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Open source software adoption and innovation performance of SMEs in South Africa

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A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

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ABSTRACT

Open source software (OSS) has become pervasive in the software development arena over the recent years and is used by many SMEs in South Africa in the production of products and services. Theory suggests that relative advantage can be achieved in terms of innovation performance by utilizing inbound open innovation, such as OSS, to augment limited resources available to SMEs that produce software related products and services. The purpose of this research was to investigate the nature and relative influence of OSS adoption factors on the innovation performance in the specified SME population using the technology, organization and environment (TOE) model as a theoretical framework.

A self-administered online survey questionnaire was used to collect data for a quantitative analysis of the influence of OSS adoption on innovation performance in South African SMEs in the software products and services market.

The key finding of this study indicates that the innovation performance of SMEs in South Africa is influenced by the adoption of open source software. There is a positive influence from the use of business and collaboration tools. The replacement of commercial business applications with their open source equivalents and the adoption of open source desktop platforms (e.g. Ubuntu) are supported by the findings. Managers of SMEs should consider migration to open source equivalent software in these categories in order to take advantage of not only the obvious direct cost saving but also the possible increase in innovation performance from OSS adoption.

A surprising result is the relatively strong negative influence of perceptions around the stability and performance of open source operating systems compared their commercial counterparts. The results indicate that a negative perception of the relative stability and performance of the Linux operating system compared to the Microsoft Windows operating system leads to better

innovation performance. This research has opened up a number of new avenues of investigation in the areas of innovation, open innovation, software open source software and product development in the South African SME context and contributes to this relatively new field of research by providing confirmation of the TOE model as a suitable framework for open source and innovation research via empirical study.

DECLARATION

I, _____, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Barend Christiaan Greyling

Signed at ……

On the …….. day of …… 2014

DEDICATION

I dedicate this research paper to my parents Arnold and Petra Greyling, my wife Annemie and my children, Elizabeth, Alexander and Carla. Without your encouragement I would not have completed this study.

ACKNOWLEDGEMENTS

I would like to thank Professor Boris Urban for his constant support, insight and inspiration as my supervisor. I am also indebted to Professor Barry Dwolatzky for his support for the online survey at the JCSE. Thanks to Hennie Gerber and Professor Gregory Lee for their guidance on the statistical analysis.

My gratitude goes to my wife and children for their patience and understanding during the survey as well as the writing of the research report.

I would also like to thank everyone from the open source software SME community in South Africa who participated in the online survey and gave their valuable time and encouragement towards this research.

TABLE OF CONTENTS

ABSTRACT ..... **II**

DECLARATION ..... **IV**

DEDICATION ..... **V**

ACKNOWLEDGEMENTS ..... **VI**

LIST OF TABLES ..... **X**

LIST OF FIGURES ..... **XI**

1. CHAPTER 1: INTRODUCTION **1**

1.1 PURPOSE OF THE STUDY 1
1.2 CONTEXT OF THE STUDY 1
1.3 PROBLEM STATEMENT 3
1.3.1 MAIN PROBLEM 3
1.4 SIGNIFICANCE OF THE STUDY 3
1.5 DELIMITATIONS OF THE STUDY 4
1.6 DEFINITION OF TERMS 4
1.7 ASSUMPTIONS 4

2. CHAPTER 2: LITERATURE REVIEW **6**

2.1. INTRODUCTION 6
2.2. OPEN SOURCE SOFTWARE 6
2.2.1 OSS ADOPTION IN SOUTH AFRICA 7
2.2.2 THE TOE MODEL AND OSS ADOPTION 8
2.2.3 THE TECHNOLOGY CONTEXT AND OSS ADOPTION 10
2.2.4 THE ORGANISATIONAL CONTEXT AND OSS ADOPTION 11
2.2.5 THE ENVIRONMENTAL CONTEXT AND OSS ADOPTION 12
2.3. INNOVATION AND OPEN INNOVATION 12
2.3.1 OPEN INNOVATION 12
2.3.2 OPEN SOURCE SOFTWARE AS OPEN INNOVATION 14
2.3.3 INNOVATION PERFORMANCE 15
2.3.4 OPEN INNOVATION AND INNOVATION PERFORMANCE 15
2.4 OPEN SOURCE SOFTWARE AND INNOVATION PERFORMANCE 16
2.4.1 HYPOTHESIS 1 17
2.4.2 HYPOTHESIS 2 17
2.4.3 HYPOTHESIS 3 17

