquist & Ljungberg, 2001) that values altruism and reciprocity (Wu, Gerlach, & Young, 2007), satisfying personal needs for the software (Lerner & Tirole, 2002; Hertel et al., 2003), self enjoyment (Roberts, Hann, & Slaughter, 2006), career development (Lerner & Tirole, 2002; Wu et al., 2007), enhanced reputation (Franke & Hippel, 2003), and seeking direct compensation as a result of their involvement (Krishnamurthy, 2006; Roberts et al., 2006). While former factors reflect intrinsic drivers that motivate developers to contribute to OSS, there are other external factors that might have an influence on developers' choice to contribute to a particular project. A recent study found that the status of a project and prior ties with its members might influence developers' decisions to contribute to that project (Hahn, Moon, & Zhang, 2008).

Expressed in economic terms, OSS developers' motivation to contribute to OSS could be measured as the sum of immediate and delayed payoffs (AlMarzouq et al., 2005). While

[2] http://www.opensource.org

satisfaction from using the software represents immediate payoffs, prospective career opportunities and community recognition symbolize delayed future payoffs.

Dissimilar to the exchange economy society where allocation of scarce commodities (i.e. goods and services) takes place in a decentralized fashion through trade and voluntary contribution, gift culture, such as OSS, is characterized by abundance not scarcity (Raymond, 2001). To achieve the goal of attaining reputable social status in a gift culture, OSS contributors are judged by what they give to the community rather than by what they control. In a sense, an open source software developer denotes their prominence in the community by handing over solitary control over developed code and sharing with the public.

Some studies argue that the success of a project is largely a function of that project's ability to attract and retain skillful contributors. The recruitment initiative and project attributes have to match prospective contributors' motivations (Stewart, Ammeter, & Maruping, 2006) and also assure that the project creates distinguished value (Raghunathan, Prasad, Mishra, & Hsihui, 2005). Some developers are primarily driven by the enjoyment and satisfaction of solving complex problems and crafting well designed operational software. Others stress the importance of being recognized in the community as outstanding individuals capable of delivering successful results. This notion of recognition compensation as substitution for monetary compensation is acknowledged by an open source developer as:

> "You may not work to get reputation, but the reputation is a real payment with consequences if you do the job well" (Raymond, 2001).

This testimony confirms that open source developers' renewed interest and commitment to open source is determined, in part, by the level of recognition received for contributed work and peers' high regard.

2.3 Open Source Licenses

Some critics of free/open source software regard OSS as being antagonistic towards intellectual property rights. The fact that OSS developers and contributors in general acknowledge and preserve individual's intellectual property is reflected by the diverse open source software licensing schemes. The licensing scheme, in part, serves as a governing mechanism (Bonaccorsi & Rossi, 2003). This governance apparatus functions as safeguard measures against opportunistic and ill-behaviors that might inflict a community or transgress against the community's norms and values.

OSS software source code is primarily hosted on the public domain for free use. Accordingly, the free and open source group invented the concept of 'copyleft' as an alternative to proprietary software copy rights, which prevent users from having access, modifying, or redistributing rights over source code. The "free" software adheres to four levels of freedom (zero-3). These levels are established by the Free Software Foundation as a measure of software openness. Essentially, the higher levels of freedom are dependent on satisfying the basic level of having access to the code (level zero). As a general rule, users should be able to have the following privileges (FSF, 2009):

1. Run the program for any purpose (freedom level zero).
2. Study program design and functionality, and adapt it to personal needs (freedom level 1).
3. Redistribute copies of the program (freedom level 2).

4. Improve the program and subsequently release improvements (and modified versions in general) to the public (freedom level 3).

The two major entities that provide approved free/OSS software licenses are Open Source Initiative (OSI) and Free Software Foundation (FSF). FSF licenses are classified in terms of whether the license qualifies as a free software license, whether it is a copyleft license, or whether it is compatible with the principal GNU GPL. Finally a license is assessed whether it causes any particular practical problems that could jeopardize its use.

The main purpose of setting up OSS intellectual property protection schemes is to stimulate ongoing innovation and creative thinking of members developing software while protecting an individual's contribution from being misused in a way against OSS mission or original contributor's intent. The establishment of the licensing system is an integral part of the OSS social structure, which seeks to empower users and a wider field of developers by assuring free access to the code and granting rights to utilize it. In addition, the licenses apply necessary check points to discourage attempts of restricting access to other users and developers (Weber, 2004).

Although there are practical differences between various free/open source licenses, the differences primarily reflect the original software developers' motivations and level of restrictiveness associated with code usage and derivative works. While some licenses are relatively lenient in terms of usage, others are considered 'viral' and restrictive. For instance, GNU GPL is considered more restrictive than Berkeley Software Distribution (BSD). GPL requires that all derivatives of the original code to be also 'free'/open. In

addition, GNU GPL demands that code distributed under this license be included only with other software distributed under copyleft licenses.

A project choice to adopt a specific type of license defines direction of the project and potential opportunities for commercialization initiatives involving commercial partners supporting the project or building auxiliary services around core projects.
Furthermore, the OSS licensing scheme behaves as a safeguard mechanism for protecting projects from detrimental pursuits that violate open source mission and objectives. Some studies argue that choice of license type and organization sponsorship of a project will have an influence on users' interest in the project (Stewart et al., 2006). However, it may subsequently limit potential adoption due to marginalization of users' need to incorporate the code with other software.

2.4 Projects

Open source software projects are virtual communities that operate under social structures (Butler, 2001). An open source software project is recognized as the entity that receives significant support from voluntary contributions represented in time, effort, and/or money. A project is also a mechanism for protecting and maximizing developer's reputation incentives (Raymond, 2001). Reputation guarding is realized by protecting the integrity of unit of work against negatively regarded activities by the OSS community such as 'forking' and 'rogue-patching'.
Research found that administrative and infrastructure open source software projects with advanced technical user-base have more momentum and enjoy larger developer contributions (Söderberg, 2007). These applications serve the needs of users/developers, whose participation in the project is driven by fulfilling personal needs.

One example of administrative and infrastructure software adoption and diffusion among various user levels is the Linux open source operating system compared to Microsoft Windows proprietary software. End users' familiarity with the graphical user interface and relatively minimal acquaintance with shell scripting and command-line instructions limit mass adoption of a more robust operating system for client machines. To fulfill this limitation, a group within OSS community is pushing to extend the power and advantage of Linux beyond enterprise data centers to the desktop/notebook space. Ubuntu[3] is an example of a growing OSS project that vows to fill this gap by simplifying end user deployment and usage of the Linux operating system.

The above examples reflects the OSS community dynamism and continuous strive to adjust itself to fulfill and take advantage of emerging opportunities. In response, new project structures emerge, existing ones undergo restructuring, and projects fork and mergers occur. Some projects are successful at achieving their goals and mission. Others fail to take off and draw critical mass to carry on substantial operations. A project cannot survive if founders are unable to recruit and retain talented and competent developers and contributors. A project also needs to have a large enough community user-base for product testing and improvement.

OSS projects follow an agile incremental development method. The concept of release early and release often, where developers work on frequent iterations of software released by members of the community, is one of the principles that define open source software development process. Perpetual beta ($^{P}\beta$) or continuous underdevelopment proved to be an optimal software development life cycle (SDLC) methodology. Many commercial

[3] http://www.ubuntu.com

software development organizations adopted open source software SDLC approach for their product offerings. Some of the direct benefits of this process are lowering cost of development and exploiting the power of community for debugging and functionality enhancements.

2.5 Project Governance

Open source projects vary widely in terms of attributes and management styles. Project life-cycle and application domain are some of the primary factors in determining appropriate administration configuration. While some projects employ structured and well-defined processes, others opt for more freedom and creativity in defining and managing project tasks (Shah, 2006). Currently, there is no taxonomy for open source software project governance. As a result, painting an absolute picture of the OSS management process is a far reaching goal. Overall, it could be argued that OSS movement is primarily cooperatively instituted. Yet, research shows that not all OSS projects were successful in realizing a governance structure that drives tidiness and efficiency (Scacchi, 2002).

An open source project typically has a non-standard process of inception. The prevalent mode is community established projects, initiated by one or more individuals independent of their employment context (e.g. Linux, GNOME, etc) (West & O'Mahony, 2005). Passionate volunteers exchange knowledge and ideas, which leads to the shaping and creation of a working product (prototype). Project roadmap and feature prioritization are usually decided via voting.

In relatively less popular instances, an open source project could be established by commercial companies. Such companies opt for one of two means. They typically either decide to 'open source' part or whole of their products by releasing the source code, or

seek to establish an open source community to work on a project. One of the prominent examples of a company initiated project is Mozzila[4] that was established as a result of Netscape releasing its browser source code (Mockus, Fielding, & Herbsleb, 2002). A recent initiative by Google aims to establish a strong community by taking the Android[5] project open source.

Normally, project initiators/owners are in charge of resolving some of the conflicts that may arise as the project continue to develop. Despite the fact that some developers might have more influence on the direction of the project; either because of seniority or better design approach; such practice of having the whole community involved in the decision making process insures everyone is respected and their opinion gets heard.

In general, three main conflict dilemmas require constant and careful resolution to insure a healthy project community that abides by the OSS values. Research found that timeliness and helpfulness of communication to be crucial in OSS work (Stewart & Gosain, 2006). Disagreements could emerge as a result of identifying an individual or a group in command of a) arbitration and final decision on the project, b) efforts to reduce duplication, and c) demand accountability for work performed on the project (Raymond, 2001).

The process of documenting and defining work processes comes into mainstream as the community grows and tasks become more complex and interdependent. The project attracts external collaboration and sponsorship through communicating project features,

[4] http://www.mozilla.org/

[5] Android open source mobile platform: http://source.android.com/

functionality on mailing lists, newsgroups or online news services (Evers, 2000). Interested participants recognize potential mutual benefits and examine project results and milestones. Organizations planning to establish an alliance with an open source project usually provide suggestions and recommendations for improvement to the community. Favorable signals of community acceptance of commercial organization suggestions and feedback sets the stage for forging a partnership between open source project and commercial parties.

Various relationship structures exist between open source projects and commercial partners (Dahlander & Magnusson, 2005). The symbiotic approach, where both parties gain from the alliance, might be the most effective at influencing the project members and achieving collaborative governance mechanisms. The symbiotic relationship between open source projects such as Linux and large commercial partners such as IBM enables the project to achieve the expanded reach and efficiencies (Etemad, Wright, & Dana, 2001). One of the advantages of such vendor collaboration with Linux for example, is developing the project into enterprise-level software that meets high demands of scalability and throughput.

However, the symbiotic approach introduces managerial challenges related to decision rights and control between the different parties. A consensual shared authority is needed prior to parties' attempt of establishing successful governance structure. Some of the operational means of enabling governance require resolving ambiguity about control and ownership, aligning different interests, creating and maintaining a positive reputation, and investing in channels for proactive interactions.

Violation of open source formal and informal social structure for managing project's methodical process or failure to direct individual efforts towards a common goal could result in creating a project clone or a process of forking (O'Mahony & Ferraro, 2007). A project fork is a situation where a particular aspect or feature of an established project is used as the basis for creating a new project. The process implies that the newly formed group is dissatisfied with the direction of the original project and they vow to take it to a new level.

It is considered a relatively simple process to start a new open source software project fork that typically has a different governance structure and common goals. As an "anti-authoritarian" system, freedom of acquisition and modification of source code is conferred by open source licenses. New project initiators are not required to secure permission from the original developers, nor do they have an obligation to collaborate with the developers of the base project. In practice, it is quite often the case that the developers of a fork will have frequent interactions with the original project's developers and administrators, or the two projects will develop a common working relationship. Yet, the level of communication and collaboration is entirely voluntary. The forking of Foswiki project from TWiki in October 2008 is an example of community dissatisfaction with the hostile governance model imposed by the commercialization of the open source project. It is unlikely both projects will survive and dominate across market share in the long run.

Another form of structuring an open source project is by joining the work forces of two or more projects in a merger-like transaction. The new structure is set to overcome scalability issues and decision making complexity. The merger of open source web development

frameworks projects, Rails[6] and Merb[7], announced late December 2008 (Niccolai, 2008), into a single project reflects a restructuring of individual project's management and processes to accommodate newly formed project needs. The merger is considered a healthy step to carry the project forward, since rivalry development leads to community segregation and duplication of effort. It has been argued that changes in decision-making processes and managerial procedures of the newly created project will benefit both parties by ensuring architectural decisions that meet the needs of both parties. The decision to join forces of the two projects position Rails, the merged project, to receive additional contribution from commercial supporters.

Perens' (2005) taxonomy of contributors to the open source software development demonstrates several groups with diverse agendas and venture interest in open source software. Contributors' pay-offs expectations and course taken to get involved in OSS is beyond the scope of this research. However, occasionally, commercial companies adopt a secretive strategy (or at least a less publicized strategy) when determined to get involved in open source initiative. Some of these companies' objective is merely to counter proprietary competitors' market dominance (Kogut & Turcanu, 2000) or to tap into open source think tanks for new ideas and innovations (Lerner & Tirole, 2005).

In part, this study explores viability and organizing form, when opposing incentive groups come together to engage in OSS development transaction. Table 2.1 presents diverse segments of non-volunteer contributors to OSS. These groups have different needs and

[6] http://rubyonrails.org/

[7] http://merbivore.com/

motivations. Also each stakeholder category satisfies a different role or function in the open source ecosystem.

Table 2.1 **Open Source Software Non-volunteer Contributors**

Contributor	Motivation	Major Role	Example
Software Packagers	Revenue generating through brand quality service	Integration, certification	Fedora Core, Novell, Red Hat, Ubuntu
Flagship open source software companies	Revenue stream from dual licensing mode, proprietary add-ons, training, and support	Funds ongoing operation of underlying OSS project, certification	MySQL AB, Pentaho, Sendmail Inc.
Commercial hardware and middleware vendors	Open source software as an enabler of hardware or solutions sales, cost-efficiency	Sponsor	Hewlett Packard, IBM, Intel
Service Businesses	Develop custom business solutions, take advantage of loopholes in OSS licenses by limit to internal use only	Integrators of multiple OSS projects	Financial industry
End-user businesses and their contractors	Utilize OSS in daily operations	Contribute own employees/contractors to work on OSS projects	Amazon, eBay, Google, Yahoo
Government	Not favoring particular vendor, avoid potential switching costs	OSS development as a public benefit	European Union (EU)

Table 2.1 (Con't.)

Contributor	Motivation	Major Role	Example
Academic and scientific researchers	Platform for publications, cost efficiency	Free labor contribution by students and grants	Bell Labs, University of California Berkeley
Software Foundations	Accelerate the development and usage of free and open source software	Directorship driven organization, provide support for the project community	Apache Foundation, Linux Foundation, Mozilla Foundation

2.6 Governance Challenges

Open source software is predominantly a community-oriented development. All design, implementation, and maintenance activities are carried out by a community of volunteers, whose actions determine the prospects and directions of their project. This approach is enormously different from proprietary software development. The emergence of OSS as a viable product and successful method of organizing appealed to organizations and commercial vendors.

In a different way, the tremendous success achieved by open source and emergence of recognized brands such as Apache, Sendmail, MySQL and Linux associated with OSS projects poses a threat to proprietary "closed-code" vendors. Proprietary software vendors expressed their deep concern over OSS momentum and felt compelled to react in some way. Microsoft's reaction to open source momentum is expresses by the CEO statement:

> "Noncommercial software products in general and Linux in particular present a competitive challenge for us and our entire industry and they require our concentrated focus and attention" (Topdog08.com, 2003).

Nowadays, several organizations actively pursue collective intelligence and innovative production in partnership with project communities. Recent research identified finding the optimal form of governance for this newly formed alliance between OSS project and commercial partners to be a major obstacle (Sadowski, Sadowski-Rasters, & Duysters, 2008). The study also found that bazaar governance proved to be inefficient as OSS project grows in terms of technical and structural complexity. As a result, an alternative mode of governance emerged to account for new tasks structures and control mechanism. Various levels of 'quasi-hierarchical' governance forms are being shaped across various

projects to different degrees. Projects such as Linux and Apache demonstrate adapted forms of hybrid bazaar governance.

2.6.1 Commercialization of Open Source

The phenomenal progress of the OSS bazaar style development fueled interest in adopting the method in commercial and revenue-driven environments. In some cases, OSS outperforms competing proprietary software in terms of market share dominance. One of the key measures of successful open source project is level of adoption and user base. Organizations and commercial vendors have been tracking open source projects that have the potential to fill some gaps in commercial software product offerings or venture into new technology innovation. The primary focus of these companies is to identify projects that are able to present 'plausible promise' (Raymond, 2001). Acknowledging the fact no open source project has a complete set of features; emerging business models are established to fill gaps in OSS software ecology. Several commercial open source companies are competing with proprietary software providers introducing themselves as direct competitors providing value-added services and business support (Fitzgerald, 2006).

Analytical investigation of commercial open source revealed that several OSS companies dominated proprietary software in terms of market share and achieved higher user base, when proprietary software vendors have relatively low strength of network effects (Sen, 2007).

2.6.2 Institutions Involvement

The passion about open source software and the intensity of growth has extended beyond the community level. A number of commercial organizations and IT vendors made a decision to seize the opportunity of OSS thrust. Today, organizations make an attempt to

reap both direct and indirect benefit gains. Building auxiliary services and ecosystem around OSS core products are examples of additional software related services exploited by these organizations. Furthermore, several organizations are exploring the potentials of leveraging an OSS-like environment to garner some of the organizational and structural benefits enjoyed by OSS (Sharma, Sugumaran, & Rajagopalan, 2002).

Some studies looked at the entry strategies adopted by such organizations to engage in OSS (Bonaccorsi, Giannangeli, & Rossi, 2006), while others attempt to understand the mechanism of reconciling differences between OSS community and rent-seeker institutions (Franck & Jungwirth, 2003). Results show that commercial organizations and IT vendors do not adopt a free ride strategy mentality of not contributing back to the OSS community. Quite the opposite , most of these organizations regard their participation in open source software projects as an opportunity for gaining alternative operational approach and acquiring novel competitive methodologies.

Organizations involvement in open source projects could take different forms and various levels of involvement. Nevertheless, the top engagement patterns include coordination, collaboration, and provision of code (Bonaccorsi, Lorenzi, Merito, & Rossi, 2007). Project coordination is a widely common practice by organizations and IT vendors to facilitate project activities and provide numerous support activities. One example of coordination is organizations offering hosting services for OSS projects. On the other hand, collaboration represents actual involvement in several phases of software development activities. For instance design, development, testing, and bug fixes are part of collaboration activities between project community and commercial partner. Ultimately, provision of code/protocols includes organizations and commercial vendors' specification of code or

protocols such as network communication protocols that define handshake and fall-over mechanisms.

Apart from organizations' involvement type, OSS project partnership with commercial partners could serve as a signal for evaluating project that give confidence and invigorate users' interest (Stewart et al., 2006). Since most users lack technical expertise for thoroughly evaluating the project and examining its full features, presence of commercial partners' sponsors and supporters act as a surrogate for OSS project usefulness and quality. Overall, the quality of project and its success is dependent, to a large extent, on level of organization, communication, and control mechanisms. These factors and other dimensions of governance are examined in more details in the next chapters.

3. Theoretical Framework

3.1 Transaction Cost Economics Theory

Transaction cost economics (TCE) is an interdisciplinary field that borrows from economics, organization theory, and contract law (Williamson, 1979). It's part of micro-level institutional economics that deals with the establishment of governance and institutional arrangements. Neoclassical institutional theory identifies institutional arrangement as:

> "Arrangement between economic units that governs the ways in which these units can cooperate and/or compete. It ... [can] provide a structure within which its members can cooperate ... or [it can] provide a mechanism that can effect a change in laws or property rights" (Davis & Smorodin, 1971).

The Nature of the Firm (Coase, 1937) seminal article is considered a path-breaking contribution (Hardt, 2006) that laid the foundation for originating the theory by pointing out controversial resource allocation problems planned through market mechanism versus those planned within firm. In an attempt to justify existence of the firm, Coase argued that the cost associated with usage of the market could be avoided or minimized through the establishment of a substitute form of organizing (firm). In addition, Coasian theorem admits a trade-off between the cost of organizing transactions within the firm and those incurred in open markets. Critics of these assumptions contend that Coase failed to acknowledge the focal characteristic of the firm as a governing structure of the production-distribution process (Fourie, 1989). The differentiation factor between the market's role and

the firm's is that the first involves connecting production and consumption entities, while the later launches production of goods and services (Fourie, 1989).

Expanding Coase's proposal, extension work on transaction cost is founded upon three major elements: asset specificity, opportunism, and bounded rationality. Seminal empirical work on the theory asserts that opportunism and bounded rationality are the key behavioral assumptions on which TCE relies (Williamson, 1985). Asset specificity has been ascribed as the degree to which durable and human assets are tailored for a specific economic exchange, or 'quasi-rents' that lose value when redeployed in a different transaction. Adopting classical behavioral notion of the bounded rationality construct (Simon, 1957, 1987), Williamson embraced the concept based on two aspects. The first factor deals with individuals' limited capacity for dealing with information complexities. The second factor has to do with economic actors' incomplete access to information about the world. A phenomenon recognized by Simon as "intendedly rational, but only limitedly so". The bounded rationality concept stems from the fact that humans have limited capacity, in terms of skills, knowledge, and foresight. The organization model is a feasible alternative for overcoming human limitations.

The principal thesis of transaction cost analysis is that since transactions with different cost attributes can have different costs consequences, transactions with certain characteristics can be organized relatively more efficiently, incurring lower transaction costs, by the organization than by market. Some studies argue that transactions should be organized so as to economize on bounded rationality while simultaneously safeguarding them against the hazards of opportunism (Williamson, 1993). The theory explains why some products/services are produced internally within a firm (vertically integrated) with a

hierarchical governance structure while others are produced and purchased on an external market. This traditional view of optimal degree of outsourcing and choice of governance structure is regarded in terms of market or hierarchy alternative (Williamson, 1975).

Over the last several decades, transaction cost economics has been instrumental in explaining different forms of organizing. Compared to the neoclassic economic view, transaction cost economists consider transaction as the fundamental unit of analysis. Precisely, a transaction is considered any form of exchange involving good or service transfer across separate economic actors' barriers. Examples of broad discipline application of the theory include outsourcing, strategic alliance, and contractual agreement (Monteverde & Teece, 1982; Walker & Weber, 1987; Masten, 1993). The theory implies that poor management of transaction costs would lead to an institution's decline and failure (Rindfleisch & Heide, 1997). A summary of the underlying elements of TCE[8] is presented in the next subsections.

3.1.1 Governance Branch of TCE

Transaction cost operationalization emphasized relative efficiency of alternative governance structures (Geyskens, Steenkamp, & Kumar, 2006). As one of TCE emphasized concepts, applications of the theory largely focus on governance structures. Operationalization work on the theory hypothesized that establishment of various forms of governance is an indication of distinct explanation of various arrangement types (Williamson, 1991b). Yet, the governance is largely a function of the institutional

[8] Due to the extensive literature of TCE across various domains, selective review related to governance in collaborative setting is presented here. We direct attention to cited sources for further details.

environment within which transactions are taking place (Williamson, 1993). According to TCE theory, Williamson argues that the key driving hypothesis is to:

> "Align transactions, which differ in their attributes, with governance structures, which differ in their costs and competencies, in a discriminating (mainly, transaction cost economizing) way" (Williamson, 1991b).

Furthermore, the theory predicts that transactions are embedded in governance structures that minimize vulnerability (Williamson, 1998). Gies, Ott, and Shafritz (1990, p. 178) recognized governance as the function of control and administration, which takes place when, a group of people come together to legally incorporate under the laws of a state for a nonprofit organizational purpose. TCE theorists argue that in interfirm cooperation settings, there might be adverse consequences to collaboration due to potential untrustworthiness and self-interest behavior of argents involved in a transaction (Williamson, 1979). Hence, having collaborating parties retain the incentive for maintaining the relationship, by the establishment of governance mechanisms, also acknowledged as 'safeguards', in order to reduce transaction costs incurred by opportunism and environment uncertainty becomes an essential goal of the theory.

TCE differentiate between three general forms of governance mechanisms, namely: vertical (hierarchical) highly-specific governance (Williamson, 1979; Barney, 1999), intermediate or hybrid (semi-specific) governance (Williamson, 1979, 1985), and market (non-transaction-specific) governance (Williamson, 1979; Judge & Dooly, 2006). This study is motivated by the second type of governance; explicitly semi-specific or intermediate structures for governing alliances between an open source project and profit-oriented[9]

[9] Could be any group, not just for-profit organizations

partners. In an attempt to address the governance decision, some earlier studies maintained that the governance question is simply a factor of early selection and setting some form of socialization efforts, or a combination of both (Heide & John, 1990). Equally, level of integration of operational decisions between two economic entities is regarded as a key aspect of governance structure (Clemons & Row, 1992). Williamson (1991a) recognized exchange agreement and reciprocal trading as forms of hybrid structures. Other studies recognized this form of organization as value-added partnership (Johnston & Lawrence, 1988), strategic network (Jarillo, 1988), and strategic alliance (Webster, 1992; Saxton, 1997).

3.1.2 Semi Specific Integration

Vertical integration represents a restrictive form of organization favoring internal exchanges within firm boundaries. There are two main characteristics that identify vertically integrated firms: a) employing whole output of a process, as part or all, of one intermediate input into the process; b) acquiring the entire quantity of one intermediate input of the process from, all or part of, the output of the process (Perry, 1989). This method implies full control of resources by organization and eliminates dependency on external assets.

According to one view (Perry, 1989); transactional economies perception is one of the key determinants of vertical integration. Seemingly, the outcome of vertical integration is reducing the requirements of intermediate exchange inputs. TCE theorize that one of the incentives of firm's adoption of integration of a process is to internalize transactional economies and eventually reduce its transaction costs. From a transaction cost point of view, various forms of interorganizational relationship, such as joint ventures or network structures, are considered alternative forms of governance and departures from the

generic organizational hierarchy (make) or market (buy) decision (Barringer & Harrison 2000).

3.1.3 Asset Specificity

Asset specificity is a characteristic of an investment's transferability from one transaction or setting to an alternative one. Recognized as a notion of sunk cost, TCE maintain that switching specific assets from one setting to a different one will result in lowering the value of these assets. Therefore, partners associated with a transaction that involves "appropriable quasi-rents" are more likely to remain in partnership and work together to attain mutual satisfactory benefits. Essentially, the theory upholds the precondition assumption that asset specificity implications come into play only under circumstances of incomplete contracts (Williamson, 1975, 1979; Klein, Crawford, & Alchian, 1978).

Correspondingly, TCE research differentiates between two types of asset specificity: intangible and tangible. Intangible factors are identified by the uniqueness of skills, functions and business knowledge required for completing a particular transaction (Williamson, 1985; Young-Ybarra & Wiersema, 1999; Subramani, 2004). On the other hand, tangible assets include any form of physical or monetary contributions. In summary, the six major types of assets specificity recognized in the literature can be represented as (Williamson, 1989):

1. Site specificity, which is most common in manufacturing facilities that benefit from close proximity and geographical location to complete the transaction.
2. Physical asset specificity, which represents special purpose equipment and other tangible capital investments dedicated to a particular transaction.

3. Human asset specificity, referring to specialized skills and knowledge capital developed by engaging in a specific transaction.
4. Dedicated assets, in the form of discrete investments devoted for a single transaction.
5. Temporal specificity, occurs when synchronous and timely response is required for the transaction.
6. Brand name capital, that provides useful information to users and customer about product quality and value.

It's important to point out that other forms of asset specificity might take place during the course of a transaction. For example Polanyi (1998) identified personal knowledge as an important type of idiosyncratic assets. This implies that the more an asset is customized for a specific transaction, the more idiosyncratic that asset becomes.

As a consequence, the theory claims that asset specificity leads to diverse forms of governance structure, formed in response to protect such investments (Williamson, 1989). This assumption becomes an integral notion in explaining why organizations adopt different forms of governance.

3.1.4 Uncertainty

Human bounded rationality and limited capacity to encompass all variables of decision making has an effect on degree of uncertainty present in a transaction. TCE acknowledge that hazards are eminent due to behavioral uncertainty appearing as a result of a combined effect of incomplete contracting and asset specificity. The theory highlights the critical effect of uncertainty in the presence of substantial asset specificity investment

(Williamson, 1985). Therefore, determination of most relevant aspects of a transaction is achieved with reasonable amount of uncertainty. In cases of high environmental variability, the writing of complete contracts might be difficult and contractual gaps may demand and escalate adaptations of the contract as the transaction evolves.

