FACTORS THAT CONTRIBUTE TO OPEN SOURCE SOFTWARE PROJECT SUCCESS

by

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ABSTRACT

This research examines the factors that contribute to the success of open source software projects. Examination of 70 replies from software developers led to the identification of the two measures of project success used in this research: number of downloads and number of releases. The multivariate general linear model was used to examine data from a sample comprised of 350 open source software projects and a sub-sample comprised of 108 production/stable and mature projects. Results suggest that: i. developers who contribute to open source projects define project success in ways not traditionally used to measure the success of product development projects, ii. the most successful open source projects are those that develop application development and deployment tools, attract a greater number of experienced developers, and target users who are developers, iii. use of commonly used programming languages and non-restrictive software licenses does not significantly affect open source project success, iv. production/stable and mature open source projects that develop application development and deployment tools are more successful than projects that develop application and system infrastructure software, and v. development status affects the factor-success relationship for open source projects.

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1. INTRODUCTION

1.1 Objective

The objective of this exploratory research is to examine the factors that contribute to the success of open source software (OSS) projects. The explanatory factors examined in this research were identified from a review of the literature. These factors are: number of developers, experience of developers, target user type, programming language type, software type, license type, and development status.

Traditionally, software product success is measured from the perspective of corporate users who purchase the software, whereas the success of OSS projects seems to depend on the continued contribution of volunteer developers (Crowston, Annabi, Howison, and Masango, 2004). According to the product development literature, product success and process performance influence the financial success of a product (Brown and Eisenhardt, 1995). Success measures such as profits, market share, development cost, development time, and engineering productivity are difficult to apply to open source software.

For the purpose of identifying what measures of project success to use in this research, 700 developers were asked via email to define success of their OSS projects; 70 replied. Most of those who replied suggested number of downloads and number of releases.

These two measures of success, not conventionally used to measure product development project success, were used in this research.

1.2 Relevance

This research is relevant because its results increase our understanding of which OSS projects are likely to succeed. Knowing what factors contribute to OSS success will assist company managers and entrepreneurs who wish to set up successful OSS projects as well as project managers who wish to incorporate OSS into their development projects.

Better understanding of the factors that contribute to the success of OSS projects will help company managers and entrepreneurs to avoid costly mistakes and reduce the risk of failure when setting up OSS projects. Moreover, this understanding will also help project managers reduce the cost of having to change an OSS component due to the failure of the OSS project that produces it.

1.3 Contribution

Most of the studies on open source are case based and address issues of developing, testing, and releasing OSS code (Gallivan, 2001). However, empirical studies of the factors that contribute to OSS project success are lacking (Comino, Manenti, and Parisi, 2005; Koch, 2004).

This research makes at least five contributions. First, this research highlights the fact that developers who contribute to OSS projects define project success in ways

not traditionally used to measure the success of the software development projects that companies undertake.

Second, the results of the research suggest that the open source projects which are designed to: i. produce application development and deployment tools, ii. attract a greater number of experienced developers, and iii. target developers as users, are more successful than other open source projects.

Third, the results of the research suggest that the type of programming language used and the type of software license do not affect the success of open source projects.

Fourth, the results of the research suggest that production/stable or mature OSS projects that produce application development and deployment tools are more successful than OSS projects that produce application software and system infrastructure software.

Finally, the results of the research suggest that the development status of an OSS project affects the relationship between factors such as number of developers, experience of developers, target users type, programming language type, type of open source software developed, and type of open source license and the success of the OSS project.

1.4 Organization

The thesis is organized into seven chapters. Chapter 1 is the introduction. Chapter 2 reviews the academic literature and provides the lessons learned from it. Chapter 3 develops the hypotheses that were tested. Chapter 4 describes the research strategy and method to be used. Chapter 5 provides the results obtained when testing the hypotheses. Chapter 6 discusses the results obtained. Finally, Chapter 7 provides the conclusions, limitations, and suggestions for future research.

2. LITERATURE REVIEW

This chapter is organized into four sections. The first section reviews the literature on product development success. The second section reviews the literature on open source software. The third section describes the software taxonomy provided by the International Data Corporation (IDC). Finally, section four provides the lessons learned from reviewing the literature.

2.1 Review of product development success literature

Clearly understanding the factors that contribute to product success can help top management teams and development project managers allocate required R&D resources and increase the demand for new products (Zirger and Maidique, 1990).

Rational planning and execution, autonomous problem solving by team members, high communication and organization of work according to the requirements of the development task results in successful product development (Brown and Eisenhardt, 1995).

Competent people should staff product development projects (Brown and Eisenhardt, 1995). Skills of employees are very crucial for the success of new product development (Storey and Easingwood, 1996; Brown and Eisenhardt 1995).

For product development success, it is important to properly define an attractive market as target market for the product (Brown and Eisenhardt, 1995; Cooper and Kleinschmidt, 1987). Identification of users as well as their needs contribute to the success of product development (Brown and Eisenhardt, 1995). If the company understands the market place and the customer understands the product offering then chances of product success increase (Storey and Easingwood, 1996).

Developing a new product that provides new benefits, satisfies customers' needs, and solves customers' problems increases the likelihood of its success (Cooper and Kleinschmidt, 1987; Storey and Easingwood, 1996). The provision of unique benefits to customers is critical for the success of new product development (Brown and Eisenhardt, 1995).

Focusing on financial returns is the traditional way of measuring new product development success. However, it is not the only important measure of success. A new product can be successful if it has a major impact on the market or if it provides a new opportunity to the company (Cooper and Kleinschmidt, 1987). According to Page (1993), customer need satisfaction is the most common non-financial measure of the success of a new product.

A number of dimensions are used to assess product success. It is unlikely that a single dimension is used to assess product success. For example, profit and sales performance assess financial success of the product; opportunity window assesses the degree to which

the new product opened up new opportunities to the company; and market impact specifies the impact of the product on market share (Cooper and Kleinschmidt, 1987).

According to Griffin and Page (1993), the three independent dimensions of project success are: customer-based success, financial success, and technical or process-based success. A firm can assess the success or failure of a development project in terms of customer satisfaction, financial return and technical advantage (Griffin and Page, 1996).

Griffin and Page (1996), argued that in every firm, new products are developed for different reasons. Depending on the project strategy, measures of product success can be different. In a very competitive market, new products may have to be developed to retain current customers. Product development may also be used as a tool to attract new customers or market when revenue growth is required. For most projects, customer based success is mostly assessed by customer satisfaction with the product and customer acceptance, financial success is indicated by the degree to which the project met profit goals, and performance-based success is measured by the degree to which the project provides a competitive advantage (Griffin and Page, 1996).

Success of product development can be interpreted in terms of efficiency and effectiveness. Efficient product development means less development cost, less time to market, and greater speed, productivity and performance of the product development process. Effectiveness of the product means fit of the product with firm competencies and market needs, revenue, profitability, and market share (Brown and Eisenhardt, 1995).

2.2 Review of open source software literature

2.2.1 Open source software project

OSS is software whose source code is distributed free of charge to all users under an open source license. These users can further modify and distribute the software free of charge. Open source license allows anyone to access source code, modify the software, and redistribute the software with or without modification (Open Source Initiative, 2005). An OSS project is the network of a community of developers who are geographically distributed. Developers contribute to the OSS project's activities through the Internet (Krogh and von Hippel, 2003; Freshtman and Gandal, 2004; Evers, 2000).

Projects protect their work by using trademarks and license of the software (O'Mahony, 2003). Lerner and Tirole (2005) argued that timing, exclusivity, and fee structure are important aspects for licensing of intellectual property. However, in case of open source software projects these are irrelevant. Hence, various open source leaders jointly establish criteria for open source licensing (Open Source Initiative, 2005).

A software is said to be open source if it is released under a license approved by the Open Source Initiative (OSI). OSI standards for open source software licenses include the following provisions (Open Source Initiative, 2005).

- Availability of source code of the software at nominal or no charge
- Permission of redistribution of the source code without fee.

- Permission of distribution of modified software without discrimination.
- Permission of distribution of modified software on the same terms as the original one.

For OSS projects any license can be chosen from a number of approved open source licenses. Further the OSS projects can create their own licenses as long as it fulfils the provisions mentioned above (Open Source Initiative, 2005).

Fershtman and Gandal (2004) and Lerner and Tirole (2005) have categorized open source licenses into three categories: very restrictive, moderately restrictive, and not restrictive.

- GNU General Public License (GPL) is the most popular open source license. According to the requirements of this license the source code be made available and that other software that incorporate code from a GPL licensed software must also make the source code fully available under GPL. It prohibits the mixing of open source and closed source software in any distributed work. Hence, software that use code from a GPL licensed software cannot become propriety software. The GPL is classified as “very restrictive license” (Fershtman and Gandal, 2004; Lerner and Tirole, 2005).
- GNU Lesser GPL (LGPL) is another popular license. It is less restrictive than GPL. It is flexible regarding to the mixing of open source and closed source software. It allows software to link with or employ code from other software that is not available under open source license. In other respects it is similar to GPL.

The LGPL is classified as “moderately restrictive” license. Other moderately restrictive licenses are: Apple Public Source License 1.2, Common Public Source License, Eiffel Forum License, IBM Public License 1.0, Jabber OSL, Motosoto License, Mozilla Public License 1.0 & 1.1, Nethack Public License, Nokia OSL, Qt Public License, Recoh Source Code License, Sleepycat License, and Sun Public license (Freshtman and Gandal, 2004; Lerner and Tirole, 2005).

- Berkeley Software Distribution (BSD) license has fewer restrictions than GPL and LGPL type of licenses. Commercial software can be developed using software under a BSD license as long as credit for the underlying code is given to the University of California. BSD license is classified as “non-restrictive” license. Other non-restrictive licenses are: Apache Software License, Artistic license, Intel OSL, MIT License, Open Group Test Suite License, Python (CNRI) License, Python Software foundation License, Sun Industry Standards Source License, University of Illinois/NCSA OSL, Vovida Software License 1.0, W3C License, X.Net License, Zope Public License 2.0, zlib/libpng License, and Public Domain License (Freshtman and Gandal, 2004; Lerner and Tirole, 2005).

Table 1 shows a comparison between GPL, LGPL, and BSD licenses (Nissila 2004).

West and O’Mahony (2005) have classified OSS projects into two types. One they called community-founded OSS projects, started and operated by individuals and group of developers. Second they called spun-out OSS projects, started initially by a company and later released as open source software.

Table 1. Comparison of GPL, LGPL, and BSD open source licenses (Nissila, 2004)

License	Can be mixed with non-free software	Modifications can be taken private and not returned to author	Can be licensed by anyone	Contains special privileges for the original copyright holder over user's modifications
GPL	No	No	No	No
LGPL	Yes	No	No	No
BSD	Yes	Yes	No	No

According to Raymond (1999), traditional software development is different than that of OSS development. He termed the former process as resembling a cathedral model and the later one resembling a bazaar model. OSS development depends on volunteer developers who develop the software by coordinating without a formal organizational structure and the software is generally provided freely. Therefore, in-time delivery, be within budget, and meeting specifications that are important for commercial software development may not apply in case of OSS (Stewart, Ammeter, and Maruping, 2005).

2.2.2 Interest in open source software project development

The interest in OSS development is increasing both from individuals and organizations. Research on open source has focused on the motivation of individuals and companies to participate in open source software development. According to Bates, Wolf, and Lakhani (2002), individuals are motivated to participate in open source software development due to: fun, skill, freedom, and need. Increasing knowledge is the biggest benefit and losing sleep is the biggest cost for participation in open source software development. Ghosh, Glott, Krieger, and Robes (2002) found that participation in open source community, skill improvement, learning and knowledge sharing are the most important factors that motivate individuals to take part in open source software development. Hertel, Nieder, and Hermann (2003), emphasized that increase in personal career chances and improvement in one's own software tools could motivate developers to participate in open source development process. Bonaccorsi and Rossi (2003) found that social factors: conforming to the values of free software movement, placing source code and skills at the disposal of software community, and believing software should not be proprietary motivate individuals to participate in open source software development.

Bonaccorsi and Rossi (2003) found that companies participate in open source software development due to economical and technological incentives. Economical incentives include: affordability of innovation by small enterprises, ease of finding good IT specialists, and gaining reputation among customers and competitors. Technological incentives include: reliability and quality of OSS, bug fixing and software improvement, use of source code to develop new programs and solutions, accessibility to products that

are not available in proprietary software market. According to Rossi and Bonaccorsi (2005), organizations participate in open source software projects because of extrinsic incentives whereas individuals do so due intrinsic motivation. They refer extrinsic motivation as the situation when need is fulfilled indirectly, especially with monetary compensation. However, in case of intrinsic motivation, need is fulfilled from the pleasures of carrying out any activity.

2.2.3 Open source software project success

Most of the studies on open source are case based and focus on a small number of glamorous and successful projects. Linux and Apache are the examples. The reason may be that both of these OSS projects are very successful in terms of their market acceptance (Gallivan, 2001). To expand product growth, increase market share, and increase penetration, companies are adopting the open source development model (Paulson, Succi, and Eberlein, 2004). Majority of the case studies address issues of developing, testing, and releasing OSS code (Gallivan, 2001). However, empirical studies of the factors that contribute to success are lacking (Comino, Manenti, and Parisi, 2005; Koch, 2004).

While there is a good understanding of the factors that contribute to success of the traditional software development model, similar empirical studies of the factors that contribute to the success of the open source development model are lacking (Comino, Manenti, and Parisi, 2005; Koch, 2004).

For determining the suitability of open source software for an organization, Duijnhouwer and Widdows (2003) has developed the Open Source Maturity Model (OSMM). With the help of customer OSMM evaluates and analyze open source software by looking into its maturity, assessing whether it is suitable to business requirement or not, and comparing it with alternative commercial software. On the basis of this analysis, the customer can decide whether or not to use open source software.

Duijnhouwer and Widdows (2003), has defined twelve indicators that are used to assess strengths and weaknesses of open source products. These are licensing, age, human hierarchies, selling points, developer community, modularity, collaboration with other products, standards, support, ease of deployment, user community, and market penetration. These indicators can provide the basis for determining factors that may contribute to the success of OSS projects.

Projects with a large number of developers participating in their development seem more successful (Crowston and Scozzi, 2002; Healy and Schussman, 2003). With more developers working on the project, problems are quickly fixed and the rate of software development is increased (Raymond, 1999).

Open source software projects run by professionals are more successful than those run by amateurs. Successful OSS projects should have professional developers whose professionalism can be assessed using the length of their practical experience and professional qualification (Healy and Schussman, 2003).

The OSS community is mostly comprised of user-developers, who have high software knowledge. An OSS project that targets user-developers, addresses their needs and solves their problems seems to be more successful (Crowston and Scozzi, 2002). As the users of the open source software are developers, therefore, its usefulness for them may be an important factor for its success (Stewart, Ammeter, and Maruping, 2005).

The selection of an open source license depicts the way in which users are approached and may affect the success of an OSS project (Duijnhouwer and Widdows, 2003). The people who initiate open source project select the license for the OSS project (Fershtman and Gandal, 2004). Most OSS projects use very restrictive and restrictive licenses (Lerner and Tirole 2002; O'Mahony 2003). The choice of restrictive license limits the possibilities of commercial use of the open source software. Developers with an idealistic approach or in need of recognition are more prone to contribute to projects with restrictive license. The choice of a less restrictive license increases the possibilities of commercial use and the chances of contribution of developers motivated by financial benefits (Comino, Manenti, and Parisi, 2005).

Fershtman and Gandal (2004) found that output per contributor of open source programs is much higher when licenses are less restrictive. The success of open source software was measured by the output per contributor. Comino, Manenti, and Parisi (2005) found that less restrictive the licensing terms the larger the likelihood of reaching an advanced development stage. License restrictiveness will be having negative effect on the popularity of open source software (Stewart, Ammeter, and Maruping, 2005).

For software, success can be gauged in various manners. From the developers' point of view, success might be an active project or one that successfully releases software. From the users' point of view, satisfaction with the software could be the measure of success. Commercially, success can be measured by the number of users (Crowston and Scozzi, 2002).

Conventional measures of project success are difficult to apply to OSS projects.

Traditionally, software product success is measured from the perspective of corporate users who purchase the software, whereas the success of OSS projects seems to depend on the continued contribution of volunteer developer (Crowston, Annabi, Howison, and Masango, 2004)

2.3 Software types

International Data Corporation (IDC) is a global market intelligence advisory firm with expertise in the information technology industry. IDC's software taxonomy represents a collectively exhaustive and mutually exclusive view of the worldwide software marketplace (Heiman and Byron, 2003). Table 2 shows the IDC software taxonomy. Peng (2004) used this for the categorization of Linux-based software products.

Table 2. Software taxonomy by IDC (2003)

Categories	Sub-categories
Applications	<ul style="list-style-type: none"> • Consumer software • Collaborative application • Content applications • Back-office application • Engineering applications • CRM and Sales and Marketing applications
Application development and deployment tools	<ul style="list-style-type: none"> • Information and Data management software • Application Design and construction software • Application life-cycle management software • Application deployment platforms • Middleware • Other development tools • Information access and delivery
System infrastructure software	<ul style="list-style-type: none"> • System management software • Network management • Security software • Storage software • Serverware • Networking software • System-level software

2.4 Lessons learned from the literature

This section provides the key lessons learned from the literature review.

Number of experienced designers and OSS project's success

OSS projects with a greater number of experienced developers seem more successful (Crowston and Scozzi, 2002). With more developers the software development rate is increased (Raymond, 1999). Successful OSS projects should have professional developers whose professionalism can be assessed by length of practical experience and professional qualification (Healy and Schussman, 2003).

Target market and OSS project's success

For product development success it is important to define its target market (Cooper and Kleinschmidt, 1987). Identifying users is critical for the success of product development (Brown and Eisenhardt, 1995). If the company understands the market place then chances of product success are higher (Storey and Easingwood, 1996). Successful products are more likely if they are designed and targeted at attractive markets (Brown and Eisenhardt, 1995).

The OSS community is mostly comprised of user-developers, who have high software knowledge. These user-developers could be the attractive market for OSS projects. OSS

projects that target these user-developers will be more successful (Crowston and Scozzi, 2002).

Type of software and project's success

Introducing a product that reduces customers' costs and solves their problem increases the likelihood that the product will be successful (Cooper and Kleinschmidt, 1987).

Provision of unique benefits to customers is critical for the success of new product development (Brown and Eisenhardt, 1995). The likelihood of product success increases if the product performs a unique task or solves an important problem the customer has (Cooper and Kleinschmidt, 1987).

The three main categories of the software are applications, application development and deployment tools, and system infrastructure software (Heiman and Byron, 2003). The OSS community is mostly composed of user-developers, who have high software knowledge. OSS projects that address needs and solve problems of this community will be more successful (Crowston and Scozzi, 2002). The community should be more interested in the software that will help them in software development i.e., application development and deployment tools.

Measures of project success

For most development projects customer satisfaction and customer acceptance are two of the best measures of customer-based success. The degree to which profit goals are met

may be an appropriate indicator of financial success. The degree to which a project provides a competitive advantage is the most useful indicator of performance-based success (Griffin and Page, 1996).