2.5 Conclusion of Literature Review 18
2.5.1 Hypothesis 1: 18
2.5.2 Hypothesis 2: 18
2.5.3 Hypothesis 3: 18

3. CHAPTER 3: RESEARCH METHODOLOGY 19

3.1 Research methodology /paradigm 19
3.2 Research Design 19
3.3 Population and sample 20
3.3.1 Population 20
3.3.2 Sample and sampling method 20
3.4 The research instrument 21
3.5 Procedure for data collection 21
3.6 Data analysis and interpretation 21
3.7 Limitations of the study 22
3.8 Validity and reliability 22
3.8.1 External validity 23
3.8.2 Internal validity 23
3.8.3 Reliability 23

4. CHAPTER 4: PRESENTATION OF RESULTS 25

4.1 Introduction 25
4.2 Demographic profile of respondents 25
4.3 Data Preparation 29
4.4 Factor Analysis 30
4.5 Results pertaining to Hypothesis 1: 35
4.6 Results pertaining to Hypothesis 2: 37
4.7 Results pertaining to Hypothesis 3: 38
4.8 Summary of the results 40

5. CHAPTER 5: DISCUSSION OF THE RESULTS 41

5.1 Introduction 41
5.2 Demographic profile of respondents 41
5.3 Discussion pertaining to the factor analysis 42
5.4 Discussion pertaining to Hypothesis 1 43
5.5 Discussion pertaining to Hypothesis 2 44
5.6 Discussion pertaining to Hypothesis 3 45
5.7 Conclusion 46

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS 48

6.1 INTRODUCTION 48
6.2 CONCLUSIONS OF THE STUDY 48
6.3 RECOMMENDATIONS 49
6.4 SUGGESTIONS FOR FURTHER RESEARCH 49

REFERENCES 51

APPENDIX A: SURVEY QUESTIONNAIRE 58

SURVEY QUESTIONNAIRE 58
INSTRUCTIONS 58
SECTION 1: DEMOGRAPHIC QUESTIONS 58
SECTION 2: QUESTIONS ON ADOPTION OF OSS IN THE TECHNOLOGY DIMENSION 59
SECTION 4: QUESTIONS ON ADOPTION OF OSS IN THE ENVIRONMENT DIMENSION 62
SECTION 5: QUESTIONS ON INNOVATION PERFORMANCE 63

APPENDIX B: SUMMARY DATA 65

APPENDIX C: FACTOR ANALYSIS 66

APPENDIX D: REGRESSION ANALYSIS 70

APPENDIX E: CONSISTENCY MATRIX 73

LIST OF TABLES

Table 1 Relevant TOE Factors Influencing OSS Adoption (Van Belle & Reed, 2012) 10

Table 2 Firm size distribution by employee count 26

Table 3 Firm size descriptive statistics 26

Table 4 Firm age distribution 27

Table 5 Firm age descriptive statistics 27

Table 6 Distribution per CIPC business sector 28

Table 7 Distribution of product categories 28

Table 8 Product and process count descriptive statistics 29

Table 9 KMO and Batlett's Test results 30

Table 10 Factor analysis scree plot 32

Table 11 Factor analysis results 33

Table 12 Pearson correlation of variables 35

Table 13 Number of new products and services model summary 35

Table 14 Number of new products and services regression 36

Table 15 Number of new products and services coefficients 36

Table 16 Number of new processes model summary 37

Table 17 Number of new processes regression 37

Table 18 Number of new processes coefficients 38

Table 19 Percentage of sales from new products and services model 39

Table 20 Percentage of sales from new products and services model 39

Table 21 Percentage of sales from new products and services model 39

Table 22 Percentage of sales from new products and services model 39

Table 22: Consistency matrix 74

LIST OF FIGURES

Figure 1: Concept map of free software (Böhm, 2007) 7

Figure 2: Technology, organization and environment (TOE) framework (Oliveira & Martins, 2011) as per (Tornatzky et al., 1990) 8

Figure 3: Three archetypes of open innovation processes (Gassmann et al., 2010) 13

1. CHAPTER 1: INTRODUCTION

1.1 Purpose of the study

The purpose of this research was to measure the extent to which the adoption of Open Source Software (OSS) influences the innovation performance of Small to Medium Enterprises (SMEs) in South Africa.