Empirical studies have shown that certain forms of uncertainty have direct influence on the choice of governance structure and subsequently transaction costs (Heide & John, 1990; Masten, Meehan, & Snyder, 1991; Zaheer & Venkatraman, 1995). A multi-dimensional uncertainty construct identified in the literature includes: technological uncertainty, which involves technical level of future product change (Walker & Weber, 1984; Balakrishnan & Wernerfelt, 1986), behavioral uncertainty involving parties joined in a condition of bilateral dependency (Anderson, 1985; Williamson, 1989; Heide & John, 1990) and environment uncertainty originating from external factors associated with surroundings (Koopmans, 1991; Walker & Weber, 1984). The theory also involves a secondary type of uncertainty factor, demonstrated by lack of communication between decision makers that restrict access to concurrent decisions and plans made by others (Koopmans, 1991). While some studies claim the latest type of uncertainty to be "nonstrategic" (Williamson, 1989, p. 143), this study argues that uncertainty due to lack of or non-established channels of communication becomes important in transactions linking parties of corporate and community organizations.

Some studies also argue that presence of environmental uncertainty induce organizations to build coalition in the form of vertical and horizontal interorganizational relationships (Galaskiewicz, 1985). By expanding boundaries, interorganizational relations are better positioned to sense-and-respond to environment uncertainty.

3.1.5 Opportunism

Acknowledged as one of transaction cost economics behavioral assumptions, opportunism is characterized as the human trait of seeking self-interest with guile (Williamson, 1989, p. 139). These moral hazards take the form of intentional efforts to mislead, distort, and misrepresent factual situations to achieve personal gain and reward at the expense of the other party or relationship in general. The potential of a partner or human agent to default on the other or exhibit opportunistic behavior will have negative implications reflected in incurring higher transaction costs.

The theory also argues that threats of significant opportunism will lead players in a transaction to opt for a governance of collaboration that safeguard against these threats. Safeguarding against potential opportunistic behavior might involve transaction costs in the form of negotiating costs, bonding costs, monitoring costs, and enforcement costs (Hill, 1990). Correspondingly, research reveals that opportunism is deterred by choosing between two main protection modes: equity-based and non-equity-based safeguard mechanisms (Oxley, 1997). These mechanisms largely came in response to prior studies that pointed to the negative effect opportunism had on partnership performance and outcome (Anderson, 1988; Hill, 1990; Miranda & Kim, 2006).

Strategic alliance research showed that opportunism is a particularly important problem, especially in alliances that engages members from different organizations (Judge & Dooley, 2006). In addition, several studies revealed that while it is not necessary all agents have or exhibit the same level of opportunistic behavior, any perception of opportunism

between the parties of an alliance would negatively impact performance (Williamson 1979; Ring & van de Ven, 1994; Saxton, 1997).

3.2 Interorganizational Cooperation Theory

While transaction cost theory represents a general framework for examining governance, it does not fully address some of the important aspects of alternative forms of governance. To the extent that TCE is an adequate theoretical lens for this study, other aspects of interorganizational cooperation and the role of trust in joint collaboration between open source and for-profit organizations must be taking into account. Directing the investigation within definitive boundaries, by concentrating on key activities characterized by the institutional model yields more informative explanation of the hybrid relationship between OSS project and commercial partners. Employing the interorganizational cooperation premise, within the domain of transaction cost economics, the study introduces key elements of the partnership governance. Although transaction cost economics is a useful tool to investigate various aspects of strategic alliance (Gulati, 1995), this research posit that TCE and articulated dimensions of interorganizational cooperation behavior, together, provide a richer foundation for explaining governance issues of open source projects and commercial companies collaborative transactions.

Emphasizing the impact of interdependence between the parties involved in a transaction, interorganizational cooperation theory argues that parties tend to cooperate when there are shared assets and dependency on each other (Williamson 1985, 1991b; Osborn & Hagedoorn, 1997). Early research investigating determinates of interorganizational cooperation found that cooperation is more likely to take place in circumstances where organizational domains are not sensitive issues (Schermerhorn, 1975). In most cases, the

parties are not engaged in competing activities. Also, collaboration is likely to occur where mutual goals among parties are obtainable.

Although studies differ in their justifications for why organizations want to enter into this form of alliance (Lefton & Rosengren, 1966; Aiken & Hage, 1968; Doz & Hamel, 1998; Barringer & Harrison, 2000), some of the common reasons include: increased efficiency (Clemons, Reddi, & Row, 1993), knowledge sharing, internal organizational diversity, lateral and longitudinal dimensions of organizational commitment to clients, attainment of objectives that can only be achieved through cooperation, help firms create value by combining resources, increasing speed to market, and gaining access to foreign markets. However, one of the main benefits of cooperation is the potential reduction of transaction cost for interorganizational alliances (Jarillo, 1988).

There are also some negative implications associated with interorganizational cooperation. For example, entities participating in interorganizational cooperation venues might suffer a loss of decision-making autonomy, experience loss or damage to their identity and image, or they might over burden their limited organizational resource (Schermerhorn, 1975). Furthermore, all aforementioned forms of disadvantage potentially incorporate extra costs attributable to interorganizational cooperation.

Due to the diverse and multifaceted nature of interorganizational relationship formation, the scope of this study lays emphasis on the TCE paradigm, as one of the major theory-perspectives for explaining collaboration. Next section embarks upon transaction cost's institutional arrangements and established cooperative activities in the context of governance of open source and commercial organization alliance.

3.3 Application of Theoretical Framework to Open Source

Following from the previous discussion, TCE is considered the study of 'alternative institutional governance' (Klein, 2008). As affirmed by the theory, TCE assert that economizing is the core problem of economic organizations. Moreover, the principle of defining various forms of governance structures, or safeguard and control mechanisms, is to promote transaction's egalitarianism. This study argues that open source software development is considered a special economic arrangement. Although it appears to lack monetary incentive drivers, still other forms of organization apply including labor and resource allocation in order to produce public goods and services. Open source software development provision as public good stems from the fundamental voluntary contribution notion of the public goods theory (Johnson, 2002). In particular, OSS development regimes create software products available for both original volunteer contributors, as well as, the masses.

A strong open source project's community is a predecessor for success. Projects cannot survive and take-off without a resilient community. The significance of building a vibrant community becomes more critical for proprietary spinoff projects seeking to initiate a new open source project. The importance of dedicated and enthusiastic leadership is recognized as one of the major factors for ensuring focused vision and fueled innovation. In contrast to commercial software development process management, OSS project leadership is less authoritative and more about recruiting and vetting good talent for the project and avoiding interference.

In a hybrid collaborative setting, the partnership between OSS and the alliance organization could be a result of the company being the initiator of the project. For example Hewlett-Packard open sourced proprietary code of the Spectrum Object Model (SOM) linker and created some of the governance structure for the open sourced project (Feller, 2005, p. 68). Alternatively, the partner proprietary organization joins an existing open source development effort. Regardless of original partner leadership status, the new leadership typically has to earn credibility (Fogel, 2005). One of the objectives of collaborative software development between open source projects and commercial partners is the arrangement of institutional form based on principal values and an interest in minimizing cost. This new configuration would lead each party to perceive themselves at an advantage point by continuing the alliance than by ending it. As a consequence of establishing governance mechanisms for managing the partnership, parties would reduce transaction costs incurred by opportunism and other environment uncertainty (Williamson, 1985). Although no formal contacts are defined to oversee cooperation between the two parties, yet OSS-commercial vendor affiliation is governed through embedded unofficial 'self-enforcing' agreements (Telser, 1980), sponsorship and safeguards.

Extending transaction cost analysis to "non-profit" organizations, the OSS domain requires careful treatment of the predicted variable. Nevertheless, the hybrid model attempts to define an optimal governance structure that yields meritorious results. The special control form is established to oversee exchange agreement and joint operation as a semi-specific structure. From a commercial perspective the partnership between an OSS project and business entity is considered a special form of value-added partnership.

Given recognition of the special form of collaboration between open source and commercial organizations, it's expected that a new form of interorganizational cooperation would emerge to account for two-party differences. In addition, it is likely that the role of transaction cost will presume another level of importance and allow for alternative interpretations within the open source context. For the purpose of the research, the study focus attention towards the type of organizational interdependency that involves the establishment of joint, cooperative activities between open source software project communities and revenue-driven organizations (i.e. OSS companies, IT vendors, etc...).

This study uses a multi-construct scale for assessing governance arrangements for open source project and commercial vendor collaboration, pertaining to information exchange, level of flexibility, influence restraint, shared responsibility, and overall satisfaction with the relationship. In conformity with established view of alliance and domains of cooperation (Heide & John, 1990; Heide & Miner, 1992), the study hypothesize that the degree of cooperation between the two parties involved in a hybrid mode of open source software development, as opposed to pure open source or totally proprietary development, is a function of their boundary transparency and readiness to rationalize commitment to each other. Such practice is a first step towards achieving a justifiable cost- suppressant governance structure along with underlying building blocks. Research revealed that satisfaction with the alliance and experienced meritorious results leads to sustained cooperation between the members of an alliance (Williams, 2005).

Primarily, open source software development is a diverse economic activity, wherein players are conscious about potential hazards and dynamically adjust processes and work norms for enhanced efficiencies. As a result, software development as a transaction is

embedded in governance structures that minimize vulnerability (Williamson, 1998) and create a perpetual environment for future growth and scalability. The importance of establishing bilateral communication channels is recognized in classical organizational theory to have both supplementary and complementary roles to existing channels in any organization structure (Hrebiniak & Joyce, 1984). In the absence of formal firm boundaries, open source projects undertake transparency and a free flow of knowledge and information on project mailing lists and discussion boards as mechanisms for mitigating uncertainty and potential conflicts.

As commercial vendors show active presence in the project, amplified levels of communication and information sharing becomes more eminent for resolving dependency and assuring complete engagement. Collaboration research shows that the alliance form of governance is influenced by the level of interdependence and requirement for information sharing (Gulati & Singh, 1998). The higher the level of interdependence and transaction complexity, the greater the amount of information sharing needed between partners.

3.3.1 Branding

Branding is claimed to be driven by human needs to differentiate between different products and services. Brand name is considered a special form of specific assets investment by parties engaged in a transaction. It creates an expression of the core values of the organization (Holland, 2006). Although brand capital and brand management are well investigated aspects in the commercial sector, it started making its way into research within nonprofit contexts. Although most of brand research for nonprofit is conceptual based or case study type, it constitutes a valuable addition and distinction from marketing and profit-based brand equity. Saxton (1994) highlighted the importance of and process

involved in creating strong charity brand. In addition, Ewing and Napoli (2005) found that brand image has a significant role in shaping stakeholders attitudes and actions, and stimulating their commitment. Another study found that human resources management, brand communication and brand leadership are pre-required factors for provoking brand commitment (Burmann & Zeplin, 2005). From a transaction cost standpoint, the collective efforts put by the parties could determine the value of brand capital for the partnership. Such value will diminish by parties' exhibition of opportunistic behavior (Klein, Crawford, & Alchian, 1978).

3.3.2 Trust

Trust as a multi-dimensional construct across personal and organizational levels plays a key role in interorganizational relations and relational governance. In particular, trust is proven to have positive impact on negotiation costs, managing cross-organizational conflicts, and ultimately overall performance (Zaheer, McEvily, & Perrone, 1998). Emphasizing role of 'societal culture' on economic organizations, Williamson (1993) argues that group culture, such as open source software culture, serves as a check for opportunism in informal organizations. An informal organization, where moral hazards such as lying and deception are inhibited is more likely to experience efficiency enforcing social contract and maintaining personal integrity.

According to TCE, firm's opportunistic behavior (Williamson 1975, 1985) leads to increased transaction costs due to necessity of safeguard mechanisms. However, trust as a mediator factor in relational exchange is recognized as a source of competitive advantage (Barney & Hanson, 1995). Zaheer et al. (1998) defined interorganizational trust as the degree to which members of one organization maintain a communal trust orientation toward another

organization. Yet, this definition does not equate interorganizational trust to that of an individual-to-individual trust. An economic view, recognized trust as a quasi-rational calculation of the probability of subsequent future benevolent actions (Gambetta, 1988). Alternatively, an organizational view identifies trust as being relational or reciprocal in nature (Zaheer & Harris, 2005). It is imperative to acknowledge the fact that asymmetric nature of interorganization trust may involve power and resource dependency that stem from one party's vulnerability on other parties of the alliance (Pfeffer & Salancik, 1978). The role of trust within interorganizational collaboration and transaction cost economics framework embark on choosing an organizational structure that safeguards against opportunism and lowers transaction costs. Fostering commitment and trust among parties or participants in a transaction is found to be an antecedent to ensure effective cooperation (Heide & Miner, 1992).

3.3.3 Product Distinctiveness

Two products are considered differentiated when users or customers perceive the two products to be close substitute to each other (Eaton & Lipsey, 1989). Open source software project and commercial organization alliance involves sharing part of their value-creation activities (Ghosh & Morita, 2007) such as product design, technology development and evangelism. These procedures represent a subset of activities for promoting project distinctiveness. The parties' engagement in promoting product exceptionality would lead each to assume ownership of the alliance and ensure a successful and high rewarding relationship.

3.4 Competing Theories

This study assessed various other information systems and economic-based theories that could be adopted for studying unorthodox forms of structure or capable of explaining some of the research questions. The research concluded that while some of these theories might have some relevancy for understanding open source and commercial partner collaboration, TCE proved to be the most relevant theory for conducting the study. Some of the primary justifications for adopting transaction cost and interorganizational cooperation analysis as theoretical lens for this research are:

1. TCE regards the organization (firm) as a governance structure rather than a production function.
2. OSS project is an organization with casual, non-hierarchical governance structure.
3. The theory is self-conscious about organizational behavioral assumptions and incorporate safeguard methods for protecting against vulnerability related to parties' behaviors.
4. OSS project is a self-organizing, self-enforcing governance structure that utilizes alternative mechanisms for formal contracts.
5. TCE relies on comparative institutional analysis (OSS project and IT vendor have different governance structures).
6. TCE is micro-analytic, which fits the study level of analysis (Williamson, 1989).

This section provides an overview of alternative theories used in IS research and their applicability to research hybrid form of OSS governance. The decision to adopt TCE and interorganizational cooperation theories as lens to investigate open source project and commercial partners' collaboration is based on being the best suitable framework for the

special nature of the alliance. However some of the questions addressed by this study might be approached using alternative theories.

3.4.1 Contingency Theory

The contingency theory deals with behavioral issues related to organization structure and organization managerial approach. Seminal article on the theory argue that there is no prescribed best way to organize. Moreover, not all forms of organizing are considered equally effective (Galbraith, 1973). The theory tries to identify factors that affect organization performance and efficiency. A study investigated the organizational contingencies and their influence on the selected mode of IT governance found that multiple interacting contingency forces have reinforcing, conflicting, or dominating effect on the IT governance mode (Sambamurthy & Zmud, 1999).

Prior IS research adopted contingency theory for exploring the effects of IT outsourcing strategies on success (Lee, Miranda, & Kim, 2004). Yet these studies admit that outsourcing choices, make-or-buy decision, are better understood within the light of the theories of the firm and governance (TCE).

The theory has potential usefulness in identifying contextual variables related to an open source project that leads to a successful governance structure. Contingency theory study of organization strategy could be relevant to examining contextual variables that vary based on OSS project size and type.

3.4.2 Resource-based View of the Firm

The resource-based view (RBV) theory focuses on organization's resources subset that enables attainment of competitive advantage, as well as, the subset that enables sustainability of competiveness (Wade & Hulland, 2004). Although, OSS project does not

own the contributing resources, it is fair to assume that a subset of these resources, mainly leadership and core developers, drive competitive advantage for the project. RBV relevancy for IS research in general and open source in particular stems from identifying distinct resources that contribute to overall performance. Application of the theory would be more relevant for studies investigating nature and characteristics of each resource that lead them to achieve sustained competitive advantage. A study trying to identify factors that lead to particular OSS project dominance would look at the project's asset and attributes in addition to complementary assets that fueled sustained competiveness. The theory is not situated to investigate alternative governance structures for hybrid OSS. Another limitation of the theory application to this study has to do with vagueness of defining variables that capture competitive advantage for the hybrid model.

3.4.3 Agency Theory

The agency theory contract metaphor deals with the conflicting goals and desires of cooperation parties, ascribed as principal and agent. The theory posit that the party who delegates work (principal) has limited or no control on the other party (agent) executing the task (Eisenhardt, 1989). The latest problem stems from principal's vulnerability of agents' self interests and inappropriate behavior. Employing contract as the unit of analysis, agency theory is motivated by development of efficient contracts that govern the relationship between principal and agent. However, when an organization opts for vertical integration of product or service, technically the principal is taking over an end-to-end process without relying on agents to accomplish task on their behalf.

Lack of contracting in alliance involving open source project and commercial partner greatly limits explanation of hybrid governance structure using agency theory. The OSS-

commercial partner relationship does not fit theory's discrete roles. Appropriate labeling of principal/agent parties involved in this type of informal alliance is a challenge. Although the parties might have competing motives, lack of formal contract held by the theory, provoke alternative measures for developing efficient structure that safeguard against opportunistic behavior. Some studies employ both agency theory and transaction cost economics to fully explain outsourcing risks and managing relationships between parties (Bahli & Rivard, 2003). The focus of this research is to assess optimal forms of governance for OSS project and commercial partner special alliance. Agency theory might be relevant in addressing some of the risks associated with conflicting goals between non-profit open source and profit-oriented commercial partner.

3.4.4 Resource Dependency Theory

Resource dependency theory (RDT) investigates organization success in terms of power exercising. Power maximization is one of the criteria for determining organizational success (Pfeffer, 1981). As one of the theories used to investigate interorganizational relationship patterns, RDT posits that entities lacking resources will establish relationships with other parties to fulfill needs for external resources. Adjustment of power relation between organizations engaged in a relationship defines social coalitions, which emerged from social exchange (Ulrich & Barney, 1984). The theory assumes that increased dependence of other organizations on a focal actor will lead to the perception that focal organization is the more influential in the relationship.

Environment uncertainty is one of the factors that determine an organization's ability to obtain scarce resources from other parties. To reduce uncertainty, organizations attempt to exercise control over such resources or exert control over other organizations that own

these resources. The theory is more relevant to explore social network power structure. It could also be applied to investigate commercial partner influence and control on open source software project when they engage in an alliance or a social exchange transaction.

3.4.5 Structuration Theory

Structuration analysis is primarily positioned as a social organization theory. It deals with the establishment of social structure at an abstract level. This social structure as a resource is obtained by human agents' interactions (Giddens, 1984). Structuration is defined as conditions of governing the continuity or transformation of structures. Connections between actors define the system (Jones & Karsten, 2003). The theory argues that the rational model of powers is form of dialectic of control with negotiable power and influence.

The theory is more relevant in investigating some of the non-technology aspects of open source. The social structure, knowledge management and why participants chose to maintain a certain form of structure are some of the viable applications for the theory. In addition, there has been some attempts in IS to employ structuration theory in studying dynamics of globally distributed virtual teams and their effectiveness (Maznevski & Chudoba, 2000).

3.4.6 Noncooperative Game Theory

As a multi-person decision making, noncooperative game theory is a modeling framework for analyzing stakeholders' diverse optimal decisions, noncooperative, influenced by their background and believes (Fudenberg & Tirole, 1989). The theory assumes that opponent players are rational and able to assess other party's actions. Research indicated that

games serve as satisfactory models for simulating situations involving conflicts of interest (Ritzberger, 2002). The three main pillars for designing a game include:

1. interacting parties, participating in the game
2. rules of the game or game form, define specific actions, roles, and behaviors
3. outcomes

Since most social interactions incorporate all of the aforementioned constituents, the game could simulate organizations interactions and OSS agents' roles. The theory acknowledges imperfect players monitoring and potential hazards of ill behavior. Noncooperative game theory could be used to simulate open source and commercial partner conflicting motives and decision making process. Having players with dissimilar cultures and backgrounds, the theory could model interactions to determine the equilibrium point that yields optimal outcomes.

Table 3.1 presents a summary of identified theories and potential relevance for addressing particular questions related to the study of open source and commercial partner alliance.

Table 3.1 Summary of Alternative Theories

Theory	**Potential relevancy for the study**
Contingency Theory	Optimal form of governance is a function of OSS project and commercial vendor partner's cultural and structural differences. Success of a governance structure will vary based on contextual variables.
Resource-based View of the Firm	Complementary assets contributed by OSS project and commercial organization partner to develop product distinctiveness and successful long-term relationship.
Agency Theory	Could be applicable for investigating the mechanisms used by an OSS project (principal) to safeguard against IT vendor's (agent)opportunism, but not why want to collaborate
Resource Dependence Theory	OSS project lack of resources could be a driving motivator for seeking IT vendor partnership. The theory does not explain what's the optimal form of governance for the alliance
Structuration Theory	More appropriate for investigating individual OSS contributor's behavior to shape project casual structure and work norms.
Noncooperative Game Theory	Alignment of conflicting motives and interests in an alliance

4. Hybrid Open Source Software Project Efficiency

Applying the premise of transaction cost economics to the open source software domain addresses some of the puzzling questions about the development of OSS and the emergence of numerous organizing models. An assessment of transaction cost research revealed a significant amount of TCE investigation aimed at examining the efficient form of organization for various economic activities (Shelanski & Klein, 1995). Yet, few endeavors have been made towards addressing the characteristics of special governance structures, which involve commercial organizations and open source community organization. This study maintains that OSS development is an economic activity in quest of establishing efficient organization for managing activities. Examining determinants of hybrid OSS efficiency is one of the research objectives addressed in this chapter.

Grounded in the foundational work on TCE presented in the previous chapter, this study introduces an analytical assessment of the hybrid model of open source software development. Specifically, this part of the study adopts transaction cost fundamentals for investigating the efficient form of organization for the OSS hybrid relationship. The efficiency model is designated as a primary step essential to understanding the phenomenon of OSS project partnership with commercial organizations and proprietary vendors. The initiative of extending alliance denotes departure from the classic OSS bazaar-oriented approach primarily driven and governed by volunteer contributors. This analysis looks at the underlying factors for determining efficiency of the relationship and drivers of persistent alliance. Satisfactory outcome of the alliance is an indication of

successful establishment of an efficient form of organization for the OSS-commercial partner relationship and representation of a sustained relationship. This logic is supported by positive economics view that assumes inefficient governance arrangements are likely to be discovered and abandoned (Friedman, 1953). Therefore, the chances of survival for an alliance that is not perceived as yielding meritorious end results are very limited.

A principal goal of hybrid OSS collaborative development between open source software projects and commercial partners is the institutionalization of efficient forms of organizing that achieve mutual goals while adhering to the basic notion of minimizing cost (Sidahmed & Gerlach, 2009). This novel configuration guides a hybrid alliance's parties to realize added-value of a sustained relationship and commands both OSS project community and commercial partners' representatives to coordinate innovative governance structure that insures long-term proficiency.

As a consequence of establishing efficient governance mechanisms for managing the relationship, parties would reduce transaction cost incurred by opportunism and other forms of uncertainty (Williamson, 1985). Also, joint investment in specific assets dedicated for the two parties' transaction will direct both parties to insure process efficiencies in the long run. Despite the fact that the relationship between OSS project and commercial partner is administered under informal contracts, still, other social and community protection mechanisms may take place as precautions. One example of the preventative measures is institutionalization of a governance structure with embedded 'self-enforcing' agreements (Telser, 1980). Subsequent sections introduce the hypothesized model and empirical assessment outcome. The theoretical research model for the study is depicted in Figure 4.1.

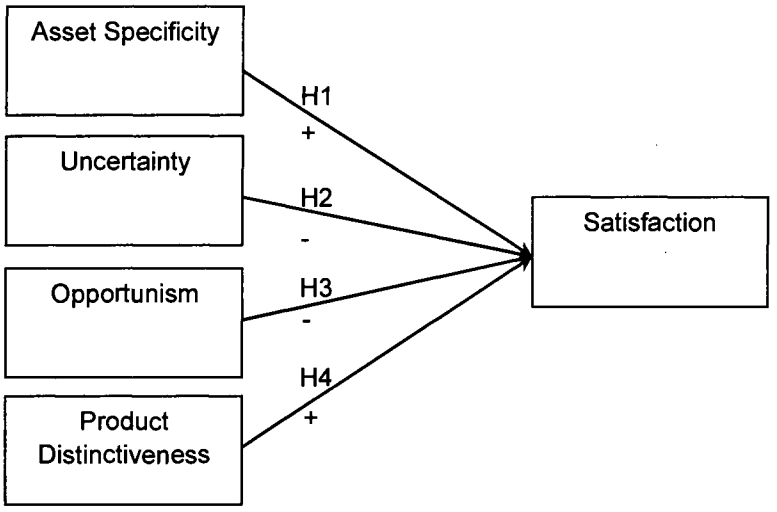


Figure 4.1 Efficiency Theoretical Research Model

4.1 Research Hypotheses

Building on the theoretical framework presented in chapter 3, this chapter develops and tests a hypothesized efficiency model. Applying fundamental TCE constructs, the empirical analysis aims to test strategic factors that determine hybrid OSS model efficiency. The remainder of this chapter is structured as follows: derived hypotheses are introduced next, a pilot study assessment is presented in § 4.2. § 4.3 discuss the study sample, variable measure, and analytical procedures. Hypotheses testing results are presented in § 4.5. Finally the last section presents the conclusion, study limitations, and future research issues.

Asset specificity

Asset specificity is considered the most important dimension of a transaction (Williamson, 1981). This notion entails investments transferability from one transaction or setting to an alternative one. It has been argued that switching specific assets from one setting to a different one will result in lowering the value of such assets. As a consequence, partners associated with a transaction that involves special assets dedicated to the transaction are more likely to remain in partnership and work jointly to attain mutual satisfactory benefits. TCE posit that asset specificity criticality stems from the fact that investment in such type of assets creates a bilateral or to some extent, a quasi-bilateral operating environment that ensures continuity of relationship for an extended period of time.

Specific assets dedicated to the transaction involving open source project and commercial partner organization, such as knowledge specific skills to the OSS project, forms a cost-conscious parsimonious assembly. TCE hypothesizes that the relationship between parties of an alliance would vary depending on the level of specific assets involved in the

transaction. In general, commercial organizations involved in hybrid OSS development transaction would insure some promise from the OSS project community before investing in specific types of assets. Pledging commitment from both parties on investment would ensure desire for continuation of the relationship and achievement of efficient form of establishment. Accordingly, the first hypothesis related to specific asset investments on hybrid OSS efficiency is stated as follows:

> H1: Investment in specific assets for open source project and commercial partner alliance will have a positive effect on satisfaction with the partnership.

Uncertainty

TCE differentiates between two types of uncertainty: behavioral or internal, and environmental or external (Williamson, 1985). Behavioral uncertainty is related to partners' behavior, while environmental uncertainty is a function of external factors related to the operating environment. It includes such contingencies that unfold during the course of transaction execution. A recent study, found that environmental uncertainty increases the risk level for organizations (Fink, Edelman, Hatten, & James, 2006). Technological uncertainty and resource uncertainty are foremost types of environmental uncertainty. Technological uncertainty represents future technological changes that could impact product development and users' expectations. Resource uncertainty has to do with resources availability and steady availability of skillful work force. Some studies argue that firm's perceived uncertainty about resource availability is likely to impact their decision to form relationships (Williamson, 1985).

The environmental, technological, and behavioral uncertainties are perceived as the major constituents of this construct. Former study argues that environmental uncertainty can motivate organizations to develop interorganizational relations to mitigate uncertainty (Galaskiewicz, 1985). The partnership between open source project and commercial organization could suffer from emergence of unpredictable behavior from one partner, or experience of negative consequences for either party. As a mitigation strategy, some recommend a three-dimensional strategy to cope with uncertainty in interorganizational collaboration. The triangular plan incorporates forestalling, forecasting, and absorption (Penning, 1981). The OSS-commercial partner's alliance is predisposed and inclined to be exposed to technological and environmental uncertainty. Such rendering is detrimental to process efficiencies and require members of both parties to exercise more governing control and establish ties to the environment (Pfeffer & Salancik, 1978). The greater control and increased formalization of work processes, to some extent, defeats the purpose of leveraging OSS informal and inexpensive flexible structure. Overall, hybrid OSS model efficiency is negatively related to uncertainty associated with the development transaction. Subsequently, the second hypothesis is positioned as:

> H2: Increased level of uncertainty will have a negative effect on satisfaction with the partnership.