The success of a project is rarely measured using a single success measure. A number of measures are used (Cooper and Kleinschmidt, 1987). From the perspective of software developers, the success of a project may be measured in terms of the activity of the project or the number of times the software is released in a given period. From the perspective of a user, project success may be measured in terms of the frequency of use or satisfaction with the software (Crowston and Scozzi, 2002).

Traditionally, software product success is measured from the perspective of corporate users who purchase the software, whereas the success of OSS projects seems to depend on the continued contribution of volunteer developers (Crowston, Annabi, Howison, and Masango, 2004).

Lack of empirical research on OSS success

Most of the studies on open source are case based and focus on a small number of glamorous and successful projects. Empirical studies of the factors that contribute to success are lacking (Comino, Manenti, and Parisi, 2005; Koch, 2004).

3. HYPOTHESES

This chapter is comprised of two sections. In section 3.1 the hypotheses to be tested are developed. Section 3.2 provides a list of the hypotheses developed.

3.1 Hypotheses development

In this section, six hypotheses are developed. For the purpose of this research, the success of an OSS project is measured using two indicators, number of downloads and number of releases of new software versions. The use of these two indicators as measures of success is the result of an on-line survey conducted by the researcher. The purpose of the survey was to figure out the success measures for OSS projects. Two hundred projects were randomly selected from www.sourceforge.net and three developers per project were sent emails asking, “How you would measure the success of an OSS project”. The same question was also asked to 100 of the 156 developers listed on www.fsf.org as having contributed to the GNU project.

Of the 700 developers to which emails were sent, 70 replied. The majority of the 70 replies indicated that the success of an open source project can be measured using: number of downloads and number of releases.

3.1.1 Number of OSS developers

Developers contribute to open source projects by concurrently writing, testing and debugging software (Zhao and Elbaum, 2003). The larger the number of developers examining the code may result in the finding of a greater number of bugs. This may accelerate the rate at which the software is completed (Raymond, 1999). Open source projects with a greater number of developers contributing to it; seem more successful (Crowston and Scozzi, 2002).

A mature OSS development project has a very large developer community contributing to it and the procedure for becoming a member of this community is documented (Duijnhouwer and Widdows, 2003). The saying ‘many hands make light work’ certainly holds true when dealing with an open source project. The greater the number of developers actively contributing to the OSS project, the smaller the likelihood that the OSS project will stall (Duijnhouwer and Widdows, 2003). Therefore,

Hypothesis 1. Number of developers is positively associated with the success of OSS projects.

The complementary hypotheses are:

Hypothesis 1a. Number of developers is positively associated with the number of downloads of OSS projects.

Hypothesis 1b. Number of developers is positively associated with the number of releases of OSS projects

3.1.2 Experience of OSS developers

When competent people undertake product development activities, the likelihood of product success increases (Brown and Eisenhardt, 1995). The skills of employees are vital for new product success (Storey and Easingwood, 1996). Competent individuals are reassigned to new projects (Johns and Snelson, 1988).

Capable, motivated and experienced teams are crucial for project success in software development (Krishnan, 1998; Carmel and Sawyer, 1998; Curtis et al., 1988). Greater years of experience in the specific software domain help programmers to fix bugs earlier (Krishnan, 1998; Curtis, 1981).

The performance of programmers in software tasks depends upon their years of experience (Krishnan, 1998). Experienced software development teams are more familiar with the programming language used in OSS projects. This results in lower numbers of defects (Krishnan, 1998).

An OSS project needs developers who have the competencies required to develop the software. For OSS projects, the main competencies needed are the design and programming skills possessed by the developers who contribute to the project. Each developer should master particular programming languages, operating systems or

programming environments and have developed experience in software applications (Crowston and Scozzi, 2002). Most contributors of OSS projects are experienced and professional programmers (Lakhani, Wolf, Bates, and DiBona, 2002). Experience of developers contributes to the success of OSS projects as well as conventional product development projects (Healy and Schussman, 2003). Therefore,

Hypothesis 2. Experience of developers is positively associated with the success of OSS projects.

The complementary hypotheses are:

Hypothesis 2a. Experience of developers is positively associated with the number of downloads of OSS projects.

Hypothesis 2b. Experience of developers is positively associated with the number of releases of OSS projects.

3.1.3 Target users

Fit with market needs is a characteristic of successful products (Brown and Eisenhardt, 19995; Cooper and Kleinschmidt, 1987). Product success is more likely if developers understand the market place and product specifications (Story et al., 2000). Product success is also more likely if the customer understands the product offering (Storey and Easingwood, 1996).

A large number of successful open source software addresses the needs of users who are also developers. It is difficult to find successful OSS projects that address the needs of unsophisticated users (Comino, Manenti, and Parisi, 2005). The communities of successful open source projects are comprised mostly of user-developers, who have high software knowledge. It is surmised that OSS projects that target users who are developers will be more successful (Crowston and Scozzi, 2002). Therefore,

Hypothesis 3. Targeting developers as users is positively associated with the success of OSS projects.

The complementary hypotheses are:

Hypothesis 3a. Targeting developers as users is positively associated with the number of downloads of OSS projects.

Hypothesis 3b. Targeting developers as users is positively associated with the number of releases of OSS projects.

3.1.4 Programming language type used to develop OSS

The programming language type used in an OSS project is an important feature of the project. The community that contributes to an OSS project may prefer the use of widely known programming languages—programming languages for which the competency of

writing a program is widely available. Thus, OSS projects that use languages that are widely used may be more successful (Crowston and Scozzi, 2002). Therefore,

Hypothesis 4. Using a commonly used programming language is positively associated with the success of OSS projects.

The complementary hypotheses are:

Hypothesis 4a. Using a commonly used programming language is positively associated with the number of downloads of OSS projects.

Hypothesis 4b. Using a commonly used programming language is positively associated with the number of releases of OSS project.

3.1.5 Type of OSS

Software can be organized into three main categories: applications, application development and deployment tools, and system infrastructure software (Heiman and Byron, 2003). The OSS community is mostly comprised of user-developers. OSS projects that address developers' needs and solve developers' problems may be more successful (Crowston and Scozzi, 2002). Code availability allows developers to modify the tools produced by OSS projects and make them fit their needs. Thus, OSS projects that develop application development and deployment tools may be more successful than OSS projects that develop applications and system infrastructure software. Therefore,

Hypothesis 5. Development of application development and deployment tools is positively associated with the success of OSS projects.

The complementary hypotheses are:

Hypothesis 5a Development of application development and deployment tools is positively associated with the number of downloads of OSS projects.

Hypothesis 5b Development of application development and deployment tools is positively associated with the number of releases of OSS projects.

3.1.6 Type of OSS license

License restrictiveness will be having negative effect on the popularity of open source software (Stewart, Ammeter, and Maruping, 2005). The type of license under which the OSS is released may affect the success of the OSS project (Fershtman and Gandal, 2004; Duijnhouwer and Widdows, 2003).

Fershtman and Gandal (2004) found that the output per contributor of open source programs is much higher for software licenses that are less restrictive. Comino, Manenti, and Parisi (2005) found that the less restrictive the licensing terms are the larger the likelihood of the OSS project reaching an advanced development status. License restrictiveness will be having negative effect on the popularity of open source software (Stewart, Ammeter, and Maruping, 2005). Therefore,

Hypothesis 6. Use of non-restrictive OSS licenses is positively associated with the success of OSS projects.

The complementary hypotheses are:

Hypothesis 6a Use of non-restrictive OSS license is positively associated with the number of downloads of OSS projects.

Hypothesis 6b Use of non-restrictive OSS license is positively associated with the number of releases of OSS projects.

3.2 List of hypotheses

This section lists the six hypotheses developed in section 3.1:

Hypothesis 1. Number of developers is positively associated with the success of OSS projects.

Hypothesis 2. Experience of developers is positively associated with the success of OSS projects.

Hypothesis 3. Targeting developers as users is positively associated with the success of OSS projects.

Hypothesis 4. Using a commonly used programming language is positively associated with the success of OSS projects.

Hypothesis 5. Development of application development and deployment tools is positively associated with the success of OSS projects.

Hypothesis 6. Use of non-restrictive OSS license is positively associated with the success of OSS projects.

4. RESEARCH METHOD

4.1 Unit of analysis

The unit of analysis is an OSS project.

4.2 Sample selection

The sample was drawn from a list of 100,341 OSS projects registered on the Sourceforge OSS project database (www.sourceforge.net) as of June 20, 2005. Convenience sampling technique was used. Sourceforge is the largest repository of OSS projects available on the Internet. It provides hosting services for project developers, allowing them to manage their source code, communicate with one another (via email, mailing lists and discussion forums), and make their work available for download. Although developers are located all over the world, Sourceforge's servers are where the day-to-day interaction and innovation actually happens for a very large numbers of OSS projects.

4.3 Study period

The data was collected between June 2005 and October 2005.

4.4 Data collection

The data was collected from the Sourceforge OSS project database (www.sourceforge.net).

4.5 Variable definition

4.5.1 Number of developers

For each project, the number of developers was measured by counting the number of developers contributing to the development of the OSS as of the date shown in Appendix A. The project's summary page was used to obtain the information required to calculate number of developers.

4.5.2 Experience of developers

Experience of developers was measured as the sum of the years of experience of the developers contributing to the development of the OSS as of the date shown in Appendix A. The developers' info page was used to obtain the information required to calculate experience of developers.

4.5.3 Type of target users

Target users are the users for which the OSS is developed. Type of target users is a categorical variable. For this research, three types of target users were used: developers, system administrators, and end-users.

The variable Type of target users was measured on a nominal scale with values:

1 = developers

2 = system administrators

3 = end-users

The OSS project's summary page indicates whether the project is intended for developers, system administrators or end-users. For example, the summary page of the "Slickworm" project states that the users the project targets are end-users. Therefore, the researcher assigned the Type of target users variable a value of 3.

4.5.4 Type of programming language

Programming language is the language developers that contribute to the OSS project used to write code. Type of programming language is a categorical variable. For this research, two types of programming language are defined: i. Commonly used programming languages and ii. Others.

Commonly used programming languages include C, C++, Java, and PHP. The competency for writing a program in these languages is widely available.

Others included programming languages other than C, C++, Java, and PHP.

The type of programming language was measured using a nominal scale with values:

1 = commonly used programming languages

2 = others

The OSS projects' summary pages were used to obtain the information that identifies the programming language type used in the OSS project. For example, the summary page of the "Security Policy Manager" project states that the programming language used is C++. C++ is a commonly used programming language type. Therefore, the researcher assigned a value of 1 to the variable Type of programming language.

4.5.5 Type of software

Type of software is a categorical variable. For this research, software is categorized using the IDC software taxonomy (Heiman and Byron, 2003) into three major types: application software, application development and deployment tools, and system infrastructure software

Type of software was measured on a nominal scale with values:

1 = application software

2 = application development and deployment tools

3 = system infrastructure software

The OSS projects' home pages and summary pages were used to obtain information on the type of software developed. For example, the home page of the "Scintilla" project states that Scintilla is a free source code-editing component. As well as features found in standard text editing components, Scintilla includes features especially useful when editing and debugging source code such as support for syntax styling, error indicators, code completion and call tips. Therefore, the software produced by the Scintilla project

was categorized as an application development and deployment tool. The researcher assigned a value of 2 to the variable Type of software.

4.5.6 Type of license

Type of license is a categorical variable. For this research, OSS licenses are categorized into the three categories defined by Fershtman and Gandal (2004) and Lerner and Tirole (2005): very restrictive, moderately restrictive, and non-restrictive licenses.

Very restrictive licenses include: GNU General Public License (GPL).

Moderately restrictive licenses include: GNU Lesser GPL (LGPL), Apple Public Source License 1.2, Common Public Source License, Eiffel Forum License, IBM Public License 1.0, Jabber OSL, Motosoto License, Mozilla Public License 1.0 & 1.1, Nethack Public License, Nokia OSL, Qt Public License, Recoh Source Code License, Sleepycat License, and Sun Public license.

Non restrictive licenses include: Berkeley Software Distribution (BSD) license, Apache Software License, Artistic license, Intel OSL, MIT License, Open Group Test Suite License, Python (CNRI) License, Python Software foundation License, Sun Industry Standards Source License, University of Illinois/NCSA OSL, Vovida Software License 1.0, W3C License, X.Net License, Zope Public License 2.0, zlib/libpng License, and Public Domain License.

The type of license variable was measured using a nominal scale with values:

1 = very restrictive licenses

2 = moderately restrictive licenses

3 = nonrestrictive licenses

The OSS projects' summary pages were used to obtain the information for the type of license variable. For example, the summary page of the "Scintilla" project states that the type of license under which the code was released is the Python (CNRI) License, a license categorized as a non-restrictive license. Therefore, the researcher assigned the value 3 to the Type of license variable.

4.5.7 Success

To identify the measures of success for OSS projects, the researcher conducted an online survey. Two hundred projects were randomly selected from www.sourceforge.net and three developers per project were sent emails asking them the following question: "How you would measure the success of an OSS project?" The same question was also asked to 100 of the 156 developers listed on www.fsf.org as having contributed to the GNU project. Out of the 700 people to whom emails were sent, 70 replied.

Twenty-eight respondents said that they would measure the success of an OSS project by counting the number of its users. Thirty two respondents said that the number of downloads is a reasonable proxy of success because it is an indicator of interest showed

by users, user base, user satisfaction, number of users, and popularity of an OSS project. Nine respondents said that the release of a new version of an OSS project could be used as the measure of success. Maturity and stability, goal accomplishment, quality of code, page views, and need fulfillment were measure of success according to one or two developers.

The result of this on line survey suggested that a majority of the respondents supported the use of number of users, number of downloads, and number of releases as indicators of the success of OSS projects.

Number of downloads

Number of downloads was used as a proxy measure for the success of OSS projects. The OSS projects' statistics pages were used to obtain the number of downloads as of the dates shown in Appendix A.

Number of releases

Number of releases was used as a proxy measure of success of OSS projects. The OSS projects' summary pages were used to obtain the number of downloads as of the dates shown in Appendix A.

Each of the above success measures of OSS development projects has good face validity, in the sense that an OSS development project that many users download and has greater

number of releases does seem like it deserves to be described as a success (Crowston, Annabi, and Howison, 2003).

4.5.8 Development status

Development status provides information about the maturity of OSS projects.

Sourceforge specifies six development statuses for OSS projects: 1. planning, 2. pre-alpha, 3. alpha, 4. beta, 5. production/stable, and 6. mature. Each project registered on Sourceforge is classified into one of these six statuses. Its developers themselves report the development status of the OSS project. No formal definitions of these development statuses are available on Sourceforge (Comino, Manenti, and Parisi, 2005).

For this research the development status was measured using a nominal scale with values:

1 = 1. planning

2 = 2. pre-alpha

3 = 3. alpha

4 = 4. beta

5 = 5. production

6 = 6. mature

The OSS projects' summary pages were used to obtain the information for the development status variable. For example, the summary page of the "Scintilla" project

states that the development status of this project is production. Therefore, the researcher assigned the value 5 to the Development status variable.

4.6 Measurement of variables

Table 3 provides a summary of how the variables used in this research were measured.

Table 3. Measurement of variables

Variable	Measurement
Number of developers	Number of developers taking part in the development of the OSS project
Experience of developers	Total years of experience of the developers taking part in the development of the OSS project
Type of target users	Categorical variable measured on a nominal scale with values: 1 = developers 2 = system administrators 3 = end-users

Type of programming language	Categorical variable measured on a nominal scale with values: 1 = common programming languages (C, C++, Java, and PHP) 2 = others
Type of software	Categorical variable measured on a nominal scale with values: 1 = application software 2 = application development and deployment tools 3 = system infrastructure software
Type of OSS license	Categorical variable measured on a nominal scale with values: 1 = very restrictive license 2 = moderately restrictive license 3 = nonrestrictive license
Number of downloads	Total number of downloads from the start of the OSS development project to the date of data collection.
Number of releases	Total number of releases from the start of the OSS development project to the date of data collection.

Development status	Categorical variable measured on a nominal scale with values: 1 = planning 2 = pre-alpha 3 = alpha 4 = beta 5 = production 6 = mature
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4.7 Data analysis

To analyze the data, the SPSS software was used. First, bar graphs showing the OSS development projects by the type of target user, type of programming language used, type of software developed, type of licenses under which code is released and by their development status were produced.

Then the data was examined using a five-step procedure. In the first step, the histograms with normality curve of dependent variables: number of downloads and number of releases were drawn to examine how closely the data were Normally distributed. The descriptive statistics for these variables were also calculated. To decide whether or not a variable was Normally distributed, its Kurtosis and Skewness statistics were examined. A variable was deemed to be Normally distributed if its Skewness was within two times the standard error of the Skewness statistic and its Kurtosis was within -2 and +2.

In the second step, quad root transformations were used to transform the variables that were not Normally distributed. The intent was to provide distributions with the characteristics of a Normal distribution.

In the third step, the Multivariate General Linear Model (GLM) was used to explore the relationship between the factors expected to contribute to the success of an OSS project (number of developers, experience of developers, type of target users, type of programming language used, type of OSS developed and type of OSS license) and two proxies for success of OSS projects: number of downloads and number of releases.

In the fourth step, computing the Levene test checked the equality of variance for categorical variables.

Finally, in the fifth step, the six hypotheses were tested. The remainder of this section describes how each Hypothesis was tested.

Hypothesis 1. Number of developers is positively associated with the success of OSS projects

Spearman correlations were used to test hypotheses 1a and 1b. This test was used because the independent variable (number of developers) and the two dependent variables (number of downloads and number of releases) are quantitative variables.

Hypothesis 2. Experience of developers is positively associated with the success of OSS projects

Spearman correlations were used to test Hypothesis 2a and 2b. This test was used because the independent variable (experience of developers) and the two dependent variables (number of downloads and number of releases) are quantitative variables.

Hypothesis 3. Targeting developers as users is positively associated with the success of OSS projects

The Welch and Brown-Forsythe robust F tests were used to test Hypothesis 3a and One-Way ANOVA test was used to test Hypothesis 3b. These tests were used because the independent variable (type of target users) is a categorical variable measured on a nominal scale and the two dependent variables (number of downloads, and number of releases) are quantitative variables.

Hypothesis 4. Using a commonly used programming language is positively associated with the success of OSS projects

The One-way ANOVA was used to test Hypothesis 4a and Welch and Brown-Forsythe robust F tests were used to test Hypothesis 4b. These test were used because the independent variable (type of programming language) is a categorical variable and the two dependent variables (number of downloads and number of releases) are quantitative variables.

Hypothesis 5. Development of application development and deployment tools is positively associated with the success of OSS projects

The One-Way ANOVA test was used to test Hypothesis 5a and 5b. The test was used because the independent variable (type of software) is a categorical variable and the two dependent variables (number of downloads and number of releases) are quantitative variables.

Hypothesis 6. Use of non-restrictive OSS licenses is positively associated with the success of OSS projects

Welch and Brown-Forsythe robust F test were used to test Hypothesis 6a and One-way ANOVA test was used to test Hypothesis 6b. These tests were used because the independent variable (type of license) is a categorical variable and the two dependent variables (number of downloads and number of releases) are quantitative variables.