1.2 Context of the study

Open source software (OSS) or Free/open source software (FOSS) is denoted by two main characteristics, viz. first, the software source code (instructions that comprise the program) is freely available and second, the software and source code are distributed under licensing agreements that allow free distribution as well as modification of the source code (Rossi, 2004). The freedom aspect of open source software is explained by the four essential freedoms:

(F. S. Foundation, 2013)

- The freedom to run the program, for any purpose (freedom 0).
- The freedom to study how the program works, and change it so it does your computing as you wish (freedom 1). Access to the source code is a precondition for this.
- The freedom to redistribute copies so you can help your neighbour [sic] (freedom 2).
- The freedom to distribute copies of your modified versions to others (freedom 3). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this (para.6).

Notable milestones since the inception of the notion of OSS in the 1960s and 1970s (Androutsellis-Theotokis, Spinellis, Kechagia, & Gousios, 2011) are the establishment of the Free Software Foundation (FSF) and the creation of the GNU operating system (Stallman, 2009) in 1985, and the introduction of the Linux operating system in 1991 (Cicoria, Sherlock, Clarke, & Muniswamaiah, 2012). Examples of open source software products are 1) operating system – Linux 2) Web server – Apache, 3) Business Application – LibreOffice, 4) Database – MySQL and 5) Software development tool - CVS (FOSSFA, 2010).

By the very nature of the supply of source code as well as software development tools and methodologies, OSS is beneficial to the software development process (Cicoria et al., 2012). Deshpande and Riehle (2008) noted in 2008 that OSS is now an integral part of the software development market. More recent results from the Future of Open Source Survey (Research, 2013) found that there are over a million active open source software projects active today.

Adoption of OSS by organisations in South Africa has been studied by the use of case studies (Ellis & Van Belle, 2009; Van Belle & Reed, 2012; Van Beulen, Van Belle, & Madhusudhan, 2009). These case studies have, as per Dedrick and West (2003) made use of the technology, organisational and environment (TOE) framework (Tornatzky, Fleischer, & Chakrabarti, 1990), see Figure 2, to assess the adoption of OSS. The TOE framework was used for this research to analyse the adoption characteristics of OSS as drivers of technological innovation.

The concept of open innovation (Chesbrough, 2003) was used to frame OSS to research the relationship between OSS and innovation performance. Innovation performance was considered in respect of the product and process innovations of SMEs in the Information Communications and Technology (ICT) industry sector of South Africa. In this regard, European studies (Inauen & Schenker-Wicki, 2011; Parida, Westerberg, & Frishammar, 2012) have found that there is a positive relationship between open innovation and innovation performance. Parida et al. (2012) focus on SMEs but (Inauen & Schenker-Wicki, 2011) have stock-listed firms as their population. One recent study in Italy by Piva, Rentocchini, and

Rossi-Lamastra (2012) shows a positive relationship between OSS adoption and innovation performance and provides a basis for the research. To my knowledge, no study of the relationship between OSS adoption and innovation performance of SMEs has been done in the South African context.

1.3 Problem statement

1.3.1 *Main problem*

The main problem of the research is to establish the relationship between the adoption attributes of OSS and the innovation performance of SMEs in South Africa. This will help solve the business problem of understanding how the various adoption factors of OSS contribute to influencing innovation performance in the defined business sector.

1.4 Significance of the study

The study fills a gap in that existing studies on OSS in South Africa have concentrated on the adoption of OSS (Ellis & Van Belle, 2009; Van Belle & Reed, 2012; Van Beulen et al., 2009) and not on the impact of the adoption and more specifically, not the link between OSS adoption and innovation performance. It is noteworthy that these three cases mentioned previously are case studies and call for further quantitative research in their recommendations sections. To the best of my knowledge, no study on the link between OSS and innovation performance has been done in the South African context. In the literature study section of this study, further investigation into European studies on the links between open innovation OSS and innovation performance is done.