Opportunism

Transaction cost economics recognize the negative impact of opportunistic behavior of parties involved in a transaction on the outcome (Williamson, 1989). Correspondingly, open source software project and commercial partner's relationship is not immune against opportunism. As an economic actor's behavior of satisfying self interest with guile,

opportunism involves cheating, deception, and misrepresentation conduct. Acknowledging the fact that not all people are honest or trustworthy, and they might seek crooked ways to take advantage or exploit other parties involved in a transaction, some will occasionally act opportunistically. TCE theory admits the difficulty or unfeasibility to identify in advance those who are likely to default or deviate from partnership agreement.

In a hybrid open source software transaction domain, opportunism might occur due to the fact that OSS project has limited control over commercial partners. Also the commercial partners have personal agendas and interests. Moreover, lack of contract, incomplete information and impracticality of monitoring partner's activities leads to low efficiency and unsatisfactory relationship (E. Anderson, 1988). Similarly, a study revealed that opportunism intensity increases by one party's employment of tactics and methods used to exercise influence (John, 1984). Also bureaucratic and complex structured settings with low communication levels between partners, compared to loose and informal relations, increase the likelihood of experiencing negative consequences of opportunism.

Concerning OSS project and commercial organization's alliance, parties could undertake different forms of self interest seeking such as misrepresenting information, efforts, and/or activities. Concisely, opportunism among parties will lead to inefficient and unsatisfactory hybrid OSS development relationship. The third hypothesis is framed as:

> H3: Perceived opportunistic behavior among parties involved in hybrid OSS development alliance will have a negative influence on open source software project's satisfaction with the relationship.

Product Distinctiveness

One of the value-added advantages of building alliance is leveraging each party's efficiencies to create a product larger than the sum of individual efforts. Some of the common activities shared between an OSS project and commercial organization alliance include product design, technology development and evangelism. Such activities represent mutual efforts to promote project and product distinctiveness. Each party's endeavor is driven by their voluntary assessment of leveraged competencies that yield remarkable and efficient outcomes. By sharing their value-creation activities, the parties' engagement in promoting product exceptionality would lead to an efficient alliance and guarantee a rewarding relationship. The fourth hypothesis of the model is delineated as:

H4: Creation of product distinctiveness will have positive influence on open source project's satisfaction with the alliance.

4.2 Pilot Study

To insure validity of theoretical model constructs and underlying variables, a pilot study was conducted during the early phase of the research. A small set of open source software project managers were contacted and solicited for participation in the pilot study. Each of these project managers was asked to indicate whether their project has commercial partner engagement. Based on the individual responses, each was notified whether they qualify for the study. The inclusion principle was determined based on whether those project managers experienced a formed relationship with a commercial partner. To preclude responses based on perception only rather that genuine experience; subsequent activities of the study were exclusively limited to participated members of open source software projects, where at least one commercial partner is/was involved.

The study employs pre-validated instruments. No attempts were made to develop new measures for the constructs. Instead, the pilot was aimed to test the appropriateness of the customized instrument to suit the context of the OSS realm. Given the novelty of empirical treatment of TCE to open source software, careful examination and interpretation of the theory constructs within the OSS domain was a primary intent of the pilot study.

A beta version of an online survey was sent to a small group of open source project managers to obtain feedback on the instrument face validity, quality, and clarity of items. Follow up phone interviews were conducted with a subset of the pilot study participants. Those who indicated willingness to provide feedback on IT vendor's involvement in their projects were the primary contacts. Each interview lasted between 20-45 minutes. Based on the outcome of the interviews and the pilot study, rewording and ordering of questions was applied to the final version of the instrument.

4.3 Data and Method

4.3.1 Study Sample

Building on the pilot study results, a large scale data collection task was launched. The final survey instrument is presented in appendix A. The study targeted sampling included open source projects listed on three major open source repositories, namely, SourceForge, Freshmeat, and Savannah. OSS transparent development process is manifested on these public domain hosting sites. An OSS repository is an integrated workbench for source code versioning, bug tracking, mailing lists and discussion forums. Information about project information, activity, and latest release are also provided by an OSS repository for both

developers and users of the software. A comprehensive overview of OSS project could be developed based on information derived from these hosting websites.
There are several smaller or dedicated hosting sites for open source projects; however, the three identified virtual collaborative development hosting sites represent assorted categories of OSS projects with diverse user bases and community support.

The study data collection method is a common practice in experimental research on TCE (Richman & Macher, 2006). Positivist survey research and semi-structured interviews are the primary methods for data collection. During the data collection phase, personalized emails with an online survey link and an invitation letter were sent to project managers and administrators of different open source projects hosted on SourceForge, Freshmeat, and Savannah. Ascribed to the key informant methodology, those individuals are assumed to be the most knowledgeable people about the project and typically they earn such status through quality contributions and lengthy attachment to the project (Raymond, 2001).

The data collection efforts acknowledge the fact that not all initiated OSS projects takeoff and there are many 'dead-beat' projects that are still hosted online. To overcome predicaments caused by solo developer/user projects and inactive or abandoned projects listed on these sites, a systematic filtering criterion was implemented. Selected projects Has to have the following attributes: a) project has active status, b) project activity is ranked at the 80^{th} percentile or higher, c) project has at least five developers working on the project, and d) project maturity is greater than or equal to three years. Project maturity is defined as the date of inception on the hosting development site. In addition, each project had at least one designated project manager responsible for coordinating project activities. The number of project managers is usually a good indicator of project activity.

Typically, moderately active projects have one or two project managers, and highly active and more complex projects involve several project managers. Project managers are primarily responsible for coordinating development activity and resolving conflicts regarding coding and feature design.

A total of 1437 survey invitations were sent out. Of the 340 who responded to the invitation, 116 respondents indicated belonging to OSS project with commercial partner involvement. After eliminating incomplete responses, the final dataset has 101 points, each representing a different open source project. The response rate was 23.7%.
Due to the non-traditional nature of the relationship between open source software project and commercial organizations, prior identification of projects that have organization sponsorship or other form of alliance with commercial partners is not feasible. Also limitations of the OSS hosting sites mailing lists used do not allow for identification of projects that have commercial partners involved. The only way to obtain such information is surveying the project manager.

Previous studies that employed transactions cost economics are heavily skewed towards adopting a single case study methodology for investigating variations of discriminating alignment hypotheses (Richman & Macher, 2006). Since most of the studies were retroactive in nature (i.e., make-versus-buy or outsourcing decision already made) there was no difficulty in identifying those organizations where such transactions took place beforehand. The study selection criteria was developed in an attempt to include as many projects involved in transactions with commercial partners as possible, but results in a relatively moderate response rate.

In accord with table 2.1 classification, the data confirmed various categories of stakeholders involved in open source. The majority of those who responded to the survey (62%) indicated they work for open source voluntarily. Of the non-volunteers, 15% are paid by a flagship open source company, 4% are paid by an open source foundation, 8% are paid by a software packager or hardware/middleware vendor organization, and 11% designated paid by other, which include any other party excluded from the previous categories. To insure there are no significant differences in responses between volunteer participants in a project and those paid by a commercial partner or other organization, a chi-square test to assess between groups difference was conducted. Statistical test indicates no significant difference; therefore the two groups were pooled for analysis.

To gain insights of collaboration length between open source project and commercial organization(s), subjects were solicited to identify their project relation with a commercial partner. The data show that engagement ranges from less than a year to more than ten years for some projects. It can be inferred that some alliances between OSS community and commercial organizations dated back for a decade or so. However, the majority indicated a relationship length between three and less than four years. The continuation of the relationship is also an indication of successful establishment of efficient hybrid form between the parties that bear low cost for the transaction, since it is unlikely that relationships would continue with experienced deficiencies from either side.

An additional assessed attribute of the hybrid model is demographics. This includes the number of OSS foundations, OSS companies, IT vendors, or other organizations involved in a project. The data reveal that OSS projects have between one and more than five partner organization(s) working in collaboration. It also shows that the GNU General Public

License (GPL) and subsequent GNU General Public License version 3.0 (GPLv3) dominated across the projects sampled, with over 65% of projects adopted the license. In addition, some projects adopted a dual license that likely served multiple parties' interests. Dual licensing could be regarded as a strategic tactic that positions the open source project as an appealing candidate for diverse stakeholders.

4.3.2 Non-response Bias

To account for non-response bias that might be introduced in the data a statistical significance test was conducted to assess potential impact of the non-respondent group. The data collection phase was designed to have single round of survey invitation. Therefore, a traditional non-response assessment method was not feasible. As an option, this study employs an alternative approach (Armstrong & Overton, 1977) for testing for non-response bias effect. The study treatment of late respondents to the survey consider those who responded to the survey invitation after more than two weeks from the invitation date as similar to the theoretical non-respondent group.

By conducting a two-tail test ($\alpha = 0.05$) for the difference between early and late respondents in the sample, results conclude that there is no significant difference between the two groups and the non-respondent set is similar to those who participated in the survey. Therefore, it is reasonable to assume that the non-response bias is minimal or has negligible effect on the subsequent analysis of the data.

4.4 Measures

4.4.1 Dependent Variable

To identify the outcome of the hybrid OSS efficiency model, satisfaction with the partnership was measured. The decision whether to engage a commercial partner in the project development or maintain the purity of open source model is primarily a process efficiency decision. Utilizing satisfaction with the partnership as a proxy for realizing efficiencies that economize on transaction cost is a natural choice for examining the make-versus-buy (fully open source developed vs. OSS- commercially developed project) decision in this special setting. The study posits that satisfaction with the hybrid structure is an indication of achieving a degree of institutionalization that effectively governs the alliance between the project and commercial partners; thereby, lowering transaction cost for both sides. If achieved, it represents an outcome of an all-winner scenario.
Satisfaction is measured using three items that capture open source project managers' perceived fulfillment of the project efficiency under joint relationship, as well as the perceptions of fulfillment of project contributors who are paid by the commercial partner.

4.4.2 Independent Variables

The model includes four independent latent variables, namely, asset specificity, uncertainty, opportunism, and product distinctiveness. Each latent variable (factor) is measured through direct observed variables.
Asset specificity construct is operationalized with four observed variables. It corresponds to the amount of investment in specialized assets dedicated to the partnership between open source project and commercial partners. It defines parties' commitment to the alliance and the objective to promote an efficient long-term relationship. It also leads to the establishment of efficient processes for moderating uncertainty, and guarding against potential opportunism occurrence. The uncertainty construct is estimated using four items that capture behavioral and environmental uncertainties facing hybrid OSS projects.

The opportunism construct is a seven-item scale that captures the essences of parties' opportunistic behaviors exhibited during the alliance. It assesses the way OSS project perceived commercial partner activities and actions in the project. Product distinctiveness is the joint activities by the relationship parties to develop differentiable product and related activities to achieve such goal. This construct was measured by a four-item scale.

Table 4.1 displays latent variables and their respective observed items. Reliability analysis, assessed by Cronbach's alpha for each factor, is also included in the table.

Table 4.1 Efficiency Model Constructs Reliability and Measures

Construct	Observed Variables	Reliability (Cronbach's α)	Adopted From
Asset Specificity (ASPC)	ASPC1 ASPC2 ASPC3 ASPC4	0.69	(Zaheer & Venkatraman, 1995)
Uncertainty (UNCRT)	UNCRT1 UNCRT2 UNCRT3 UNCRT4	0.74	(Walker & Weber, 1987)
Opportunism (OPRT)	OPRT1 OPRT2 OPRT3 OPRT4 OPRT5 OPRT6 OPRT7	0.92	(Chiou & Shen, 2006)

Table 4.1 (Con't.)

Construct	Observed Variables	Reliability (Cronbach's α)	Adopted From
Product Distinctiveness (DSTN)	DSTN1 DSTN2 DSTN2 DSTN4	0.80	(Stone-Romero & Stone, 1997)

4.5 Data Analysis and Results

4.5.1 Test of Research Model and Hypotheses

This study employs both exploratory and confirmatory statistical analysis. Structural equation modeling (SEM) technique is used to specify and assess the theoretical model. SEM analysis is a multi-step analysis that involves compound techniques including: multiple regression, analysis of variance, and factor analysis. One of the principal benefits of using structural equation modeling is set by SEM's capabilities of enabling simultaneous analysis of the complete model variables and causal effect. Having the study objective of realizing efficiency drivers in hybrid OSS model and being able to examine multiple factors effects on project efficiency concurrently, rather than in several individual regression equations, strengthens the overall predictive power of the model.

Moreover, the hypothesized model seeks to validate support for each hypothesis. SEM lends itself as capable of hypothesis testing by allowing for nullification of hypotheses and eventually rejecting unsupported ones.

The statistical analysis and assessment is carried out using maximum likelihood (ML) estimation procedure of LISREL 8.8 (Jöreskog & Sörbom, 1996) for simultaneous multivariate regression computation. The rationale for adopting this technique stems from efficient operation carry out of covariance matrix analysis (Byrne, 1998). Also ML is considered both scale free and scale invariant, by being considerably robust at handling violations of the multivariate normality assumption (Kline, 2005). Likewise, SEM review and recommended approach indicates that the technique is robust with small sample size and still holds even with sample size of 50 (J. C. Anderson & Gerbing, 1988).

4.5.2 Measurement Model

As part of model specification, a confirmatory factor analysis was conducted to assess constructs operationalization. In addition, factor score loadings were assessed to insure that each measured item is measuring a single construct and inter-factor loadings are negligible. The measurement model factor score regressions are presented in table 4.2. In addition, the computed mean, standard deviation, and correlations of measured variables are depicted in table 4.3.

The factors correlations between the five constructs (ASPC (asset specificity), UNCRT (uncertainty), OPRT (opportunism), DSTN (product distinctiveness), and STSF (satisfaction)) in the model are calculated. The model maintains the assumption that zero correlations between errors (e_i) and residuals (res_i) for each item exist. The measurement model is illustrated in figure 4.2.

Table 4.2 Efficiency Measurement Model Factor Score Regression

	DSTN1	DSTN2	DSTN3	DSTN4	UNCRT1	UNCRT2	UNCRT3
DSTN	0.19	0.60	0.02	0.13	-0.01	0.00	0.00
UNCRT	-0.01	-0.03	0.00	-0.01	0.42	0.20	0.15
ASPC	0.00	-0.01	0.00	0.00	0.01	0.01	0.00
OPRT	0.00	0.01	0.00	0.00	0.01	0.00	0.00
STSF	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.2 (Con't.)

	UNCRT4	ASPC1	ASPC2	ASPC3	ASPC4	OPRT1	OPRT2
DSTN	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNCRT	0.13	0.01	0.01	0.00	0.00	0.01	0.00
ASPC	0.00	0.12	0.30	0.09	0.10	0.00	0.00
OPRT	0.00	0.00	0.00	0.00	0.00	0.11	0.09
STSF	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.2 (Con't.)

	OPRT3	OPRT4	OPRT5	OPRT6	OPRT7	STSF1	STSF2	STSF3
DSTN	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.00
UNCRT	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.00
ASPC	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
OPRT	0.32	0.13	0.11	0.13	0.05	-0.01	-0.02	0.00
STSF	0.00	0.00	0.00	0.00	0.00	0.33	0.64	0.02

Table 4.3 Efficiency Measured Variables Mean, Standard Deviation, and Correlation

	μ	σ	1	2	3	4	5	6
1. DSTN1	5.83	1.393	1.000					
2. DSTN2	5.87	1.180	.771**	1.000				
3. DSTN3	4.16	1.906	.232*	.294**	1.000			
4. DSTN4	5.41	1.328	.578**	.697**	.429**	1.000		
5. UNCRT1	3.38	1.548	-.156	-.094	-.200*	-.163	1.000	
6. UNCRT2	3.11	1.599	-.113	-.083	-.153	-.049	.549**	1.000
7. UNCRT3	3.51	1.507	-.073	-.047	-.178	-.050	.465**	.458**
8. UNCRT4	4.07	1.576	-.200*	-.140	-.197*	-.195	.481**	.338**
9. ASPC1	3.42	1.602	-.080	-.194	.116	-.118	.013	-.014
10. ASPC2	2.88	1.620	.000	-.092	-.010	-.084	.158	.109
11. ASPC3	3.28	1.632	.117	.019	.002	-.025	.204*	.207*
12. ASPC4	3.61	1.827	.108	.065	.176	.078	.048	.045
13. OPRT1	2.74	1.604	.088	.014	-.013	.012	.221*	.108
14. OPRT2	3.15	1.602	.114	.084	.045	.028	.134	.115
15. OPRT3	2.30	1.446	.020	-.036	.092	.015	.106	.142
16. OPRT4	2.43	1.374	.053	-.021	.054	.025	.032	.056
17. OPRT5	2.73	1.599	-.007	.019	.070	.080	.118	.148
18. OPRT6	2.48	1.566	.142	.131	.186	.142	.115	.155
19. OPRT7	3.23	1.574	.182	.231*	-.015	.113	.083	.058
20. STSF1	5.73	1.392	.281**	.253*	.035	.211*	-.092	-.131
21. STSF2	5.74	1.405	.254*	.245*	.004	.207*	-.065	-.108
22. STSF3	5.48	1.467	.206*	.192	.044	.141	-.093	-.184

Table 4.3 (Con't.)

	7	8	9	10	11	12	13	14
1. DSTN1								
2. DSTN2								
3. DSTN3								
4. DSTN4								
5. UNCRT1								
6. UNCRT2								
7. UNCRT3	1.000							
8. UNCRT4	.229*	1.000						
9. ASPC1	-.148	.226*	1.000					
10. ASPC2	.038	.074	.443**	1.000				
11. ASPC3	-.030	.109	.231*	.349**	1.000			
12. ASPC4	-.051	-.053	.325**	.427**	.315**	1.000		
13. OPRT1	.217*	.233*	.085	.207*	.005	-.137	1.000	
14. OPRT2	.134	.178	.038	.161	.168	-.059	.704**	1.000
15. OPRT3	.136	.087	.028	.118	.109	-.085	.702**	.710**
16. OPRT4	.130	.023	.173	.203*	.072	-.037	.649**	.584**
17. OPRT5	.087	.166	.095	.150	.040	-.149	.620**	.593**
18. OPRT6	.128	.116	.124	.109	.155	-.030	.686**	.534**
19. OPRT7	.081	.062	.097	.019	-.025	-.035	.447**	.561**
20. STSF1	.052	.022	-.107	-.059	-.024	.085	-.264**	-.305**
21. STSF2	.054	.022	-.125	-.040	.014	.093	-.274**	-.298**
22. STSF3	.056	-.127	-.055	.037	.049	.196*	-.347**	-.354**

Table 4.3 (Con't.)

	15	16	17	18	19	20	21	22
1. DSTN1								
2. DSTN2								
3. DSTN3								
4. DSTN4								
5. UNCRT1								
6. UNCRT2								
7. UNCRT3								
8. UNCRT4								
9. ASPC1								
10. ASPC2								
11. ASPC3								
12. ASPC4								
13. OPRT1								
14. OPRT2								
15. OPRT3	1.000							
16. OPRT4	.746**	1.000						
17. OPRT5	.757**	.603**	1.000					
18. OPRT6	.767**	.719**	.654**	1.000				
19. OPRT7	.484**	.542**	.445**	.552**	1.000			
20. STSF1	-.477**	-.233*	-.455**	-.239*	-.291**	1.000		
21. STSF2	-.484**	-.254*	-.472**	-.244*	-.294**	.982**	1.000	
22. STSF3	-.468**	-.250*	-.453**	-.304**	-.346**	.802**	.807**	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

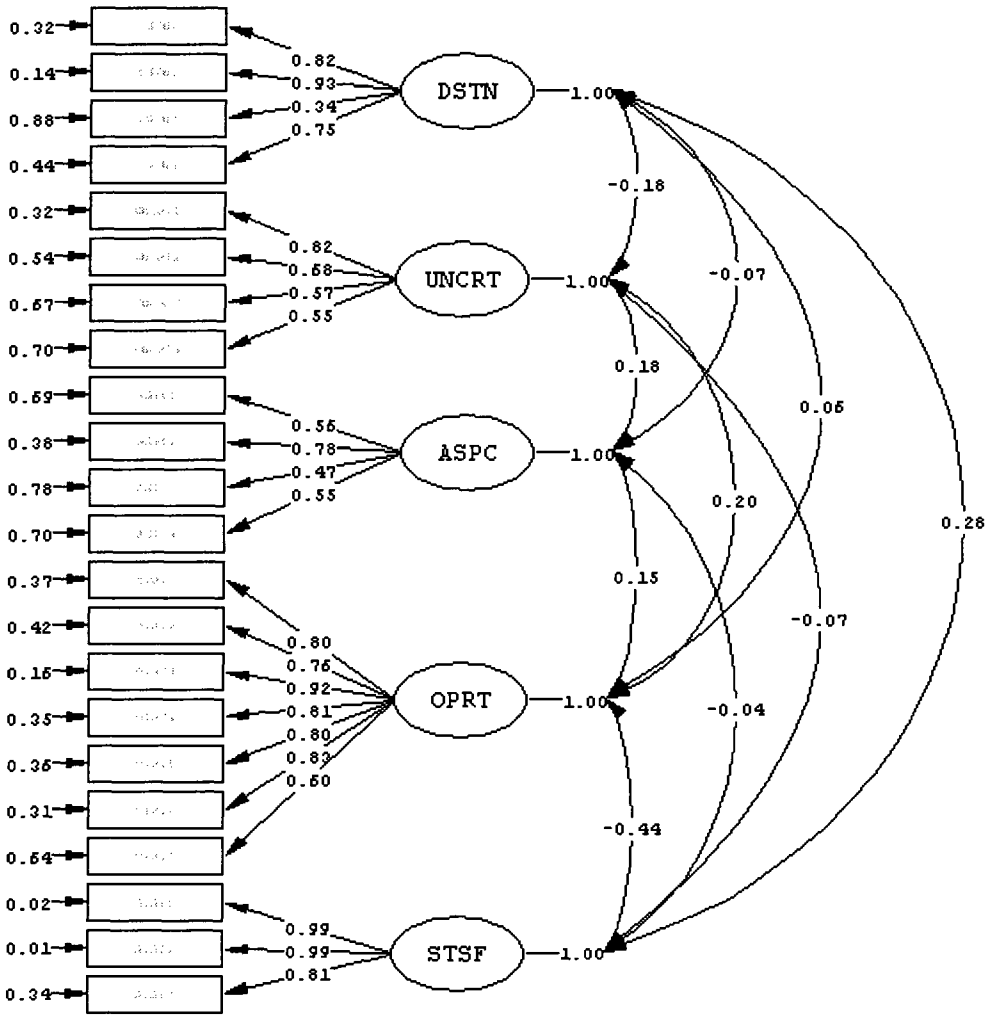


Figure 4.2 Efficiency Measurement Model

The measurement model confirmatory factor analysis denotes chi-square (χ^2_{199}) value of 259.5. The model is over-identified with 199 degrees of freedom. The model fit is assessed using multiple fit indices. The Comparative Fit Index (CFI) and Incremental Fit Index (IFI) are both 0.94. The Normed Fit Index (NFI) is 0.85; Goodness of Fit Index (GFI) is 0.81, the Root Mean Square Residual (RMR) is 0.19, and the Standardized RMR is 0.07. A comprehensive set of the measurement model fit indices is presented in table 4.4.

The squared multiple correlations of the observed variables and standardized regression weights for the measurement model are displayed in tables 4.5 and 4.6 respectively. As specified in table 4.5 observed variables' R^2 values are relatively high, with the exception of DSTN3 and ASPC3. Each of these measured items is able to explain at least 30% of the variance related to their respective construct. Similar observation could also be made regarding standardized regression weights presented in table 4.6. All items measuring the five constructs are significant at $\alpha = 0.001$. The estimates, standard errors, critical ratio, and P-values for the constructs items are displayed in table 4.7.

Table 4.4 Efficiency Measurement Model Fit Indices

Index	Value
Degrees of Freedom	199
Minimum Fit Function Chi-Square	297.7 (P = 0.00)
Normal Theory Weighted Least Squares Chi-Square	259.5 (P = 0.0025)
Estimated Non-centrality Parameter (NCP)	60.5
90 Percent Confidence Interval for NCP	(22.9 ; 106.3)
Minimum Fit Function Value	2.9
Population Discrepancy Function Value (F0)	0.6
90 Percent Confidence Interval for F0	(0.03 ; 1.06)
Root Mean Square Error of Approximation (RMSEA)	0.05
90 Percent Confidence Interval for RMSEA	(0.03 ; 0.07)
P-Value for Test of Close Fit (RMSEA < 0.05)	0.3
Expected Cross-Validation Index (ECVI)	3.7
90 Percent Confidence Interval for ECVI	(3.3 ; 4.1)
ECVI for Saturated Model	5.1
ECVI for Independence Model	19.7
χ^2_{231} for Independence Model with *df* =231	1921.9
Independence AIC	1965.9
Model AIC	367.5
Saturated AIC	506.0
Independence CAIC	2045.4
Model CAIC	562.8
Saturated CAIC	1420.6
Normed Fit Index (NFI)	0.85
Non-Normed Fit Index (NNFI)	0.93
Parsimony Normed Fit Index (PNFI)	0.73

Table 4.4 (Con't.)

Index	Value
Comparative Fit Index (CFI)	0.94
Incremental Fit Index (IFI)	0.94
Relative Fit Index (RFI)	0.82
Critical N (CN)	84.42
Root Mean Square Residual (RMR)	0.19
Standardized RMR	0.07
Goodness of Fit Index (GFI)	0.81
Adjusted Goodness of Fit Index (AGFI)	0.76
Parsimony Goodness of Fit Index (PGFI)	0.64

Table 4.5 Efficiency Measurement Model Squared Multiple Correlations

	R^2
DSTN1	.68
DSTN2	.86
DSTN3	.12
DSTN4	.56
OPRT1	.63
OPRT2	.58
OPRT3	.85
OPRT4	.65
OPRT5	.64
OPRT6	.69
OPRT7	.37
UNCRT1	.68
UNCRT2	.46
UNCRT3	.34
UNCRT4	.30
ASPC1	.31
ASPC2	.62
ASPC3	.22
ASPC4	.30
STSF3	.66
STSF2	.99
STSF1	.98

Table 4.6 Efficiency Measurement Model Standardized Regression Weights

			Estimate
STSF1	<---	STSF	.99
STSF2	<---	STSF	.99
STSF3	<---	STSF	.81
ASPC4	<---	ASPC	.55
ASPC3	<---	ASPC	.47
ASPC2	<---	ASPC	.79
ASPC1	<---	ASPC	.56
UNCRT4	<---	UNCRT	.55
UNCRT3	<---	UNCRT	.57
UNCRT2	<---	UNCRT	.68
UNCRT1	<---	UNCRT	.82
OPRT7	<---	OPRT	.60
OPRT6	<---	OPRT	.83
OPRT5	<---	OPRT	.80
OPRT4	<---	OPRT	.81
OPRT3	<---	OPRT	.92
OPRT2	<---	OPRT	.76
OPRT1	<---	OPRT	.80
DSTN4	<---	DSTN	.75
DSTN3	<---	DSTN	.35
DSTN2	<---	DSTN	.93
DSTN1	<---	DSTN	.82

Table 4.7 Efficiency Measurement Model Estimates

			Estimate	S.E.	C.R.	P
STSF1	<---	STSF	1.00			
STSF2	<---	STSF	0.96	0.10	9.84	***
STSF3	<---	STSF	0.57	0.17	3.55	***
ASPC4	<---	ASPC	1.12	0.29	3.83	***
ASPC3	<---	ASPC	.85	0.25	3.43	***
ASPC2	<---	ASPC	1.42	0.35	4.03	***
ASPC1	<---	ASPC	1.00			
UNCRT4	<---	UNCRT	0.68	0.14	4.75	***
UNCRT3	<---	UNCRT	0.85	0.25	3.43	***
UNCRT2	<---	UNCRT	1.42	0.35	4.03	***
UNCRT1	<---	UNCRT	1.00			
OPRT7	<---	OPRT	0.74	0.12	6.29	***
OPRT6	<---	OPRT	1.02	0.11	9.46	***
OPRT5	<---	OPRT	1.00	0.11	8.97	***
OPRT4	<---	OPRT	0.87	0.10	9.09	***
OPRT3	<---	OPRT	1.04	0.10	10.85	***
OPRT2	<---	OPRT	0.96	0.11	8.44	***
OPRT1	<---	OPRT	1.00			
DSTN4	<---	DSTN	0.87	0.10	8.28	***
DSTN3	<---	DSTN	0.57	0.17	3.38	***
DSTN2	<---	DSTN	0.96	0.10	9.84	***
DSTN1	<---	DSTN	1.00			

4.5.3 Structural Model

To test and cross validate the impact of asset specificity, uncertainty, opportunism, and product distinctiveness on satisfaction (see figure 4.1), a full path analysis was conducted to test efficiency model hypotheses. The confirmatory factor analysis is intended to assess independent constructs effects that determine the predicted satisfaction with joint relationship efficiencies between open source software project and commercial partners. The specified structural model is illustrated in figure 4.3.