5. RESULTS

This chapter has eleven sections. The first section describes the sample. The second section provides the descriptive statistics. The third section provides the results of testing the hypotheses using the Multivariate General Linear model. Sections four through nine examine the hypothesis one at a time. The tenth section summarizes the results obtained when testing the six hypotheses. Finally, the eleventh section provides the results obtained when testing the six hypotheses using a sub sample of OSS projects that have a production and stable development status.

5.1 Sample

The sample was comprised of 350 OSS projects. The sample was drawn from a list of 100,341 OSS projects registered with the Sourceforge OSS project database (www.sourceforge.net) as of June 20, 2005. Convenience sampling technique was used. The data was collected between June 2005 and October 2005. Appendix A shows the OSS projects included in the sample.

Figure 1 provides a bar graph of the OSS projects in the sample by type of target users. Of the 350 projects in the sample, 134 (38 %) targeted end users.

Figure 1. OSS projects by type of target user

Figure 2 provides a bar graph of the OSS projects in the sample by type of programming language used. Of the 350 projects, 252 (72%) used C, C++, Java, and PHP. The category called other included the following programming languages: ActionScript, Ada, APL, Applescript, ASP, AspectJ, ASP.NET, Assembly, AWK, BASIC, C#, COBOL,

Figure 2. OSS projects by type of programming language

Cold Fusion, Common Lisp, D, Delphi/Kylix, Dylan, Eiffel, Emacs-Lisp, Erlang, Euler, Euphoria, Forth, Fortran, Groovy, Haskell, IDL, JSP, LabVIEW, Lisp, Logo, LPC, Lua, MATLAB, Modula, MUMPS, Oberon, Objective C, Object Pascal, OCaml, Pascal, Perl, Pike, PL/SQL, PROGRESS, Prolog, Python, REALbasic, REBOL, Rexx, Ruby, Scheme, Simula, Simulink, Smalltalk, S/R, Standard ML, Tcl, Unix Shell, VBScript, Visual Basic, Visual Basic.Net, Visual FoxPro, XBasic, Yacc, and Zope

Figure 3 provides a bar graph of the OSS projects in the sample by type of software developed. Of the 350 projects in the sample, 129 (40 %) were application software.

Figure 3. OSS projects by type of software developed

Figure 4 provides a bar graph of the OSS projects in the sample by type of license used. Of the 350 projects, 204 (58%) used very restrictive OSS licenses.

Figure 4. OSS projects by the type of license used

Figure 5 provides a bar graph of the OSS projects in the sample by their development status. Of the 350 projects in the sample, 76 (22%) held a production/stable development status and 71 (20%) held a beta development status.

Figure 5. OSS projects by their development status

5.2 Descriptive statistics

Table 4 provides descriptive statistics of the two dependent variables used in this research: number of downloads and number of releases. To decide whether or not a variable was Normally distributed, its Kurtosis and Skewness statistics were examined. A variable was considered to be Normally distributed when its Skewness was within 2 times the standard error of the Skewness statistic and Kurtosis was within -2 and +2.

Table 4. Descriptive statistics of dependent variables

(Sample size = 350)

	Min	Max	Mean	Std. deviation	Skewness (Std. error .130)	Kurtosis (Std. error .260)	Normally distributed
Number of downloads	1	7744989	122764.89	594729.84	8.74	92.25	No
Number of releases	1	307	14.51	25.60	5.84	52.38	No

For each variable in Table 4, the Skewness is greater than twice the standard error and the Kurtosis is outside of the -2 to +2 range. Results in Table 4 indicate that Number of downloads and Number of releases are not Normally distributed.

Figures 6 and 7 provide histograms of the two dependent variables. The figures also suggest that the two variables are not Normally distributed.

Figure 6. Histogram: Number of downloads

Figure 7. Histogram: Number of releases

Quad root transformations were used in an attempt to generate Normally distributed variables. Table 5 provides descriptive statistics for the transformed variables (identified by adding a 'QRT' in parentheses after the name of the variable).

Table 5. Descriptive statistics of dependent variables with transformations
(Sample size = 350)

	Min	Max	Mean	Std. deviation	Skewness (Std. error .130)	Kurtosis (Std. error .260)	Normally distributed
Number of downloads (QRT)	1.50	53.25	10.58	7.90	2.06	5.79	No
Number of releases (QRT)	1.50	4.69	2.17	.56	.876	1.01	Yes

The results in Table 5 suggest that the conditions for normality are improved after the quad transformation. The data for the square root of the number of downloads is close to being Normally distributed. For this variable, the Skewness is not much greater than twice the standard error. However, the Kurtosis is outside the -2 to $+2$ range. The data for the square root of number of releases is Normally distributed. The skewness is less than twice the standard error and the Kurtosis is within the -2 to $+2$ range.

Figures 8 and 9 provide the histograms of the transformed dependent variables.

Figure 8. Histogram: Number of downloads (QRT)

Figure 9. Histogram: Number of releases (QRT)

5.3 Multivariate General Linear Model (GLM)

Multivariate GLM was used to explore the relationship between the factors assumed to contribute to the OSS project's success and the two measures of OSS project success.

Prior to using the multivariate GLM to examine the data, the researcher first checked the homogeneity of the variance, homogeneity of the covariance, and the homogeneity of regression.

Levene's test was used to check for the homogeneity of variance. This test assesses whether or not the variance of the number of downloads and number of releases is homogeneous across the target users types, programming language types, software types, and types of license.

Box's M test was used to check for the homogeneity of covariance. This test assesses whether or not the covariance between number of downloads and number of releases is similar across the target users types, programming language types, software types, and types of license.

Homogeneity of regression is a test that assesses whether or not the coefficients (slopes of regression lines) of number of developers and experience of developers are the same for target users types, programming language types, software types, and types of license. Effects of interactions between number of developers, experience of developers and target users type, programming language type, software type, type of license, development status on number of downloads and number of releases were observed.

Table 6 provides the results of the Levene's test.

Table 6. Levene's test for homogeneity of variances for number of downloads and number of releases across target users types, programming language types, software types, types of license, and development status

(Sample size = 350)

	Levene statistic	df1	df2
Number of downloads (QRT)	1.162 .275	24	325
Number of releases (QRT)	1.001 .465	24	325

* p < 0.10

** p < 0.05

*** p < 0.01

The results of Table 6 indicate that the Levene statistic is not significant for number of downloads and number of releases. Therefore, the variance of the number of downloads and number of releases is equal across target user types, programming language types, software types, and license types.

The assumption of homogeneity of variances is met for the number of downloads and number of releases.

Table 7 provides the result of the Box's M test.

Table 7. Box's M test for homogeneity of covariance between number of downloads and number of releases across target users types, programming language types, software types, types of license, and development status

(Sample size = 350)

Box's M	F	df1	df2
171.569(***) .000	3.218(***) .000	48	4581.81

* p < 0.10

** p < 0.05

*** p < 0.01

The results of Table 7 indicate that the Box's M and F statistics are significant (at $p < 0.01$). Therefore, the covariance between number of downloads and number of releases is not equal across target users types, programming language types, software types, and license types.

The assumption of homogeneity of covariances between the number of downloads and the number of releases is not met. However, GLM is relatively robust against the violation of this assumption when the groups are of not very unequal sample size and the sample size is adequate. Further SPSS adjusts automatically for unequal group sizes.

Table 8 provides the results of the effects of the interactions between the number of developers, years of experience of developers and target user type, programming language type, software type, license type on number of downloads and number of releases.

Table 8. Interaction effects between number of downloads, number of releases and target users type, programming language type, software type, license type, development status on number of downloads and number of releases

(Sample size = 350)

Effect		Value	F	Hypothesis df	Error df	Partial Eta squared coefficient	Observed power
Target users type*Number of developers	Pillai's trace	.003	.232 (.920)	4	646	.001	.175
	Wilk's lambda	.997	.231 (.921)	4	644	.001	.175
	Hotelling's trace	.003	.231 (.921)	4	642	.001	.175
	Roy's largest root	.002	.384 (.682)	2	323	.001	.189
Target users type*Experience of developers	Pillai's trace	.001	.048 (.996)	4	646	.000	.115
	Wilk's lambda	.999	.048 (.996)	4	644	.000	.115
	Hotelling's trace	.001	.048 (.996)	4	642	.000	.115
	Roy's largest root	.001	.092 (.912)	2	323	.001	.121
Programming language type*Number of	Pillai's trace	.006	.936 (.393)	2	322	.006	.318

developers	Wilk's lambda	.994	.936 (.393)	2	322	.006	.318
	Hotelling's trace	.006	.936 (.393)	2	322	.006	.318
	Roy's largest root	.006	.936 (.393)	2	322	.006	.318
Programming language type*Experience of developers	Pillai's trace	.007	1.249 (.288)	2	322	.007	.388
	Wilk's lambda	.993	1.249 (.288)	2	322	.007	.388
	Hotelling's trace	.008	1.249 (.288)	2	322	.007	.388
	Roy's largest root	.008	1.249 (.288)	2	322	.007	.388
Software type*Number of developers	Pillai's trace	.002	.126 (.973)	4	646	.001	.140
	Wilk's lambda	.998	.126 (.973)	4	644	.001	.140
	Hotelling's trace	.002	.126 (.973)	4	642	.001	.140
	Roy's largest root	.002	.253 (.777)	2	323	.002	.159
Software type*Experience of developers	Pillai's trace	.002	.160 (.958)	4	646	.001	.151

	Wilk's lambda	.998	.160 (.958)	4	644	.001	.151
	Hotelling's trace	.002	.160 (.958)	4	642	.001	.151
	Roy's largest root	.002	.291 (.748)	2	323	.002	.168
Type of license*Number of developers	Pillai's trace	.022	1.848 .118	4	646	.011	.684
	Wilk's lambda	.978	1.849 .118	4	644	.011	.684
	Hotelling's trace	.022	1.849 .118	4	642	.011	.684
	Roy's largest root	.022	3.286 .109	2	323	.019	.736
Type of license*Experienc e of developers	Pillai's trace	.016	1.327 .258	4	646	.008	.545
	Wilk's lambda	.984	1.328 .258	4	644	.008	.546
	Hotelling's trace	.016	1.329 .258	4	642	.008	.546
	Roy's largest root	.016	2.616 .175	2	323	.015	.644
Development status*Number of developers	Pillai's trace	.011	.897 .465	10	646	.006	.407

	Wilk's lambda	.989	.897 .465	10	644	.006	.407
	Hotelling's trace	.011	.897 .465	10	642	.006	.407
	Roy's largest root	.011	1.774 .171	5	323	.011	.497
Development status*Experience of developers	Pillai's trace	.027	.882 .550	10	646	.013	.603
	Wilk's lambda	.973	.881 .551	10	644	.013	.603
	Hotelling's trace	.075	.880 .552	10	642	.014	.602
	Roy's largest root	.021	1.357 .240	5	323	.021	.607

* p < 0.10

** p < 0.05

*** p < 0.01

The results shown in Table 8 indicate that the interaction effects between number of developers, experience of developers and type of target users, programming language type, software type, type of license, development status on number of downloads and number of releases are not significant because the values of Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant. Furthermore the observed power is also less, which should be closer to 1 for significance. Therefore, the coefficients (slopes of regression lines) of number of developers and experience of developers are the same for target user types, programming language types,

software types, license types, and development status. Hence, the assumption of homogeneity of regression is met.

Table 9 provides the results of using the multivariate GLM to examine the data. The effect of all independent variables: number of developers, experience of developers, target users type, programming language type, software type, type of license, and development status were observed simultaneously on the two dependent variables: number of downloads and number of releases. Pillai's trace, Wilk's lambda, Hotelling's trace, and Roy's largest root tests were used to assess the strength of the relationships.

Table 9. Multivariate GLM tests
(Sample size = 350)

Effect		Value	F	Hypothesis df	Error df	Partial Eta squared coefficient	Observed power
Intercept	Pillai's trace	.924	2048.35(***) (.000)	2	336	.924	1
	Wilk's lambda	.076	2048.35(***) (.000)	2	336	.924	1
	Hotelling's trace	12.193	2048.35(***) (.000)	2	336	.924	1
	Roy's largest root	12.193	2048.35(***) (.000)	2	336	.924	1

Number of developers	Pillai's trace	.019	3.27(**) (.039)	2	334	.019	.734
	Wilk's lambda	.971	3.27(**) (.039)	2	334	.019	.734
	Hotelling's trace	.020	3.27(**) (.039)	2	334	.019	.734
	Roy's largest root	.020	3.27(**) (.039)	2	334	.019	.734
Experience of developers	Pillai's trace	.023	3.63(**) (.018)	2	334	.021	.860
	Wilk's lambda	.969	3.63(**) (.018)	2	334	.021	.860
	Hotelling's trace	.023	3.63(**) (.018)	2	334	.021	.860
	Roy's largest root	.023	3.63(**) (.018)	2	334	.021	.860
Target users type	Pillai's trace	.029	2.43(**) (.047)	4	670	.014	.720
	Wilk's lambda	.972	2.43(**) (.047)	4	668	.014	.720
	Hotelling's trace	.029	2.43(**) (.047)	4	666	.014	.720
	Roy's largest root	.020	3.31(**) (.038)	2	335	.019	.737

Programming language type	Pillai's trace	.010	1.66 (.192)	2	334	.010	.474
	Wilk's lambda	.990	1.66 (.192)	2	334	.010	.474
	Hotelling's trace	.010	1.66 (.192)	2	334	.010	.474
	Roy's largest root	.010	1.66 (.192)	2	334	.010	.474
Software type	Pillai's trace	.040	3.45(***) (.009)	4	670	.022	.917
	Wilk's lambda	.960	3.45(***) (.009)	4	668	.022	.917
	Hotelling's trace	.042	3.45(***) (.009)	4	666	.022	.917
	Roy's largest root	.039	6.45(**8) (.002)	2	335	.026	.947
Type of license	Pillai's trace	.021	1.810 (.125)	4	670	.011	.675
	Wilk's lambda	.980	1.813 (.125)	4	668	.011	.675
	Hotelling's trace	.022	1.815 (.124)	4	666	.011	.676
	Roy's largest root	.021	1.913 (.114)	2	335	.012	.690

Development status	Pillai's trace	.343	13.89 .000(***)	10	670	.182	1
	Wilk's lambda	.665	15.13 .000(***)	10	668	.185	1
	Hotelling's trace	.492	16.37 .000(***)	10	666	.187	1
	Roy's largest root	.465	31.16 .000(***)	5	335	.317	1

* p < 0.10

** p < 0.05

*** p < 0.01

The results of Table 9 indicate the following.

- The effect of number of developers on number of downloads and number of releases is significant because the Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are significant (at $p < 0.05$) with coefficient .019 and observed power equal to 0.734.
- The effect of experience of developers on number of downloads and number of releases is significant because the Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are significant (at $p < 0.05$) with coefficient .021 and observed power equal to 0.860.
- The effect of target users type on number of downloads and number of releases is significant because the Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant (at $p < 0.05$) with coefficient .014 and observed power equal to 0.720. Roy's largest root and its F statistic is significant (at $p <$

0.05) with coefficient .019 and observed power equal to 0.737. Due to the significance of F statistics the null Hypothesis that average number of downloads and releases are the same for all types of targeted users can be rejected.

- The effect of programming language type on number of downloads and number of releases is not significant because the Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant. Therefore, the null Hypothesis that average number of downloads and releases are the same for all types of programming languages cannot be rejected.
- The effect of software type on number of downloads and number of releases is significant because the Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant (at $p < 0.01$) with coefficient .022 and observed power equal to 0.917. Roy's largest root and its F statistic is significant (at $p < 0.05$) with coefficient .026 and observed power equal to 0.947. Due to the significance of F statistics the null Hypothesis that average number of downloads and releases is the same for all types of software can be rejected.
- The effect of type of license on number of downloads and number of releases is not significant because the Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant. Therefore, the null Hypothesis that average number of downloads and releases are the same for all types of license cannot be rejected.
- The effect development status on number of downloads and number of releases is significant because the Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant (at $p < 0.01$) with coefficient .18 and observed

power equal to 1. Roy's largest root and its F statistic is significant (at $p < 0.01$) with coefficient .317 and observed power equal to 1.

Results in Table 9 suggest that the number of developers, experience of developers, target users type, software type and development status significantly affect number of downloads and number of releases. However, programming language type and license type used did not significantly affect number of downloads and number of releases.

The Partial Eta square coefficient estimates the effect size of an independent variable on the dependent variable. Ranking the five independent variables that significantly affect the dependent variables using their Partial Eta squared coefficients shown in Table 9, provides the following results: 1. development status (.182 to .317), 2. software type (0.022), 3. experience of developers (0.021), 4. number of developers (0.019) and 5. targeting developers as users (0.014).

The ranking above suggests that:

- the effect of development status on number of downloads and number of releases is significant
- software type, experience of developers, and number of developers affect number of downloads and number of releases more than targeting developers as users

Table 10 provides multiple comparison results of the Bonferroni test. It was used to compare average number of downloads across the types of target users because it assumes equal variances. Results shown in Table 10 indicate that the average number of downloads is greater if the target users of the OSS project are developers instead of system administrators and end users. The results are significant at $p < 0.05$. However, the difference between average number of downloads is not significant when target users of the OSS projects are either system administrators or end users.

Table 11 provides multiple comparison results of the Bonferroni test. It was used to compare average number of releases across the types of target users because it assumes equal variances.

Results of Table 11 indicate that average number of releases is greater if the target users of the OSS project are developers instead of system administrators and end users. The results are significant at $p < 0.01$. Moreover, the average number of releases is greater if the target users of the OSS software project are system administrators instead of end users. The results are significant at $p < 0.05$.

Table 10. Multiple comparisons of average number of downloads across types of target users

(Sample size = 350)

Number of downloads (QRT)

(I) Target users type	Mean	(J) Target users type	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Developers	12.2315	System administrators	2.4035(*) .075	.1214	4.6855
		End users	2.3861(**) .050	.2232	4.5490
System administrators	9.8280	Developers	-2.4035(*) .075	-4.6855	-.1214
		End users	-.0174 (1.000)	-2.1913	2.1566
End users	9.8454	Developers	-2.3861(**) .050	-4.5490	-.2232
		System administrators	.0174 (1.000)	-2.1566	2.1913

* p < 0.10

** p < 0.05

*** p < 0.01

Table 11. Multiple comparisons of average number of releases across types of target users

(Sample size = 350)

Number of releases (QRT)

(I) Target users type	Mean	(J) Target users type	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Developers	2.3992	System administrators	.2352(***) .004	.0791	.3914
		End users	.4047(***) .000	.2567	.5527
System administrators	2.1639	Developers	-.2352(***) .004	-.3914	-.0791
		End users	.1694(**) .046	.0207	.3182
End users	1.9945	Developers	-.4047(***) .000	-.5527	-.2567
		System administrators	-.1694(**) .046	-.3182	-.0207

* p < 0.10

** p < 0.05

*** p < 0.01

Table 12 provides multiple comparison results of Bonferroni test. It was used to compare average number of downloads across the types of software because it assumes equal variances.