The study will provide guidance on the use of OSS adoption as an enabler of innovation performance for SMEs that produce software development products in South Africa. This will be valuable in the areas of new venture creation, technology strategy formulation and new product development. Entrepreneurs planning to start software development ventures, as well as existing owners and

directors of software development firms will benefit from this study. It is hoped that they will benefit by being able to make better decisions around the adoption of OSS as the basis for the creation of new and innovative software products and solutions.

1.5 Delimitations of the study

The scope of the study is limited to firms registered in South Africa. The focus was on SMEs in the private sector. These firms have their primary focus of business activity defined as new product development through their own software development efforts.

1.6 Definition of terms

- Free/Open Source Software (FOSS) or Open Source Software (OSS) – "software distributed with a license allowing access to its source code, free redistribution, the creation of derived works and unrestricted use" (Androutsellis-Theotokis et al., 2011, p. 189)

- Innovation – "1: the introduction of something new and 2: a new idea, method, or device: novelty" (Merriam-Webster.com, 2013, p. 1).

- Entrepreneurship – "The ability to create and build a vision from practically nothing." (Timmons & Saputro, 1999) as cited in (Morris, Kuratko, & Covin, 2010, p. 10).

1.7 Assumptions

- **The respondents reflected normal perspectives and experiences of South African-based firms** – This is reasonable because it was expected that the targeted firms operate in the South African context. The research outcome is sensitive to this assumption due to the fact that the technological influences and socio-economics of South Africa are very

different from its African neighbours as well as the rest of the world. A firm with say, a United States base, would be exposed to a very different economic climate and technological factors than a local one.

- **Respondents were familiar with open source software and understood the various OSS characteristics** – This was reasonable because the sample group was chosen from the specific population of ICT SMEs that participate in software development activities and should therefore have been familiar with OSS.

- Respondents answered the survey questions honestly.

2. CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

This section presents the literature review of the topics of the research. Open source software, its characteristics and specific research on OSS adoption in the South African context is reviewed. Use of the technology, organisation and enterprise (TOE), as well as the diffusion of information (DOI) theoretical models in the adoption of OSS, is explained.

This is followed by a critical review of literature on innovation and the specific sub-section of open innovation, as well as relevant innovation performance measurements for product development relevant to this research. The relevance of open source software as a form of open innovation is then covered. Specific review of the available literature on outside-in or inbound open innovation is presented next.

Previous studies on the relationship between OSS, open innovation and innovation performance are then reviewed. The hypotheses are then explained in the context of the literature and theory. Finally, the conclusion of the literature review is given.

2.2. Open Source Software

The free/open source software phenomenon is not just about access to source code but comprises a number of factors, viz. individual motivation of contributors (Crowston, Wei, Howison, & Wiggins, 2012; Fang & Neufeld, 2009; Ghosh, 1998; Hann, Roberts, & Slaughter, 2004; Shah, 2006), software development processes (Feller & Fitzgerald, 2000; Fitzgerald, 2006; Henkel, 2006; Raymond, 1999; Rolandsson, Bergquist, & Ljungberg, 2011; Von Krogh, 2003), licensing models (FSF, 2013), business models (Bonaccorsi, Giannangeli, & Rossi, 2006; Fosfuri,

Giarratana, & Luzzi, 2008; OSI, 2013) and community participation and collaboration (Dahlander & Magnusson, 2008; Schofield & Cooper, 2006). Figure 1 shows a concept map of free/open FOSS from the Free Software Foundation (Böhm, 2007) that gives further context.