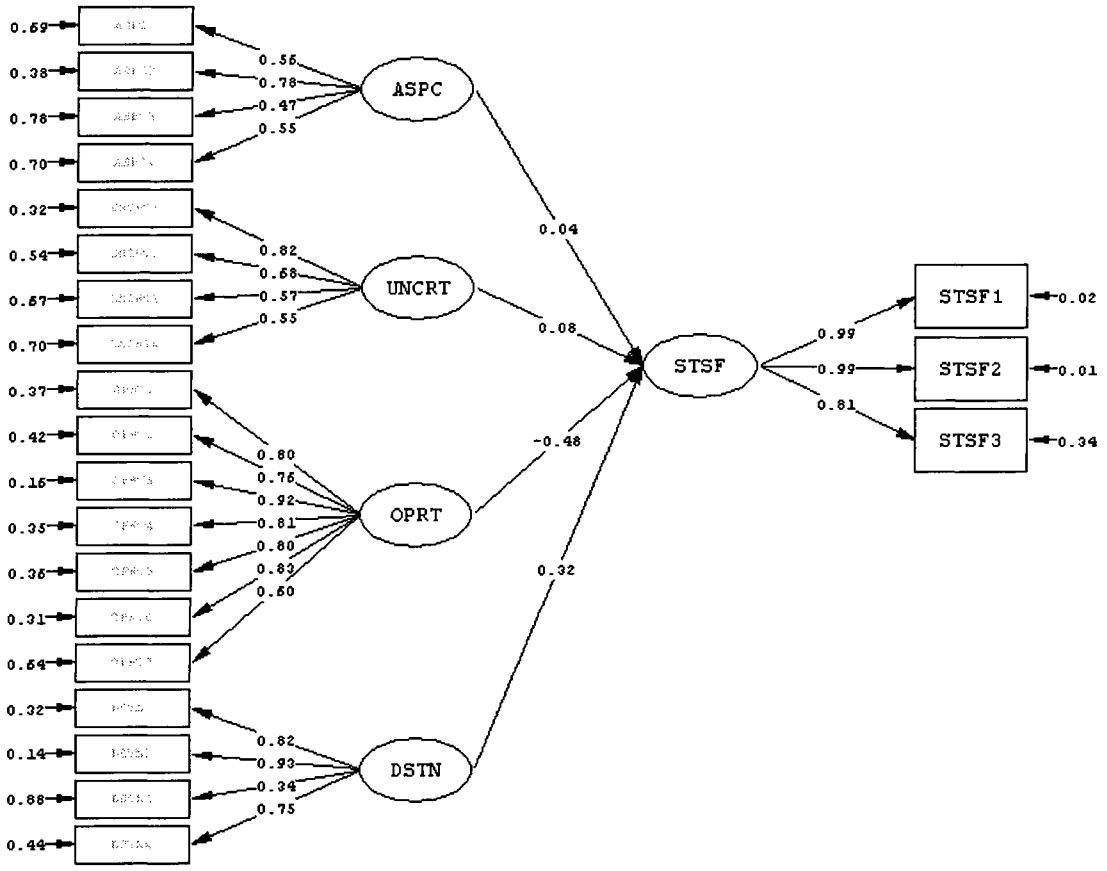


Figure 4.3 Efficiency Structural Model

The structural model fit is assessed by several fit indices. The model chi-square value is 259.5 with 199 degrees of freedom. The Comparative Fit Index (CFI) and Incremental Fit Index (IFI) are both 0.94. The Normed Fit Index (NFI) is 0.85; Goodness of Fit Index (GFI) is 0.81, the Root Mean Square Residual (RMR) is 0.19, and the Standardized RMR is 0.07. A compete list of the structural model fit indices is presented in table 4.11.

The analysis results show that all the observed variables measuring each of the five constructs are significant at the 0.001 level. The estimates, standard errors, critical ratio, and p-values are displayed in table 4.8. Results also show support for hypotheses three (H3) and four (H4). However both H1 and H2 are not supported by the data.

The squared multiple correlations of the observed variables and standardized regression weights for the measurement model are displayed in tables 4.9 and 4.10 respectively. As shown in table 4.9 the dependent construct's (STSF) R^2 value is 0.314. This indicates that the model is capable of explaining more than 31% of the variance related to satisfaction with efficiency of the hybrid OSS model.

Table 4.8 Efficiency Structural Model Estimates

			Estimate	S.E.	C.R.	P
STSF	<---	ASPC	.046	.131	.354	.723
STSF	<---	UNCRT	.101	.157	.641	.522
STSF	<---	OPRT	-.687	.160	-4.289	***
STSF	<---	DSTN	.434	.131	3.304	***
STSF1	<---	STSF	1.000			
STSF2	<---	STSF	1.015	.023	44.764	***
STSF3	<---	STSF	.867	.063	13.762	***
ASPC4	<---	ASPC	1.000			
ASPC3	<---	ASPC	.720	.210	3.430	***
ASPC2	<---	ASPC	1.150	.284	4.051	***
ASPC1	<---	ASPC	.854	.219	3.892	***
UNCRT4	<---	UNCRT	1.000			
UNCRT3	<---	UNCRT	1.026	.250	4.101	***
UNCRT2	<---	UNCRT	1.281	.285	4.490	***
UNCRT1	<---	UNCRT	1.509	.327	4.612	***
OPRT7	<---	OPRT	1.000			
OPRT6	<---	OPRT	1.378	.214	6.437	***
OPRT5	<---	OPRT	1.356	.216	6.283	***
OPRT4	<---	OPRT	1.177	.186	6.327	***
OPRT3	<---	OPRT	1.412	.206	6.848	***
OPRT2	<---	OPRT	1.295	.213	6.084	***
OPRT1	<---	OPRT	1.351	.216	6.256	***
DSTN4	<---	DSTN	1.000			
DSTN3	<---	DSTN	.652	.200	3.261	.001
DSTN2	<---	DSTN	1.116	.129	8.672	***
DSTN1	<---	DSTN	1.152	.140	8.230	***

Table 4.9 Efficiency Structural Model Squared Multiple Correlations

	R^2
STSF	.314
DSTN1	.669
DSTN2	.875
DSTN3	.114
DSTN4	.555
OPRT1	.630
OPRT2	.579
OPRT3	.847
OPRT4	.652
OPRT5	.638
OPRT6	.688
OPRT7	.358
UNCRT1	.682
UNCRT2	.461
UNCRT3	.333
UNCRT4	.289
ASPC1	.321
ASPC2	.570
ASPC3	.220
ASPC4	.338
STSF3	.667
STSF2	.988
STSF1	.977

Table 4.10 Efficiency Structural Model Standardized Regression

			Estimate
STSF	<---	ASPC	.035
STSF	<---	UNCRT	.061
STSF	<---	OPRT	-.463
STSF	<---	DSTN	.307
STSF1	<---	STSF	.988
STSF2	<---	STSF	.994
STSF3	<---	STSF	.817
ASPC4	<---	ASPC	.582
ASPC3	<---	ASPC	.469
ASPC2	<---	ASPC	.755
ASPC1	<---	ASPC	.567
UNCRT4	<---	UNCRT	.538
UNCRT3	<---	UNCRT	.577
UNCRT2	<---	UNCRT	.679
UNCRT1	<---	UNCRT	.826
OPRT7	<---	OPRT	.599
OPRT6	<---	OPRT	.829
OPRT5	<---	OPRT	.799
OPRT4	<---	OPRT	.807
OPRT3	<---	OPRT	.920
OPRT2	<---	OPRT	.761
OPRT1	<---	OPRT	.794
DSTN4	<---	DSTN	.745
DSTN3	<---	DSTN	.338
DSTN2	<---	DSTN	.935
DSTN1	<---	DSTN	.818

Table 4.11 Efficiency Structural Model Fit Indices

Index	Value
Degrees of Freedom	199
Minimum Fit Function Chi-Square	297.7 (P = 0.00)
Normal Theory Weighted Least Squares Chi-Square	259.5 (P = 0.0025)
Estimated Non-centrality Parameter (NCP)	60.5
90 Percent Confidence Interval for NCP	(22.9; 106.3)
Minimum Fit Function Value	2.98
Population Discrepancy Function Value (F0)	0.6
90 Percent Confidence Interval for F0	(0.2; 1.1)
Root Mean Square Error of Approximation (RMSEA)	0.055
90 Percent Confidence Interval for RMSEA	(0.03 ; 0.07)
P-Value for Test of Close Fit (RMSEA < 0.05)	0.3
Expected Cross-Validation Index (ECVI)	3.7
90 Percent Confidence Interval for ECVI	(3.3 ; 4.1)
ECVI for Saturated Model	5.1
ECVI for Independence Model	19.7
χ^2_{231} for Independence Model with *df* =231	1921.9
Independence AIC	1965.9
Model AIC	367.5
Saturated AIC	506.0
Independence CAIC	2045.4
Model CAIC	562.8
Saturated CAIC	1420.6
Normed Fit Index (NFI)	0.85
Non-Normed Fit Index (NNFI)	0.93
Parsimony Normed Fit Index (PNFI)	0.73

Table 4.11 (Con't.)

Index	Value
Comparative Fit Index (CFI)	0.94
Incremental Fit Index (IFI)	0.94
Relative Fit Index (RFI)	0.82
Critical N (CN)	84.42
Root Mean Square Residual (RMR)	0.19
Standardized RMR	0.07
Goodness of Fit Index (GFI)	0.81
Adjusted Goodness of Fit Index (AGFI)	0.76
Parsimony Goodness of Fit Index (PGFI)	0.64

4.6 Discussion

The empirical assessment of the efficiency model reveals mixed results for the theorized effect. Contrary to classical TCE industrial organization, the hybrid OSS model is not mostly driven by specific assets invested in the transaction. Practically, a developer who's contributing to a particular project is able to make his skills available in other domains without losing much of his valuable skill set. As a result, the notion of asset specificity is less important for establishing efficient hybrid open source software models.

In part, the findings confirm prior TCE studies that uncertainty only plays a role when there are significant amount of specific asset investment. Since OSS hybrid model is not influenced by either party's investment in dedicated assets to the transaction, this could be one of the reasons behind the negligible effect of uncertainty on satisfaction. Another factor that could explain the unsupported influence of uncertainty on hybrid efficiency model is that OSS development experiences less behavioral and environmental uncertainty. For instance, technological uncertainty effect is down played as more OSS developers are exposed to the latest technological developments that might impact the project.

The research model holds support for the negative impact of opportunistic behavior on the hybrid efficiency model. OSS community perceives opportunistic behavior of commercial partner as having adverse consequences on the relationship efficiency. Furthermore, collaborative activities between OSS project and commercial partner to develop a distinctive and differentiated product by leveraging each party's competencies improve overall efficiency and yield meritorious results of the alliance. Overall, the results show that the hybrid form of OSS that involves open source project community and commercial partners has merits and produces efficiencies, not achievable otherwise. The specified

model is able to explain about one third of the total variance in satisfactory efficiency outcome, influenced by the four exogenous factors. The summary of hypotheses testing is presented in table 4.12.

Table 4.12 Efficiency Model Hypotheses Testing Summary

Hypotheses	Finding
H1: Investment in specific assets for open source project and commercial partner alliance will have a positive effect on satisfaction with the partnership.	Not Supported
H2: Increased level of uncertainty will have a negative effect on satisfaction with the partnership.	Not Supported
H3: Perceived opportunistic behavior among parties involved in hybrid OSS development alliance will have a negative influence on open source software project's satisfaction with the relationship.	Supported***
H4: Creation of product distinctiveness will have positive influence on open source project's satisfaction with the alliance.	Supported***

***. Significant at the 0.001 level

4.7 Conclusion

This study adopts transaction cost economics to investigate efficient forms of organizing hybrid open source software projects that engage community and commercial partners. The study presumes a novel position to help understand open source software phenomenon. It offers concrete contribution to the literature and paves the way for future OSS research beyond conventional approaches. Moreover, results of the study are of interest for practice, by offering insights on factors contributing to developing efficient alliance between open source community and commercial partners.

The hybrid open source software model is regarded as a mode of governance structure that differs from classical profit maximization organization model. Development in TCE suggests that hybrid models of structure are likely to exist, instead of pure forms that represent a trade-off between two extremes; vertical integration (pure OSS) and market organizing. The study argues that forming relationships between open source software projects and commercial partners, willing to sponsor OSS projects, will result in enhanced efficiencies and favorable outcomes for the open source movement. Essentially, the relationship is based on creating a distinctive product that provides unique benefits for both parties. The OSS project efficiency is realized through joint development of a product that present significant improvements and provides significant relative advantages compared to competing software.

The study embraces the OSS project's point of view to assess significant factors of the structure of the model. The next chapter introduces on an empirical evaluation of optimal governance approach for controlling OSS hybrid models.

5. Governance Mechanisms of Hybrid Open Source Projects

Given that more open source software projects are extending collaboration beyond the volunteer community, methodical consideration of organizing patterns for emerging structures is needed. Extending transaction cost economics theory to open source software domain is a sought goal of this study. This chapter introduces an analytical assessment of hybrid governance model of open source software project and commercial partner's alliance.

OSS development is experiencing increasingly significant involvement of commercial IT vendors and other proprietary software development companies. Until recently, commercial vendors considered open source as a low profile hobbyist activity with insignificant impact on their market share. Advocates of OSS claim it to be the "next great thing" that would revolutionize the software industry (Raymond, 2001), while those facing threat from OSS; mainly proprietary software development shops; complained of intellectual property infringement. However, as OSS grew and amassed a strong following, commercial IT vendors developed an interest in OSS and embraced the 'movement'. Currently, giant vendors such as IBM, Intel, Oracle, and HP are participating and supporting different open source projects. Various forms of support include: contributing tangible and human assets to the project, giving away patents and proprietary code, and announcing platform certification and endorsement of open source products.

Mostly, why OSS projects are open to commercial IT organizations involvement is unknown. Yet previous research on alliance presents various justifications for why organizations would want to form an alliance (Lefton & Rosengren, 1966; Aiken & Hage, 1968; Doz & Hamel, 1998; Barringer & Harrison, 2000). Some of the common reasons include: knowledge sharing, internal organizational diversity, lateral and longitudinal dimensions of organizational commitment to clients, attainment of objectives that can only be achieved through cooperation, help firms create value by combining resources, increasing speed to market, and gaining access to foreign markets.

There are also some negative implications associated with interorganizational cooperation. For example, entities participating in interorganizational cooperation venues might suffer a loss of decision-making autonomy, experience loss or damage to their identity and image, or they might over burden their limited organizational resources (Schermerhorn, 1975). Furthermore, all aforementioned forms of disadvantage potentially incorporate extra costs attributable to interorganizational cooperation.

On a different setting, research revealed that nonprofit organizations, not unlike for-profits, economize on transaction cost. Volunteers are conscious of opportunity cost of invested time (V. Valentinov, 2008) and organizers want to operate efficiently while upholding community values, mainly by emphasizing community responsibility (V. L. Valentinov, 2007). Likewise, it is reasonable to assume that OSS phenomenon is driven by economic agents performing actions that maximize their utility function. This study argues that open source software is an efficient arrangement. Although it appears to lack profit incentive drivers for OSS projects, still other forms of organization apply including labor and resource allocation in order to produce public goods and services.

Open source's extraordinary method of organization should be giving rise to a new collaborative structure that engages competing resources. Given recognition of the special form of collaboration between open source and commercial organization(s), it is expected that a new form of interorganizational cooperation would emerge to account for two-party differences since governance is recognized as the fundamental function of control and administration that takes place when a group of people come together to legally incorporate under the laws of a state for a nonprofit organizational purpose (Gies, Ott, & Shafritz, 1990, p. 178). In addition, it is likely that the role of transaction cost will presume another level of importance and allow for alternative interpretations within the open source context.

From a transaction cost point of view, various forms of interorganizational relationship, such as joint ventures or network structures, are considered alternative forms of governance and departures from the generic organizational hierarchy (make) or market (buy) decision (Barringer & Harrison, 2000). This research focuses attention towards the type of organizational interdependency that involves the establishment of joint, cooperative activities between open source software project communities and for-profit organizations (e.g. OSS companies, IT vendors). Moreover, as participants maintain potentially conflicting goals and missions, it is imperative to take into consideration special characteristics of the transaction.

This study applies the premise of transaction cost economics and interorganizational collaboration theory of adopting cost-minimizing governance structure for open source software project and commercial (for-profit) organization partner(s), designed for software

development transaction. Attempt to understand the implications of such relationships is conducted on the basis that both parties agreed to form an out-of-band association in the form of 'cooperative adaptation' (Williamson, 2002), which is a departure from the classical form of alliance, in order to achieve mutual benefits and cost savings. While it is expected that both parties have relative dependency on the other, nevertheless adoption of safeguard mechanisms and low perception of opportunistic behavior likely enable launching successful institutional establishments. The study adopts open source project level of analysis and community perspective to examine cooperation patterns and antecedents of bilateral governance structure of hybrid OSS projects. The next section proceeds to provide a review of relevant literature and background work that guides the development of the theoretical model and hypotheses. The rest of the chapter is structured as follows: the next section introduces the theoretical framework for driving hypotheses of the study. Section 5.2 presents study sample, variable measure, and analytical procedure adopted. Hypotheses testing results are presented next. Finally the last sections present the discussion and conclusion.

5.1 Research Hypotheses

One of the objectives of collaborative software development between open source projects and commercial partner(s) is the arrangement of institutional form based on principal foundations and an interest in minimizing cost (Sidahmed & Gerlach, 2009). This new configuration would lead each party to perceive themselves at an advantage point by continuing the alliance than by ending it. As a consequence of establishing governance mechanisms for managing the partnership, parties would reduce transaction costs incurred by opportunism and other environment uncertainty (Williamson, 1985). Since no formal contacts are defined to oversee cooperation between the two parties, OSS-commercial

vendor affiliation is governed through embedded unofficial 'self-enforcing' agreements (Telser, 1980), sponsorship and safeguards. The theoretical research model for the study is depicted in Figure 5.1.

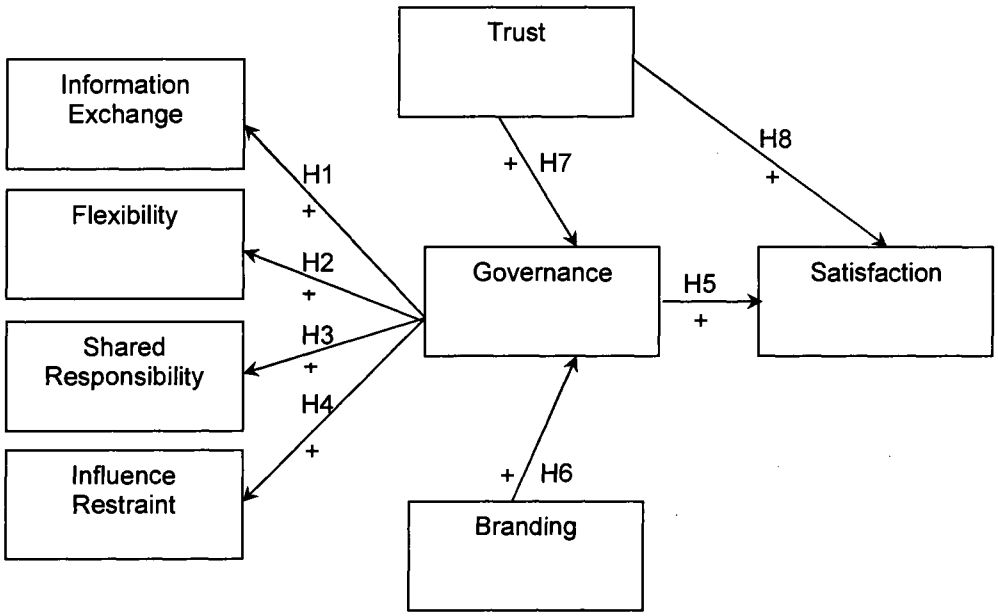


Figure 5.1 Hybrid OSS Governance Theoretical Model

The importance of establishing bilateral communication channels is recognized in classical organizational theory to have both supplementary and complementary roles to existing channels in any organization structure (Hrebiniak & Joyce, 1984). In the absence of formal firm boundaries, open source projects undertake transparency and a free flow of knowledge and information on project mailing lists and discussion boards as mechanisms for mitigating uncertainty and potential conflicts.

As commercial vendors show active presence in the project, amplified levels of communication and information sharing becomes more eminent for resolving dependency and assuring complete engagement. Collaboration research shows that the alliance form of governance is influenced by the level of interdependence and requirement for information sharing (Gulati & Singh, 1998). The higher the level of interdependence and transaction complexity, the greater the amount of information sharing needed between partners. Given that software development is a highly complex task that involves multiple dependencies across different parties, it is the control mechanism of OSS project-commercial partnership that comes into effect for managing flow and defining level of information granularity. Certainly, it is the access to information possessed by each party that reduces the degree to which information asymmetry might pose a risk to the performance of partnership. This study maintain that partnership form of governance will resolve the challenges for coordinating tasks between open source project and commercial partners by investing in economical methods that reduce coordination costs. Accordingly, hypothesis one is stated as:

> H1: A meritorious hybrid governance structure would have an institutionalized streamline of information exchange between open source project and commercial partner.

The other dimension of governance implicates strategic flexibility of relationship between open source project and commercial partners. Previous research revealed that increased flexibility of interorganizational collaboration to be a pre-required phase for improved efficiency and cost reduction (Chebbi, Dustdar, & Tata, 2006). Moreover, a rapidly changing software and technology environment demands swift response and managed adaptability.

In alliance setting, flexibility attribute, identified as the partnership's ability to cope with environment changes (Aaker & Mascarenhas, 1984) and continuous adjustment to emerging states (Bahrami, 1992), stems from instituted governance mode of the joint collaboration. The two common forms of flexibility related to OSS-IT vendor alliance are modification and exit (Young-Ybarra & Wiersema, 1999). Modification refers to willingness and ability of parties to amend their behavior and/or norms to accommodate the other party's requirements. The other form of flexibility is the extent to which partners are loosely-coupled to each other and able to opt-out of the relationship as a result of changing directions or unsatisfactory outcome.

Success of the relationship between the open source project and proprietary vendor partner commands the latter party to refrain from attempting to impose corporate-style structure and bear approachable attitude towards open source's casual nature. The new formed governance should be established according to the needs of partnership, and availability of competencies and matching roles. Parallel to previous studies that found establishment of flexible arrangements to have a positive effect on alliance performance and satisfaction (Johnston, McCutcheon, Stuart, & Kerwood, 2004), this study argues that

parties' willingness to alter agreements and priorities when unexpected events arise will positively affect satisfaction with the outcome of the partnership. Accordingly the second hypothesis is defined as:

> H2: A meritorious hybrid governance structure would have a flexible and social cooperative relationship between open source project and commercial partner.

Arguably, within the open source context, vertical integration would encompass full development and control of a project by open source members without relying on support or sponsorship from any commercial organization or foundation. All efforts of design, organization, implementation, and promotion of the project are exclusively under the project's internal governance. As a result of total 'vertical integration' open source grows to maintain a fuzzy set of distributed responsibilities among volunteer members. Collectively, this comes to define overall commitment to the success of open source in general. Shared values, self esteem, and altruism are key players for maintaining OSS developers renewed interest and desire for successful results.

As commercial vendors' employees and paid contractors hold direct involvement in OSS projects, a new framework of responsibility would necessarily come into effect. Interorganizational cooperation literature assumes that cooperative activities of an alliance would take some form of joint decision-making process and mutual control (Mulford & Rogers, 1982). Moreover, in support of common responsibility, the theory calls for building consensus and coordinating actions of member partners (Galaskiewicz, 1985). Because profit-oriented companies are inclined to introduce a structured model of accountability to the partnership, the new governance model will have to account for the

extent to which open source projects and commercial partners distribute responsibility in a fashion that supports the alliance and build safety nets for handling future lapses. Some studies found that the governance choice of an alliance facilitates identification of knowledge sources and promotes joint actions required to solve problems within a coalition setting (Heiman & Nickerson, 2002). Commonly, resources required for particular tasks are drawn from the shared pool of open source project and commercial organization's resources. Hence the third hypothesis is positioned as follows:

> H3: A meritorious hybrid governance structure would have a joint and shared responsibility governance pattern between open source project and commercial partner.

Often, strategic relationships involve stakeholders that are cautious about power exploitation that could lead to the damage of the offending party's "social face" and show concern about the potential loss of future opportunities for the spoiled partner (Cook & Emerson, 1978; Luo, 2001). The fact that the party with superior power willingly abstains from exercising their veto power to override the less powerful party's shared control on project direction and key decisions is a crucial protection against power friction, potential project 'forking' and/or demise of the relationship.

Several studies support the favorable implications of fair power distribution and equally shared control of the alliance. Some of the direct implications of such positive practices are reflected in improved work attitudes and behavior and organizational commitment (McFarlin & Sweeney, 1992; van den Bos, Wilke, & Lind, 1998).

A typical example of partnership influence restraint is represented by the scenario that when given the chance, the commercial partner avoids exploiting the open source project and vice versa (Heide & Miner, 1992). Moreover studies on cross-organizational power sharing and use underscores the positive role of interfirm power control in promoting trust and effective coordination of partners' activities (Frazier & Summers, 1986; Zaheer & Harris, 2005). This research suggests that setting up well-defined limits for each party's level of power will stimulate favorable results of open source project-commercial partner affiliation. Therefore, hypothesis four is stated as:

> H4: A meritorious hybrid governance structure would have a mechanism that mandates restraint of power and influence of one party on the less dominant between an open source project and commercial partner.

In general, acknowledging diverse stakeholders' goals and intentions of collaboration, it is legitimate to argue that the new form of OSS development requires a special control structure, well defined roles, and departure from 'bazaar-like' governance mode. Also, research shown that establishment of a special form of governance structure that is in alignment with transaction attributes has a first order effect on subsequent patterns of participation and engagement of future partners (Shah, 2006). In addition, different aspects related to governance choice are found to yield dissimilar performance outcome for transactions with diverse organizational forms (Leiblein, Reuer, & Dalsace, 2002). The latest conclusion supports earlier results, which identified the influence of governance choice on partnership performance (Walker & Weber, 1984, 1987; Williamson 1985; Heide & John, 1990). This study hypothesize that satisfaction with a new form of collaboration for open source software development forms an integral part of the organizational assimilation

process (Pieters, Koelmeijer, & Roest, 1995). Also, the moderating effect of experience with the commercial partner can provide an evaluation for making subsequent judgments about the hybrid mode viability. Consequently, the governance hypothesis is stated as:

> H5: A meritorious hybrid governance structure for open source project and commercial partner will have positive impact on satisfaction with the partnership.

Strongly enough, leveraging a brand became an increasingly important emerging issue for open source, as a consequence of established cooperation with commercial organizations and other agencies (Fitzgerald, 2006). The two models for establishing a strong brand are: from leveraging product advantage to intangible values, or from value to product (Kapferer, 2008). Regardless of the approach adopted, research findings indicate that combined efforts to promote a brand as a valuable asset would result in building a whole that's greater than the sum (Rao & Ruekert, 1994).

Recognizing association between governance and branding, some studies showed that establishment of brand name serve as an enabler for creating a high degree of interorganizational coordination (Gereffi, 1994). Brand creates quasi-rents that can only be realized by either party if the relationship succeeds. IT vendor partner's rationale about anticipated cash flow govern the incentive of maintaining the relationship with open source project. If the present value of taking over the open source project or starting their own project is higher than the future value, this will mark an end to the collaborative alliance between the two. Nevertheless, proprietary partner's perception of higher value for the long-term relationship with OSS project fosters the relationship and leads to an adequate working atmosphere.

Correspondingly, earlier results found that branding is used to improve the level of communication between different parties of an alliance (Alchian & Woodward, 1987). Within an OSS-commercial organization alliance, it's expected that the sponsoring companies' effort to promote OSS project would have a positive impact on the adopted governance model and collaboration efforts as both parties work together to promote their strategic partnership. The open source project will benefit from having the vendor's name such as IBM attached to it, while a commercial company would boost its identity and market image by collaborating with innovative and hyped open source projects such as Linux.