The results shown in Table 12 indicate that the average number of downloads is greater if the application development and deployment tools are developed instead of system infrastructure software and application software. The results are significant at $p < 0.01$. However, the difference between average number of downloads is not significant when the type of OSS software is either system infrastructure software or application software.

Table 12. Multiple comparisons of average number of downloads across types of software

(Sample size = 350)

Number of downloads (QRT)

(I) Type of software	Mean	(J) Type of software	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Application software	9.3579	Application development and deployment tools	- 3.0662(***) .008	-5.2402	-.8922
		System infrastructure software	-.8448 1.000	-3.0029	1.3134
Application development and deployment tools	12.4242	Application software	3.0662(***) .008	.8922	5.2402
		System infrastructure software	2.2215 .106	-.0268	4.4697
System infrastructure software	10.2027	Application software	.8448 1.000	-1.3134	3.0029
		Application development and deployment tools	-2.2215 .106	-4.4697	.0268

* p < 0.10

** p < 0.05

*** p < 0.01

Table 13 provides multiple comparison results of Bonferroni test. It was used to compare average number of releases across the types of software because it assumes equal variances.

Table 13. Multiple comparisons of average number of releases across software types

(Sample size = 350)

Number of releases (QRT)

(I) Type of software	Mean	(J) Type of software	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Application software	1.9711	Application development and deployment tools	-.4529(***) .000	-.6005	-.3054
		System infrastructure software	-.1881(**) .019	-.3346	-.0416
Application development and deployment tools	2.4240	Application software	.4529(***) .000	.3054	.6005
		System infrastructure software	.2648(***) .001	.1122	.4174
System infrastructure software	2.1592	Application software	.1881(**) .019	.0416	.3346
		Application development and deployment tools	-.2648(***) .001	-.4174	-.1122

* p < 0.10

** p < 0.05

*** p < 0.01

The results shown in Table 13 suggest that the average number of releases is greater if the application development and deployment tools are developed instead of system infrastructure software and application software. The results are significant at $p < 0.01$.

Moreover, the average number of releases is greater if the system infrastructure software is developed instead of application software. The results are significant at $p < 0.05$.

5.4 Hypothesis 1. Number of developers is positively associated with the success of OSS projects

Hypotheses 1a and 1b posit that number of developers is positively associated with the number of downloads and number of releases of the OSS project respectively.

The results shown in Table 9 provide support for Hypotheses 1a and 1b. Spearman correlation was also used to test Hypotheses 1a and 1b. Table 14 provides the Spearman correlation coefficients for the number of developers, the number of downloads, and number of releases of OSS projects.

Table 14. Spearman correlation between number of developers and measures of success of OSS development project

(Sample size = 350)

	Number of downloads (QRT)	Number of releases (QRT)
Number of developers	.621(***) .000	.597(***) .000

* p < 0.10 (1-tailed)

** p < 0.05 (1-tailed)

*** p < 0.01 (1-tailed)

One tailed tests of the alternative Hypothesis at $p < 0.01$ showed the following associations:

- Number of developers is positively associated with the number of downloads of the OSS project
- Number of developers is positively associated with the number of releases of the OSS project

Results shown in Table 14 also support Hypotheses 1a and 1b.

5.5 Hypothesis 2. Experience of developers is positively associated with the success of OSS projects

Hypotheses 2a and 2b posit that the years of experience of developers is positively associated with the number of downloads and number of releases of the OSS project respectively.

The results shown in Table 9 provide support for Hypotheses 2a and 2b. Spearman correlation was also used to test Hypotheses 2a and 2b. Table 15 provides the Spearman correlation coefficients for years of experience of developers, number of downloads and number of releases of OSS projects.

Table 15. Spearman correlation between experience of developers and measures of success of OSS development project

(Sample size = 350)

	Number of downloads (QRT)	Number of releases (QRT)
Experience of developers	.622(***) .000	.563(***) .000

* p < 0.10 (1-tailed)

** p < 0.05 (1-tailed)

*** p < 0.01 (1-tailed)

One tailed tests of the alternative Hypothesis at $p < 0.01$ showed the following associations:

- Years of experience of developers is positively associated with the number of downloads of the OSS project
- Years of experience of developers is positively associated with the number of releases of the OSS project

Results shown in Table 15 also provide support for Hypotheses 2a and 2b.

5.6 Hypothesis 3. Targeting developers as users is positively associated with the success of OSS projects

Hypotheses 3a and 3b posit that targeting developers as users is positively associated with the number of downloads and the number of releases of the OSS project respectively.

The results shown in Table 9 provide support for Hypotheses 3a and 3b. To test hypotheses 3a and 3b, the researcher first checked whether or not the variance of the number of downloads and the number of releases is homogeneous across the types of target users. The Levene test of homogeneity of variances was used for this purpose. Table 16 provides the results.

Table 16. Levene test for homogeneity of variances for number of downloads and number of releases across types of target users

(Sample size = 350)

	Levene statistic	df1	df2
Number of downloads (QRT)	3.963(**) .020	2	347
Number of releases (QRT)	.620 (.539)	2	347

* p < 0.10

** p < 0.05

*** p < 0.01

Results of Table 16 indicate that the Levene statistic is significant for number of downloads (at $p < 0.05$) and not significant for number of releases. Therefore, the variance for number of downloads is not equal across target user types. However, variance for number of releases is equal across target users types.

Since the number of downloads have unequal variance, the Welch and Brown-Forsythe robust F tests were used to test hypotheses 3a instead of the One-Way ANOVA (which

requires equality of variance). As the number of releases has equal variances, One-Way ANOVA test was used to test Hypothesis 3b

Table 17 provides the results of using the Welch and Brown-Forsythe robust F tests to examine Hypothesis 3a.

Table 17. Welch and Brown-Forsythe robust F tests of equality of means of number of downloads across types of target users

(Sample size = 350)

		Statistic	df1	df2
Number of downloads (QRT)	Welch	4.064(***) .018	2	231.080
	Brown-Forsythe	3.672(***) .026	2	338.723

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of downloads is the same for all three target users types. The results in Table 17 show that the Welch and Brown-Forsythe statistics are significant at $p < 0.05$. Therefore, the null Hypothesis that the average number of downloads is the same for all target users types can be rejected.

Table 18 provides the multiple comparison results of the Tamhane T2 test used to examine Hypothesis 3a. The test was used to compare average number of downloads across the three target users types because it does not assume equal variances.

Table 18. Multiple comparisons of average number of downloads across types of target users

(Sample size = 350)

Number of downloads (QRT)

(I) Target users type	Mean	(J) Target users type	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Developers	12.2315	System administrators	2.4035(*) .071	.1214	4.6855
		End users	2.3861(**) .030	.2232	4.5490
System administrators	9.8280	Developers	-2.4035(*) .071	-4.6855	-.1214
		End users	-.0174 (1.000)	-2.1913	2.1566
End users	9.8454	Developers	-2.3861(**) .030	-4.5490	-.2232
		System administrators	.0174 (1.000)	-2.1566	2.1913

* p < 0.10

** p < 0.05

*** p < 0.01

Results of Table 18 indicate that the average number of downloads is greater if the target users of the OSS project are developers instead of system administrators and end users.

The results are significant at $p < 0.05$. However, the difference between average number

of downloads is not significant for system administrators or end users. These results also indicate support for Hypothesis 3a.

Table 19 provides the results of the One-Way ANOVA test for Hypothesis 3b.

Table 19. One-Way ANOVA test of equality of means of number of releases across types of target users

(Sample size = 350)

		Sum of squares	df	Mean square	F
Number of releases (QRT)	Between groups	9.853	2	4.927	17.084(***) .000
	Within groups	100.071	347	.288	
	Total	109.924	349		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of releases is the same for all three target users types. The results in Table 19 indicate that the F statistic is significant at $p < 0.01$. Therefore, the null Hypothesis that the average number of releases is the same for all categories of target user types can be rejected.

Table 20 provides the multiple comparison results of using the Bonferroni test to examine Hypothesis 3b. This test was used to compare the average number of releases across the target users types because it assumes equal variances.

The results shown in Table 20 indicate that the average number of releases is greater if the targeted users of the OSS software project are developers instead of system administrators and end users. The results are significant at $p < 0.01$. Moreover, the average number of releases is greater if the target users are system administrators instead of end users. The results are significant at $p < 0.05$. These results also indicate support for Hypothesis 3b.

Table 20. Multiple comparisons of average number of releases across types of target users

(Sample size = 350)

Number of releases (QRT)

(I) Target users type	Mean	(J) Target users type	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Developers	2.3992	System administrators	.2352(***) .004	.0791	.3914
		End users	.4047(***) .000	.2567	.5527
System administrators	2.1639	Developers	-.2352(***) .004	-.3914	-.0791
		End users	.1694(**) .046	.0207	.3182
End users	1.9945	Developers	-.4047(***) .000	-.5527	-.2567
		System administrators	-.1694(**) .046	-.3182	-.0207

* p < 0.10

** p < 0.05

*** p < 0.01

5.7 Hypothesis 4. Using a commonly used programming language is positively associated with the success of OSS project

Hypotheses 4a and 4b posit that the use of a commonly used programming language is positively associated with the number of downloads and the number of releases of the OSS project respectively.

The results shown in Table 9 failed to support Hypotheses 4a and 4b. To test hypotheses 4a and 4b, the researcher first checked whether or not the variance of the number of downloads and the number of releases is homogeneous across the two programming language types. Table 21 provides the results of using the Levene test of homogeneity of variances.

Table 21. Levene test for homogeneity of variances for number of downloads and number of releases across programming language types

(Sample size = 350)

	Levene statistic	df1	df2
Number of downloads (QRT)	.607 (.437)	1	348
Number of releases (QRT)	3.764 .053(*)	1	348

* p < 0.10

** p < 0.05

*** p < 0.01

Results of Table 21 indicate that the Levene statistic is not significant for number of downloads and is significant for number of releases (at $p < 0.05$). Therefore, the variance

for number of downloads is equal across the two programming language types. However, variance for number of releases is not equal across programming language type.

Since the number of downloads have equal variance, the One-Way ANOVA test was used to test hypotheses 4a. As the number of releases have unequal variance, Welch and Brown-Forsythe robust F tests were used to test Hypothesis 4b.

Table 22 provides the results of using the One-way ANOVA test to examine Hypothesis 4a.

Table 22. One-Way ANOVA test of equality of means of number of downloads across programming language types

(Sample size = 350)

		Sum of squares	df	Mean square	F
Number of downloads (QRT)	Between groups	1.310	1	1.310	.021 (.885)
	Within groups	21803.070	348	62.653	
	Total	21804.380	349		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of downloads is the same for the two types of programming languages. Results in Table 22 indicate that the F statistic is not

significant. Therefore, the null Hypothesis that the average number of downloads is the same for all types of programming language cannot be rejected. Thus, Hypothesis 4a is not supported.

Table 23 provides the results of the Welch and Brown-Forsyth robust F tests used to examine Hypothesis 4b.

Table 23. Welch and Brown-Forsyth robust F tests of equality of means of number of releases across programming language types

(Sample size = 350)

		Statistic	df1	df2
Number of downloads (QRT)	Welch	1.472 .226	1	210.634
	Brown-Forsythe	1.472 .226	1	210.634

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of releases is the same for all types of programming language. The results shown in Table 23 indicate that the Welch and Brown-Forsyth statistics are not significant. Therefore, the null Hypothesis that the average number of releases is the same for all types of programming language cannot be rejected. Thus, Hypothesis 4b is not supported.

5.8 Hypothesis 5. Development of application development and deployment tools is positively associated with the success of OSS projects

Hypotheses 5a and 5b posit that the development of application development and deployment tools is positively associated with the number of downloads and number of releases of OSS project respectively.

To test hypotheses 5a and 5b, the researcher first checked whether or not the variance of number of downloads and number of releases is homogeneous across the types of software. Table 24 provides the results of using the Levene test of homogeneity of variances.

Table 24. Levene test for homogeneity of variances for number of downloads and number of releases across types of software

(Sample size = 350)

	Levene statistic	df1	df2
Number of downloads (QRT)	1.776 (.171)	2	347
Number of releases (QRT)	.827 (.438)	2	347

* p < 0.10

** p < 0.05

*** p < 0.01

Results shown in Table 24 indicate that the Levene statistic is not significant both for number of downloads and number of releases. Therefore, the variances for number of downloads and number of releases are equal across the types of software.

Since number of downloads and number of releases for types of software have equal variance, the One-Way ANOVA test was used to test hypotheses 5a and 5b.

Table 25 provides the results of using the One-Way ANOVA test to examine Hypothesis 5a.

Table 25. One-Way ANOVA test of equality of means of number of downloads across types of software

(Sample size = 350)

		Sum of squares	df	Mean square	F
Number of downloads (QRT)	Between groups	579.294	2	289.647	4.735(***) .009
	Within groups	21225.086	347	61.167	
	Total	21804.380	349		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of downloads is the same for all types of software. The results shown in Table 25 indicate that the F statistic is significant at $p < 0.01$. Therefore, the null Hypothesis that the average number of downloads is the same for all types of software can be rejected.

Table 26 provides the multiple comparison results of the Bonferroni test for Hypothesis 5a. The test was used to compare the average number of downloads across the types of software because it assumes equal variances.

The results shown in Table 26 indicate that the average number of downloads is greater if the application development and deployment tools are developed instead of system infrastructure software and application software. The results are significant at $p < 0.01$. However, the difference between average number of downloads is not significant when the type of OSS software is either system infrastructure software or application software. These results indicate support for Hypothesis 5a.

Table 26. Multiple comparisons of average number of downloads across types of software

(Sample size = 350)

Number of downloads (QRT)

(I) Type of software	Mean	(J) Type of software	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Application software	9.3579	Application development and deployment tools	- 3.0662(***) .008	-5.2402	-.8922
		System infrastructure software	-.8448 1.000	-3.0029	1.3134
Application development and deployment tools	12.4242	Application software	3.0662(***) .008	.8922	5.2402
		System infrastructure software	2.2215 .106	-.0268	4.4697
System infrastructure software	10.2027	Application software	.8448 1.000	-1.3134	3.0029
		Application development and deployment tools	-2.2215 .106	-4.4697	.0268

* p < 0.10

** p < 0.05

*** p < 0.01

Table 27 provides the results of using the One-Way ANOVA test to examine Hypothesis 5b.

Table 27. One-Way ANOVA test of equality of means of number of releases across types of software

(Sample size = 350)

		Sum of squares	df	Mean square	F
Number of releases (QRT)	Between groups	12.158	2	6.074	21.556(***) .000
	Within groups	97.776	347	.282	
	Total	109.924	349		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of releases is the same for all types of software. Results shown in Table 27 indicate that the F statistic is significant at $p < 0.01$. Therefore, the null Hypothesis that the average number of releases is the same for all types of software can be rejected.

Table 28 provides multiple comparison results of Bonferroni test for Hypothesis 5b. This test was used to compare average number of releases across the types of software because it assumes equal variances.

The results shown in Table 28 indicate that the average number of releases is greater if the application development and deployment tools are developed instead of system infrastructure software and application software. The results are significant at $p < 0.01$. Moreover, the average number of releases is greater if the system infrastructure software is developed instead of application software. The results are significant at $p < 0.05$. These results indicate support for Hypothesis 5b.

Table 28. Multiple comparisons of average number of releases across software types

(Sample size = 350)

Number of releases (QRT)

(I) Type of software	Mean	(J) Type of software	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Application software	1.9711	Application development and deployment tools	-.4529(***) .000	-.6005	-.3054
		System infrastructure software	-.1881(**) .019	-.3346	-.0416
Application development and deployment tools	2.4240	Application software	.4529(***) .000	.3054	.6005
		System infrastructure software	.2648(***) .001	.1122	.4174
System infrastructure software	2.1592	Application software	.1881(**) .019	.0416	.3346
		Application development and deployment tools	-.2648(***) .001	-.4174	-.1122

* p < 0.10

** p < 0.05

*** p < 0.01

5.9 Hypothesis 6. Use of non-restrictive OSS license is positively associated with the success of OSS projects

Hypotheses 6a and 6b posit that use of non-restrictive OSS license is positively associated with the number of downloads and number of releases of OSS project respectively.

To test hypotheses 6a and 6b, the researcher first checked whether or not the variance of number of downloads and number of releases is homogeneous across the types of license. Table 29 provides the results of using the Levene test of homogeneity of variances to examine homogeneity of variances for number of downloads and number of releases across license types.

Table 29. Levene test for homogeneity of variances for number of downloads and number of releases across types of license

(Sample size = 350)

	Levene statistic	df1	df2
Number of downloads (QRT)	4.582(**) .011	2	347
Number of releases (QRT)	1.505 (.223)	2	347

* p < 0.10

** p < 0.05

*** p < 0.01

The results shown in Table 21 indicate that the Levene statistic is significant for number of downloads (at $p < 0.05$) and is not significant for number of releases. Therefore, the variance for number of downloads is not equal across the software types. However, variance for number of releases is equal across software types.

Since the number of downloads have unequal variance, the Welch and Brown-Forsyth robust F tests were used to test hypotheses 3a instead of the One-Way ANOVA (which requires equality of variance). As the number of releases have equal variance, One-Way ANOVA test was used to test Hypothesis 3b.

Table 30 provides the results of using the Welch and Brown-Forsyth robust F tests to examine Hypothesis 6a.

Table 30. Welch and Brown-Forsythe robust F tests of equality of means of number of downloads across types of license

(Sample size = 350)

		Statistic	df1	df2
Number of downloads (QRT)	Welch	3.214(**) .044	2	119.708
	Brown-Forsythe	3.516(**) .032	2	202.002

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of downloads is the same for all types of license. The results shown in Table 30 indicate that the Welch and Brown-Forsyth statistic are significant at $p < 0.05$. Therefore, the null Hypothesis that the average number of downloads is the same for all types of license can be rejected.

Table 31 provides the multiple comparison results for the Tamhane T2 test used to examine Hypothesis 6a. This test was used to compare average number of downloads across the types of license because it does not assume equal variances.

Table 31. Multiple comparisons of average number of downloads across license types

(Sample size = 350)

Number of downloads (QRT)

(I) Type of license	Mean	(J) Type of license	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Very restrictive	9.5543	Moderately restrictive	-1.85147 .295	-4.0847	.5815
		Non-restrictive	-2.55240(*) .073	-4.7646	-.1402
Moderately restrictive	11.4058	Very restrictive	1.85147 .295	-.5818	4.0847
		Non-restrictive	-.70093 .939	-3.642	2.2023
Non-restrictive	12.1067	Very restrictive	2.55240(*) .073	.1402	4.7646
		Moderately restrictive	.70093 .939	-2.2023	3.6042

* p < 0.10

** p < 0.05

*** p < 0.01

The results shown in Table 31 indicate that the average number of releases is greater if a non-restrictive OSS license is used instead of a very restrictive OSS license. The results are significant at $p < 0.1$. These results indicate support for Hypothesis 6a.

Table 32 provides the results of using the One-way ANOVA test to examine Hypothesis 6b.

Table 32. One-Way ANOVA test of equality of means of number of releases across types of license

(Sample size = 350)

		Sum of squares	df	Mean square	F
Number of releases (QRT)	Between groups	5.203	2	2.601	8.620(***) .000
	Within groups	104.722	347	.302	
	Total	109.924	349		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of releases is the same for all types of license. Results in Table 32 indicate that the F statistic is significant at $p < 0.01$.