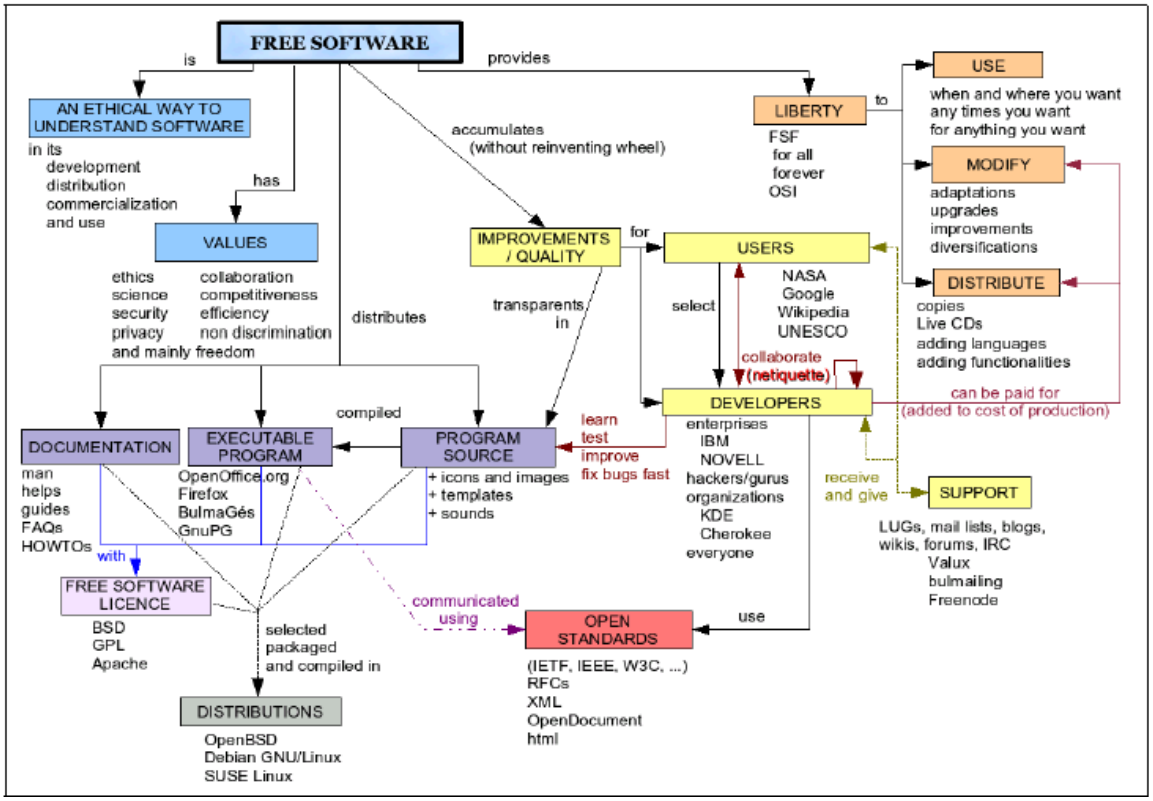


Figure 1: Concept map of free software (Böhm, 2007)

2.2.1 *OSS Adoption in South Africa*

The Free Software and Open Source Foundation for Africa (FOSSFA) was established in 2003 in Geneva, Switzerland to promote the adoption of OSS in Africa (FOSSFA, 2013). In South Africa, a policy paper on OSS adoption by the government was published in 2006 (RSA, 2006). Various studies have also shown that OSS adoption in the private sector has become more and more popular (May, 2006; Mosoval, Gardiner, Healey, Prestedge, & Johnston, 2006; Santhosh, 2007; Sowe, 2011). A more recent country level study on OSS activity and potential for both the private and public sector rates South Africa as the leading African nation (Noonan, Baker, Seavey, & Moon, 2011).

2.2.2 *The TOE Model and OSS Adoption*

Studies on the adoption of OSS in South Africa have been conducted using case studies as the research method (Ellis & Van Belle, 2009; Van Belle & Reed, 2012; Van Beulen et al., 2009). In the above papers the technology, organisation and environment (TOE) context model (Tornatzky et al., 1990) was used as a theoretical basis to determine barriers and enablers of OSS adoption. This framework was also used as the theoretical basis for the research.