On the other hand, as the project continues to thrive as a high quality and well-recognized product, collaborative parties will experience increased levels of flexibility, improved channels of communication, and assume further mutual responsibilities. Therefore, the influence of branding will reinforce the combined underlying cooperation behaviors (governance dimensions) mentioned earlier and strengthen governance means for adopting a differentiation strategy. Investigation of brand development impact in a non-profit setting indicates that institutionalization of brand will have a positive outcome on overall performance (Ewing & Napoli, 2005). In the case of open source-vendor software development transaction, the study hypothesizes it will have an indirect effect on transaction cost and satisfaction with partnership through governance choice:

> H6: Investment in brand capital will have a positive influence on the governance structure of open source project and commercial partner.

Another factor that influences the governance structure is trust. Trust is defined as an individual or organization's willingness to make oneself vulnerable to potential harm or damage from another party (Gallivan & Depledge, 2003). It is also recognized as a multi-dimensional construct across personal and organizational levels plays a key role in interorganizational relations and relational governance. In particular, trust proved to have positive impact on negotiation costs, managing cross organizational conflicts, and ultimately overall performance (Zaheer, McEvily, & Perrone, 1998). According to TCE, firm's opportunistic behavior (Williamson, 1975; Williamson 1985) leads to increased transaction costs due to necessity of safeguard mechanisms. However, trust as a mediating factor in relational exchange is recognized as a source of competitive advantage (Barney & Hansen, 1994).

Interorganizational trust is defined as the degree to which members of one organization maintain a communal trust orientation toward another organization (Zaheer et al. 1998). Yet, this definition does not equate interorganizational trust to that of an individual-to-individual trust. An economic view, recognized trust as a quasi-rational calculation of the probability of subsequent future benevolent actions (Gambetta, 1988). Alternatively, an organizational view identifies trust as being relational or reciprocal in nature (Zaheer & Harris, 2005). It is imperative to acknowledge the fact that asymmetric nature of interorganizational trust may involve power and resource dependency that stem from one party's vulnerability on other parties of the alliance (Pfeffer & Salancik, 1978). The role of trust within interorganizational collaboration and transaction cost economics framework embark on choosing an organizational structure that safeguards against opportunism, substitutes need for complete contract (Poppo & Zenger, 2002), and lowers transaction costs.

Strategic alliance research showed that opportunism is a particularly important problem, especially in alliances that engages members from different organizations (Judge & Dooley, 2006). In addition, several studies revealed that while it is not necessary all agents have the same level of opportunistic behavior, any perception of opportunism between the parties of an alliance would negatively impact performance (Williamson, 1979; Ring & van de Ven, 1994; Saxton, 1997). Trust is a force that can counter the threat of opportunism. Research indicates that collaborative relations are more likely to take place in high-trust cultures (Williamson, 1979). In contrast, low-trust environments exhibit more vertically integrated structure. Correspondingly, research showed that various forms of governance and control structures are shaped by the level of trust between parties of an alliance (Gallivan & Depledge, 2003). The importance of trust as a factor that impact organizations engaged in partnership or strategic alliance is eminent in affecting performance and relationship success (Zaheer & Harris, 2006). Consequently, the next hypotheses are derived as follows:

H7: Trust between open source project members and commercial partner will have positive influence on the hybrid governance structure.

H8: Trust between open source project members and commercial partner will have positive influence on satisfaction with the partnership.

5.2 Data and Method

5.2.1 Study Sample

The sample for the study includes open source projects listed on three major open source repositories, namely, Sourceforge, Freshmeat, and Savannah. Although there are other smaller or dedicated hosting sites for open source projects, by far, these online collaborative development hosting sites represent the first choice for OSS projects that range from newly initiated to mature ones. An indicator of magnitude of growth on these sites is reflected by Sourceforge. At the time of this study, Sourceforge incorporates over 180,000 projects and more than 1,900,000 registered users (Sourceforge, 2008).

Consistent with the data collection practice in experimental research on TCE (Richman & Macher, 2006), this study used mailed-out survey and interview as the primary methods for data collection. A pilot survey was sent to a group of open source project managers to receive feedback on the instrument and clarity of items. As part of the study, follow up phone interviews were conducted with a subset of the pilot study participants, who indicated they were willing to provide feedback on IT vendor's involvement in their projects. Each interview lasted between 20-45 minutes. Based on the outcome of the interviews and the pilot study, minor modifications incorporated to the final instrument that includes rearranging and rewording some questions. Personalized emails with a survey link and an invitation were sent to project managers and administrators of different open source projects hosted on Sourceforge, Freshmeant, and Savannah. Ascribed to key informant methodology, those individuals are assumed to be the most knowledgeable people about the project and typically they earn such status through quality contributions and lengthy attachment to the project (Raymond, 2001).

To overcome predicaments caused by single developer/user projects and inactive projects listed on these sites, the study formed a systematic inclusion and clustering criteria, where projects that hold the following attributes were identified: a) active status, b) project activity is greater than or equal to the 80th percentile, c) have at least five developers working on the project, and d) project age is greater than or equal to three years. Project maturity is defined as the date of inception on the development site. In addition, each project had at least one designated project manager responsible for coordinating project activities. The number of project managers is usually a good indicator of project activity. Typically, moderately active projects will have one or two project managers, and highly active and more complex projects will involve several project managers. Project managers are primarily responsible for coordinating development activity and resolving conflicts regarding coding and feature design.

A total of 1437 survey invitations were mailed out; the response rate was 23.7%. Of the 341 who responded to our invitation, 116 respondents indicated belonging to an OSS project with commercial partner involvement. After eliminating incomplete responses, the final dataset has 101 points, each representing a different open source project.
Due to the non-traditional nature of the relationship between open source and commercial organizations, prior identification of projects that have organization sponsorship or other form of alliance with commercial vendor(s) is not feasible. Limitations of OSS host sites mailing lists used did not allow for identification of projects that have commercial partner(s). The only way to obtain such information is surveying the project manager. Previous studies employed transactions cost economics are heavily skewed towards adopting a single case study methodology for investigating variations of discriminating alignment hypotheses (Richman & Macher, 2006). Since most of the studies were retroactive in nature (i.e.,

make-versus-buy or outsourcing decision already made) there was no difficulty in identifying those organizations, where such transactions took place beforehand. The study selection criteria was developed in an attempt to include as many projects involved in transactions with commercial organization(s) as possible, but results in relatively moderate hit of projects associated with commercial partner(s).

In accord with table 2.1 classification, the data confirmed various categories of stakeholders involved in open source. The majority of those, who responded to the survey (62%) indicated they work for open source voluntarily. The non-volunteer based group include: 15% who are paid by a flagship open source company, 4% paid by an open source foundation, 8% paid by a software packager or hardware/middleware vendor organization, and 11% designated as paid by other, which include any other party excluded from the previous categories. To insure there are no significant differences in responses between volunteer participants in a project and those paid by a commercial partner or other organization, a chi-square test was conducted to assess between groups difference. Statistical test indicates no significant difference; therefore the two groups were pooled for analysis.

To gain insights of collaboration length between open source project and commercial organization(s), the instrument solicited subjects to identify their project relation with an IT vendor partner. The data show that engagement ranges from less than a year, to more than ten years for some projects. It can be inferred that some alliances go back a decade or so. The continuation of the relationship is also an indication of successful establishment of governance between the parties that bear low cost for the transaction, since it is unlikely that relationships would continue with experienced dismay from either side.

Another informative demographic characteristic is the number of OSS foundations, OSS companies, IT vendors, or other organizations involved in a project. Data analysis show that projects have between one and more than five partner organizations working in collaboration. Analysis also found that the GNU General Public License (GPL) and subsequent GNU General Public License version 3.0 (GPLv3) dominated across the projects sampled (over 50%). The research also shows that some projects adopted a dual license that likely met collective stakeholders' needs. Dual licensing could be regarded as a strategic tactic that positions the open source project as an appealing candidate for diverse stakeholders.

5.2.2 Non-response Bias

To account for nonresponse bias that might be introduced in the data a statistical significance test was conducted. Since the study had only a single round of survey invitations, a traditional nonresponse assessment method was not feasible. The study uses Armstrong and Overton's (1977) method to test for nonresponse bias effect. The study treated late respondents to the survey as similar to the theoretical nonrespondent group. By conducting a two-tail test ($\alpha = 0.05$) for the difference between early and late respondents in the sample, It has been concluded that there is no significant difference between the two groups. Therefore, it is reasonable to assume that the nonresponse bias is minimal or has negligible effect on the subsequent analysis of the data.

5.3 Measures

5.3.1 Dependant Variable

To identify the outcome of the hybrid governance structure, the study measured satisfaction with the partnership. The decision whether to engage a commercial partner in

the project development or maintain the purity of open source model is a governance scheme choice. Utilizing satisfaction with the partnership as a proxy for transaction cost is a natural choice for examining the make-versus-buy (fully open source developed vs. OSS-commercially developed project) decision in this special setting. The study posit that satisfaction with the hybrid mode of governance is an indication of achieving a degree of institutionalization that effectively governs the alliance between the project and commercial partners; thereby, lowering transaction cost for both sides. If achieved, it represents an outcome of an all-winner scenario.

The study measured satisfaction using three items that capture open source project managers' perceived fulfillment of the project direction under joint governance, as well as the perceptions of fulfillment of project contributors who are paid by the commercial partner.

5.3.2 Independent Variables

Four first order latent variables (information exchange, flexibility, shared responsibility, and influence restraint) that represent the underlying construct of governance are measured through direct observed variables.

The information exchange construct is measured using four items. It represents the level and nature of information flow between open source project and partner organization. It defines the way parties established their communication channels that result in lowering transaction cost, moderating uncertainty, and guarding against potential opportunism occurrence. The flexibility construct is estimated using four items that capture the level of elasticity that shapes the software development relationship between open source project and proprietary companies and the willingness to consider alternative forms of work as need may arise. The shared responsibility construct is a four-item scale that captures the

fundamental nature of the alliance. It assesses the way open source project and commercial companies assume responsibility for the partnership and their willingness to lower friction due to divergence in agendas. Influence restraint is the degree to which the more powerful party in the transaction is willing to abstain from exercising excessive pressure on the other party; a process that results in power-mitigation implementation. This construct was measured by a three-item scale.

5.3.3 Mediating Variables

Two mediating constructs are designated as having influence on the outcome of the alliance (satisfaction). Branding construct is measured using seven items and it is intended to assess the degree to which the hybrid mode of open source software development is building a brand identity by utilizing combined and coordinated efforts of open source project and commercial partner. In addition, trust construct is measured using three items. It reflects the degree of trust between open source project and partner commercial organization. The study posits that trust plays a dual role in the OSS project-commercial partner collaboration, by having both direct and indirect influence on the outcome. Appendix A presents the instrument questions for the measured variables along with their respective constructs. Table 5.1 displays governance model latent variables (constructs) reliability and measures, along with respective observed items. All constructs' reliability (Cronbach's Alpha) values are above 0.80.

Table 5.1 Governance Model Constructs Reliability and Measures

Construct	Observed Variables	Reliability (Cronbach's α)	Adopted From
Brand (BRND)	BRND1 BRND2 BRND3 BRND4 BRND5 BRND6 BRND7	0.869	Ewing & Napoli, 2005
Information Exchange (INFX)	INFX1 INFX2 INFX3 INFX4	0.820	Heide & Miner, 1992
Flexibility (FLEX)	FLEX1 FLEX2 FLEX3 FLEX4	0.825	Heide & Miner, 1992
Influence Restraint (INFL)	INFL1 INFL2 INFL3	0.880	(Heide & Miner, 1992)
Shared Responsibility (SRSP)	SRSP1 SRSP2 SRSP3 SRSP4	0.891	(Heide & Miner, 1992)
Satisfaction (STSF)	STSF1 STSF2 STSF3	0.950	(Chiou & Shen, 2006)

Table 5.1 (Con't.)

Construct	Observed Variables	Reliability (Cronbach's α)	Adopted From
Trust (TRST)	TRST1 TRST2 TRST3	0.899	(Zaheer & Venkatraman, 1995)

5.4 Data Analysis and Results

5.4.1 Test of Research Model

The study used Structural Equation Modeling (SEM) to build and test our model. Recognized as a super set of multiple regression, analysis of variance, and factor analysis, SEM has the advantage of enabling simultaneous analysis of the complete model variables and causal effect. Moreover, it lends itself as capable of hypothesis testing by allowing for nullification of hypotheses. Adopting the most widely used fitting function for general SEM models, this study used Maximum Likelihood (ML) estimation procedure of LISREL 8.8. This technique works well with covariance matrix analysis (Byrne, 1998); also ML is considered both scale free and scale invariant, relatively robust at handling violations of the multivariate normality assumption (Kline, 2005). Moreover, SEM review and recommended approach indicates that the technique still holds even with sample size of 50 (Anderson & Gerbing, 1988). The fitting function for minimization is defined as (Bollen, 1989):

$$F_{ML} = \log | \Sigma(\Theta) | + tr(S\Sigma^{-1}(\Theta)) - \log | S | - (p + q) \qquad (5.1)$$

Where S is the Wishart distribution of the sample covariance matrix (S)

The mean, standard deviation, and correlation matrix for the observed variables are shown in table 5.2.

Table 5.2 Governance Model Means, Standard Deviations, and Correlations of Observed Variables

	Mean	STDev	1	2	3	4	5
1. INFX1	5.47	1.51	1.00				
2. INFX2	5.35	1.56	.603**	1.00			
3. INFX3	4.08	1.86	.276**	.470**	1.00		
4. INFX4	5.15	1.44	.729**	.686**	.433**	1.00	
5. FLEX1	5.16	1.44	.592**	.657**	.529**	.708**	1.00
6. FLEX2	5.50	1.51	.435**	.540**	.256**	.539**	.399**
7. FLEX3	4.92	1.60	.481**	.481**	.504**	.554**	.475**
8. FLEX4	4.91	1.52	.349**	.346**	.451**	.426**	.489**
9. SRSP1	4.45	1.72	.410**	.416**	.402**	.499**	.339**
10. SRSP2	4.61	1.66	.478**	.401**	.403**	.554**	.408**
11. SRSP3	5.04	1.50	.639**	.534**	.416**	.676**	.498**
12. SRSP4	5.10	1.53	.593**	.507**	.343**	.622**	.470**
13. INFL1	4.98	1.67	.517**	.388**	0.19	.473**	.389**
14. INFL2	5.42	1.42	.440**	.448**	.271**	.468**	.494**
15. INFL3	4.92	1.54	.580**	.499**	.376**	.543**	.416**
16. TRST1	5.46	1.36	.447**	.496**	.259**	.451**	.412**
17. TRST2	5.29	1.53	.520**	.315**	0.14	.477**	.389**
18. TRST3	5.29	1.55	.404**	.318**	0.15	.380**	.217*
19. BRND1	4.40	1.74	.234*	.343**	0.14	.303**	.261**
20. BRND2	4.88	1.50	.202*	.270**	0.02	0.13	.231*
21. BRND3	5.10	1.28	.208*	.297**	.210*	.273**	.240*
22. BRND4	4.45	1.69	.240*	.344**	.212*	.286**	.328**
23. BRND5	4.28	1.97	.196*	.298**	.210*	.339**	.274**
24. BRND6	4.01	1.80	0.11	.231*	0.19	.251*	.250*
25. BRND7	4.50	1.54	0.11	.232*	0.14	.201*	0.14
26. STSF1	5.73	1.39	.537**	.490**	.217*	.515**	.395**
27. STSF2	5.74	1.40	.534**	.516**	.222*	.524**	.401**
28. STSF3	5.48	1.47	.537**	.513**	.228*	.516**	.395**

Table 5.2 (Con't.)

	6	7	8	9	10	11	12
1. INFX1							
2. INFX2							
3. INFX3							
4. INFX4							
5. FLEX1							
6. FLEX2	1.00						
7. FLEX3	.591**	1.00					
8. FLEX4	.683**	.613**	1.00				
9. SRSP1	.239*	.450**	0.17	1.00			
10. SRSP2	.434**	.442**	.295**	.680**	1.00		
11. SRSP3	.618**	.595**	.458**	.542**	.689**	1.00	
12. SRSP4	.588**	.594**	.477**	.559**	.688**	.865**	1.00
13. INFL1	.400**	.431**	.330**	.429**	.592**	.554**	.641**
14. INFL2	.417**	.485**	.386**	.312**	.506**	.622**	.662**
15. INFL3	.506**	.611**	.389**	.403**	.537**	.669**	.688**
16. TRST1	.397**	.302**	.247*	.349**	.385**	.532**	.522**
17. TRST2	.387**	.354**	.248*	.271**	.433**	.622**	.546**
18. TRST3	.470**	.288**	.265**	0.16	.266**	.443**	.393**
19. BRND1	.314**	0.17	0.16	.258**	.396**	.373**	.361**
20. BRND2	0.18	0.08	0.05	0.10	.260**	.207*	.285**
21. BRND3	.231*	0.16	0.07	.216*	.305**	.232*	.332**
22. BRND4	.244*	.325**	0.15	0.19	.284**	.282**	.348**
23. BRND5	0.08	.255**	0.06	.283**	0.13	.282**	.271**
24. BRND6	0.05	.216*	0.00	.284**	0.16	0.16	0.18
25. BRND7	0.16	.203*	0.03	.320**	.252*	.234*	.209*
26. STSF1	.610**	.444**	.314**	.347**	.423**	.634**	.549**
27. STSF2	.640**	.463**	.321**	.338**	.408**	.652**	.558**
28. STSF3	.575**	.456**	.274**	.300**	.393**	.611**	.528**

Table 5.2 (Con't.)

	13	14	15	16	17	18	19
1. INFX1							
2. INFX2							
3. INFX3							
4. INFX4							
5. FLEX1							
6. FLEX2							
7. FLEX3							
8. FLEX4							
9. SRSP1							
10. SRSP2							
11. SRSP3							
12. SRSP4							
13. INFL1	1.00						
14. INFL2	.665**	1.00					
15. INFL3	.708**	.754**	1.00				
16. TRST1	.352**	.335**	.337**	1.00			
17. TRST2	.454**	.354**	.448**	.785**	1.00		
18. TRST3	.312**	.208*	.349**	.705**	.755**	1.00	
19. BRND1	0.20	.279**	.261**	.265**	.209*	0.13	1.00
20. BRND2	.211*	.295**	.273**	.198*	0.17	0.03	.408**
21. BRND3	.197*	0.11	0.19	.237*	0.17	0.10	.411**
22. BRND4	.273**	.284**	.310**	.216*	.222*	.199*	.503**
23. BRND5	0.11	0.17	0.15	0.18	0.16	0.07	.484**
24. BRND6	0.08	0.10	0.10	0.15	0.08	-0.03	.449**
25. BRND7	0.01	0.11	0.06	0.13	0.06	0.04	.496**
26. STSF1	.317**	.299**	.484**	.540**	.555**	.596**	.390**
27. STSF2	.339**	.324**	.508**	.533**	.553**	.599**	.356**
28. STSF3	.306**	.316**	.490**	.547**	.564**	.629**	.231*

Table 5.2 (Con't.)

	20	21	22	23	24	25	26	27	28
1. INFX1									
2. INFX2									
3. INFX3									
4. INFX4									
5. FLEX1									
6. FLEX2									
7. FLEX3									
8. FLEX4									
9. SRSP1									
10. SRSP2									
11. SRSP3									
12. SRSP4									
13. INFL1									
14. INFL2									
15. INFL3									
16. TRST1									
17. TRST2									
18. TRST3									
19. BRND1									
20. BRND2	1.00								
21. BRND3	.692**	1.00							
22. BRND4	.488**	.625**	1.00						
23. BRND5	.256**	.429**	.565**	1.00					
24. BRND6	.309**	.489**	.473**	.815**	1.00				
25. BRND7	.251*	.384**	.399**	.579**	.699**	1.00			
26. STSF1	.220*	.255**	.302**	.254*	.225*	.272**	1.00		
27. STSF2	.213*	.253*	.285**	.218*	0.18	.244*	.982**	1.00	
28. STSF3	.208*	.235*	.253*	0.16	0.05	0.16	.802**	.807**	1.00

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5.4.2 Measurement Model

Following recommended iterative steps of SEM analysis (Kline, 2005) the research embarked on model specification, followed by theoretical assessment of model identification. Using pre-validated measures (Table 5.1) for the variables represented in the model, the study applied limited adjustments to the original scales to suit study purposes. The measurement model was evaluated by conducting confirmatory factor analysis (CFA) to examine factor loadings of observed variables on their respective latent variables. The factor scores and regression weights for predicting the latent constructs from the observed variables are presented in table 5.3.

Table 5.3 Hybrid Governance Model Factor Score Weights

	STSF1	STSF2	STSF3	TRST1	TRST2	TRST3	INFL1
STSF	0.330	0.500	0.017	0.002	0.003	0.001	0.000
TRST	0.025	0.039	0.001	0.252	0.391	0.177	0.000
INFL	-0.008	-0.013	0.000	0.001	0.001	0.000	0.161
SRSP	0.012	0.019	0.001	0.012	0.019	0.009	0.020
FLEX	0.027	0.040	0.001	-0.007	-0.011	-0.005	0.012
INFX	0.009	0.014	0.000	0.010	0.015	0.007	0.007
BRND	0.007	0.010	0.000	-0.004	-0.006	-0.003	-0.002

Table 5.3 (Con't.)

	INFL2	INFL3	SRSP1	SRSP2	SRSP3	SRSP4	FLEX1
STSF	0.000	-0.001	0.000	0.000	0.002	0.001	0.001
TRST	0.000	0.001	0.003	0.005	0.023	0.020	-0.003
INFL	0.251	0.366	0.009	0.016	0.074	0.064	0.010
SRSP	0.032	0.046	0.043	0.078	0.356	0.310	0.008
FLEX	0.019	0.027	0.004	0.008	0.034	0.030	0.106
INFX	0.011	0.016	0.004	0.008	0.036	0.032	0.024
BRND	-0.003	-0.005	0.001	0.002	0.011	0.009	-0.002

Table 5.3 (Con't.)

	FLEX2	FLEX3	FLEX4	INFX1	INFX2	INFX3	INFX4
STSF	0.001	0.001	0.001	0.000	0.000	0.000	0.001
TRST	-0.005	-0.004	-0.004	0.006	0.005	0.002	0.013
INFL	0.016	0.014	0.012	0.008	0.008	0.002	0.018
SRSP	0.013	0.011	0.009	0.012	0.010	0.003	0.025
FLEX	0.176	0.159	0.128	0.035	0.031	0.009	0.075
INFX	0.039	0.036	0.029	0.164	0.146	0.042	0.352
BRND	-0.003	-0.003	-0.002	0.006	0.006	0.002	0.014

Table 5.3 (Con't.)

	BRND1	BRND2	BRND3	BRND4	BRND5	BRND6	BRND7
STSF	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TRST	-0.001	-0.001	-0.001	-0.001	-0.003	-0.004	-0.002
INFL	-0.001	-0.001	-0.002	-0.001	-0.003	-0.004	-0.002
SRSP	0.002	0.001	0.002	0.002	0.005	0.006	0.003
FLEX	-0.001	-0.001	-0.002	-0.001	-0.003	-0.004	-0.002
INFX	0.003	0.002	0.004	0.004	0.008	0.011	0.005
BRND	0.059	0.040	0.082	0.073	0.174	0.217	0.106

5.4.3 Second Order Measurement Model

In order to capture the essence of institutional establishments that govern the alliance between open source projects and commercial organizations, the study identified four major constructs; namely information exchange (INFX), flexibility (FLEX), shared responsibility (SRSP), and influence restraint (INFL). These latent factors are reflective of a higher order governance construct. Despite the fact that the second order governance (GVRN) factor does not have its own observed variables, it is related indirectly to the actual measures of lower order factors. The study hypothesizes that covariation between the four first-order constructs would be explained by their regression on the second-order construct (Byrne, 2001). Also, the model assumes that there are no correlations between errors and residuals of each item (*i.e.* e_i, res_i).

Figure 5.2 depicts a diagrammatic representation of the second order confirmatory factor analysis model.

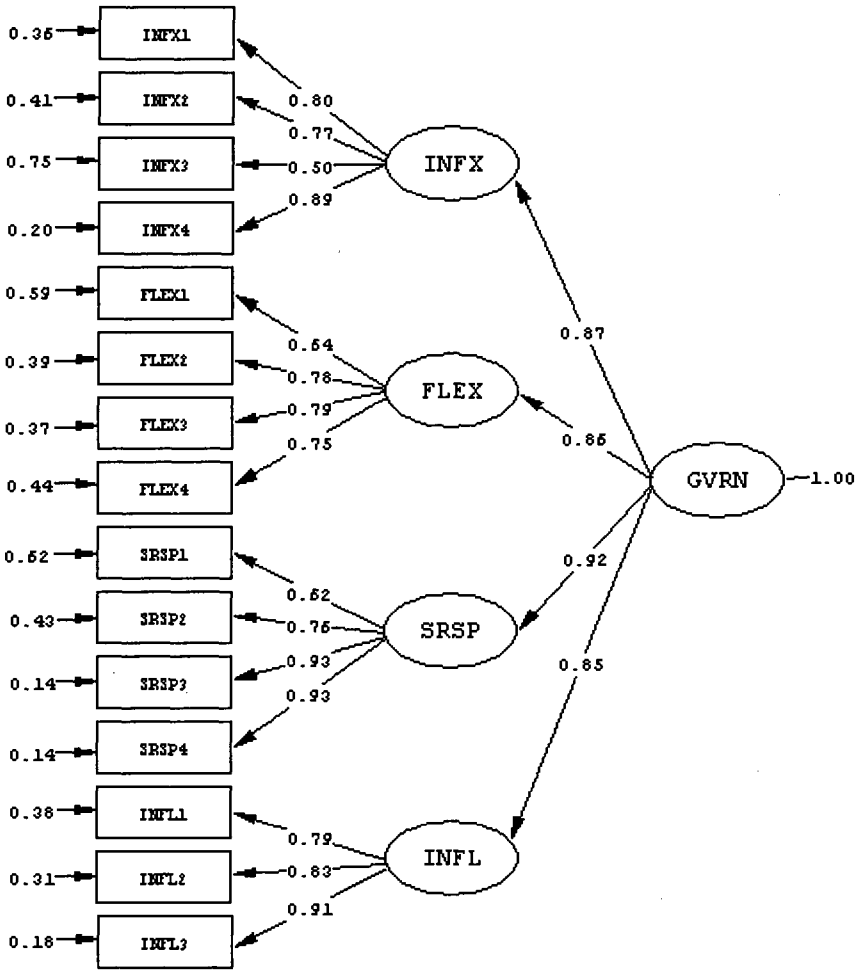


Figure 5.2 Governance Model Second-Order Confirmatory Factor Analysis

The second-order CFA chi-square (χ^2_{86}) value is 189.04. The model is over-identified with 86 degrees of freedom. Although this value was significant (p = 0.00), an indication that the model might not fit the data well, earlier studies found that this measure might be unsuitable for assessing the overall model fit (Fornell & Larcker, 1981).

The comparative fit index (CFI) is 0.94. The normed fit index (NFI) is 0.91; goodness of fit index (GFI) is 0.80, and the root mean square residual (RMR) is 0.20. The complete listing of measurement model fit indices is displayed in table 5.6. The standardized regression weights and squared multiple correlations (R^2s) for the second-order CFA are displayed in tables 5.4 and 5.5 respectively. The complete measurement model is presented in figure 5.3.