Therefore, the null Hypothesis that the average number of releases is the same for all types of license can be rejected.

Table 33 provides the multiple comparison results of the Bonferroni test for Hypothesis 6b. This test was used to compare the average number of releases across the types of license because it assumes equal variances.

Table 33. Multiple comparisons of average number of releases across license types
(Sample size = 350)

Number of releases (QRT)

(I) Type of license	Mean	(J) Type of license	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Very restrictive	2.0743	Moderately restrictive	-.15010 .277	-.3400	.0398
		Non-restrictive	-.27541(***) .000	-.4192	-.1316
Moderately restrictive	2.2244	Very restrictive	.15010 .277	-.0398	.3400
		Non-restrictive	-.12531 .596	-.3332	.0826
Non-restrictive	2.3497	Very restrictive	.27541(***) .000	.1316	.4192
		Moderately restrictive	.12531 .596	-.0826	.3332

* p < 0.10

** p < 0.05

*** p < 0.01

The results shown in Table 33 indicate that the average number of releases is greater if a non-restrictive OSS license is used instead of a very restrictive OSS license. The results are significant at $p < 0.01$. These results indicate support for Hypothesis 6b.

5.10 Summary of the results organized by hypothesis

Table 34 provides a summary of the results of testing the six hypotheses.

Table 34. Summary of test results organized by hypothesis

(Sample size $N = 350$)

Hypothesis	Decision based on test results	Rationale
Hypothesis 1a. Number of developers is positively associated with the number of downloads of OSS projects.	Supported	<p>In multivariate GLM the effect of number of developers on number of downloads is significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are significant at $p < 0.05$ with observed power equal to 0.734 and co-efficient equal to 0.019.</p> <p>Spearman correlation coefficient between number of developers and number of downloads of OSS development project was positive and significant at $p < 0.01$.</p>
Hypothesis 1b. Number of developers is positively associated	Supported	In multivariate GLM the effect of number of developers on number

<p>with the number of releases of OSS projects.</p>		<p>of releases is significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are significant at $p < 0.05$ with observed power equal to 0.734 and coefficient equal to 0.19.</p> <p>Spearman correlation coefficient between number of developers and number of releases of OSS development project was positive and significant at $p < 0.01$.</p>
<p>Hypothesis 2a. Experience of developers is positively associated with the number of downloads of OSS projects.</p>	<p>Supported</p>	<p>In multivariate GLM the effect of experience of developers on number of downloads is significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are significant at $p < 0.05$ with observed power equal to 0.860 and coefficient equal to 0.021.</p> <p>Spearman correlation coefficient</p>

		between experience of developers and number of downloads of OSS development project was positive and significant at $p < 0.01$.
Hypothesis 2b. Experience of developers is positively associated with the number of releases of OSS projects.	Supported	<p>In multivariate GLM the effect of experience of developers on number of releases is significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are significant at $p < 0.05$ with observed power equal to 0.860 and coefficient equal to 0.021.</p> <p>Spearman correlation coefficient between experience of developers and number of releases of OSS development project was positive and significant at $p < 0.01$.</p>
Hypothesis 3a. Targeting developers as users is positively associated with the number of downloads of OSS projects.	Supported	In multivariate GLM the effect of target users type on number of downloads is significant because

		<p>Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant at $p < 0.05$ with observed power equal to 0.720 and coefficient equal to 0.014. Roy's largest root and its F statistic is significant at $p < 0.05$ with observed power equal to 0.720 and coefficient equal to 0.019. Therefore, average number of downloads varied across types of target users. Results of Bonferroni test showed that average number of downloads was greater for developers as target users than those of system administrators and end-users and were significant at $p < 0.05$.</p> <p>Results of Welch and Brown-Forsythe robust F tests showed that average number of downloads varied across types of target users and were significant at $p < 0.05$. Results of Tamhane T2 test</p>
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		showed that average number of downloads was greater for developers as target users than those of system administrators and end-users and were significant at $p < 0.05$.
Hypothesis 3b. Targeting developers as users is positively associated with the number of releases of OSS projects.	Supported	In multivariate GLM the effect of target users type on number of releases is significant because Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant at $p < 0.05$ with observed power equal to 0.720 and coefficient equal to 0.014. Roy's largest root and its F statistic is significant at $p < 0.05$ with observed power equal to 0.720 and coefficient equal to 0.019. Therefore, average number of releases varied across types of target users. Results of Bonferroni test showed that average number of releases was greater for

		<p>developers as target users than those of system administrators and end-users and were significant at $p < 0.01$.</p> <p>Results of One-Way ANOVA test showed that average number of releases varied across types of target users and were significant at $p < 0.01$. Results of Bonferroni test showed that average number of releases was greater for developers as target users than those of system administrators and end-users and were significant at $p < 0.01$.</p>
<p>Hypothesis 4a. Using a commonly used programming language is positively associated with the number of downloads of OSS projects.</p>	Not supported	<p>In multivariate GLM the effect of programming language type on number of downloads is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$. Therefore, average number of</p>

		<p>downloads did not vary across the types of programming language.</p> <p>Results of One-Way ANOVA test showed that average number of downloads did not vary across the types of programming language and were not significant at $p < 0.1$.</p>
<p>Hypothesis 4b. Using a commonly used programming language is positively associated with the number of releases of OSS projects.</p>	Not supported	<p>In multivariate GLM the effect of programming language type on number of releases is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$. Therefore, average number of releases did not vary across the types of programming language.</p> <p>Results of Welch and Brown-Forsythe robust F tests showed that average number of releases did not vary across the types of programming language and were</p>

		not significant at $p < 0.1$.
<p>Hypothesis 5a. Development of application development and deployment tools is positively associated with the number of downloads of OSS projects.</p>	Supported	<p>In multivariate GLM the effect of software type on number of downloads is significant because Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant at $p < 0.01$ with observed power equal to 0.91 and coefficient equal to 0.022. Roy's largest root and its F statistic is significant at $p < 0.05$ with observed power equal to 0.947 and coefficient equal to 0.026. Therefore, average number of downloads varied across the types of software. Results of Bonferroni test showed that average number of downloads was greater for development of application development and deployment tools than those of system infrastructure software and application software and were significant at $p < 0.01$.</p> <p>Results of One-Way ANOVA test showed that average number of downloads varied across the types of software and were significant at</p>

		<p>$p < 0.01$. Results of Bonferroni test showed that average number of downloads was greater for development of application development and deployment tools than those of system infrastructure software and application software and were significant at $p < 0.01$.</p>
<p>Hypothesis 5b. Development of application development and deployment tools is positively associated with the number of releases of OSS projects.</p>	Supported	<p>In multivariate GLM the effect of software type on number of releases is significant because Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant at $p < 0.01$ with observed power equal to 0.91 and coefficient equal to 0.022. Roy's largest root and its F statistic is significant at $p < 0.05$ with observed power equal to 0.947 and coefficient equal to 0.026. Therefore, average number of releases varied across the types of software. Results of Bonferroni test showed that average number of releases was greater for development of application development and deployment tools than those of system infrastructure software and application software</p>

		<p>and were significant at $p < 0.01$.</p> <p>Results of One-Way ANOVA test showed that average number of releases varied across the types of software and were significant at $p < 0.01$. Results of Bonferroni test showed that average number of releases was greater for development of application development and deployment tools than those of system infrastructure software and application software and were significant at $p < 0.01$.</p>
<p>Hypothesis 6a. Use of non-restrictive license is positively associated with the number of downloads of OSS projects.</p>	Not supported	<p>In multivariate GLM the effect of type of license on number of downloads is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$. Therefore, average number of downloads did not vary across the types of license.</p> <p>Results of Welch and Brown-Forsythe robust F tests showed that average number of downloads varied across the types of license</p>

		<p>and were significant at $p < 0.05$. Results of Tamhane T2 test showed that average number of releases was greater for use of non-restrictive OSS license than those for use of very restrictive ones and were significant at $p < 0.1$.</p>
<p>Hypothesis 6b. Use of non-restrictive license is positively associated with the number of releases of OSS projects.</p>	Not supported	<p>In multivariate GLM the effect of type of license on number of releases is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$.</p> <p>Therefore, average number of releases did not vary across the types of license.</p> <p>Results of One-Way ANOVA test showed that average number releases varied across the types of license and were significant at $p < 0.01$. Results of Bonferroni test showed that average number of</p>

		releases was greater for use of non-restrictive OSS license than those for use of very restrictive ones and were significant at $p < 0.01$.
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5.11 Production/stable and mature OSS projects

A sub-sample of 108 OSS projects that held a production/stable or mature status was drawn for the total sample of 350 projects. Multivariate GLM was used to examine the relationship between the six factors assumed to contribute to OSS project success and the two measures of OSS project success.

Table 35 provides the results of the Levene's test.

The results of Table 35 indicate that the Levene statistic is significant for number of downloads and not significant for number of releases. Therefore, the variance of the number of downloads is not equal across target user types, programming language types, software types, and license types. Whereas, the variance of the number of releases is equal across target user types, programming language types, software types, and license types.

Table 35. Levene's test for homogeneity of variances for number of downloads and number of releases across target users types, programming language types, software types, and types of license

(Sample size = 108)

	Levene statistic	df1	df2
Number of downloads (QRT)	4.627(***) .000	17	90
Number of releases (QRT)	.669 (.825)	17	90

* p < 0.10

** p < 0.05

*** p < 0.01

The assumption of homogeneity of variances is met for the number of downloads and not met for number of releases. However, GLM is relatively robust against the violation of this assumption when the groups are of not very unequal sample size and the sample size is adequate. Further SPSS adjusts automatically for unequal group sizes.

Table 36 provides the result of the Box's M test.

The results of Table 36 indicate that the Box's M and F statistics are significant (at $p < 0.01$). Therefore, the covariance between number of downloads and number of releases is not equal across target users types, programming language types, software types, and license types.

Table 36. Box's M test for homogeneity of covariance between number of downloads and number of releases across target users types, programming language types, software types, and types of license

(Sample size = 108)

Box's M	F	df1	df2
129.767(***) .000	3.528(***) .000	30	1684.971

* p < 0.10

** p < 0.05

*** p < 0.01

The assumption of homogeneity of covariances between the number of downloads and the number of releases is not met. However, GLM is relatively robust against the violation of this assumption when the groups are of not very unequal sample size and the sample size is adequate. Further SPSS adjusts automatically for unequal group sizes.

Table 37 provides the results of multivariate GLM. The effect of all independent variables: number of developers, experience of developers, target users type, programming language type, software type, and type of license were observed simultaneously on the two dependent variables: number of downloads and number of releases. Pillai's trace, Wilk's lambda, Hotelling's trace, and Roy's largest root tests were used to examine the data.

Table 37. Multivariate GLM tests

(Sample size = 108)

Effect		Value	F	Hypothesis df	Error df	Partial Eta squared coefficient	Observed power
Intercept	Pillai's trace	.888	384.31(***) (.000)	2	97	.888	1
	Wilk's lambda	.112	384.31(***) (.000)	2	97	.888	1
	Hotelling's trace	7.924	384.31(***) (.000)	2	97	.888	1
	Roy's largest root	7.924	384.31(***) (.000)	2	97	.888	1
Number of developers	Pillai's trace	.010	.489 (.615)	2	97	.010	.212
	Wilk's lambda	.990	.489 (.615)	2	97	.010	.212
	Hotelling's trace	.010	.489 (.615)	2	97	.010	.212
	Roy's largest root	.010	.489 (.615)	2	97	.010	.212
Experience of developers	Pillai's trace	.005	.242 (.785)	2	97	.005	.155
	Wilk's lambda	.995	.242 (.785)	2	97	.005	.155

	Hotelling's trace	.005	.242 (.785)	2	97	.005	.155
	Roy's largest root	.005	.242 (.785)	2	97	.005	.155
Target users type	Pillai's trace	.059	1.480 (.210)	4	196	.029	.584
	Wilk's lambda	.941	1.488 (.207)	4	194	.030	.586
	Hotelling's trace	.062	1.495 (.205)	4	192	.030	.588
	Roy's largest root	.062	3.048(*) (.052)	2	98	.059	.699
Programming language type	Pillai's trace	.015	.697 (.500)	2	97	.014	.260
	Wilk's lambda	.986	.697 (.500)	2	97	.014	.260
	Hotelling's trace	.014	.697 (.500)	2	97	.014	.260
	Roy's largest root	.014	.697 (.500)	2	97	.014	.260
Software type	Pillai's trace	.082	2.097(*) (.083)	4	196	.041	.732
	Wilk's lambda	.919	2.099(*) (.082)	4	194	.041	.733

	Hotelling's trace	.088	2.101(*) (.082)	4	192	.042	.733
	Roy's largest root	.076	3.722(*) (.028)	2	98	.071	.778
Type of license	Pillai's trace	.054	1.354 (.251)	4	196	.027	.548
	Wilk's lambda	.947	1.349 (.253)	4	194	.027	.546
	Hotelling's trace	.056	1.343 (.255)	4	192	.027	.544
	Roy's largest root	.047	2.284 (.107)	2	98	.045	.584

* p < 0.10

** p < 0.05

*** p < 0.01

The results of Table 37 suggest that the effect of software type is significant on number of downloads and number of releases. Number of developers, experience of developers, target users type, programming language type and license type used have no significant effect on number of downloads and number of releases.

Table 38 provides multiple comparison results of the Tamhane T2 test. It was used to compare average number of downloads across the types of software because it assumes unequal variances.

Table 38. Multiple comparisons of average number of downloads across types of software

(Sample size = 108)

Number of downloads (QRT)

(I) Type of software	Mean	(J) Type of software	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Application software	14.7701	Application development and deployment tools	-7.0705 (.471)	-19.1780	5.0369
		System infrastructure software	-6.7243 (.437)	-19.5758	4.7422
Application development and deployment tools	21.8407	Application software	7.0705 (.471)	-5.0369	19.1780
		System infrastructure software	.3463 (.995)	-2.9998	3.6923
System infrastructure software	21.4944	Application software	6.7243 (.437)	-4.7422	19.5758
		Application development and deployment tools	-.3463 (.995)	-3.6923	2.9998

* p < 0.10

** p < 0.05

*** p < 0.01

Results shown in Table 38 indicate that the difference between average number of downloads across all three types of software is not significant.

Table 39. Multiple comparisons of average number of releases across software types

(Sample size = 108)

Number of releases (QRT)

(I) Type of software	Mean	(J) Type of software	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Application software	2.2083	Application development and deployment tools	-.4153(*) .058	-.7917	-.0388
		System infrastructure software	-.2433 (.569)	-.6409	.1542
Application development and deployment tools	2.6236	Application software	.4153(*) .058	.0388	.7917
		System infrastructure software	.1719 (.470)	-.0879	.4318
System infrastructure software	2.4517	Application software	.2433 (.569)	-.1542	.6409
		Application development and deployment tools	-.1719 (.470)	-.4318	.0879

* p < 0.10

** p < 0.05

*** p < 0.01

Table 39 provides multiple comparison results of Bonferroni test for Hypothesis 5b. This test was used to compare average number of releases across the types of software because it assumes equal variances.

The results shown in Table 39 indicate that the average number of releases is greater if the application development and deployment tools are developed instead of system infrastructure software and application software. The results are significant at $p < 0.1$. However, the difference between average number of releases is not significant when the type of OSS software is either system infrastructure software or application software.

Hypothesis 1. Number of developers is positively associated with the success of OSS projects

Hypotheses 1a and 1b posit that number of developers is positively associated with the number of downloads and number of releases of the OSS project respectively.

Table 40. Spearman correlations between number of developers and measures of success of OSS project

(Sample size = 108)

	Number of downloads (QRT)	Number of releases (QRT)
Number of developers	.364(***) .000	.390(***) .000

* p < 0.10 (1-tailed)

** p < 0.05 (1-tailed)

*** p < 0.01 (1-tailed)

Spearman correlation was used to test Hypotheses 1a and 1b. Table 40 provides the Spearman correlation coefficients for the number of developers, the number of downloads, and number of releases of OSS project.

One tailed tests of the alternative Hypothesis at $p < 0.01$ showed the following associations:

- Number of developers is positively associated with the number of downloads of the OSS project
- Number of developers is positively associated with the number of releases of the OSS project

Results shown in Table 40 support Hypotheses 1a and 1b. This finding contradicts the results shown in Table 37.

Hypothesis 2. Experience of developers is positively associated with the success of OSS projects

Hypotheses 2a and 2b posit that experience of developers is positively associated with the number of downloads and number of releases of the OSS project respectively.

Spearman correlation was used to test Hypotheses 2a and 2b. Table 41 provides the Spearman correlation coefficients for the experience of developers, the number of downloads, and number of releases of OSS project.

Table 41. Spearman correlations between experience of developers and measures of success of OSS project

(Sample size = 108)

	Number of downloads (QRT)	Number of releases (QRT)
Number of developers	.318(***) .000	.323(***) .000

* p < 0.10 (1-tailed)

** p < 0.05 (1-tailed)

*** p < 0.01 (1-tailed)

One tailed tests of the alternative Hypothesis at $p < 0.01$ showed the following associations:

- Number of developers is positively associated with the number of downloads of the OSS project
- Number of developers is positively associated with the number of releases of the OSS project

Results shown in Table 41 support Hypotheses 2a and 2b. This finding contradicts the results shown in Table 37.

Hypothesis 3. Targeting developers as users is positively associated with the success of OSS projects

Hypotheses 3a and 3b posit that targeting developers as users is positively associated with the number of downloads and the number of releases of the OSS project respectively.

To test Hypotheses 3a and 3b, the researcher first checked whether or not the variance of the number of downloads and the number of releases is homogeneous across the types of target users. The Levene test of homogeneity of variances was used for this purpose.

Table 42 provides the results.

Table 42. Levene test for homogeneity of variances for number of downloads and number of releases across types of target users

(Sample size = 108)

	Levene statistic	df1	df2
Number of downloads (QRT)	21.458(***) .000	2	105
Number of releases (QRT)	1.371 (.258)	2	105

* p < 0.10

** p < 0.05

*** p < 0.01

Results of Table 42 indicate that the Levene statistic is significant for number of downloads (at $p < 0.01$) and not significant for number of releases. Therefore, the

variance for number of downloads is not equal across target user types. However, variance for number of releases is equal across target users types.

Since the number of downloads have unequal variance, the Welch and Brown-Forsythe robust F tests were used to test hypotheses 3a instead of the One-Way ANOVA (which requires equality of variance). As the number of releases have equal variance, One-Way ANOVA test was used to test Hypothesis 3b.

Table 43 provides the results of using the Welch and Brown-Forsythe robust F tests to examine Hypothesis 3a.

Table 43. Welch and Brown-Forsythe robust F tests of equality of means of number of downloads across types of target users
(Sample size = 108)

		Statistic	df1	df2
Number of downloads (QRT)	Welch	.890 (.421)	2	30.474
	Brown-Forsythe	1.512 (.245)	2	19.518

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of downloads is the same for all three target users types. The results in Table 43 show that the Welch and Brown-Forsythe statistics are not significant. Therefore, the null Hypothesis that the average number of

downloads is the same for all target users types cannot be rejected. Thus, Hypothesis 3a is not supported. This finding is consistent with the results shown in Table 37.