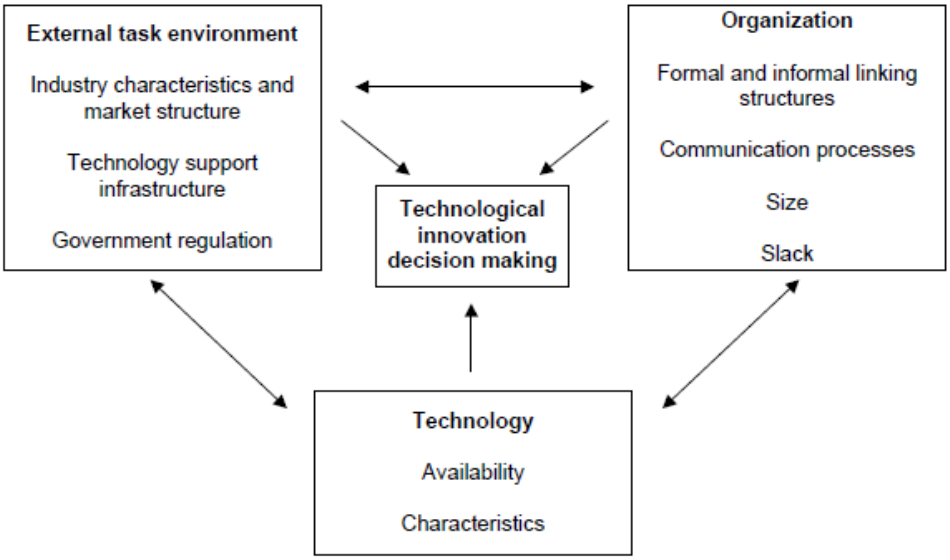


Figure 2: Technology, organization and environment (TOE) framework (Oliveira & Martins, 2011) as per (Tornatzky et al., 1990)

The TOE framework is an organisational-level theory that explains the elements of the firm's context influence on adoption decisions (Baker, 2012). It is consistent with the diffusion of innovation (DOI) theory of Rogers (1995) which emphasises the internal as well as the external characteristics of the firm that drive organisational innovativeness (Oliveira & Martins, 2011). The three contexts,

technology context, organisational context and environmental context are depicted in Figure 2.

The studies (Ellis & Van Belle, 2009; Van Belle & Reed, 2012; Van Beulen et al., 2009) have made use of the research by Dedrick and West (2003) who assert that Rogers (1983) lists five DOI technology characteristics that have an impact on the adoption decision. They are: “relative advantage, compatibility, complexity, trialability and observability” (Dedrick & West, 2003, p. 237).

2.2.3 *The Technology Context and OSS Adoption*

The technology context of the TOE model speaks to the characteristics and technology available to the firm (Baker, 2012) that have a bearing on its productivity (Lippert & Govindarajulu, 2006). Table 1 show the findings from Ellis and Van Belle (2009) on adoption characteristics for OSS.

Table 1 Relevant TOE Factors Influencing OSS Adoption (Van Belle & Reed, 2012)

TOE	Factor	Barrier	Enabler	New Factor
T	Hardware cost	No	Yes	No
T	Software cost	No	Yes	No
T	Reliability	No	Yes	No
T	Compatibility	Yes	No	No
T	Difficulty in administration	Yes	No	No
T	Maintenance Cost	Yes	Yes	Yes
T	Performance	No	Yes	Yes
O	Innovativeness of organisation	No	Yes	No
O	Boundary Spanning	Yes	Yes	No
O	Product Knowledge	Yes	Yes	No
O	Idealism	No	Yes	Yes
O	Resistance to change	Yes	No	Yes
E	Legitimacy	Yes	Yes	No
E	External support	Yes	Yes	No
E	Marketing	Yes	No	Yes
E	Vendors	Yes	No	Yes
E	Business Environment	Yes	No	Yes

Van Belle and Reed (2012) and Ellis and Van Belle (2009) have found, in the context of SMEs, that *cost*, under the relative advantage characteristic had a positive influence over OSS adoption. Hardware cost, however, does not play a significant role, while software cost does. *Reliability* also had a positive influence, but was mediated by prior experience with OSS and thus did not have a significant influence (Ellis & Van Belle, 2009; Van Belle & Reed, 2012). *Performance* also had a positive impact on adoption decisions, but the influence

was stronger with prior OSS experience (Ellis & Van Belle, 2009; Van Belle & Reed, 2012).

Compatibility and *complexity* were both found to be barriers and have a negative influence on adoption (Ellis & Van Belle, 2009; Van Belle & Reed, 2012). Interestingly, Van Beulen et al. (2009) found that firms in his sample in South Africa do not modify source code. This finding was tested on the larger quantitative sample group in the research via the survey instrument of this study. *Trialability*, or the ability to use the software in a test environment prior to adopting, did not seem to have a marked influence on the adoption decisions of OSS (Ellis & Van Belle, 2009; Van Belle & Reed, 2012). The *maturity* of OSS software, as defined by the open source maturity model (Woods & Guliani, 2005), was also an important influencing factor (Ellis & Van Belle, 2009; Van Beulen et al., 2009).