Table 5.4 Governance Model Second-Order CFA Standardized Regression Weights

			Estimate
INFX	<---	GVRN	0.87
FLEX	<---	GVRN	0.86
INFL	<---	GVRN	0.92
SRSP	<---	GVRN	0.85
INFX1	<---	INFX	0.80
INFX2	<---	INFX	0.77
INFX3	<---	INFX	0.50
INFX4	<---	INFX	0.89
FLEX1	<---	FLEX	0.64
FLEX2	<---	FLEX	0.78
FLEX3	<---	FLEX	0.79
FLEX4	<---	FLEX	0.75
SRSP1	<---	SRSP	0.62
SRSP2	<---	SRSP	0.76
SRSP3	<---	SRSP	0.93
SRSP4	<---	SRSP	0.93
INFL1	<---	INFL	0.79
INFL2	<---	INFL	0.83
INFL3	<---	INFL	0.91

Table 5.5 Governance Model Second-Order CFA Squared Multiple Correlations

	R^2
INFX	0.76
FLEX	0.74
SRSP	0.85
INFL	0.72
INFX1	0.64
INFX2	0.59
INFX3	0.25
INFX4	0.80
FLEX1	0.41
FLEX2	0.61
FLEX3	0.63
FLEX4	0.56
SRSP1	0.38
SRSP2	0.57
SRSP3	0.86
SRSP4	0.86
INFL1	0.62
INFL2	0.69
INFL3	0.82

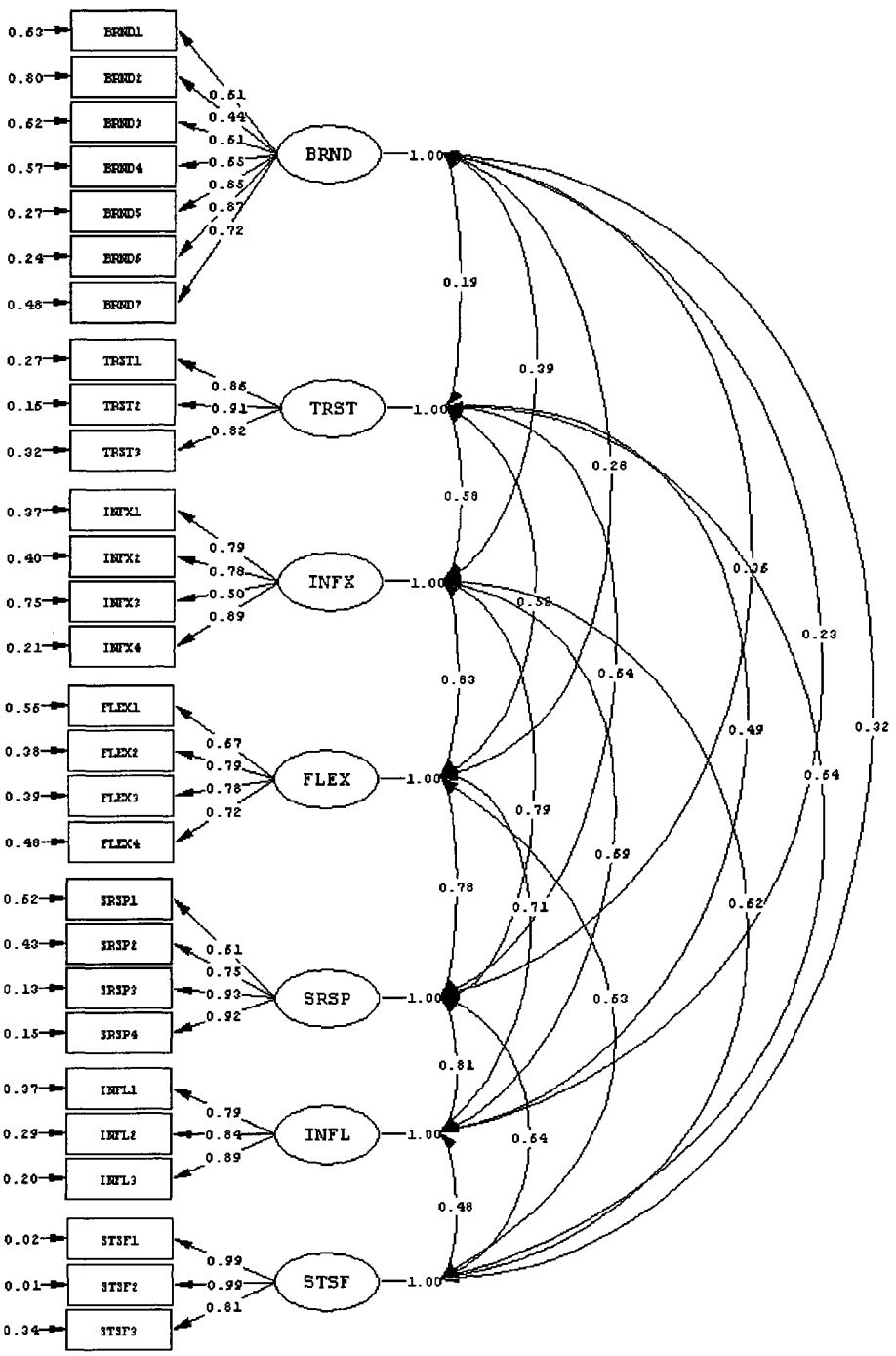


Figure 5.3 Hybrid OSS Governance Measurement Model

Table 5.6 Hybrid OSS Governance Measurement Model Goodness of Fit Indices

Index	Value
Degrees of Freedom	329
Minimum Fit Function Chi-Square	717.8 (P = 0.0)
Normal Theory Weighted Least Squares Chi-Square	630.5 (P = 0.0)
Estimated Non-centrality Parameter (NCP)	301.5
90 Percent Confidence Interval for NCP	(234.3 ; 376.4)
Minimum Fit Function Value	7.2
Population Discrepancy Function Value (F0)	3.0
90 Percent Confidence Interval for F0	(2.34 ; 3.76)
Root Mean Square Error of Approximation (RMSEA)	0.09
90 Percent Confidence Interval for RMSEA	(0.08 ; 0.11)
P-Value for Test of Close Fit (RMSEA < 0.05)	0.0
Expected Cross-Validation Index (ECVI)	7.8
90 Percent Confidence Interval for ECVI	(7.2 ; 8.6)
ECVI for Saturated Model	8.1
ECVI for Independence Model	63.9
X^2 for Independence Model with df = 300	6332.1
Independence AIC	6332.1
Model AIC	784.5
Saturated AIC	812.0
Independence CAIC	6489.3
Model CAIC	1062.8
Saturated CAIC	2279.7
Normed Fit Index (NFI)	0.9
Non-Normed Fit Index (NNFI)	0.9
Parsimony Normed Fit Index (PNFI)	0.8
Comparative Fit Index (CFI)	0.9
Incremental Fit Index (IFI)	0.9
Relative Fit Index (RFI)	0.9

Table 5.6 (Con't.)

Index	Value
Critical N (CN)	55.6
Root Mean Square Residual (RMR)	0.2
Standardized RMR	0.1
Goodness of Fit Index (GFI)	0.7
Adjusted Goodness of Fit Index (AGFI)	0.6
Parsimony Goodness of Fit Index (PGFI)	0.6

5.5 Hypotheses Testing

5.5.1 Structural Model

The full structural equation model incorporates both the measurement elements of the first and second order CFA and the theorized path relationships between latent variables. To insure the model identification with 28 observed variables, the number of distinct instances needed to drive the parameters of the model was computed as (28*29)/2, or 406 distinct sample moments. With 63 variables free to be estimated, the model is overidentified with 343 degrees of freedom (406-63).

The hypotheses were tested using SEM to estimate both measurement and structural considerations. The governance structural model illustrated in Figure 5.4 reflects latent variables path analysis along with underlying measurements.

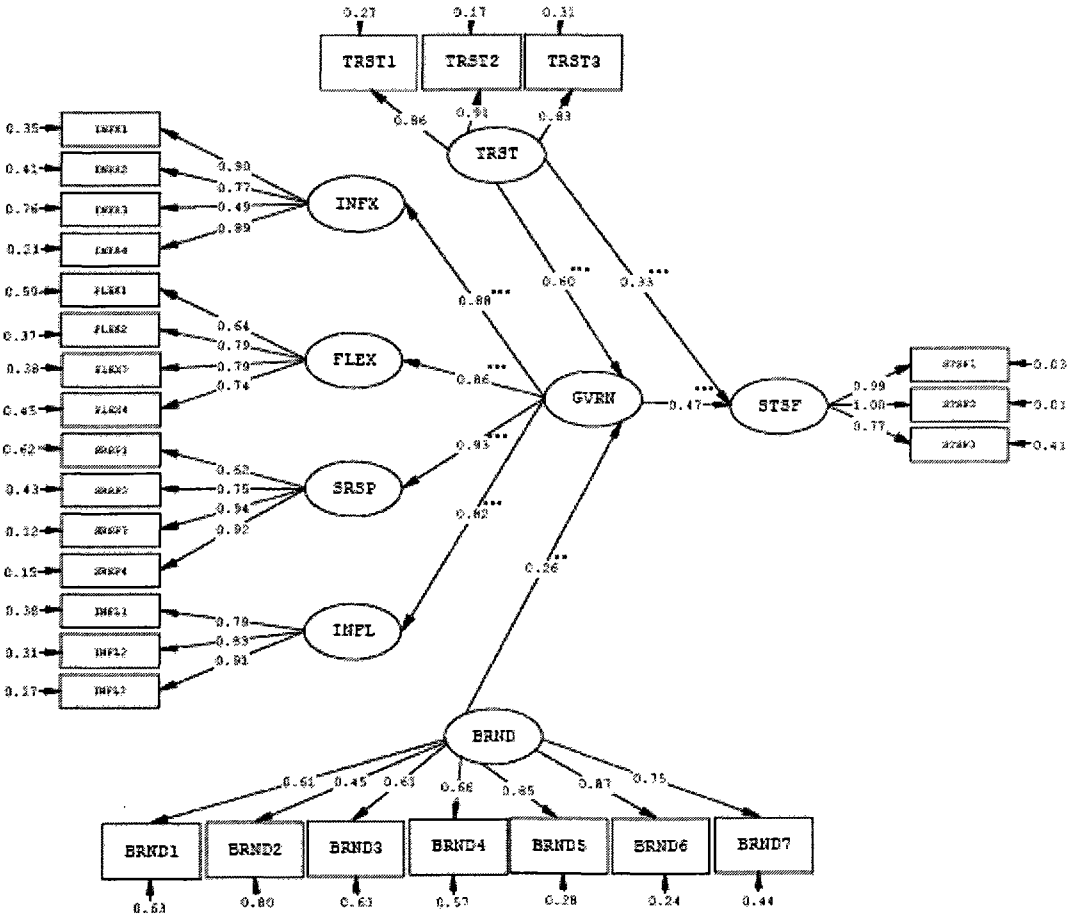


Figure 5.4 Hybrid OSS Governance Structural Model

Largely, the hypothesized model was able to explain 54% of the variance related to the satisfaction of this arrangement between open source project and commercial partners. The overall model fit is indicated by several indices. The comparative fit index (CFI) is 0.9, incremental fit index (IFI) is 0.9, the goodness of fit index is 0.7, and the root mean square residual (RMR) is 0.2. The complete listing of the structural model goodness of fit indices is presented in table 5.7.

Table 5.7 Hybrid Governance Structural Model Goodness of Fit Indices

Index	Value
Degrees of Freedom	343
Minimum Fit Function Chi-Square	740.2 (P = 0.0)
Normal Theory Weighted Least Squares Chi-Square	646.0 (P = 0.00)
Estimated Non-centrality Parameter (NCP)	303.0
90 Percent Confidence Interval for NCP	(235.2 ; 378.6)
Minimum Fit Function Value	7.4
Population Discrepancy Function Value (F0)	3.0
90 Percent Confidence Interval for F0	(2.4 ; 3.8)
Root Mean Square Error of Approximation (RMSEA)	0.09
90 Percent Confidence Interval for RMSEA	(0.08 ; 0.11)
P-Value for Test of Close Fit (RMSEA < 0.05)	0.0
Expected Cross-Validation Index (ECVI)	7.7
90 Percent Confidence Interval for ECVI	(7.0 ; 8.5)
ECVI for Saturated Model	8.1
ECVI for Independence Model	63.9
Chi-Square for Independence Model with df= 300	6332.1
Independence AIC	6388.1
Model AIC	772.0
Saturated AIC	812.0
Independence CAIC	6489.1
Model CAIC	999.8
Saturated CAIC	2279.7
Normed Fit Index (NFI)	0.9
Non-Normed Fit Index (NNFI)	0.9
Parsimony Normed Fit Index (PNFI)	0.8

Table 5.7 (Con't.)

Index	Value
Comparative Fit Index (CFI)	0.9
Incremental Fit Index (IFI)	0.9
Relative Fit Index (RFI)	0.9
Critical N (CN)	56.0
Root Mean Square Residual (RMR)	0.2
Standardized RMR	0.1
Goodness of Fit Index (GFI)	0.7
Adjusted Goodness of Fit Index (AGFI)	0.6
Parsimony Goodness of Fit Index (PGFI)	0.6

Table 5.8 lists regression weights for the estimates which are all significant. Squared multiple correlations (R^2) and standardized regression are presented in tables 5.9 and 5.10 respectively.

A summary of the hypotheses tests is presented by table 5.11, which shows that all hypotheses hold. It can be argued that departure from the classical form of open source development that completely relies on volunteers and unstructured institutional establishment is not ruled out by the open source community. In fact the data show that a majority of projects rated their association with commercial organizations and IT vendors as having favorable consequences.

Table 5.8 Governance Structural Model Regression Weights

			Estimate	S.E.	C.R.	P
GVRN	<---	BRND	0.26	0.10	2.65	0.01
GVRN	<---	TRST	0.55	0.10	5.47	***
INFX	<---	GVRN	1.00			
FLEX	<---	GVRN	0.74	0.13	5.58	***
SRSP	<---	GVRN	0.92	0.16	5.76	***
INFL	<---	GVRN	1.01	0.16	6.48	***
STSF	<---	GVRN	0.61	0.15	4.12	***
STSF	<---	TRST	0.39	0.13	3.15	***
INFX1	<---	INFX	1.00			
INFX2	<---	INFX	0.99	0.12	8.35	***
INFX3	<---	INFX	0.75	0.15	4.93	***
INFX4	<---	INFX	1.06	0.11	10.01	***
FLEX1	<---	FLEX	1.00			
FLEX2	<---	FLEX	1.31	0.20	6.40	***
FLEX3	<---	FLEX	1.37	0.21	6.38	***
FLEX4	<---	FLEX	1.23	0.20	6.09	***
SRSP1	<---	SRSP	1.00			
SRSP2	<---	SRSP	1.18	0.19	6.25	***
SRSP3	<---	SRSP	1.33	0.18	7.24	***
SRSP4	<---	SRSP	1.33	0.19	7.16	***
INFL1	<---	INFL	1.00			
INFL2	<---	INFL	0.90	0.10	8.95	***
INFL3	<---	INFL	1.07	0.11	9.86	***
STSF1	<---	STSF	1.00			
STSF2	<---	STSF	1.02	0.02	44.20	***
STSF3	<---	STSF	0.87	0.07	11.64	***

Table 5.8 (Con't.)

			Estimate	S.E.	C.R.	P
BRND1	<---	BRND	1.00			
BRND2	<---	BRND	0.63	0.16	3.95	***
BRND3	<---	BRND	0.74	0.14	5.13	***
BRND4	<---	BRND	1.05	0.19	5.40	***
BRND5	<---	BRND	1.58	0.24	6.46	***
BRND6	<---	BRND	1.48	0.23	6.56	***
BRND7	<---	BRND	1.07	0.18	5.98	***
TRST1	<---	TRST	1.00			
TRST2	<---	TRST	1.19	0.10	11.62	***
TRST3	<---	TRST	1.10	0.11	10.21	***

Table 5.9 Governance Structural Model Squared Multiple Correlations

	R^2
INFX	0.77
FLEX	0.74
SRSP	0.87
INFL	0.67
GVRN	0.49
STSF	0.54
INFX1	0.65
INFX2	0.59
INFX3	0.24
INFX4	0.74
FLEX1	0.41
FLEX2	0.63
FLEX3	0.62
FLEX4	0.55
SRSP1	0.38
SRSP2	0.57
SRSP3	0.88
SRSP4	0.85
INFL1	0.62
INFL2	0.69
INFL3	0.83
STSF1	0.97
STSF2	0.99
STSF3	0.59

Table 5.9 (Con't.)

	R^2
BRND1	0.37
BRND2	0.20
BRND3	0.37
BRND4	0.43
BRND5	0.72
BRND6	0.76
BRND7	0.56
TRST1	0.73
TRST2	0.83
TRST3	0.69

Table 5.10 Governance Structural Model Standardized Regression

			Estimate
GVRN	<---	BRND	0.26
GVRN	<---	TRST	0.60
STSF	<---	TRST	0.33
INFX	<---	GVRN	0.88
FLEX	<---	GVRN	0.86
SRSP	<---	GVRN	0.93
INFL	<---	GVRN	0.82
STSF	<---	GVRN	0.47
INFX1	<---	INFX	0.80
INFX2	<---	INFX	0.77
INFX3	<---	INFX	0.49
INFX4	<---	INFX	0.89
FLEX1	<---	FLEX	0.64
FLEX2	<---	FLEX	0.79
FLEX3	<---	FLEX	0.79
FLEX4	<---	FLEX	0.74
SRSP1	<---	SRSP	0.62
SRSP2	<---	SRSP	0.75
SRSP3	<---	SRSP	0.94
SRSP4	<---	SRSP	0.92
INFL1	<---	INFL	0.79
INFL2	<---	INFL	0.83
INFL3	<---	INFL	0.91
STSF1	<---	STSF	0.99
STSF2	<---	STSF	1.00
STSF3	<---	STSF	0.77

Table 5.10 (Con't.)

			Estimate
BRND1	<---	BRND	0.61
BRND2	<---	BRND	0.45
BRND3	<---	BRND	0.61
BRND4	<---	BRND	0.66
BRND5	<---	BRND	0.85
BRND6	<---	BRND	0.87
BRND7	<---	BRND	0.75
TRST1	<---	TRST	0.86
TRST2	<---	TRST	0.91
TRST3	<---	TRST	0.83

5.6 Discussion

The goal of this study is to uncover the emerging relationship between open source software projects and commercial and for-profit organizations and establishment of institutional structure to manage this new style of open source software development. Despite the fact that, in general, open source is not revenue driven, this study analyzes OSS arrangement as a rational organizational form, in quest of production and managerial efficiency.

The study developed and tested hypotheses in connection with underlying governance structures that substantiate meritorious hybrid governance. Findings indicate that satisfaction with alliance imply that the project has achieved efficiency as a result of alliance with its commercial partner. The results support the notion that streamline of information exchange between the parties, development of flexible cooperative alliance, control of power and influence of one party on the less dominant one, and promotion of shared and common responsibility would result in meritorious hybrid governance.

Acknowledging structural differences and absence of formal arrangement and contract agreement between open source project and commercial partner, these principal constructs become important for organizing successful alliances.

In addition the study highlights the provision of branding and how development of brand identity favorably contributes to the successful result of hybrid governance of open source development efforts. The study found that branding has positive indirect effect on satisfaction. Results show that the standardized indirect effect of branding on satisfaction with the alliance between open source project and commercial partners is 12%. This is mainly an indication of branding efforts involving various aspects of the governance dimensions mentioned. Our finding supports the theoretical assumption that branding

contributes to creating quasi-rents, which are only realizable if the relationship succeeds. Open source project and commercial partner joint investment in resources that provide higher value for the alliance yield systematic and direct information flow across transaction entities. Furthermore, coordination and accommodation for both parties' activities and roles during branding establishment strengthen the underlying constituents of governance (i.e. information exchange, flexibility, shared responsibility, and influence restraint). As a consequence, perception of higher value for the long-term relationship reinforces the governance structure and yields meritorious results.

The importance of trust factor also proved to play a significant role in the alliance between open source and commercial partner. An open source study argued that independence of trust and control notion allows OSS projects to rely more on explicit control mechanisms than on trust to achieve efficiency and meritorious results (Gallivan, 2001). Yet the study acknowledged the fact that trust might be an implicit assumption or play tacit role in project activities. Our findings confirm previous studies within OSS domain that acknowledged developing a sense of trust with the partner organization can improve alliance effectiveness (Hahn, Moon, & Zhang, 2008). Recognizing influence restraint as one of the positive dimensions of governance, parties tend to exercise moderate control on each other. This finding supports prior findings that OSS projects use trust as a final resort when limited control measures exists or excessive control could jeopardize the relationship between parties of the alliance (Gallivan, 2001). This study revealed that trust enhances hybrid governance, as well as, improves overall satisfaction with the outcome of relationship. Trust also serves as a remedy for alliance governed without written contracts or formal safeguard mechanisms. It has positive impact on managing partnership conflicts, and ultimately overall performance.

5.7 Conclusion

Although TCE has been widely adopted across various disciplines, there have been limited efforts to employ the theory within the open source domain. This study contributes to the open source literature by affirming its role as a special form of organizing. Aligned with latest novel approaches described in the empirical literature (Richman & Macher, 2006), our methodological approach estimates the effect of hybrid structure on outcome of OSS-commercial partnership.

In addition, the study answer calls for more assessment and extension of the theory (Williamson, 1979; Richman & Macher, 2006), by testing the framework and examining core principles of TCE and interorganizational cooperation within the open source context. On the contrary of the majority of transaction cost economics research focused on industrial organization, the study maintain that the theory could be applied to other special forms of organizing that deals with developing optimal institutional alignment in a non market-based framework.

5.8 Implications

As more OSS projects are inclined to join efforts with IT vendors, this study attempted to reveal implications of governance mode of the alliance using transaction cost economics and interorganizational cooperation. While open source communities continue deliberation trying to realize potentials of emerging forms of organizing and viability of hybrid system development, the results indicate that there are preconditions for successful and meritorious partnership with market-driven organizations. There might be mixed results at some point of time during the course of building the relationship, but in general the outcome is largely dependent on readiness of partners to embrace their differences and define a cohesive structure for managing a mixed mode development transaction. This

research identified a cohesive governance structure based on different levels of maturity for each construct. While some OSS projects partnership with commercial organizations experienced meritorious results as a result of their highly-ranked governance attributes, others lacking across one or more of governance structure components are experiencing less favorable outcome. The study show that shared responsibility (SRSP) between partners is the most important governance relationship. As a first order construct, SRSP is able to explain 87% of variance in governance, with an estimate of 0.93. Such inference signals the value of sustaining collaborative nature of open source software development, where developers volunteer to solve problems rather than holding others accountable, beyond the classical model.

The study also helps open source communities assess readiness and impact of extending relationships, beyond pure open source boundaries, with IT vendors and commercial organizations. It allows for systematic assessment of time, effort, and resources committed by each party to ensure successful outcome of cooperation. Since both open source projects and commercial vendors are exploring alternative options that lower transaction costs, the study helps define the most advantageous form of governance and collaboration mechanisms to facilitate achievement of this goal. In general, the findings indicate that meritorious outcome of the partnership between the open source project and commercial partner serves as an endorsement of hybrid mode of development and encourage other projects to reach out for collaboration with commercial partners. The question remains: what are the prospects of the pure open source model?

Table 5.11 Results Summary of Governance Model Hypotheses Testing

Hypotheses	Finding
H1: A meritorious hybrid governance structure would have an institutionalized streamline of information exchange between open source project and commercial partner.	Supported***
H2: A meritorious hybrid governance structure would have a flexible and social cooperative relationship between open source project and commercial partner.	Supported***
H3: A meritorious hybrid governance structure would have a joint and shared responsibility governance pattern between open source project and commercial partner.	Supported***
H4: A meritorious hybrid governance structure would have a mechanism that mandates restraint of power and influence of one party on the less dominant between an open source project and commercial partner.	Supported***
H5: A meritorious hybrid governance structure for open source project and commercial partner will have positive impact on satisfaction with the partnership.	Supported***
H6: Investment in brand capital will have a positive influence on the governance structure of open source project and commercial partner.	Supported**
H7: Trust between open source project members and commercial partner will have positive influence on the hybrid governance structure.	Supported***
H8: Trust between open source project members and commercial partner will have positive influence on satisfaction with the partnership.	Supported***

* $p < 0.05$, ** $p \leq 0.01$, *** $p < 0.001$

6. Hybrid Open Source Software Projects Case Study

Guided by the analytical results of the efficiency and governance models presented in chapters four and five respectively, this chapter explores several hybrid open source projects. Examination of the choice of governance structure in several OSS projects and the mechanisms used to steer the collaborative alliance between the open source project and commercial partners is conducted across five projects.

The next subsections present projects case studies and connotations for introduced models constructs. Projects are described by the following constructs: information exchange, flexibility, shared responsibility, influence restraint, branding, trust, asset specificity, uncertainty, opportunism, product distinctiveness, and overall satisfaction. A project-construct mapping is constructed for comparing hybrid structures across various projects. Analysis is based on publicly available sources of information.

6.1 Xen Hypervisor, Open Source Virtualization Platform

Xen hypervisor is a virtualization platform used on x86, x86_64, IA64, PowerPC, and other CPU architectures that enables hosting various guest operating systems such as BSD (e.g. FreeBSD, OpenBSD, NetBSD), Linux, Solaris, and Windows. The project was an academic research initiative started at Cambridge University, UK. As infrastructure software geared towards administrators and system engineers, the project relative complexity requires core developers who retain sustainable contribution level.

The project mission stated by the community is defined as:

- Building industry standard open source hypervisor that becomes the core "engine" in multiple vendors' product offerings.
- Maintain Xen industry leading performance by becoming the first to exploit new hardware virtualization features
- Help operating system vendors paravirtualize their OSes
- Support Xen reputation for stability and quality (Branding)
- Support multiple CPU types for large and small systems
- Foster innovation
- Drive interoperability (Xen.org, 2009)

The Xen software is an example of successful hybrid OSS developed jointly by Xen project members and more than twenty commercial partners. Some of the prominent IT vendors supporters include AMD, Citrix, Cisco, Dell, HP, IBM, Intel, Mellanox, Network Appliance, Novell, RedHat, SGI, Sun Microsystems, Unisys, Veritas, and Voltaire. To the contrary of typical OSS projects, the majority of contributions to the project come from commercial partners. This is roughly accounts for ninety five percent of the Xen total lines of code. One of the reasons for the significant commercial partners' contribution is the special nature of the project and limited community's expertise of vendors' platforms.

Xen established an advisory board to guide the vision and direction of the project. The board includes leaders from the community and members of top five commercial partners contributing to and sponsoring the project. The current commercial partners on the project's board are Citrix, HP, IBM, Intel, Novell, Oracle, RedHat, and Sun Microsystems.

To accommodate multiple vendors' involvement, the project adheres to a full transparent information access and flow. The project established multiple channels to exchange information about roadmap, feature requests, identify and comment on modules/new features proposed by various contributors, and manage defects tracking and resolution. Some of these channels include mailing list, wiki, blog, ICR chat channel, and Bugzilla defects tracking system. In addition, the project developed a solution search tool that server as a knowledgebase for know-how and solution templates. To enhance communication and information sharing Xen mailing lists search aggregation (MarkMail) tool was setup to summarize and organize all messages exchanged.

A recent Xen.org community-based survey revealed that more than 90% of Xen community relies on mailing list as the primary source of information about proposed features and architectural/design discussions. 84.7% indicated they use the project Wiki, 62.5% use the blog, and more than 22% use the IRC channel (Spector, 2009). It is essential to point out that these categories are not mutually exclusive and contributors tend to use more than one medium. The percentages show that the mailing list, wiki, and blog are highly used and represent primary choices to locate information.
A typical roadmap proposal and feature requests is usually listed on the community wiki.

The Xen project structure and level of participation by commercial vendors present adaptable environment that accommodates different needs. When a contributor puts out an architectural design or feature implementation plan, it's expected that the partner will be open to accept feedback and accommodate other parties' needs. This level of flexibility insures that there will be less confrontation and friction between the community and commercial partners. Volunteer contributors welcome vendors' comments and suggestions

to improve code standards to enterprise level. On the other hand, the commercial partners are receptive to community requests and demands.

All parties are working together to insure the success of the project. One example is Intel's support to accommodate development of new features on latest platforms. Insuring that code developed by various contributors is a shared responsibility. The commercial partner works closely with the community and other vendor partners to make it work and ready for merge into the next release.

In terms of product branding efforts, the project collective efforts by the community and commercial vendors created a strong brand and established good reputation as a leading virtualization solution. The commercial partners' dedication to insure continuous successful relation is driven by the prospect of added value gained from engaging with the community and other vendors in developing the project and boosting its status.

The project faces low technological and behavioral uncertainties and is relatively immune to environmental uncertainty risks. Having several commercial partners contributing full time labor force and being at front in technology development, Xen is capitalizing on these assets to mitigate uncertainty. Competition from commercial rival products has narrow effect on the project, because of established recognition as a low cost reliable virtualization technology.

Considerable level of work and development of the project is contributed by the commercial vendor partners, therefore there are no signs of negative sentiment from the community that commercial companies are trying to take advantage on their behalf or get a free ride. Hitherto, Xen is mainly enterprise software, where it's expected to be used in organization setting and getting the project backed by IT vendors serve as an advantage.

The project support of assorted vendors' platforms creates uniqueness in terms of substantial relative advantages compared to other competing products. The involvement of Intel, HP, and AMD for example position Xen ahead of OSS Linux-KVM competing virtualization solution.