Table 44 provides the results of the One-Way ANOVA test for Hypothesis 3b.

Table 44. One-Way ANOVA test of equality of means of number of releases across types of target users

(Sample size = 108)

		Sum of squares	df	Mean square	F
Number of releases (QRT)	Between groups	1.547	2	.773	2.347 (.101)
	Within groups	34.601	105	.330	
	Total	36.148	107		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of releases is the same for all three target users types. The results in Table 44 indicate that the F statistic is not significant. Therefore, the null Hypothesis that the average number of releases is the same for all categories of target user types cannot be rejected. Thus, Hypothesis 3b is not supported. This finding is consistent with the results shown in Table 37.

Hypothesis 4. Using a commonly used programming language is positively associated with the success of OSS projects

Hypotheses 4a and 4b posit that the use of a commonly used programming language is positively associated with the number of downloads and the number of releases of the OSS project respectively.

To test hypotheses 4a and 4b, the researcher first checked whether or not the variance of the number of downloads and the number of releases is homogeneous across the two programming language types. Table 45 provides the results of using the Levene test of homogeneity of variances.

Table 45. Levene test for homogeneity of variances for number of downloads and number of releases across programming language types

(Sample size = 108)

	Levene statistic	df1	df2
Number of downloads (QRT)	.126 (.724)	1	106
Number of releases (QRT)	2.802 .097(*)	1	106

* p < 0.10

** p < 0.05

*** p < 0.01

Results of Table 45 indicate that the Levene statistic is not significant for number of downloads and is significant for number of releases (at $p < 0.1$). Therefore, the variance

for number of downloads is equal across the two programming language types. However, variance for number of releases is not equal across programming language type.

Since the number of downloads have equal variance, the One-Way ANOVA test was used to test Hypotheses 4a. As the number of releases have unequal variance, Welch and Brown-Forsythe robust F tests were used to test Hypothesis 4b.

Table 46 provides the results of using the One-way ANOVA test to examine Hypothesis 4a.

Table 46. One-Way ANOVA test of equality of means of number of downloads across programming language types

(Sample size = 108)

		Sum of squares	df	Mean square	F
Number of downloads (QRT)	Between groups	11.698	1	11.698	.127 (.722)
	Within groups	9750.073	106	91.982	
	Total	9761.771	107		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of downloads is the same for the two types of programming languages. Results in Table 46 indicate that the F statistic is not

significant. Therefore, the null Hypothesis that the average number of downloads is the same for all types of programming language cannot be rejected. Thus, Hypothesis 4a is not supported. This is consistent with the results shown in Table 37.

Table 47 provides the results of the Welch and Brown-Forsyth robust F tests used to examine Hypothesis 4b.

Table 47. Welch and Brown-Forsyth robust F tests of equality of means of number of releases across programming language types

(Sample size = 108)

		Statistic	df1	df2
Number of downloads (QRT)	Welch	4.237 .142	1	89.297
	Brown-Forsythe	4.237 .142	1	89.297

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of releases is the same for all types of programming language. The results shown in Table 47 indicate that the Welch and Brown-Forsyth statistics are not significant. Therefore, the null Hypothesis that the average number of releases is the same for all types of programming language cannot be rejected. Thus, Hypothesis 4b is not supported. This finding is consistent with the results shown in Table 37.

Hypothesis 5. Development of application development and deployment tools is positively associated with the success of OSS projects

Hypotheses 5a and 5b posit that the development of application development and deployment tools is positively associated with the number of downloads and number of releases of OSS project respectively.

To test hypotheses 5a and 5b, the researcher first checked whether or not the variance of number of downloads and number of releases is homogeneous across the types of software. Table 48 provides the results of using the Levene test of homogeneity of variances.

Table 48. Levene test for homogeneity of variances for number of downloads and number of releases across types of software

(Sample size = 108)

	Levene statistic	df1	df2
Number of downloads (QRT)	23.655(***) (.000)	2	105
Number of releases (QRT)	2.347 (.101)	2	105

* p < 0.10

** p < 0.05

*** p < 0.01

Results of Table 48 indicate that the Levene statistic is significant for number of downloads (at $p < 0.01$) and not significant for number of releases. Therefore, the

variance for number of downloads is not equal across software types. However, variance for number of releases is equal across software types.

Since the number of downloads have unequal variance, the Welch and Brown-Forsythe robust F tests were used to test hypotheses 5a instead of the One-Way ANOVA (which requires equality of variance). As the number of releases have equal variance, One-Way ANOVA test was used to test Hypothesis 5b.

Table 49 provides the results of using the Welch and Brown-Forsythe robust F tests to examine Hypothesis 5a.

Table 49. Welch and Brown-Forsythe robust F tests of equality of means of number of downloads across types of software
(Sample size = 108)

		Statistic	df1	df2
Number of downloads (QRT)	Welch	1.008 (.378)	2	28.726
	Brown-Forsythe	1.703 (.211)	2	17.469

* p < 0.10
 ** p < 0.05
 *** p < 0.01

The null Hypothesis was that the average number of downloads is the same for all three software types. The results in Table 49 show that the Welch and Brown-Forsythe statistics are not significant. Therefore, the null Hypothesis that the average number of

downloads is the same for all software types cannot be rejected. Thus, Hypothesis 5a is not supported. This finding is not consistent with the results shown in Table 37.

Table 50 provides the results of the One-Way ANOVA test for Hypothesis 5b.

Table 50. One-Way ANOVA test of equality of means of number of releases across types of software

(Sample size = 108)

		Sum of squares	df	Mean square	F
Number of releases (QRT)	Between groups	2.062	2	1.031	3.177(**) .046
	Within groups	34.085	105	.325	
	Total	36.148	107		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of releases is the same for all three software types. The results in Table 50 indicate that the F statistic is significant.

Therefore, the null Hypothesis that the average number of releases is the same for all categories of target user types can be rejected.

Table 51 provides multiple comparison results of Bonferroni test for Hypothesis 5b. This test was used to compare average number of releases across the types of software because it assumes equal variances.

Table 51. Multiple comparisons of average number of releases across software types

(Sample size = 108)

Number of releases (QRT)

(I) Type of software	Mean	(J) Type of software	Mean difference (I-J)	90 % Confidence interval	
				Lower bound	Upper bound
Application software	2.2083	Application development and deployment tools	-.4153(*) .058	-.7917	-.0388
		System infrastructure software	-.2433 (.569)	-.6409	.1542
Application development and deployment tools	2.6236	Application software	.4153(*) .058	.0388	.7917
		System infrastructure software	.1719 (.470)	-.0879	.4318
System infrastructure software	2.4517	Application software	.2433 (.569)	-.1542	.6409
		Application development and deployment tools	-.1719 (.470)	-.4318	.0879

* p < 0.10

** p < 0.05

*** p < 0.01

The results shown in Table 51 indicate that the average number of releases is greater if the application development and deployment tools are developed instead of system infrastructure software and application software. The results are significant at $p < 0.1$. However, the difference between average number of releases is not significant when the type of OSS software is either system infrastructure software or application software. These results indicate support for Hypothesis 5b. This is consistent with the results shown in Table 37.

Hypothesis 6. Use of non-restrictive OSS license is positively associated with the success of OSS projects

Hypotheses 6a and 6b posit that use of non-restrictive OSS license is positively associated with the number of downloads and the number of releases of the OSS project respectively.

To test Hypotheses 6a and 6b, the researcher first checked whether or not the variance of the number of downloads and the number of releases is homogeneous across the types of target users. The Levene test of homogeneity of variances was used for this purpose.

Table 52 provides the results.

Table 52. Levene test for homogeneity of variances for number of downloads and number of releases across types of license

(Sample size = 108)

	Levene statistic	df1	df2
Number of downloads (QRT)	3.057(**) .050	2	105
Number of releases (QRT)	.448 (.640)	2	105

* p < 0.10

** p < 0.05

*** p < 0.01

Results of Table 52 indicate that the Levene statistic is significant for number of downloads (at $p < 0.05$) and not significant for number of releases. Therefore, the variance for number of downloads is not equal across license types. However, variance for number of releases is equal across license types.

Since the number of downloads have unequal variance, the Welch and Brown-Forsythe robust F tests were used to test hypotheses 6a instead of the One-Way ANOVA (which requires equality of variance). As the number of releases have equal variance, One-Way ANOVA test was used to test Hypothesis 6b.

Table 53 provides the results of using the Welch and Brown-Forsythe robust F tests to examine Hypothesis 6a.

Table 53. Welch and Brown-Forsythe robust F tests of equality of means of number of downloads across types of license

(Sample size = 108)

		Statistic	df1	df2
Number of downloads (QRT)	Welch	1.929 (.154)	2	60.686
	Brown-Forsythe	2.517 (.101)	2	95.094

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of downloads is the same for all three license types. The results in Table 53 show that the Welch and Brown-Forsythe statistics are not significant. Therefore, the null Hypothesis that the average number of downloads is the same for all license types cannot be rejected. Thus Hypothesis 6a is not supported. This is consistent with the results shown in Table 37.

Table 54 provides the results of the One-Way ANOVA test for Hypothesis 6b.

Table 54. One-Way ANOVA test of equality of means of number of releases across types of license

(Sample size = 108)

		Sum of squares	df	Mean square	F
Number of releases (QRT)	Between groups	2.219	2	1.109	3.433 (.102)
	Within groups	33.929	105	.323	
	Total	36.148	107		

* p < 0.10

** p < 0.05

*** p < 0.01

The null Hypothesis was that the average number of releases is the same for all three license types. The results in Table 54 indicate that the F statistic is not significant.

Therefore, the null Hypothesis that the average number of releases is the same for all categories of license types cannot be rejected. Thus, Hypothesis 6b is not supported. This finding is consistent with the results shown in Table 37.

Table 55 provides a summary of the results of testing the six hypotheses using the sub sample comprised of 108 projects with development status of production/stable and mature.

Table 55. Summary of test results organized by hypothesis

(Sample N = 108)

Hypothesis	Decision based on test results	Rationale
Hypothesis 1a. Number of developers is positively associated with the number of downloads of OSS projects.	Not supported	<p>In multivariate GLM the effect of number of developers on number of downloads is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$.</p> <p>Spearman correlation coefficient between number of developers and number of downloads of OSS development project was positive and significant at $p < 0.01$.</p>
Hypothesis 1b. Number of developers is positively associated with the number of releases of OSS projects.	Not supported	<p>In multivariate GLM the effect of number of developers on number of releases is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$.</p> <p>Spearman correlation coefficient between number of developers and</p>

		number of releases of OSS development project was positive and significant at $p < 0.01$.
Hypothesis 2a. Experience of developers is positively associated with the number of downloads of OSS projects.	Not supported	<p>In multivariate GLM the effect of experience of developers on number of downloads is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$.</p> <p>Spearman correlation coefficient between experience of developers and number of downloads of OSS development project was positive and significant at $p < 0.01$.</p>
Hypothesis 2b. Experience of developers is positively associated with the number of releases of OSS projects.	Not supported	<p>In multivariate GLM the effect of experience of developers on number of releases is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$.</p> <p>Spearman correlation coefficient</p>

		between experience of developers and number of releases of OSS development project was positive and significant at $p < 0.01$.
Hypothesis 3a. Targeting developers as users is positively associated with the number of downloads of OSS projects.	Not supported	<p>In multivariate GLM the effect of target users type on number of downloads is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are not significant at $p < 0.1$. Therefore, average number of downloads did not vary across types of target users.</p> <p>Results of Welch and Brown-Forsythe robust F tests showed that average number of downloads did not vary across types of target users and were not significant at $p < 0.1$.</p>
Hypothesis 3b. Targeting developers as users is positively associated with the number of releases of OSS projects.	Not supported	In multivariate GLM the effect of target users type on number of releases is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics

		<p>for these are not significant at $p < 0.1$. Therefore, average number of releases did not vary across types of target users.</p> <p>Results of One-Way ANOVA test showed that average number of releases did not vary across types of target users and were not significant at $p < 0.1$. 0.01</p>
<p>Hypothesis 4a. Using a commonly used programming language is positively associated with the number of downloads of OSS projects.</p>	Not supported	<p>In multivariate GLM the effect of programming language type on number of downloads is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$. Therefore, average number of downloads did not vary across the types of programming language.</p> <p>Results of One-Way ANOVA test showed that average number of downloads did not vary across the types of programming language and were not significant at $p < 0.1$.</p>
<p>Hypothesis 4b. Using a commonly used programming language is</p>	Not supported	<p>In multivariate GLM the effect of programming language type on</p>

<p>positively associated with the number of releases of OSS projects.</p>		<p>number of releases is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$. Therefore, average number of releases did not vary across the types of programming language.</p> <p>Results of Welch and Brown-Forsythe robust F tests showed that average number of releases did not vary across the types of programming language and were not significant at $p < 0.1$.</p>
<p>Hypothesis 5a. Development of application development and deployment tools is positively associated with the number of downloads of OSS projects.</p>	<p>Not supported</p>	<p>In multivariate GLM the effect of software type on number of downloads is significant because Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant at $p < 0.1$ with observed power equal to 0.7 and coefficient equal to 0.04. Roy's largest root and its F statistic is significant at $p < 0.1$ with observed power equal to 0.778 and coefficient equal to 0.071. Therefore, average number of downloads varied across the</p>

		<p>types of software. Results of Tamhane T2 test showed that the difference between average number of downloads across all three types of software is not significant.</p> <p>Results of Welch and Brown-Forsythe F tests showed that average number of downloads did not vary across the types of software and were not significant at $p < 0.1$.</p>
<p>Hypothesis 5b. Development of application development and deployment tools is positively associated with the number of releases of OSS projects.</p>	Supported	<p>In multivariate GLM the effect of software type on number of releases is significant because Pillai's trace, Wilk's lambda, Hotelling's trace and F statistics for these are significant at $p < 0.1$ with observed power equal to 0.7 and coefficient equal to 0.04. Roy's largest root and its F statistic is significant at $p < 0.1$ with observed power equal to 0.778 and coefficient equal to 0.071. Therefore, average number of releases varied across the types of software. Results of Bonferroni test showed that average number</p>

		<p>of releases was greater for development of application development and deployment tools than those of system infrastructure software and application software and were significant at $p < 0.1$.</p> <p>Results of One-Way ANOVA test showed that average number of releases varied across the types of software and were significant at $p < 0.05$. Results of Bonferroni test showed that average number of releases was greater for development of application development and deployment tools than those of system infrastructure software and application software and were significant at $p < 0.1$.</p>
<p>Hypothesis 6a. Use of non-restrictive license is positively associated with the number of downloads of OSS projects.</p>	Not supported	<p>In multivariate GLM the effect of type of license on number of downloads is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$. Therefore, average number of downloads did not vary across the types of license.</p>

		Results of Welch and Brown-Forsythe robust F tests showed that average number of downloads did not vary across the types of license and were not significant at $p < 0.1$.
Hypothesis 6b. Use of non-restrictive license is positively associated with the number of releases of OSS projects.	Not supported	<p>In multivariate GLM the effect of type of license on number of releases is not significant because Pillai's trace, Wilk's lambda, Hotelling's trace, Roy's largest root and F statistics for these are not significant at $p < 0.1$. Therefore, average number of releases did not vary across the types of license.</p> <p>Results of One-Way ANOVA test showed that average number releases did not vary across the types of license and were significant at $p < 0.1$.</p>

6. DISCUSSION OF RESULTS

This chapter discusses the results obtained in Chapter 5. It is organized into eight sections, each of which discusses a key finding from this research.

6.1 OSS project success

The success measures of OSS development projects seem to be different from those specified for development projects examined in the product development literature.

According to Brown and Eisenhardt (1995), success of product development can be measured in terms of process efficiency and product effectiveness. Measures of process efficiency include development cost, development time, and engineering productivity.

Measures of product effectiveness include sales revenue, profitability, and market share.

According to Griffin and Page (1993), project success can be assessed using three dimensions: Customer-based success, financial success, and performance-based success.

For most development projects, customer satisfaction and customer acceptance are two of the best measures of customer-based success. The degree to which profit goals are met may be an appropriate indicator of financial success. The degree to which a project provides a competitive advantage is the most useful indicator of performance-based success (Griffin and Page, 1996).

Success measures such as development cost, development time, engineering productivity, sales, profits and attainment of profit goals, customer satisfaction, market share, source of

competitive advantage and other similar metrics are difficult to apply in the context of OSS projects. Other success measures are needed.

The results of an on line survey conducted to identify the measures of open source project success indicated that a majority of the developers that contribute to open source projects define success in terms of: number of users, number of downloads, and number of releases. Data on number of users is not publicly available. Thus, this research used number of downloads and number of releases as indicators of OSS project success.

6.2 Factors that significantly affect OSS project success

The results shown in Tables 9 and 34 suggest that the number of developers, experience of developers, target users type, software type, and development status significantly affect number of downloads and number of releases. Ranking the five independent variables that significantly affect the dependent variables using the Partial Eta squared coefficients shown in Table 9, provides the following results: 1. development status (.182 to .317), 2. software type (0.022), 3. experience of developers (0.021), 4. number of developers (0.019) and 5. targeting developers as users (0.014).

The ranking above suggests that:

- the effect of development status on number of downloads and number of releases is significant

- software type, experience of developers, and number of developers affect number of downloads and number of releases more than user type targeted

6.3 OSS projects that develop application development and deployment tools

The results shown in Tables 9 and 34 support Hypotheses 5a and 5b. OSS projects that produce application development and deployment tools are more successful than OSS projects that produce application software and system infrastructure software.

According to Brown and Eisenhardt (1995), provision of unique benefits to customers is critical for the success of new product development. According to Crowston and Scozzi (2002), the OSS community is mostly comprised of user who have high software knowledge and can also develop software. OSS projects that address developers' needs for tools may be more successful than OSS projects that address the needs of end users and system administrators for application software and system infrastructure software.

6.4 OSS projects that attract a greater number of experienced developers

The results shown in Tables 9 and 34 support Hypotheses 1a, 1b, 2a and 2b. The number and experience of developers is positively associated with the success of OSS projects. To develop OSS successfully, the OSS project must motivate a large number of experienced developers to contribute to it.

The number of developers has been identified as a factor that affects the success of OSS projects in the literature (Raymond, 1999; Crowston and Scozzi, 2002; Healy and Schussman, 2003; Duijnhouwer and Widdows, 2003). According to Raymond (1999), with more developers the rate of software development is increased. According to Crowston and Scozzi (2002) and Healy and Schussman (2003), OSS projects with more developers seem more successful. According to Duijnhouwer and Widdows (2003), the greater the number of developers that actively contribute to the OSS project, the smaller the likelihood that the OSS project will stall.

The literature has also reported that the greater the number of experienced developers the greater the likelihood that a development project will be successful. According to Healy and Schussman (2003), the experience of developers contributes to the success of OSS projects as well as conventional product development projects. Johnne and Snelson (1988), Brown and Eisenhardt (1995), Storey and Easingwood, (1996), Carmel and Sawyer (1998), Curtis et al. (1988), Curtis (1981), Sheppard et al. (1979), and Krishnan (1998) emphasized that the experience of development teams is critical for the success of new product development.