2.2.4 *The Organisational Context and OSS Adoption*

The organisational context of the TOE model is relevant to the resources and characteristics of the firm (Baker, 2012). These include both formal and informal linking structures, the communication processes, the size of the firm and the availability of slack resources (Baker, 2012; Oliveira & Martins, 2011).

As seen in Table 1 all the organisational adoption factors had a positive influence on adoption decisions except *resistance to change* (Ellis & Van Belle, 2009). *Product knowledge* and *boundary spanning* (Van Beulen et al., 2009), defined as the presence of IT staff with open source experience that can influence adoption (Kwan & West, 2005), are both factors that can be strong enablers or barriers to OSS adoption (Ellis & Van Belle, 2009). Both *idealism*, where the organisation strongly identified with OSS beliefs, as well as the firm's perception of its own *innovativeness* were enablers and had a positive effect on OSS adoption decisions (Ellis & Van Belle, 2009). *Slack time* was found to not have an influence on OSS adoption (Ellis & Van Belle, 2009; Van Beulen et al., 2009).

2.2.5 *The Environmental Context and OSS Adoption*

The environmental context of the TOE model refers to the market structure and industry characteristics, technology and support structure and government regulation in which the firm operates (Baker, 2012) as per Table 1.

Legitimacy and external support were both found by Ellis and Van Belle (2009) to be enablers as well as barriers. Legitimacy depends on perceptions of long-term viability of OSS while support is sub-divided into the availability of skilled ICT workers and external support services (Ellis & Van Belle, 2009). Marketing, the availability of vendors, and the business environment are seen to be barriers to adoption (Ellis & Van Belle, 2009).

The TOE framework should also be viewed in the four levels of OSS engagement of the firm as described by Theunissen et al. (2004). The levels are 1) simple use of OSS products, 2) modification of products without sharing, 3) modification of OSS product and contribution back into the OSS community, and 4) initiation and/or management of OSS projects. Van Beulen et al. (2009) notes that consistent results show that in South Africa, and specifically SMEs, the engagement is mostly along levels one and two. This finding is of great significance to the adoption of OSS in terms of its ideals (F. S. Foundation, 2013) and was also tested via the survey questionnaire in the research.

2.3. Innovation and Open Innovation

In the tradition of Schumpeter (1934) innovation in this research covers the first two aspects he describes, viz. the introduction of a new product or a new quality of the product as well as the introduction of a new process.

2.3.1 *Open innovation*

In the article entitled The Era of Open Innovation (Chesbrough, 2003), Chesbrough defined the model of open innovation where “firms commercialise external (as well as internal ideas) by deploying outside (as well as in-house)

pathways to the market" (Chesbrough, 2003, p. 36). Ideas can thus be generated outside the firm and brought into the firm for commercialisation. In this model the boundary between the firm and its surrounding environment is therefore more porous and thus allows more free movement of innovation (Chesbrough, 2003). This is a major departure from closed innovation where information is not shared and a "not invented here" (NIH) syndrome prevails (Chesbrough, 2003, p. 38). Gassmann, Enkel, and Chesbrough (2010) identified three core archetypes of open innovation, viz. 1) the outside-in process which integrates external knowledge, customers and suppliers, 2) the inside-out process which brings ideas to the firm's market, sells/licenses intellectual property and multiplies technology and 3) the coupled process, which is a combination of the outside-in and inside-out processes with a focus on alliances and complimentaries as shown in Figure 3.