The dimensions of governance that include information exchange, flexibility, influence restraint, and shared responsibility are aligned with analytical findings. The stream line of information exchange is a key aspect of the hybrid project. Several communication channels and protocols have been established to simplify communication between the project community and commercial partners. All design and implementation discussions take place in the public mailing list, wiki, blog, IRC channel and solution search knowledgebase. Also, commercial partners involved in the project make every effort to accommodate community requests. Similarly community members welcome comments and feedback from partners to insure that developed code and features meet enterprise standards and in synch with other features developed by the other parties.
In general, the commercial partners adopt a crossbreed solution model and do not attempt to enforce their view on the project. All resources, information and resolutions are shared among community and commercial partners. Occasionally, few members might seem to be contributing more efforts to resolve an issue or own major feature design and implementation. Yet all other members are still responsible for maintaining and enhancing those modules.

The Xen trade mark is acquired by Citrix, which is owned by Microsoft. The joint efforts by the community and recognized commercial vendors strengthen the reputation of Xen as a

viable OSS solution. The parties view their collective efforts as the driver for creating the superior brand, rather than being owned by a single vendor or sole community.

6.2 Pentaho Open Source Business Intelligence Suite

Pnetaho was founded in 2004 as a commercial open source software business model. The primary objective was to build a full OSS business intelligence (BI) suite. Pentaho BI suite includes: Mondiran OLAP analysis services, reporting (originally JFree Report project), data integration (Kettle project), and data mining (Weka project). Some of these components started as individual OSS projects that eventually got folded under Pentaho's platform.

Relative to typical pure open source projects, where majority of code is contributed by volunteers, the company is the main source code contributor (Dixon, 2007). Early in project lifecycle, the company built a working prototype 'seed', and sought to attract community members to contribute to the project.

The relationship between the company and the community is structured to leverage community resources to provide quick feedback, testing, documentation, etc. The community contribution improves code stability, usability, performance, security and fitness for use by a wide user base. The parties recognize the value of the hybrid model through improved software and increased user base, due to combined efforts of the company and the community.

The core developers and administrators, who are mainly part of the company, contribute greater part of source code. Yet features developed by the community, who are mainly consultants and integrators building suites for their clients, are accepted and maintained by the company. The relationship arrangement between the company and the community is summarized in figure 6. 2.

To avoid potential copyrights conflicts, contributors are required to sign contributor assignment agreement. The agreement transfers original contributor's rights to the company. The contribution is subject to review process before being accepted to the main line of code. Such practice ensures that only high quality code is accepted. A copy of the contributor assignment agreement is presented in appendix D.

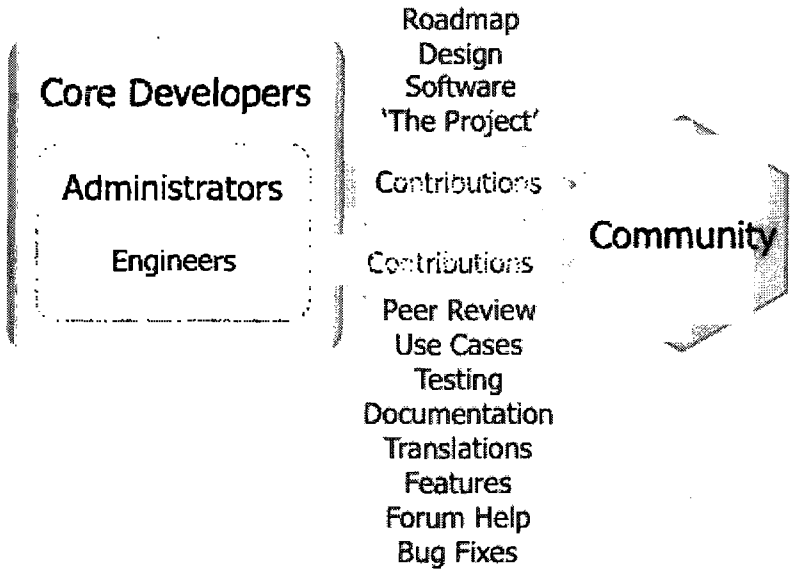


Figure 6.1 Relationship Arrangement Between Pentaho Company and the Community

The company aquired Mondrian OLAP server OSS project started about three to four years before Pentaho. The company exercised vigilance to maintain the project community and not causing major disrubtion to the process.

Pentaho realized efficiencies and achieved governance structure for managing the relationship with the community. As a consequence, the product became stable very vast. Furthermore, to avoid uncertainty related to steady contribution and volunteers churn, the company is taking over most of code development activity.
The model works well for all selfish motivated contributors, who seek to gain personal benefits from using the product and the company who receive community support. Both parties try to maintain a fragile relationship by not exploiting self-interests that could harm the other party. The product is providing added value and fills a gap of BI software that is out of reach for many professional and small/medium size organizations. The synergy between the company and the community prove that there are no signs of unsatisfactory relationship between the two.

The project maintains a very rapid information flow between the company and the community using institutionalizing tools (forums, IRC channel, blogs, and wikis). Although original contributors are responsible for the support of contributed features, the company is usually willing to provide support and maintenance for community contributed features if the original contributor is not willing to provide continuous support, or decided to move on and not contribute to the project. This reflects flexible nature of the relationship between the parties, which empowers self-organizing teams to assume various roles in the project. The governance model sustains regular adaptation to changing circumstances and

dynamism of community structure. Largely, the company does not attempt to influence the community or impose particular management structure.

Typically, when there are issues related to the project reported on the forums more experienced community members not the core developers on the company often respond to the issue and answer the posts. The company's promotion of integrated BI platform, coupled with sustained development and support created a recognized brand for the company and individual OSS projects part of the suite. Both parties agree that project is developed by motivated individuals, whom should be trusted

6.3 MySQL Open Source Relational Database Management System

MySQL is a leading open source relational database management system (RDBMS), which is part of the LAMP (Linux, Apache, MySQL, PHP/Perl/Python) OSS software stack. The product is one of the widely adopted software, with more than 100 million copies downloaded or distributed since the beginning of the project. Some of the factors that enable diffusion and establishment of large user-base include: performance, reliability, simplified installation and setup, and ease of use. The project characteristics eliminate some of the challenges related to administration, maintenance, and downtime. Overall technological uncertainty is expected to have very limited impact on the project. The database is targeted as a cross platform product, which insure interoperability and interface with various vendors' products.

The promoted branding efforts by the company and community is based on extensive code review, strong community contribution, and feedback led to the development of several unique features even ahead of competing proprietary vendors. Community members

presume that being part of a successful project is a sense of compensation and recognition that leads the community member to exhibit satisfaction with the relationship with the company. There are no symptoms or signs of complaints from the community about the company making profit from their efforts, or taking to exercise heavy influence on the community.

The governance mechanisms are institutionalized to drive efficient relationship and successful product. Collaboration tools are used effectively in the absence of face-to-face communication. The communication channels are primary source for gauging the level of discussion and engagement of the community.

The architectural work and design decisions retain elasticity and provide capacity for ate changes in requirements. Community concerns are taking into consideration when strong community voices are raised, or justifiable argument is presented. Mutually, contributors are self-managing and self-led. The company does not try to appoint their paid core developers as leading authority. Alternatively, community building and engagement process is cultured. MySQL company does not simply accept contributions from volunteers, but rather make them part of the community and allow them to assume responsibility and proud of the success of the product. The collaboration and community network created a snowball effect for promoting MySQL brand and lowered the risk of adoption for new users.

6.4 xTuple Open Source ERP Software

xTuple is a hybrid open source software business model. The business model leverages the power of open source by building on top of other open source projects and also sharing the source code with the community of partners and customers. xTuple software leverages

other open source building blocks that include Linux operating system, PostgreSQL database, and the Qt framework for delivering a complete OSS scalable solution. The company is mainly providing a solution for small manufacturers, which is based on open standards that ensures flexibility and enhanced productivity.

The company started by developing a solution and carefully put out software that attracted community. Any member of the community is welcome to contribute new features, bug fixes, or suggest alternative development direction. The feature discussion and layout of what each party is working on take place in the forums. Therefore upfront communication is strongly encouraged and expected from both the community and the company.

Regarding project direction and development, xTuple maintains control on commercial edition, while the open source edition is managed jointly by both parties. The company is continuously soliciting the community for feedback regarding feature roadmap and key architectural decisions.

As a way of stream line and organize the process, community members proposing a large functional changes or features that could have major impact on the product are encouraged to submit a specification document, which allow more systematic review and discussion on the public forums.

6.5 OpenOffice Productivity Suite

OpenOffice is a leading open source office software suite that includes word processing, spreadsheets, presentations, graphics, and databases. The product is largely developed, supported, and promoted by a global community of individual contributors and organizations. The community is very involved in the development, documentation, translation, bug reporting, and support.

OpenOffice has been mainly supported by Sun Microsystems in addition to community members' efforts. The company maintains a flexible structure for managing the project and accommodates various demands from wide stakeholders.

The open development process and feature suggestion, submission, and evaluation cycle is managed through intense discussion and flexible mindset. The peer-review process of code quality and novelty insures incorporation of innovative features that improves usage and adoption.

6.6 Manifestation of Governance in Hybrid OSS Projects

Demonstration of various structures of governance is exhibited in the case studies. This section provides comparative examination of the five case studies adopted to understand hybrid OSS projects governance mechanism. Augmenting empirical analysis findings presented in chapter four and five, this illustrates

The mappings between functional aspects and factors of the efficiency and governance models are presented in tables 6.1 and 6.2 respectively.

Table 6.1 Efficiency Model Factors Functional Aspects

Factor / Project	Asset Specificity	Uncertainty	Opportunism	Product Distinctiveness	Satisfaction
Xen	None	Minor or moderate risk reduction	No signs of negative opportunistic behaviors	Interoperability with proprietary products	No public display of dissatisfaction
Pentaho	None	Low uncertainty	No identified complaints of opportunistic behaviors	Niche market	No signs of unsatisfactory relationship
MySQL	None	Low	No signals or expressed concerns of one party pursuing harmful self-interest actions.	Innovation features	No public display of dissatisfaction
xTuple	None	Moderate	No identified opportunistic behaviors or activities	Fills a gap in needed open source ERP software for small and medium size	No public display of dissatisfaction

Table 6.1 (Con't.)

Factor / Project	Asset Specificity	Uncertainty	Opportunism	Product Distinctiveness	Satisfaction
OpenOffice	None	low	No signs of negative opportunistic behaviors	localized open source integrated productivity suite	No public display of dissatisfaction

Table 6.2 Governance Model Factors Functional Aspects

Factor / Project	Information Exchange	Flexibility	Influence Restraint	Shared Responsibility	Branding	Trust
Xen	Forums for day-to-day operations, face-to-face annual conference for problem solving and strategic decision making.	Responsive. Accommodate each other	Consensus building	Separation of work. Compartmentalization	Brand is product based	No signs of mistrust
Pentaho	Public computer based channels Annual face-to-face meetings	High flexible architecture.	Power distance	Shared problem solving	Umbrella for integrated Business Intelligence suite. Best of bread	No identified indicators of mistrust
MySQL	Highly involved communication channels.	Scalable system accommodates incremental work	Self managed, self organized community	Mutual efforts, shared problem solving	Highly successful community network effect	No identified indicators of mistrust

Table 6.2 (Con't.)

Factor / Project	Information Exchange	Flexibility	Influence Restraint	Shared Responsibility	Branding	Trust
xTuple	Excessive flow of information	High flexibility. Separation of business logic from modularized feature development	Company controls commercial edition and does not over influence OSS edition	Joint responsibility between the company and the community for the open source edition	Community engagement create a positive network effect for branding	No identified indicators of mistrust
OpenOffice	Multi-dimensional channels of communication	Flexible architecture to incorporate global develement	Retain independence	Shared responsibility, consulting arrangement	Snow-ball effect, increase value, lower risk	No identified indicators of mistrust

7. Conclusion

7.1 Research Contribution

The goal of this study is to uncover the emerging relationship between open source software projects and commercial and for-profit organizations and the establishment of institutional structures, which are flexible and efficient for managing the emerging hybrid model of open source software development. Despite the fact that, in general, open source software is not considered a revenue-driven activity, yet it can be argued that it is an alternative form of organizing. The open source software hybrid model and the joint parties' efforts create a positive network effect for sustained efficiency. This research analyzes OSS arrangement as a rational organizational form, in quest of production and managerial efficiency.

Adopting transaction cost economics and interorganizational cooperation for investigating efficient forms of organizing hybrid open source software, two analytical models were developed and tested as part of this research to examine factors influencing optimal governance and efficient relationship. The study presumes a novel position to help understand open source software phenomenon. It offers concrete contribution to the literature and paves the way for future OSS research beyond conventional approaches. Moreover, results of the study are of interest for practice, by offering insights on factors contributing to developing efficient alliance between open source community and commercial partners.

The hybrid open source software model is regarded as a mode of governance structure that differs from classical profit maximization organization model. Development in TCE suggests that hybrid models of structure are likely to exist, instead of pure forms that trade-off between vertical integration (pure OSS) and market organizing. The study argues that forming relationships between open source software projects and commercial partners will result in enhanced efficiencies and favorable outcomes for the open source movement. Essentially, the relationship is based on creating a distinctive product that provides unique benefits for both parties. The OSS project efficiency is realized through joint development of a product that present significant improvements and provides significant relative advantages compared to competing software.

Moreover, guided by the analytical findings of the two tested models, the study incorporate practical investigation of how several hybrid OSS projects achieve efficiencies and governance. To a large extent, the practical aspects of examined hybrid projects in chapter 6 support the analytical assessment findings. Also, it reveals the sensitive nature of the alliance between OSS project and commercial partners.

7.2 Implications of Research

7.2.1 Theoretical Implications

Although TCE and interorganizational cooperation have been widely adopted across various disciplines, there have been limited research endeavors to employ the theoretical frameworks for open source software domain. This study helps explain functional aspects of OSS, beyond motivational and behavioral dimensions. It contributes to the open source software literature by affirming its role as a special form of organizing.

Aligned with latest novel approaches described in the empirical literature (Richman & Macher, 2006), the research methodological approach estimates the effect of hybrid structure on the outcome of OSS project and commercial partner relationship.
In addition, the research fulfils calls for more assessment and extension of the theory, through testing the framework and examining core principles of TCE and interorganizational cooperation within the open source context (Williamson, 1979; Richman & Macher, 2006). In contrast to the majority of transaction cost economics research focused on industrial organization, this research demonstrates that the theory could be applied to other special forms of organizing that deals with developing efficient and optimal institutional alignment in a non market-based context.

7.2.2 Practical Implications

As more OSS projects are inclined to join efforts with IT vendors, this study attempted to reveal implications of governance mode of the alliance using transaction cost economics and interorganizational cooperation. While open source software communities continue deliberation trying to realize potentials of emerging forms of organizing and viability of hybrid system development, the results indicate that there are preconditions for successful and meritorious partnership with profit-driven and commercial organizations. There might be mixed results at some point of time during the course of building the relationship, but in general the outcome is largely dependent on readiness of partners to embrace their differences and define a cohesive structure for managing a mixed mode development transaction. This research identified a cohesive governance structure based on different levels of maturity for each construct. While some OSS projects partnership with commercial organizations experienced meritorious results as a result of their highly-ranked governance attributes, others lacking across one or more of governance structure

components are experiencing less favorable outcome. The study show that shared responsibility (SRSP) between partners is the most important governance relationship. As a first order construct, SRSP is able to explain 87% of variance in governance, with an estimate of 0.93. Such inference signals the value of sustaining collaborative nature of open source software development, where developers volunteer to solve problems rather than holding others accountable, beyond the classical model.

The study also helps open source software communities assess readiness and impact of extending relationships, beyond pure open source boundaries, with IT vendors and commercial partners. It allows for systematic assessment of time, effort, and resources committed by each party to ensure successful outcome of cooperation. Since both open source projects and commercial vendors are exploring alternative options that lower transaction costs, the study helps define the most advantageous form of governance and collaboration mechanisms to facilitate achievement of this goal. In general, the research findings indicate that meritorious outcome of the partnership between the open source software project and commercial partner serves as an endorsement of hybrid mode of development and encourage other projects to reach out for collaboration with commercial partners. The question remains: what are the prospects of the pure open source model?

7.3 Limitations

As a positivist empirical research, the study suffers from general limitations of survey research. The study results must be interpreted cautiously because of inherent limitations related to respondents' perception. Also, this study focused on projects listed on three major open source hosing sites (Sourceforge, Savannah, and Freshmeat). Although these are the most popular hosts for wide range of OSS projects, future research should consider

incorporating other sites as well. Such attainment is necessary for generalizing the results across different projects hosted on various sites.

7.4 Future Roadmap

As a future direction for research, this study should lead the way for investigating an elaborate model of the special form of interorganizational governance between open source software communities and revenue-oriented commercial partners. The research draws attention to potential relationships and antecedents not included in the analyzed models. Further studies need to examine the factors that influence the participation of commercial partners in open source software. This study found that commercial partners appear to participate at different levels and capacities in OSS project-related activities.

APPENDIX A. SURVEY INSTRUMENT AND MEASURED ITEMS.

Construct[10]	Items	Source
Information Exchange (INFX)	(Anchors: Completely inaccurate description/Completely accurate description). Please provide your assessments of the degree to which each party discloses information that may facilitate the other party's activities. 1. In this relationship, it is expected that any information that might help the other party will be provided to them. 2. Exchange of information in this relationship takes place frequently and informally and not only according to a prespecified agreement. 3. It is expected that the parties will provide proprietary information if it can help the other party. 4. It is expected that we keep each other informed about events or changes that may affect the other party.	Adopted from (Heide & Miner, 1992)

[10] All measures employ 7-point scale

APPENDIX A. (Con't.)

Construct	Items	Source
Flexibility (FLEX)	(Anchors: Completely inaccurate description/Completely accurate description). Please indicate your assessment of the project involved parties' flexibility 1. Flexibility in response to requests for changes is a characteristic of this relationship. 2. When some unexpected situation arises, the parties would rather work it out than holding each other responsible. 3. It is expected that the parties will be open to modifying their agreements if unexpected events occur. 4. A change in level of partnership is not ruled out by the parties, if it is considered necessary.	Adopted from (Heide & Miner, 1992)

APPENDIX A. (Con't.)

Construct	Items	Source
Shared Responsibility (SRSP)	(Anchors: Completely inaccurate description/Completely accurate description). Please indicate your assessment of the IT partner shared responsibility 1. In most aspects of this relationship the parties are jointly responsible for getting things done. 2. Problems that arise in the course of this relationship are treated by the parties as joint rather than individual responsibilities. 3. The parties in this relationship do not mind owing each other favors. 4. The responsibility for making sure that the relationship works for both us and this IT vendor is shared jointly.	Adopted from (Heide & Miner, 1992)
Influence Restraint (INFL)	(Anchors: Completely inaccurate description/Completely accurate description). Please indicate your assessment of the OSS project-IT partner influence restraint 1. The IT vender partner feels it is important not to use any proprietary information to the other party's disadvantage. 2. A characteristic of this relationship is that neither party is expected to make demands that might be damaging to the other. 3. The parties expect the more powerful party to restrain the use of their power in attempting to get their way.	Adopted from (Heide & Miner, 1992)

APPENDIX A. (Con't.)

Satisfaction (STSF)	(Anchors: Strongly disagree/Strongly agree). Please indicate your level of satisfaction with IT vendor partner 1. I think it was a good decision to forge collaboration with this IT vendor. 2. I believe that we did the right thing when we chose to build relationship with this IT vendor. 3. Overall, I am satisfied with the relationship with this IT vendor.	Adopted from (Chiou & Shen, 2006)

APPENDIX A. (Con't.)

Construct	Items	Source
Capital Brand (BRND)	(Anchors: A very little extent/A very great extent). 1. Invest adequate resources in product/service improvements that provide better value to our stakeholders 2. Keep "in touch" with our stakeholders' needs 3. Focus on creating a positive product/service experience for our stakeholders 4. Keep "in touch" with current market conditions 5. Design our integrated marketing activities to encourage consumers directly to use our products/services 6. Design our integrated marketing activities to encourage our suppliers, distributors and other key stakeholders to promote our products/services to consumers 7. Ensure that managers within the organization are aware of all of the marketing activities that involve the brand	Adopted from (Ewing & Napoli, 2005)
Trust (TRST)	(anchors: Strongly disagree/ Strongly agree) 1. The partner(s) and our OSS project have a high level of mutual trust. 2. The partner(s) is/are well known for fair dealing. 3. The partner(s) stand(s) by their word.	Adopted from (Zaheer & Venkatraman, 1995)

APPENDIX A. (Con't.)

Construct	Items	Source
Asset Specificity (ASPC)	(Anchor: Strongly disagree/Strongly agree) 1. It took us a lot of time and effort to learn the ins and outs of this partner organization(s) that we need to know to be effective. 2. Our Project developers spent a lot of time and effort learning the special design techniques used by the partner(s). 3. A lot of the tasks we perform on the partner(s) code require close coordination with their people. 4. Our partner(s) spent a lot of time and effort developing modules specifically for the open source project.	Adopted from (Zaheer & Venkatraman, 1995)
Uncertainty (UNCRT)	(Anchor: Very low uncertainty / Very high uncertainty) 1. Technological improvements impact in near future. 2. Changes expected in the project specifications. 3. Predictable patterns to our project enhancements. 4. Accuracy of prediction to recruit skillful developers for the project.	Adopted from (Walker & Webber, 1987)
Product Distinctiveness (DSTN)	(Anchor: Strongly disagree/Strongly agree) Compared to competing software products, your project provides: 1. Unique benefits. 2. Significant relative advantages. 3. A product difficult for competition to duplicate. 4. Significant improvements.	Adopted from (Stone-Romero & Stone, 1997)

APPENDIX A. (Con't.)

Construct	Items	Source
Opportunism (OPRT)	(Anchor: Strongly disagree/Strongly agree) 1. The partner(s) sometimes have to alter the facts slightly in order to get what they need. 2. Sometimes partner(s) present facts to the OSS project in such a way that they look good. 3. Partner(s) think that complete honesty does not pay when dealing with OSS project. 4. Partner(s) sometimes have to exaggerate the project requirements to get profit from it. 5. Partner(s) will do anything within their means to further their own interests. 6. On occasions, partner(s) distort information about certain things in order to protect their interests. 7. Partner(s) sometimes promise that they will do certain things without actually doing them later.	Adopted from (Chiou & Shen, 2006)

APPENDIX B. HUMAN SUBJECTS CERTIFICATE OF EXCEMPTION

University of Colorado Denver
Downtown Campus

1380 Lawrence Street, Suite 300
Campus Box 120
P.O.Box 173364
Denver, CO 80217-3364

05/29/2008

Certificate of Exemption

Investigator:	Mohamed Sidahmed	
Sponsor(s):		
Subject:	HSRC Protocol 2008-154 Initial Review (APP001) 2nd	Title: OPEN SOURCE SOFTWARE HYBRID DEVELOPMENT
Effective Date:	29 May 2008	
Expiration Date:	Exempt	
Exempt Category:	2	
Includes:	Protocol - Investigator - 1 Advertisement(s) - 1 Questionnaire(s)	

This protocol qualifies for exempt status. Periodic continuing review is not required. For the duration of your protocol, any change in the experimental design/content of this study must be approved by the HSRC before implementation of the changes.

The anticipated completion date of this protocol is 05/31/2009. HRSC will terminate this project on this date unless otherwise instructed either by correspondence, telephone or e-mail

APPENDIX C. INFORMED CONSENT

Dear [Participant name],

I'm Mohamed Sidahmed, a PhD student at the University of Colorado Denver. I am one of the enthusiasts of free/open source software, and have selected it for my thesis. Currently, I am conducting research to study the collaborative joint development between Free/OSS projects and commercial organizations. I believe this issue is of great importance as the trend for business models and financial drivers are on the increase.

You were hand selected for this study because you are an experienced and key member of a free/OSS project. Your responses are essential to developing an informed understanding of these issues. This survey should take you less than 15 minutes to complete. (Click here to take survey or use following URL: http://tinyurl.com/ossgov). Your assistance is much appreciated and acknowledged.

Your participation is voluntary. I do not know of any risks to you if you decide to participate in this survey, as the results will be published using statistical summary only. I ensure anonymity and the responses will not be identified with you personally. I will not collect your IP address or URL. You are free to skip any questions you do not want to answer.

If you have any questions or concerns about completing the questionnaire, being in this study, or if you're interested in receiving a copy of the study findings, you may contact me by simply replying to this email. The Human Subjects Research Committee (HSRC) at the University of Colorado Denver has approved this study. If you have any concerns about your rights as a participant in this study, you may contact an HSRC Administrator via mail (HSRC, UCD, 1380 Lawrence Street, Suite 300, Campus Box 120, P. O. Box 173364, Denver, CO 80217) or by phone (303-315-2732).

Thank you very much for your help with this study.

Sincerely,

Mohamed Sidahmed

University of Colorado Denver

APPENDIX D. SOFTWARE CONTRIBUTOR ASSIGNMENT AGREEMENT

Whereas I wish to contribute to Pentaho Corporation ("Pentaho") software source code, object code, documentation, or other material (collectively, "the Contribution"),

1. For the opportunity to participate in and benefit from the community of users and developers of Pentaho software, I hereby irrevocably grant, contribute, assign, and transfer to Pentaho Corporation ("Pentaho") (a) all right, title and interest, worldwide, in and to the copyrights, copyright applications and copyright registrations in the Contribution; (b) all of my right, title and interest under each U.S. and foreign patent or patent application now or hereafter owned or controlled by me, but only to the extent that it is reasonably necessary to practice an invention claimed in such patent in order to make, have made, use, import, license and sublicense (collectively, "Use") and permit others to Use the Contribution (or portions thereof), both alone and in combination with other software and documentation, and both in its present form and as it may be modified in the future, for any of its intended purposes; and (c) any and all of my other rights, title and interest in and to any trade secrets, other intellectual property rights, contract rights and licenses associated with all or part of the Contribution. If I have any rights to the Contribution that cannot be assigned as described above including, without limitation, any moral rights or the equivalent thereof, I agree to waive enforcement world-wide of such rights against Pentaho, its officers, directors, shareholders, agents, employees, licensees, or sub-licensees. If I have any rights to the Contribution that cannot be assigned or waived as described above, I hereby grant and agree to grant to the Pentaho a non-exclusive, irrevocable, fully paid-up, transferable and royalty-free license, in perpetuity and world-wide, to fully exercise such rights, including rights to sublicense through multiple tiers of sublicenses. These rights are assignable by Pentaho.

2. I represent and warrant that I am legally entitled to grant the above assignment and that by providing the Contribution I am not violating any law, breaching any contract, or infringing upon the rights of any person or entity.

3. I will take such actions as may be requested by the Pentaho, if any, to perfect the assignment of the Contribution as stated herein, including the execution and delivery of any additional instruments of assignment if appropriate and necessary.

4. I understand and acknowledge that I am not expected to provide support for the Contribution, except to the extent that I desire to provide support, and that I may provide support for free, for a fee if agreed to in advance in writing by Pentaho, or not at all.

5. I understand and acknowledge that submission of the Contribution does not guarantee that it will be accepted into any Pentaho project or product or that it will otherwise be distributed by Pentaho and/or any other entity.

6. I understand and acknowledge that in return for my Contribution, Pentaho grants to me a non-exclusive license to use the Contribution.

7. I agree to notify Pentaho in writing or via e-mail to communityconnection@pentaho.com of any copyright applications; copyright registrations; patent applications; patents; trademarks, servicemarks, or other proprietary marks or notices, and any applications or registrations for the same; trade secrets; other intellectual property rights; contract rights; and licenses that are included in my Contribution. I hereby promise to notify Pentaho if in the future I become aware of any copyright applications; copyright registrations; patent applications; patents; trade secrets; other intellectual property rights; contract rights; or licenses that are included in my Contribution (whether past, present or future) but are not included in the list above.

8. Employer/Client Disclaimer (If Applicable). I certify that my employer/client hereby disclaims all copyright and all other intellectual property interest in the Contribution.

Signature:_____

Name: _____

Date:_____

BIBLIOGRAPHY

Aaker, D. A., & Mascarenhas, B. (1984). The need for strategic flexibility. *Journal of Business Strategy, 5*(2), 74-82.

Aiken, M., & Hage, J. (1968). Organizational Interdependence and Intra-Organizational Structure. *American Sociological Review, 33*(6), 912-930.

Alchian, A. A., & Demsetz, H. (1972). Production, Information Costs, and Economic Organization. *American Economic Review, 62*(5), 777-795.

Alchian, A. A., & Woodward, S. (1987). Reflections on the Theory of the Firm. *Journal of institutional and theoretical economics (JITE), 143*(1), 110-136.

AlMarzouq, M., Zheng, L., Rong, G., & Grover, V. (2005). Open Source: Concepts, Benefits, and Challenges. *Communications of the Association for Information Systems, 16*(37), 756-784.