6.5 OSS projects that target developers as users

The results shown in Tables 9 and 34 indicate that OSS projects that target users who are developers are more successful. The more the users of the software look like the developers of the software, the greater the likelihood that the OSS project will be successful. This finding is consistent with the findings reported in the product development literature that the involvement of users in the product development process increases product success. According to Maidique and Zirger (1985), Cooper and Kleinschmidt (1987), Brown and Eisenhardt (1995), Thomke and von Hippel (2002), Callahan and Lasry (2004), and Christensen, Anthony, and Roth (2004), customer involvement in product development process is important for success.

6.6 Factors that do not significantly affect OSS project success

The results shown in Table 9 and 34 suggest that programming language type and OSS license type did not significantly affect the number of downloads and number of releases.

Hypotheses 4a and 4b tested the relationship between the type of programming language used and the success of the OSS project. The rationale for Hypotheses 4a and 4b was that developers will be concerned about the availability of the skills required to produce code. Therefore, OSS projects using a commonly used programming language may be more successful.

A possible explanation for the results obtained could be that it may not be difficult for developers to learn new programming languages on their own if they are motivated to do so and have the basic programming skills already. If a developer is competent in a programming language, and if the OSS project addresses his/her needs, the developer will learn the new programming language.

Another explanation could be that a relatively crude measure was used to measure programming language type. Results could be different if more than two categories of the variable “programming language type” were used.

Hypotheses 6a and 6b tested the relationship between the type of OSS license used and the success of OSS project. The results did not support the hypothesis that the use of non-restrictive license is positively associated with the success of OSS projects. These results are not consistent with the findings of Fershtman and Gandal (2004) and Comino, Manenti, and Parisi (2005).

The development of Hypotheses 6a and 6b was based on the rationale that open source products can choose from several different licenses. The choice made tell us the way in which intended users are approached and may affect the success of OSS project (Duijnhouwer and Widdows, 2003). License restrictiveness will be having negative effect on the popularity of open source software (Stewart, Ammeter, and Maruping, 2005).

The finding that OSS license type does not affect success is not consistent with the findings of Fershtman and Gandal (2004) and Comino, Manenti, and Parisi (2005). Fershtman and Gandal (2004) found that the output per contributor of open source programs is much higher when licenses are less restrictive. Comino, Manenti, and Parisi (2005) found that the less restrictive the licensing terms the larger the likelihood of reaching an advanced development status, a measure of project success. A potential explanation for the discrepancy in findings is that this research used different measures of success than those used by Fershtman and Gandal (2004) and Comino, Manenti, and Parisi (2005).

6.7 Development status affect factors-success relationship

In this research, the development status of an OSS project was considered as an explanatory variable. The results in Table 9 indicated that the effect of development status on number of downloads and number of releases was significant. Development status provides information about the maturity of OSS projects. There are six development statuses specified for OSS projects on Sourceforge. These are: planning, pre-alpha, alpha, beta, production/stable, and mature. Each project registered on Sourceforge is classified into one of these six statuses by the developers of the software. No formal definitions of these stages are available on Sourceforge (Comino, Manenti, and Parisi, 2005).

6.8 Production/stable and mature OSS projects that develop application development and deployment tools

In this research, the development status of an OSS project was considered as an explanatory variable. The results in Table 9 indicated that the effect of development status on number of downloads and number of releases was significant. Development status provides information about the maturity of OSS projects. There are six development statuses specified for OSS projects on Sourceforge. These are: planning, pre-alpha, alpha, beta, production/stable, and mature. Each project registered on Sourceforge is classified into one of these six statuses by the developers of the software. No formal definitions of these stages are available on Sourceforge (Comino, Manenti, and Parisi, 2005).

The results shown in Tables 37 and 55 suggest that OSS projects with a development status of production/stable or mature that produce application development and deployment tools are more successful than the OSS projects that produce application software and system infrastructure software. The only explanatory variable found to significantly affect OSS project success was software type. This is in contrast to the results shown in Tables 9 and 34 where software type, number of developers, experience of developers, and user type were found to affect OSS project success. The results when the sample is comprised of the 108 production/stable or mature OSS projects were found to be different from the results obtained when the sample is comprised of all 350 projects.

A potential explanation for the difference may be that production/stable and mature OSS projects have attracted large numbers of experienced developers and users already.

Therefore, the type of software developed might be the only factor that distinguishes OSS project success when the OSS projects are production/stable or mature.

7. CONCLUSIONS, LIMITATIONS, AND SUGGESTIONS FOR FUTURE RESEARCH

This chapter is organized into three sections. The first section provides the conclusions drawn from this research organized in two parts: i. key findings and ii. recommendations for people who set up and operate OSS projects and managers of development projects planning to incorporate open source into the company's products. The second section identifies the limitations of this research. Finally, the third section provides suggestions for future research.

7.1 Conclusions

The objective of this research was to identify the factors that contribute to the success of OSS projects measured as number of downloads and number of releases. The results of this research suggest that:

1. Developers who contribute to OSS projects define OSS project success in ways not traditionally used to measure the success of software development projects
2. Software type, experience of developers, and number of developers contribute to OSS project success more than does user targeted type
3. OSS projects that produce application development and deployment tools are more successful than OSS projects that produce application software and system infrastructure software

4. OSS projects that attract a greater number of experienced developers are more successful
5. OSS projects that target developers as users are more successful
6. OSS projects that rely on commonly used programming languages and non-restrictive software license are not more successful than other OSS projects
7. Development status affects the relationship between factors such as number of developers, experience of developers, target users type, and type of open source software developed, and the success of OSS projects
8. Production/stable and mature OSS projects that produce application development and deployment tools are most successful when success is measured as number of releases

Based on the results of this research recommendations can be made to individuals and organizations that set up and operate OSS projects as well as managers of development projects planning to incorporate open source into the company's products

Recommendations to the individuals and organizations that set up and operate OSS projects include:

- Establish mechanisms to motivate a large number of experienced developers to continuously contribute to the OSS project
- Attract experienced developers who will benefit most from advancing the OSS project

- Target users who are themselves experienced developers and may benefit the most from using the OSS project
- Establish OSS projects that focus on application development and deployment tools

Recommendations to the managers of development projects planning to incorporate open source into the company's products include

- Use OSS projects that develop software which solves problems of both your target customers and target developers
- Hire developers with experience in the OSS projects in you wish to participate
- Target customers who are comfortable with the developers of the OSS project and stand to benefit the most from these developers' efforts

7.2 Limitations

The research is not without limitations. The first limitation is that the two measures of success used in this research are crude and have not been agreed to in the literature.

Second, while measuring the experience of developers of OSS projects, the profile of some developers was not accessible. For example, if a project had three developers it may be the case that the profile of one out of these three developers was not accessible. In

these instance the approach used by the researcher to calculate the total experience of the three developers should be improved upon.

Third, this research has examined only a few of the many factors that may contribute to the success of OSS projects.

7.3 Suggestions for future research

There are three suggestions for future research. First, future research may consider the effect of other factors on the success of OSS development projects. The other factors that may be considered include: characteristics of the leaders and the communities that develop the OSS, software modularity, product complementarities, standard adoption, and ease of deployment (Duijnhouwer and Widdows, 2003).

Second, future research efforts may examine success measures other than number of downloads and number of releases. The other success measures that may be considered include: goal accomplishment, quality of code, need fulfillment, and user satisfaction, as mentioned by some respondents of online survey conducted by the researcher (Section 4.5.7).

Third, future research may examine the differences in the relationships between the factors examined in this research and measures of OSS project success across development statuses.

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Appendix A. List of projects in the sample

S. No.	Project name	Web link	Date of data capturing
1	Gaim	http://gaim.sourceforge.net	June 20, 2005
2	SNAP Platform and SNAPPIX	http://snapplatform.org/snappix/home	June 20, 2005
3	PDFCreator	http://sector7g.wurzel6.de/pdfcreator/index_en.htm	June 20, 2005
4	Complement	http://complement.sourceforge.net	June 20, 2005
5	MegaMek	http://megamek.sourceforge.net/idx.php?pg=main	June 20, 2005
6	MinGW - Minimalist GNU for Windows	http://www.mingw.org	June 20, 2005
7	PhpGedView	http://www.phpgedview.net	June 20, 2005
8	PMD	http://pmd.sourceforge.net/	June 21, 2005
9	iTextSharp	http://itextsharp.sourceforge.net	June 21, 2005
10	Fluxbox	http://fluxbox.sourceforge.net	June 21, 2005
11	The Mana World	http://themanaworld.org	June 21, 2005

12	csv2vcard	http://csv2vcard.sourceforge.net	June 21, 2005
13	IVI	http://ivi.sourceforge.net	June 21, 2005
14	FreeCol	http://www.freecol.org	June 21, 2005
15	wxGlade	http://wxglade.sourceforge.net	June 21, 2005
16	KFilm	http://kfilm.sourceforge.net	June 22, 2005
17	VASSAL Engine	http://www.vassalengine.org/community/index.php	June 22, 2005
18	FreeMind	http://freemind.sourceforge.net/wiki/index.php/Main_Page	June 22, 2005
19	NeoBio	http://neobio.sourceforge.net	June 22, 2005
20	jBpm.org - java Business Process Mgmt	http://www.jboss.com/products/jbpm	June 22, 2005
21	ShakesPeer	http://shakespeer.sourceforge.net	June 22, 2005
22	Security Policy Manager	http://iscs.sourceforge.net/	June 23, 2005
23	Scintilla	http://www.scintilla.org	June 23, 2005
24	quickplot	http://quickplot.sourceforge.net	June 23, 2005

25	Linux Submarine Simulation	http://www.linuxssn.org	June 23, 2005
26	Slickworm	http://slickworm.sourceforge.net	June 23, 2005
27	freeBASIC Compiler	http://www.freebasic.net	June 23, 2005
28	PHPBalanceSheet	http://phpbalancesheet.sourceforge.net	June 23, 2005
29	C and C++ Programming Pearls	http://cpearls.sourceforge.net	June 23, 2005
30	QuickCam Express Driver	http://qce-ga.sourceforge.net	June 23, 2005
31	wxWidgets (formerly wxWindows)	http://wxwindows.org	June 24, 2005
32	ndiswrapper	http://ndiswrapper.sourceforge.net	June 24, 2005
33	Multiple Amusement/Gaming Emulator	http://magesrc.sourceforge.net/index.php	June 24, 2005
34	PHPeclipse - PHP/SQL/HTML Eclipse-Plugin	http://www.phpeclipse.de/tiki-view_articles.php	June 24, 2005
35	JFreeChart	http://www.jfree.org/jfreechart/index.php	June 24, 2005

36	Hibernate	http://www.hibernate.org	June 24, 2005
37	UniParser toolkit	http://ex-code.com/uniparser	June 24, 2005
38	Pitcher's Duel	http://pduel.sourceforge.net	June 24, 2005
39	Topic Map API	http://tmap.sourceforge.net	June 25, 2005
40	EzSocket Library	http://ezsocket.sourceforge.net	June 25, 2005
41	Think3D	http://think3d.sourceforge.net	June 25, 2005
42	HTML Parser	http://htmlparser.sourceforge.net	June 25, 2005
43	SQLiteManager	http://www.sqlitemanager.org	June 25, 2005
44	Spineless Game Engine	http://spineless.sourceforge.net	June 26, 2005
45	Neophyte Chess Engine	http://neophyte.sourceforge.net	June 26, 2005
46	Eclipse Checkstyle Plug-in	http://eclipse-cs.sourceforge.net	June 26, 2005
47	NuSOAP - SOAP Toolkit for PHP	http://nusoap.sourceforge.net	June 26, 2005
48	DCRPG	http://dcnexusrpg.sourceforge.net	June 26, 2005

49	Live Universe	http://letalka.sourceforge.net	June 26, 2005
50	Generic Model Organism System Database	http://www.gmod.org/node/86	June 27, 2005
51	JJPasswordSafe	http://jjpasswordsafe.sourceforge.net	June 27, 2005
52	Vesta Configuration Management System	http://www.vestasys.org	June 27, 2005
53	EclipseNSIS	http://eclipsensis.sourceforge.net	June 27, 2005
54	xcrabble	http://xcrabble.sourceforge.net	June 27, 2005
55	scooter	http://scooter.sourceforge.net	June 27, 2005
56	netatalk	http://netatalk.sourceforge.net	June 27, 2005
57	PN Web Ring Module	http://www.ringlink.org	June 27, 2005
58	UPC Database	http://www.upcdatabase.com	June 27, 2005
59	Balder	http://balder.sourceforge.net	June 27, 2005
60	Ada 95 Appl. Support Component Lib.	http://ascl.sourceforge.net	June 27, 2005

61	Digital Paint Paintball 2	http://dynamic.gamespy.com/~digitalpaint/news.php	June 28, 2005
62	ZX Box	http://zxbox.sourceforge.net	June 28, 2005
63	PDFman	http://pdfman.sourceforge.net	June 28, 2005
64	Webmin System stats	http://webminstats.sourceforge.net	June 28, 2005
65	SystemImager	http://www.systemimager.org	June 28, 2005
66	WINE for Darwin and Mac OS X	http://darwine.opendarwin.org	June 28, 2005
67	Dump/Restore ext2/ext3 file system backup	http://dump.sourceforge.net	June 29, 2005
68	Inventory	http://inventory.sourceforge.net	June 29, 2005
69	jazzlib - a pure java java.util.zip	http://jazzlib.sourceforge.net	June 29, 2005
70	GFP	http://gfd.sourceforge.net	June 29, 2005
71	mod_auth_mysql	http://modauthmysql.sourceforge.net	June 30,2005
72	Anti-Spam SMTP Proxy Server	http://assp.sourceforge.net	June 30,2005
73	CAD Toolkit	http://cadkit.sourceforge.net	June 30,2005

74	Webmin	http://www.webmin.com	June 30,2005
75	DDD - Data Display Debugger	http://www.gnu.org/software/ddd	July 1,2005
76	Visu	http://visu.sourceforge.net/home.en.html	July 1,2005
77	Setserial --- serial driver config tool	http://setserial.sourceforge.net	July 1,2005
78	FindBugs	http://setserial.sourceforge.net	July 1,2005
79	OpenC++	http://opencxx.sourceforge.net	July 1,2005
80	phPhone	http://cmaser.sourceforge.net	July 1,2005
81	Xenocide	http://www.projectxenocide.com	July 1,2005
82	clib2	http://clib2.sourceforge.net	July 2,2005
83	FreePOPs	http://www.freepops.org/en	July 2,2005
84	ARSperl	http://arsperl.sourceforge.net	July 2,2005
85	XPath Explorer	http://www.purpletech.com/xpe	July 2,2005
86	XBasic	http://xbasic.sourceforge.net	July 3,2005
87	strace	http://www.liacs.nl/~wichert/strace	July 3,2005
88	MoviX	http://movix.sourceforge.net	July 3,2005

89	Modular Controller Architecture	http://mca2.sourceforge.net	July 3,2005
90	OpenFRAG	http://www.openfrag.org	July 3,2005
91	CivQuest	http://civquest.sourceforge.net	July 4,2005
92	lphantGUI	http://www.lphant.com	July 4,2005
93	Sync4j	http://www.funambol.com/opensource	July 4,2005
94	NiL Isn't Liero	http://nil.sourceforge.net	July 4,2005
95	JSwat - Java Debugger	http://jswat.sourceforge.net	July 4,2005
96	TeXnicCenter	http://www.texniccenter.org/front_content.php	July 4,2005
97	XPWeb	http://xpweb.sourceforge.net	July 4, 2005
98	Macattrick	http://www.macattrick.com	July 5,2005
99	XDoclet	http://xdoclet.sourceforge.net/xdoclet/index.html	July 5, 2005
100	Wings 3D	http://www.wings3d.com	July 5,2005
101	AndyAdmin	http://andyadmin.sourceforge.net	July 11, 2005
102	myIpacNG-stats	http://myipac-ng-stats.jems.de	July 11, 2005

103	FProfiler	http://fprofiler.sourceforge.net	July 11, 2005
104	xacting form validation service	http://xfvs.sourceforge.net	July 11, 2005
105	ClayTek 3D Game Library & Editor	http://claytek.sourceforge.net	July 11, 2005
106	ACMCo. KB	http://acmco-kb.sourceforge.net	July 11, 2005
107	BuildBot	http://buildbot.sourceforge.net	July 12, 2005
108	Server Array Management System	http://project.antimatters.org.uk	July 12, 2005
109	Direct Show AC3 Encoder	http://oss.netfarm.it	July 12, 2005
110	winadmin: waUtils for sysadmins	http://winadmin.sourceforge.net	July 12, 2005
111	LogQ Syslog Query	http://logq.sourceforge.net	July 12, 2005
112	nanoFTPd	http://nanoftpd.sourceforge.net	July 13, 2005
113	cfGlitch	http://cfglitch.sourceforge.net	July 13, 2005
114	Cute PHP library	http://www.macher24.de/cphplib_english.html	July 13, 2005

115	Compiere MFG + SCM (Manufacturing)	http://compiere-mfgscm.sourceforge.net	July 13, 2005
116	pacKAGE oRGANIZER	http://paco.sourceforge.net	July 13, 2005
117	JNetStream Protocol Decoder	http://jnetstream.sourceforge.net	July 13, 2005
118	Remote-Serial	http://remote-serial.sourceforge.net	July 14, 2005
119	NASA World Wind	http://worldwind.arc.nasa.gov	July 14, 2005
120	IM Sniffer	http://im-snif.sourceforge.net	July 14, 2005
121	Ascent	http://ascent.sourceforge.net	July 14, 2005
122	Cajun	http://cajun.sourceforge.net	July 14, 2005
123	OpenSharePoint Team Service	http://opensharepoint.sourceforge.net	July 14, 2005
124	SharpFlash	http://sharpflash.sourceforge.net	July 15, 2005
125	SNTP Client for Virtual PC	http://vsntp.sourceforge.net	July 15, 2005
126	Slack-Kickstart	http://www.slack-kickstart.org	July 15, 2005
127	Stenil - virtual games console	http://stenil.sourceforge.net	July 15, 2005

128	Kalender	http://sourceforge.net/projects/mkal	July 15, 2005
129	Swaret	http://swaret.sourceforge.net/index.php	July 15, 2005
130	Liberum Help Desk	http://www.liberum.org	July 15, 2005
131	Modus (ColdFusion CMS framework)	http://modus.sourceforge.net	July 16, 2005
132	Contact Manager	http://contact-manager.sourceforge.net	July 16, 2005
133	Automatic Random Signature Generator	http://signify.sourceforge.net	July 16, 2005
134	tacacs++ server daemon	http://sourceforge.net/projects/tacppd	July 16, 2005
135	cpShuffleSature	http://cpshufflesature.sourceforge.net	July 16, 2005
136	Fwall - Linux Firewall Script Manager	http://fwall.sourceforge.net	July 16, 2005
137	mln - My Linux Network UML services	http://mln.sourceforge.net	July 16, 2005
138	VRRP -Virtual Router Redundancy Protocol	http://www.imagestream.com/VRRP.html	July 16, 2005