Anderson, E. (1985). The Salesperson as Outside Agent or Employee: A Transaction Cost Analysis. *Marketing Science, 4*.

Anderson, E. (1988). Transaction costs as determinants of opportunism in integrated and independent sales forces. *Journal of Economic Behavior & Organization, 9*(3), 247-264.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411-423.

Armstrong, J. S., & Overton, T. S. (1977). Estimating Nonresponse Bias in Mail Surveys. *Journal of Marketing Research, 14*(3), 396-402.

Bahrami, H. (1992). The emerging flexible organization: perspectives from Silicon Valley. *California Management Review, 34*, 33-51.

Bahli, B., & Rivard, S. (2003). The information technology outsourcing risk: a transaction cost and agency theory-based perspective. *Journal of Information Technology (Routledge, Ltd.), 18*(3), 211-221.

Barney, J. B., & Hansen, M. H. (1994). Trustworthiness as a Source of Competitive Advantage. *Strategic Management Journal, 15*, 175-190.

Barringer, B. R., & Harrison, J. S. (2000). Walking a Tightrope: Creating Value Through Interorganizational Relationships. *Journal of Management, 26*(3), 367-403.

Bergquist, M., & Ljungberg, J. (2001). The power of gifts: organizing social relationships in open source communities. *Information Systems Journal, 11*(4), 305-320.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York: Wiley.

Bonaccorsi, A., Giannangeli, S., & Rossi, C. (2006). Entry Strategies Under Competing Standards: Hybrid Business Models in the Open Source Software Industry. *Management Science, 52*(7), 1085-1098.

Bonaccorsi, A., Lorenzi, D., Merito, M., & Rossi, C. (2007). *Business Firms' Engagement in Community Projects. Empirical Evidence and Further Developments of the Research*. Paper presented at the First International Workshop on Emerging Trends in FLOSS Research and Development, in conjunction with 29th Int. Conference on Software Engineering. Retrieved November 21, 2008 from http://ieeexplore.ieee.org.ezp-prod1.hul.harvard.edu/stamp/stamp.jsp?arnumber=04273084

Bonaccorsi, A., & Rossi, C. (2003). Why Open Source software can succeed. *Research Policy, 32*(7), 1243-1258.

Burmann, C., & Zeplin, S. (2005). Building brand commitment: A behavioural approach to internal brand management. *Journal of Brand Management, 12*(4), 279-300.

Butler, B. S. (2001). Membership Size, Communication Activity, and Sustainability: A Resource-Based Model of Online Social Structures. *Information Systems Research, 12*(4), 346-362.

Byrne, B. M. (1998). *Structural equation modeling with LISREL, PRELIS, and SIMPLIS: basic concepts, applications, and programming*. Mahwah, N.J.: L. Erlbaum Associates.

Byrne, B. M. (2001). *Structural equation modeling with AMOS : basic concepts, applications, and programming*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Capek, P. G., Frank, S. P., Gerdt, S., & Shields, D. (2005). A history of IBM's open-source involvement and strategy. *IBM Systems Journal, 44*(2), 249-257.

Chebbi, I., Dustdar, S., & Tata, S. (2006). The view-based approach to dynamic inter-organizational workflow cooperation. *Data & Knowledge Engineering, 56*(2), 139-173.

Chiou, J.-S., & Shen, C.-C. (2006). The effects of satisfaction, opportunism, and asset specificity on consumers' loyalty intention toward internet portal sites. *International Journal of Service Industry Management, 17*(1), 7-22.

Clemons, E. K., Reddi, S. P., & Row, M. C. (1993). The Impact of Information Technology on the Organization of Economic Activity: The "Move to the Middle" Hypothesis. *Journal of Management Information Systems, 10*(2), 9-35.

Clemons, E. K., & Row, M. C. (1992). Information Technology and Industrial Cooperation: The Changing Economics of Coordination and Ownership. *Journal of Management Information Systems, 9*(2), 9-28.

Coase, R. H. (1937). The Nature of the Firm. *Economica, 4*(16), 386-405.

Cook, K. S., & Emerson, R. M. (1978). Power, Equity and Commitment in Exchange Networks. *American Sociological Review, 43*(5), 721-739.

Crowston, K., & Howison, J. (2005). The social structure of free and open source software development. *First Monday, 10*(2).

Dahlander, L., & Magnusson, M. G. (2005). Relationships between open source software companies and communities: Observations from Nordic firms. *Research Policy, 34*(4), 481-493.

Davis, L. E., & Smorodin, C. (1971). *Institutional change and American economic growth*. Cambridge [Eng.]: University Press.

Deek, F. P., & McHugh, J. A. (2008). *Open source : technology and policy*. Cambridge ; New York: Cambridge University Press.

Dixon, J. (2007). *The Beekeeper A Description of Commercial Open Source Software Business Models*: Pentaho Corportation.

Doz, Y. L., & Hamel, G. (1998). *Alliance advantage : the art of creating value through partnering*. Boston: Harvard Business School Press.

Eaton, B. C & Lipsey, R. G. (1989). Product Differentiation. In R. Schmalensee & R. D. Willig. *Handbook of industrial organization, Volume I.* (pp. 725-768). Amsterdam: Elsevier Science Publishers B.V.

Eisenhardt, K. (1989). Agency theory: An assessment and review. *Academy of management review*, 57-74.

Etemad, H., Wright, R. W., & Dana, L. P. (2001). Symbiotic International Business Networks: Collaboration between Small and Large Firms. *Thunderbird International Business Review, 43*(4), 481-499.

Evers, S. (2000). *An Introduction To Open Source Software Development.* Technische Universität Berlin, Berlin.

Ewing, M. T., & Napoli, J. (2005). Developing and validating a multidimensional nonprofit brand orientation scale. [Special Section: The Nonprofit Marketing Landscape]. *Journal of Business Research, 58*(6), 841-853.

Fang, Y., & Neufeld, D. (2009). Understanding Sustained Participation in Open Source Software Projects. *Journal of Management Information Systems, 25*(4), 9-50.

Feller, J. (2005). *Perspectives on free and open source software.* Cambridge, Mass.: MIT Press.

Fink, R. C., Edelman, L. F., Hatten, K. J., & James, W. L. (2006). Transaction cost economics, resource dependence theory, and customer-supplier relationships. *15*(3), 497-529.

Fitzgerald, B. (2006). The Transformation of Open Source Software. *MIS Quarterly, 30*(3), 587-598.

Fogel, K. (2005). *Producing Open Source Software: How to Run a Successful Free Software Project.*

Fornell, C., & Larcker, D. F. (1981). Structural Equation Models with Unobservable Variables and Measurement Error: Algebra and Statistics. *Journal of Marketing Research, 18*(3), 382-388.

Fourie, F. C. v. N. (1989). The Nature of Firms and Markets: Do Transactions Approaches Help? , *57*(2), 92-102.

Franck, E., & Jungwirth, C. (2003). Reconciling Rent-Seekers and Donators - The Governance Structure of Open Source. *Journal of Management & Governance, 7*(4), 401-421.

Franke, N., & Hippel, E. v. (2003). Satisfying heterogeneous user needs via innovation toolkits: the case of Apache security software. *Research Policy, 32*(7), 1199-1215.

Frazier, G. L., & Summers, J. O. (1986). Perceptions of Interfirm Power and Its Use within a Franchise Channel of Distribution. *Journal of Marketing Research, 23*(2), 169-176.

Friedman, M. (1953). *Essays in positive economics* (8, reprint ed.). Chicage, IL: University of Chicago Press.

FSF. (2009). The Free Software Definition. Retrieved May 31, 2009, from http://www.fsf.org/licensing/essays/free-sw.html

Galaskiewicz, J. (1985). Interorganizational Relations. *Annual Review of Sociology, 11*(1), 281-304.

Galbraith, J. R. (1973). *Designing complex organizations*. Reading, Mass.: Addison-Wesley Pub. Co.

Gallivan, M. J. (2001). Striking a balance between trust and control in a virtual organization: a content analysis of open source software case studies. *Information Systems Journal, 11*(4), 277-304.

Gallivan, M. J., & Depledge, G. (2003). Trust, control and the role of interorganizational systems in electronic partnerships. *Information Systems Journal, 13*(2), 159-190.

Gambetta, D. (1988). *Trust : making and breaking cooperative relations*. New York, NY, USA: B. Blackwell.

Gereffi, G. (1994). The organization of buyer-driven global commodity chains: How U.S. retailers shape overseas production networks. In G. Gereffi & M. Korzeniewicz

(Eds.), *Commodity chains and global capitalism* (pp. 95-122). Westport, CT: Greenwood Press.

Geyskens, I., Steenkamp, J.-B. E. M., & Kumar, N. (2006). Make, Buy, or Ally: A Transaction Cost Theory Meta-Analysis. *Academy of Management Journal, 49*(3), 519-543.

Ghosh, A., & Morita, H. (2007). Competitor Collaboration and Product Distinctiveness. Retrieved January 6, 2009 from http://ssrn.com/abstract=926488.

Giddens, A. (1984). *The constitution of society : outline of the theory of structuration.* Cambridge [Cambridgeshire]: Polity Press.

Gies, D. L., Ott, J. S., & Shafritz, J. M. (1990). *The Nonprofit organization : essential readings.* Pacific Grove, CA: Brooks/Cole Pub. Co.

Gulati, R. (1995). Does Familiarity Breed Trust? The Implications of Repeated Ties for Contractual Choice in Alliances. *The Academy of Management Journal, 38*(1), 85-112.

Gulati, R., & Singh, H. (1998). The Architecture of Cooperation: Managing Coordination Costs and Appropriation Concerns in Strategic Alliances. *Administrative Science Quarterly, 43*(4), 781-814.

Hahn, J., Moon, J. Y., & Zhang, C. (2008). Emergence of New Project Teams from Open Source Software Developer Networks: Impact of Prior Collaboration Ties. *Information Systems Research, 19*(3), 369-391.

Hardt, L. (2006). Transaction Cost Economics as a Three Dimensional Externally Driven Research Program. *Economic Studies, 1-2*, 7-31.

Hars, A., & Qu, S. (2002). Working for Free? Motivations for Participating in Open-Source Projects. *International Journal of Electronic Commerce, 6*(3), 25.

Heide, J. B., & John, G. (1990). Alliances in Industrial Purchasing: The Determinants of Joint Action in Buyer- Supplier Relationships. *Journal of Marketing Research, 27*(1), 24-36.

Heide, J. B., & Miner, A. S. (1992). The Shadow of the Future: Effects of Anticipated Interaction and Frequency of Contact on Buyer-Seller Cooperation. *The Academy of Management Journal, 35*(2), 265-291.

Heiman, B., & Nickerson, J. A. (2002). Towards Reconciling Transaction Cost Economics and the Knowledge-based View of the Firm: The Context of Interfirm Collaborations. *International Journal of the Economics of Business, 9*(1), 97-116.

Hertel, G., Niedner, S., & Herrmann, S. (2003). Motivation of software developers in Open Source projects: an Internet-based survey of contributors to the Linux kernel. *Research Policy, 32*(7), 1159-1177.

Hill, C. W. L. (1990). Cooperation, opportunism, and the invisible hand: implications for transaction cost theory. *Academy of Management Review, 15*(3), 500-513.

Holland, D. K. (2006). *Branding for nonprofits : developing identity with integrity*. New York: Allworth Press.

Hrebiniak, L. G., & Joyce, W. F. (1984). *Implementing strategy*. New York London: Macmillan ; Collier Macmillan.

Jarillo, J. C. (1988). On strategic networks. *Strategic Management Journal, 9*(1), 31-41.

John, G. (1984). An Empirical Investigation of Some Antecedents of Opportunism in a Marketing Channel. *21*(3), 278-289.

Johnson, J. P. (2002). Open Source Software: Private Provision of a Public Good. *Journal of Economics & Management Strategy, 11*(4), 637-662.

Johnston, R., & Lawrence, P. R. (1988). Beyond Vertical Integration--the Rise of the Value Adding Partnership. *Harvard Business Review, 66*(4), 94-101.

Johnston, D. A., McCutcheon, D. M., Stuart, F. I., & Kerwood, H. (2004). Effects of supplier trust on performance of cooperative supplier relationships. *Journal of Operations Management, 22*(1), 23-38.

Jones, M. R., & Karsten, H. (2003). Review: structuration theory and information systems research.

Jöreskog, K. G., & Sörbom, D. (1996). *LISREL 8: user's reference guide* (2nd ed.). Chicago, IL: Scientific Software International, SPSS Inc.

Judge, W. Q., & Dooley, R. (2006). Strategic Alliance Outcomes: a Transaction-Cost Economics Perspective. *British Journal of Management, 17*(1), 23-37.

Kapferer, J.-N. (2008). *The new strategic brand management : creating and sustaining brand equity long term* (4th ed.). London ; Philadelphia: Kogan Page.

Klein, B., Crawford, R. G., & Alchian, A. A. (1978). Vertical Integration, Appropriable Rents, and the Competitive Contracting Process. *Journal of Law and Economics, 21*(2), 297-326.

Klein, P. G. (2008). The Make-or-Buy Decisions: Lessons from Empirical Studies *Handbook of New Institutional Economics* (pp. 435-464).

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). New York: Guilford Press.

Kogut, B., & Turcanu, A. (2000). The emergence of E-Innovation: Insights from open source software development. Working paper of the Reginal H Jones Center, The Wharton School, University of Pennsylvania.

Koopmans, T. C. (1991). *Three essays on the state of economic science*. Fairfield, NJ: A.M. Kelley.

Krishnamurthy, S. (2006). On the Intrinsic and Extrinsic Motivation of Free/Libre/Open Source (FLOSS) Developers. *Knowledge, Technology & Policy, 18*(4), 17-39.

Kroah-Hartman, G., Corbet, J., & McPherson, A. (2008). Linux Kernel Development. *The Linux Foundation, April.* Retrieved June 28, 2009 from http://www.linuxfoundation.org/publications/linuxkerneldevelopment.php

Lakhani, K. R., & von Hippel, E. (2003). How open source software works: "free" user-to-user assistance. *Research Policy, 32*, 923–943.

Lee, G. K., & Cole, R. E. (2003). From a Firm-Based to a Community-Based Model of Knowledge Creation: The Case of the Linux Kernel Development. *Organization Science, 14*(6), 633-649.

Lee, J.-N., Miranda, S. M., & Kim, Y.-M. (2004). IT Outsourcing Strategies: Universalistic, Contingency, and Configurational Explanations of Success. *Information Systems Research, 15*(2), 110-131.

Lefton, M., & Rosengren, W. R. (1966). Organizations and Clients: Lateral and Longitudinal Dimensions. *American Sociological Review, 31*(6), 802-810.

Leiblein, M. J., Reuer, J. J., & Dalsace, F. (2002). Do Make or Buy Decisions Matter? The Influence of Organizational Governance on Technological Performance. *23*(9), 817-833.

Lerner, J., & Tirole, J. (2002). Some Simple Economics of Open Source. *Journal of Industrial Economics 50*(2), 197-234.

Lerner, J., & Tirole, J. (2005). The Scope of Open Source Licensing. *The Journal of Law, Economics & Organization, 21*(1), 20-56.

Luo, Y. (2001). Antecedents and Consequences of Personal Attachment in Cross-Cultural Cooperative Ventures. *Administrative Science Quarterly, 46*(2), 177-201.

Masten, S. E. (1993). Transaction Costs, Mistakes, and Performance: Assessing the Importance of Governance. *Managerial and Decision Economics, 14*(2), 119-129.

Masten, S. E., Meehan, J. W., & Snyder, E. A. (1991). The Costs of Organization. *The journal of law, economics, & organization, 7*(1), 1-25.

Maznevski, M. & Chudoba, k. M. (2000). Bridging space over time: Global virtual team dynamics and effectiveness. *Organization Science, 11*(5), 473-492.

McFarlin, D. B., & Sweeney, P. D. (1992). Distributive and Procedural Justice as Predictors of Satisfaction with Personal and Organizational Outcomes. *The Academy of Management Journal, 35*(3), 626-637.

Miranda, S. M., & Kim, Y.-M. (2006). Professional Versus Political Contexts: Institutional Mitigation and The Transaction Cost Heuristic in Information Systems Outsourcing. *MIS Quarterly, 30*(3), 725-753.

Mockus, A., Fielding, R. T., & Herbsleb, J. D. (2002). Two case studies of open source software development: Apache and Mozilla. *ACM Transactions on Software Engineering and Methodology (TOSEM), 11*(3), 309-346.

Monteverde, K., & Teece, D. J. (1982). Appropriable Rents and Quasi-Vertical Integration. *Journal of Law and Economics, 25*(2), 321-328.

Mulford, C. L., & Rogers, D. L. (1982). Definitions and models. In D. L. Rogers & D. A. Whetten (Eds.), *Interorganizational Coordination: Theory, Research, and Implementation*. Ames, IA: Iowa State University Press.

Niccolai, J. (2008). Rails and Merb frameworks agree to merge. *ComputerWorld, December 24, 2008 12:00 PM ET.* Retrieved May 31, 2009, from http://www.computerworld.com/action/article.do?command=viewArticleBasic&articleId=9124340

O'Mahony, S., & Ferraro, F. (2007). The Emergence of Governance in an Open Source Community. *Academy of Management Journal, 50*(5), 1079-1106.

Osborn, R. N., & Hagedoorn, J. (1997). The Institutionalization and Evolutionary Dynamics of Interorganizational Alliances and Networks. *The Academy of Management Journal, 40*(2), 261-278.

Osterloh, M., & Rota, S. (2007). Open source software development--Just another case of collective invention? *Research Policy, 36*(2), 157-171.

Oxley, J. E. (1997). Appropriability Hazards and Governance in Strategic Alliances: A Transaction Cost Approach. *13*(2), 387-409.

Pennings, J. (1981) Strategically Interdependent Organizations. In *Handbook of Organizational Design*. Edited by Paul C. Nystrom and William H. Starbuck. London: Oxford University Press

Perens, B. (Oct 2005). The Emerging Economic Paradigm of Open Source. *First Monday*(Special Issue #2).

Perry, M. K. (1989). Vertical Integration: Determinants and Effects. In R. Schmalensee & R. D. Willig. *Handbook of industrial organization, Volume I.* (pp. 185-255). Amsterdam: Elsevier Science Publishers B.V.

Pfeffer, J. (1981). *Power in organizations*. Marshfield, Mass.: Pitman Pub.

Pfeffer, J., & Salancik, G. R. (1978). *The external control of organizations : a resource dependence perspective*. New York: Harper & Row.

Pieters, R., Koelmeijer, K., & Roest, H. (1995). Assimilation processes in service satisfaction formation. *International Journal of Service Industry Management, 6*(3), 17-33.

Poppo, L., & Zenger, T. (2002). Do formal contracts and relational governance function as substitutes or complements? *Strategic Management Journal, 23*(8), 707-725.

Raghunathan, S., Prasad, A., Mishra, B. K., & Hsihui, C. (2005). Open source versus closed source: software quality in monopoly and competitive markets. *Systems, Man*

and Cybernetics, Part A: Systems and Humans, IEEE Transactions on, 35(6), 903-918.

Rao, A. R., & Ruekert, R. W. (1994). Brand alliances as signals of product quality. *Sloan Management Review, v36*(n1), p87(11).

Raymond, E. S. (2001). *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*: O'Reilly & Associates, Inc.

Richman, B. D., & Macher, J. (2006). Transaction Cost Economics: An Assessment of Empirical Research in the Social Sciences. *Duke Law School Legal Studies Paper No. 115*. Retrieved November 11, 2008 from http://ssrn.com/abstract=924192

Rindfleisch, A., & Heide, J. B. (1997). Transaction Cost Analysis: Past, Present, and Future Applications. *Journal of Marketing, 61*(4), 30-54.

Ring, P. S., & van de Ven, A. H. (1994). Developmental Processes of Cooperative Interorganizational Relationships. *The Academy of Management Review, 19*(1), 90-118.

Ritzberger, K. (2002). *Foundations of non-cooperative game theory*: Oxford University Press.

Roberts, J. A., Hann, I.-H., & Slaughter, S. A. (2006). Understanding the Motivations, Participation, and Performance of Open Source Software Developers: A Longitudinal Study of the Apache Projects. *Management Science, 52*(7), 984-999.

Sadowski, B. M., Sadowski-Rasters, G., & Duysters, G. (2008). Transition of governance in a mature open software source community: Evidence from the Debian case. *Information Economics and Policy, 20*(4), 323-332.

Sambamurthy, V. & Zmud, R. W. (1999). Arrangements for Information Technology Governance: A Theory of Multiple Contingencies. *MIS Quarterly, 23*(2), 261-290.

Saxton, J. (1994). A strong charity brand comes from strong beliefs and values. *Journal of Brand Management, 2*(4), 211-220.

Saxton, T. (1997). The Effects of Partner and Relationship Characteristics on Alliance Outcomes. [Special Research Forum on Alliances and Networks]. *The Academy of Management Journal, 40*(2), 443-461.

Scacchi, W. (2002). Understanding the requirements for developing open source software systems. *Software, IEE Proceedings -, 149*(1), 24-39.

Schermerhorn, J. R., Jr. (1975). Determinants of Interorganizational Cooperation. *The Academy of Management Journal, 18*(4), 846-856.

Sen, R. (2007). A Strategic Analysis of Competition Between Open Source and Proprietary Software. *Journal of Management Information Systems, 24*(1), 233 - 257.

Shah, S. K. (2006). Motivation, Governance, and the Viability of Hybrid Forms in Open Source Software Development. *Management Science, 52*(7), 1000-1014.

Sharma, S., Sugumaran, V., & Rajagopalan, B. (2002). A framework for creating hybrid-open source software communities. *Information Systems Journal, 12*(1), 7-25.

Shelanski, H. A., & Klein, P. G. (1995). Empirical Research in Transaction Cost Economics: A Review and Assessment. *Journal of Law, Economics, & Organization, 11*(2), 335-361.

Sidahmed, M., & Gerlach, J. H. (2009). *Governance of Collaborative Open Source Software: Inference from Transaction Cost Economics Model.* Paper presented at the 15th Americas Conference on Information Systems.

Simon, H. A. (1957). *Administrative behavior; a study of decision-making processes in administrative organization* (2nd ed.). New York: Macmillan.

Simon, H. A. (1987). *Models of man, social and rational : mathematical essays on rational human behavior in a social setting.* New York: Garland Pub.

Söderberg, J. (2007). *Hacking capitalism : the free and open source software movement.* New York: Routledge.

SourceForge (2008). Retrieved June 28, 2009 from http:// www.sourceforge.net

Spector, S. (2009). Xen.org Community Survey – Make Your Voice Heard!. Retrieved June 29, 2009 from http://blog.xen.org/index.php/2009/05/12/xenorg-community-survey-make-your-voice-heard/

Stewart, K. J., Ammeter, A. P., & Maruping, L. M. (2006). Impacts of License Choice and Organizational Sponsorship on User Interest and Development Activity in Open Source Software Projects. *Information Systems Research, 17*(2), 126-144.

Stewart, K. J., & Gosain, S. (2006). The Impact Of Ideology On Effectiveness in Open Source Software Development Teams. *MIS Quarterly, 30*(2), 291-314.

Stone-Romero, E. F., & Stone, D. L. (1997). Development of a multidimensional measure of perceived product quality. *Journal of Quality Management, 2*(1), 87-112.

Subramani, M. (2004). How Do Suppliers Benefit from Information Technology Use in Supply Chain Relationships? *MIS Quarterly, 28*(1), 45-73.

Telser, L. G. (1980). A Theory of Self-Enforcing Agreements. *The Journal of Business, 53*(1), 27-44.

Topdog08.com (2003). Unconventional Insights, June 17, Retrieved February 2, 2009, from www.topdog04.com/000216.html

Ulrich, D., & Barney, J. B. (1984). Perspectives in Organizations: Resource Dependence, Efficiency, and Population. *The Academy of Management Review, 9*(3), 471-481.

Valentinov, V. (2008). The Transaction Cost Theory of the Nonprofit Firm: Beyond Opportunism. *Nonprofit and Voluntary Sector Quarterly, 37*(1), 5-18.

Valentinov, V. L. (2007). Some Reflections on the Transaction Cost Theory of Nonprofit Organisation. *Zeitschrift für öffentliche und Gemeinwirtschaftliche Unternehmen, 30*(1), 52-67.

van den Bos, K., Wilke, H. A. M., & Lind, E. A. (1998). When do we need procedural fairness? The role of trust in authority. *Journal of Personality and Social Psychology, 75*(6), 1449-1458.

von Hippel, E., & von Krogh, G. (2003). Open Source Software and the "Private-Collective" Innovation Model: Issues for Organization Science. *Organization Science, 14*(2), 209 - 223.

Wade, M., & Hulland, J. (2004). Review: The Resource-Based View and Information Systems Research: Review, Extension, and Suggestions for Future Research. *MIS Quarterly, 28*(1), 107-142.

Walker, G., & Weber, D. (1984). Transaction Costs, Mistakes, and Performance: Assessing the Importance of Governance. *Administrative Science Quarterly, 29*(3), 373-391.

Walker, G., & Weber, D. (1987). Supplier Competition, Uncertainty, and Make-or-Buy Decisions. *The Academy of Management Journal, 30*(3), 589-596.

Weber, S. (2004). *The success of open source*. Cambridge, MA: Harvard University Press.

Webster, J., Frederick E. (1992). The Changing Role of Marketing in the Corporation. *Journal of Marketing, 56*(4), 1-17.

West, J., & O'Mahony, S. (2005, January 3-6). *Contrasting Community Building in Sponsored and Community Founded Open Source Projects.* Paper presented at the

38th Annual Hawaii International Conference on System Sciences, Waikoloa, Hawaii.

Williams, T. (2005). Cooperation by design: structure and cooperation in interorganizational networks. *Journal of Business Research, 58*(2), 223-231.

Williamson, O. E. (1975). *Markets and hierarchies, analysis and antitrust implications : a study in the economics of internal organization.* New York: Free Press.

Williamson, O. E. (1979). Transaction-Cost Economics: The Governance of Contractual Relations. *Journal of Law and Economics, 22*(2), 233-261.

Williamson, O. E. (1981). The Economics of Organization:The Transaction Cost Approach. *The American Journal of Sociology, 87*(3), 548-577.

Williamson, O. E. (1985). *The economic institutions of capitalism: firms, markets, relational contracting.* New York; London: Free Press; Collier Macmillan.

Williamson, O. E. (1989). Transaction Cost Economics. In R. Schmalensee & R. D. Willig. *Handbook of industrial organization, Volume I.* (pp. 136-182). Amsterdam: Elsevier Science Publishers B.V.

Williamson, O. E. (1991a). Strategizing, Economizing, and Economic Organization. *Strategic Management Journal, 12*, 75-94.

Williamson, O. E. (1991b). Comparative Economic Organization: The Analysis of discrete Structural Alternatives. *Administrative Science Quarterly, 36,* 269-296.

Williamson, O. E. (1993). Calculativeness, Trust, and Economic Organization. *The Journal of Law and Economics, 36*(S1), 453-486.

Williamson, O. E. (1989). Transaction Cost Economics. In R. Schmalensee & R. Willig. Handbook of Industrial Organization Volume I, pp. 136-182. New York: Elsevier Science Publishers B.V.

Williamson, O. E. (2002). The Theory of the Firm as Governance Structure: From Choice to Contract. *Journal of Economic Perspectives, 16*(3), 171-195.

Wu, C.-G., Gerlach, J. H., & Young, C. E. (2007). An empirical analysis of open source software developers' motivations and continuance intentions. *Information & Management, 44*(3), 253-262.

Xen.org (2009). Home of the *Xen* Hypervisor. Retrieved June 29, 2009 from http://www.xen.org

Young-Ybarra, C., & Wiersema, M. (1999). Strategic Flexibility in Information Technology Alliances: The Influence of Transaction Cost Economics and Social Exchange Theory. *Organization Science, 10*(4), 21.

Zaheer, A., & Harris, J. D. (2005). Interorganizational Trust. *Handbook of Strategic Alliances, Oded Shenkar and Jeffrey J. Reuer, eds., Chapter 10, pp.169-197, Sage Publications, 2006.*

Zaheer, A., & Venkatraman, N. (1995). Relational Governance as an Interorganizational Strategy: An Empirical Test of The Role of Trust in Economic Exchange. *Strategic Management Journal, 16*(5), 373-392.

Zaheer, A., McEvily, B., & Perrone, V. (1998). Does Trust Matter? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance. *Organization Science, 9*(2), 141-159.