139	QJ-Pro	http://qjpro.sourceforge.net	July 17, 2005
140	Genesis3D Open Source Project	http://www.genesis3d.com	July 17, 2005
141	HTML Unit	http://htmlunit.sourceforge.net	July 17, 2005
142	phpMyEdit: MySQL Table Editor	http://www.phpmyedit.org	July 17, 2005
143	CruiseControl	http://cruisecontrol.sourceforge.net	July 17, 2005
144	Java Persistent Objects	http://www.jpox.org/index.jsp	July 18, 2005
145	SpecTcl	http://spectcl.sourceforge.net	July 18, 2005
146	StaloneTray	http://stalonetray.sourceforge.net	July 18, 2005
147	Jaluna Real-Time Component Suite	http://sourceforge.net/projects/jaluna	July 18, 2005
148	Open Outlook Connector	http://openconnector.org	July 19, 2005
149	JAud	http://sourceforge.net/projects/jaud	July 19, 2005
150	Codebook Framework for Visual FoxPro	http://codebook.sourceforge.net	July 19, 2005
151	Jajuk	http://jajuk.sourceforge.net	July 19, 2005
152	gv Postscript and PDF viewer	http://www.gnu.org/software/gv	July 19, 2005

153	Linux layer 7 packet classifier	http://l7-filter.sourceforge.net	July 19, 2005
154	MailManager	http://www.logicalware.org	July 19, 2005
155	Linux layer 7 packet classifier	http://l7-filter.sourceforge.net	July 20, 2005
156	SystemImager	http://www.systemimager.org	July 20, 2005
157	AcidRip - a Gtk2::Perl DVD encoding GUI	http://untrepid.com/acidrip	July 20, 2005
158	MyBooking System	http://mbsystem.sourceforge.net	Aug 6, 2005
159	Creative Nomad JukeBox KIO::Slave	http://kionjb.sourceforge.net	Aug 6, 2005
160	qmatplot	http://qmatplot.sourceforge.net	Aug 6, 2005
161	Firestorm IDS	http://www.scaramanga.co.uk/firestorm	Aug 6, 2005
162	PEQ	http://www.projecteq.net	Aug 6, 2005
163	Scorched Earth Online War	http://seow.sourceforge.net	Aug 6, 2005
164	baiXa	http://baixa.sourceforge.net	Aug 6, 2005

165	Smieciuch Garbage Collector	http://smieciuch.sourceforge.net	Aug 7, 2005
166	Windows Scancode Interceptor	http://sourceforge.net/projects/wsi	Aug 7, 2005
167	pMH	http://phpmyhotels.sourceforge.net	Aug 7, 2005
168	xmItVR3	http://xmItvr3.sourceforge.net	Aug 7, 2005
169	Battle for Wesnoth	http://www.wesnoth.org	Aug 8, 2005
170	JJPasswordSafe	http://jjpasswordsafe.sourceforge.net	Aug 8, 2005
171	SiGeFi	http://sourceforge.net/projects/sigefi	Aug 8, 2005
172	Bakefile	http://bakefile.sourceforge.net	Aug 8, 2005
173	Fields of Destiny	http://fod.sourceforge.net	Aug 8, 2005
174	DELI: Delivery context library	http://www.hpl.hp.com/personal/marbut	Aug 8, 2005
175	Web PO Requisition	http://sourceforge.net/projects/webprocure	Aug 9, 2005
176	OpenXDK	http://www.openxdk.org	Aug 9, 2005
177	Genealogy	http://genealogy.sourceforge.net	Aug 9, 2005

178	Loki	http://erdani.org	Aug 9, 2005
179	Publicly Available PAssworDs	http://papad.sourceforge.net	Aug 9, 2005
180	XML-RPC for PHP	http://phpxmlrpc.sourceforge.net	Aug 9, 2005
181	py-icq	http://py-icq.sourceforge.net	Aug 9, 2005
182	Tcl/Tk civserver interface	http://civtk.sourceforge.net	Aug 10, 2005
183	SDL.NET	http://cs-sdl.sourceforge.net/index.php/Main_Page	Aug 10, 2005
184	PerlGo	http://dewarim.de/de/programme/go_en.html	Aug 10, 2005
185	Atlantis Engine	http://atlantismmorpq.sourceforge.net	Aug 10, 2005
186	filewatcher	http://www.willingminds.com/resources/filewatcher.html	Aug 10, 2005
187	Job Search Management Tool	http://jobhunt.sourceforge.net	Aug 10, 2005
188	ebXML Registry/Repository	http://ebxmlrr.sourceforge.net	Aug 10, 2005

189	The Dead Walk	http://thedeadwalk.zolton.org	Aug 10, 2005
190	Vincent Mobile 3D Rendering Library	http://ogl-es.sourceforge.net/index.htm	Aug 10, 2005
191	Tortoise Mail	http://tortoise-mail.sourceforge.net/index.php?lng=en	Aug 11, 2005
192	pastabrothers pure-Linux	http://pure-linux.sourceforge.net	Aug 11, 2005
193	phpMyChord	http://phpmychord.sourceforge.net	Aug 11, 2005
194	Bacula	http://www.bacula.org	Aug 11, 2005
195	gtk2hs: A Gtk2 binding for Haskell	http://haskell.org/gtk2hs	Aug 11, 2004
196	rtEq	http://rteq.sourceforge.net	Aug 11, 2005
197	Extra Innings Computer Baseball	http://eicbaseball.sourceforge.net	Aug 12, 2005
198	Qsynth	http://qsynth.sourceforge.net/qsynth-index.html	Aug 12, 2005
199	Bombberman 3D	http://bomb3d.sourceforge.net	Aug 12, 2005
200	tkBoom	http://tkboom.sourceforge.net	Aug 12, 2005

201	MetaBoss	http://www.metaboss.com	Aug 12, 2005
202	ContAuto - Content Automation	http://genmdixml.sourceforge.net	Aug 12, 2005
203	OpenBiblio	http://obiblio.sourceforge.net	Aug 12, 2005
204	Injection	http://injection.sourceforge.net	Aug 12, 2005
205	Merchant of Venus	http://win32dxproject.sourceforge.net	Aug 12, 2005
206	Karrigell	http://karrigell.sourceforge.net	Aug 12, 2005
207	Watermill	http://watermill.sourceforge.net	Aug 12, 2005
208	DJPlay	http://djplay.sourceforge.net	Aug 12, 2005
209	activ	http://activ.sourceforge.net	Aug 13, 2005
210	Ozone - Java OODBMS	http://www.ozone- db.org/frames/home/what.html	Aug 13, 2005
211	Nagat	http://nagat.sourceforge.net	Aug 13, 2005
212	MyUptime	http://myuptime.sourceforge.net	Aug 13, 2005
213	SoulCatcher	http://soulcatcher.sourceforge.net	Aug 13, 2005
214	ADnD Simple Character	http://ascg.sourceforge.net	Aug 13, 2005

	Generator		
215	LXR Cross Referencer	http://lxr.sourceforge.net	Aug 13, 2005
216	Knights	http://www.knights-chess.com	Aug 13, 2005
217	Fields of Destiny	http://fod.sourceforge.net	Aug 13, 2005
218	XINS	http://xins.sourceforge.net	Aug 13, 2005
219	Observ	http://observ.sourceforge.net	Aug 13, 2005
220	Elephant Memory	http://reminder.sourceforge.net/	Aug 14, 2005
221	logisim	http://logisim.sourceforge.net	Aug 14, 2005
222	Karrigell	http://karrigell.sourceforge.net	Aug 14, 2005
223	BC Glyphgenerator	http://www.bravecobra.com	Aug 14, 2005
224	SageTV Plugins	http://sageplugins.sourceforge.net	Aug 14, 2005
225	Immortal Pongbat	http://pongbat.sourceforge.net	Aug 14, 2005
226	Spago	http://spago.eng.it/docs_en/index.html	Aug 14, 2005
227	Vade Mecum	http://vade-mecum.sourceforge.net	Aug 14, 2005
228	utPLSQL	http://utplsql.sourceforge.net	Aug 14, 2005

229	Open Job Control	http://openjc.sourceforge.net	Aug 15, 2005
230	Fudaa	http://fudaa.sourceforge.net	Aug 15, 2005
231	Kricketscoreboard	http://kricketsb.sourceforge.net	Aug 15, 2005
232	Eucalyptus	http://eucalyptus.sourceforge.net	Aug 15, 2005
233	libMesh: A C++ Finite Element Library	http://libmesh.sourceforge.net	Aug 15, 2005
234	GISAR	http://gisar.sourceforge.net/ENG/Index.htm	Aug 15, 2005
235	GTK+ Mac OS X	http://gtk-osx.sourceforge.net	Aug 15, 2005
236	BooLogic	http://boologic.sourceforge.net	Aug 16, 2005
237	HAPI	http://hl7api.sourceforge.net	Aug 16, 2005
238	SCMxx	http://www.hendrik-sattler.de/scmxx	Aug 16, 2005
239	GenetX Configurator	http://gxconf.sourceforge.net	Aug 16, 2005
240	MIDAS Network Monitoring Server	http://midas-nms.sourceforge.net	Aug 16, 2005

241	SISC	http://sisc.sourceforge.net	Aug 16, 2005
242	LilyPondTool for JEdit	http://lily4jedit.sourceforge.net	Aug 16, 2005
243	The Virtuality Renderer	http://virtuality.sourceforge.net	Aug 16, 2005
244	Danger from the Deep	http://dangerdeep.sourceforge.net	Aug 16, 2005
245	Gnome Pokies	http://gpokies.sourceforge.net	Aug 17, 2005
246	Turbo Vision	http://tvision.sourceforge.net	Aug 17, 2005
247	GNU/Linux 1394 AV/C Library	http://libavc1394.sourceforge.net	Aug 17, 2005
248	SibylSQL	http://www.nightstarcorporation.com/oss/sibylsql	Aug 17, 2005
249	Boson	http://boson.eu.org	Aug 17, 2005
250	Serial Gaming Network Daemon	http://sgnetd.sourceforge.net	Aug 17, 2005
251	Muttprint -- Pretty Printing Your eMails	http://muttprint.sourceforge.net	Aug 18, 2005
252	ECB	http://ecb.sourceforge.net	Aug 18, 2005
253	sql-characteristic-functions	http://sqlchar.sourceforge.net	Aug 18, 2005

254	Open SONG db	http://songdb.sourceforge.net	Aug 18, 2005
255	PacketFence	http://www.packetfence.org	Aug 18, 2005
256	Emilda	http://www.emilda.org	Aug 18, 2005
257	Visual-MinGW	http://visual-mingw.sourceforge.net	Aug 18, 2005
258	Light up X	http://www.theaterzentrum.at/technix/development/lux	Aug 18, 2005
259	Memoranda	http://memoranda.sourceforge.net	Aug 18, 2005
260	Project JEDI API Library	http://jedi-apilib.sourceforge.net	Aug 18, 2005
261	Iequalsi	http://iequalsi.sourceforge.net	Aug 18, 2005
262	Antenna	http://antenna.sourceforge.net	Aug 18, 2005
263	Windows Unattended Install Web GUI	http://winunattended.sourceforge.net	Aug 18, 2005
264	Atlas	http://atlas.sourceforge.net	Aug 18, 2005
265	iBATIS.NET DataMapper	http://ibatis.apache.org	Aug 18, 2005
266	Linuxdiagnosis	http://digilander.libero.it/_ppricerca/index.html	Aug 18, 2005
267	Phoenix Mail	http://phxmail.sourceforge.net	Aug 19, 2005

268	Pop-Up Buster	http://pobu.sourceforge.net	Aug 19, 2005
269	poEdit	http://www.poedit.org	Aug 19, 2005
270	Xbgm	http://xbgm.sourceforge.net	Aug 19, 2005
271	Rolf	http://sourceforge.net/projects/rolf	Aug 19, 2005
272	Iter Vehemens ad Necem	http://ivan.sourceforge.net	Aug 19, 2005
273	qmatplot	http://qmatplot.sourceforge.net	Aug 19, 2005
274	Ethernut Embedded Ethernet	http://www.ethernut.de/en/index.html	Aug 20, 2005
275	NukeTreasury	http://nuketreasury.sourceforge.net	Aug 20, 2005
276	Nanashi	http://nanashi.sourceforge.net	Aug 20, 2005
277	WinSTB	http://winstb.sourceforge.net/index-en.htm	Aug 21, 2005
278	A curses Debugger	http://cgdb.sourceforge.net	Aug 21, 2005
279	BACnet Protocol Stack	http://bacnet.sourceforge.net	Aug 21, 2005
280	Break the House	http://breakthehouse.sourceforge.net	Aug 21, 2005
281	Linux Trustees	http://trustees.aeruder.net	Aug 22, 2005

	(ACL) project		
282	Archetypes	http://plone.org/products/archetypes	Aug 22, 2005
283	TclAddressBook	http://webperso.easyconnect.fr/bdesgraupe/s/DocHTML/TclAB.html	Aug 22, 2005
284	Symbian OS C++ Unit Testing Framework	http://www.symbianosunit.co.uk	Aug 22, 2005
285	Fisterra GNOME development framework	http://community.igalia.com/twiki/bin/view/Fisterra	Aug 23, 2005
286	JetStyle	http://jetstyle.sourceforge.net	Aug 23, 2005
287	Middle Haven	http://middle-haven.sourceforge.net	Aug 23, 2005
288	CryptNET Key Server	http://cryptnet.net/fsp/cks	Aug 23, 2005
289	Auto MySQLBackup	http://autobackup.sourceforge.net	Aug 23, 2005
290	FreeWPS[tm]	http://www.ytztech.com/freewps	Aug 23, 2004
291	Videotron Cable Modem Usage	http://vcmu.sourceforge.net	Aug 23, 2005
292	Tourney Tracker	http://fighttracker.sourceforge.net	Aug 24, 2005
293	JET-Editor	http://jet-editor.sourceforge.net	Aug 24, 2005

294	SmartWin++	http://smartwinlib.org	Aug 24, 2005
295	SkyEye	http://www.skyeye.org/index.shtml	Aug 24, 2005
296	Simple Addressbook	http://polarisun.sourceforge.net	Aug 25, 2005
297	Quick Dungeons and Dragons	http://qd-d.sourceforge.net	Aug 25, 2005
298	StarFrag	http://starfrag.sourceforge.net	Sep 1, 2005
299	AGKit	http://agkit.sourceforge.net	Sep 1, 2005
300	Jena	http://jena.sourceforge.net	Sep 1, 2005
301	Devil-Linux	http://www.devil-linux.org/home/index.php	Sep 2, 2005
302	OpenSMART	http://opensmart.sourceforge.net	Sep 2, 2005
303	WEB-DAV Linux File System(davfs)	http://dav.sourceforge.net	Sep 2, 2005
304	OpenSharePoint Team Service	http://opensharepoint.sourceforge.net	Sep 3, 2005
305	mailscanner-mrtg	http://mailscannermrtg.sourceforge.net	Sep 4, 2005
306	Weplab	http://weplab.sourceforge.net	Sep 4, 2005
307	IP traffic volume	http://iptrafficvolume.sourceforge.net	Sep 5, 2005

	logger		
308	vpopmail - virtual domains for qmail	http://www.inter7.com/index.php?page=vpopmail	Sep 5, 2005
309	Port Forwarding Daemon	http://portfwd.sourceforge.net	Sep 7, 2005
310	Linux Trustees (ACL) project	http://trustees.aeruder.net	Sep 7, 2005
311	winadmin: waUtils for sysadmins	http://winadmin.sourceforge.net	Sep 11, 2005
312	JNetStream Protocol Decoder	http://jnetstream.sourceforge.net	Sep 11, 2005
313	Ddclient	http://ddclient.sourceforge.net	Sep 16, 2005
314	simpleproxy	http://www.crocodile.org/software.html	Sep 16, 2005
315	Enterprise Diskspace Monitoring System	http://edimos.sourceforge.net/	Sep 16, 2005
316	l2tpns	http://sourceforge.net/projects/l2tpns	Sep 16, 2005
317	zmod-stats	http://zmod-stats.sourceforge.net	Sep 17, 2005
318	get_xyz	http://get-xyz.sourceforge.net	Sep 17, 2005

319	CaiCai	http://caicai.sourceforge.net	Sep 17, 2005
320	Patch Integration Engine (PIE)	http://pie.sourceforge.net	Sep 20, 2005
321	Ida - Intrusion Detection for Apache	http://phpida.sourceforge.net	Sep 21, 2005
322	The GNU Recipe Database	http://grdb.sourceforge.net	Sep 21, 2005
323	lemonldap reverse proxy	http://lemonldap.sourceforge.net	Sep 21, 2005
324	JOPAC2	http://jopac2.sourceforge.net/html	Sep 22, 2005
325	LAN-party Web Portal System	http://osglobelan.sourceforge.net	Sep 22, 2005
326	RH Domain Controller	http://rhems.sourceforge.net	Sep 22, 2005
327	Cricket	http://cricket.sourceforge.net	Sep 22, 2005
328	IlohaMail	http://blog.ilohamail.org	Sep 23, 2005
329	mod_cas	http://mod-cas.sourceforge.net	Sep 23, 2005
330	Password Management System	http://www.harry-b.de/dokuwiki/doku.php?id=harry:cpm	Sep 23, 2005

331	vuser	http://sourceforge.net/projects/vuser	Sep 25, 2005
332	AirSnort	http://airsnort.shmoo.com	Sep 25, 2005
333	HotSaNIC	http://hotsanic.sourceforge.net	Sep 25, 2005
334	ATM on Linux	http://linux-atm.sourceforge.net	Sep 25, 2003
335	Java SMTP/POP/WEB EMail Server	http://www.ericdaugherty.com/java/mailserver	Sep 26, 2005
336	album.php	http://perl.bobbitt.ca/album	Sep 26, 2005
337	CybOrg. The CyberCafe Organizer	http://cyborg.sourceforge.net/index.html.en	Sep 26, 2005
338	MIDAS Network Monitoring Server	http://midas-nms.sourceforge.net	Sep 27, 2005
339	Pagetool	http://www.pagetool.org	Sep 27, 2005
340	Nagat	http://nagat.sourceforge.net	Sep 27, 2005
341	FAQ-O-Matic	http://faqomatic.sourceforge.net/fom-serve/cache/1.html	Sep 28, 2005
342	BPF traffic daemon/collector	http://bpft4.sourceforge.net	Sep 29, 2005

343	LeagueSite - Sports Team/League CMS	http://leaguesite.sourceforge.net	Sep 30, 2005
344	System Configurator	http://wiki.sisuite.org/SystemConfigurator	Sep 30, 2005
345	Minerva	http://minerva.sourceforge.net	Sep 30, 2005
346	PerfParse	http://perfparse.sourceforge.net	Oct 1, 2005
347	OpenVMPS	http://vmmps.sourceforge.net	Oct 1, 2005
348	Liberum Help Desk	http://www.liberum.org	Oct 1, 2005
349	Nagios Plugins and Extensions	http://naplax.sourceforge.net	Oct 1, 2005
350	WiFiAdmin, The Free WiFi Web Interface	http://wifiadmin.sourceforge.net	Oct 1, 2005