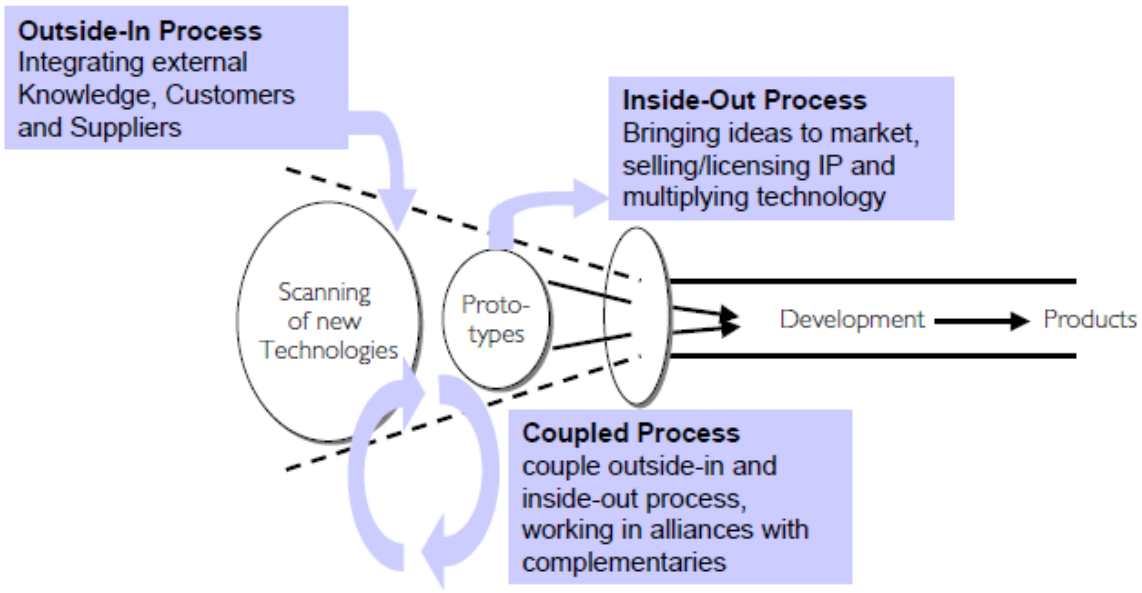


Figure 3: Three archetypes of open innovation processes (Gassmann et al., 2010)

In the context of this research, Lichtenthaler (2008) suggests that small firms may be forced to adopt more open approaches to innovation due to their limited internal resources.

Of note are a number of counter arguments to open innovation in SMEs. Wynarczyk, Piperopoulos, and McAdam (2013) hypothesise that firms which operate in isolation could be less entrepreneurial and thus less growth-orientated than those which have a more outward-looking view. He calls for more research on the link between different entrepreneurial characteristics and innovation practices. He also criticises the view of Chesbrough (2003) which focussed mainly on R&D innovation and not on the knowledge based innovative scope of SMEs. Oakey (2013) focusses on high technology small firms and argues that most R&D towards new product development is fully closed. He asserts that Chesbrough first, overstates the case for the demise of the closed innovation firm, second, uses a oversimplified model by claiming that, for instance talking to customers is a new phenomenon and third, exaggerates the applicability of systems of open innovation, given that R&D is risky and expensive which necessitates confidentiality (Oakey, 2013). A word of caution on the possibility of the negative impact to innovation performance though the adoption of open innovation is also given by Theyel (2013).

2.3.2 *Open Source Software as Open Innovation*

West and Gallagher (2006b) make the case for open source software using the example of the Linux operating system. The characteristics of collaboration between firms, suppliers and customers are all present. In the South African context, Gastrow (2009) has also found this to be true for a case study in terms of networking and collaboration. An example of open source as open innovation is that of the Apache web server where the model of selling complements to the core OSS has been successful (West & Gallagher, 2006b).

West and Gallagher (2006a) have noted four patterns of combining internal and external innovation in open source that relate to open innovation. These are 1) Pooled R&D – This is an essential component of OSS, 2) Spinouts which refer to commercialisation of innovations outside the firm, 3) Selling complements, which is the ability to produce differentiated products using commodity components and 4) Donated complements, which match the user toolkits sold to users to create

their own innovations that Von Hippel and Katz (2002) describes. The absorptive capacity or the ability to exploit external knowledge (Cohen & Levinthal, 1990) has been argued to be an important component of innovation performance.

2.3.3 *Innovation Performance*

For the purpose of this study, innovation performance was measured as 1) the number of new innovative products introduced into the firm's market, 2) the number of new innovative processes produced by the firm and 3) the percentage of the firm's total sales provided by the introduction of new products. This is consistent with a study on the firm-level innovation performance measures by the National Endowment for Science and Technology and Arts, NESTA, in the United Kingdom (R. Adams, Neely, Yaghi, & Bessant, 2008) and commonly agreed definitions and measures as provided by the Oslo Manual (Oecd, 2005) as used by (Inauen & Schenker-Wicki, 2011) as well as that of Parida et al. (2012) which is based on scales developed by Laursen and Salter (2006) and Atuahene-Gima (1992). The article by Piva et al. (2012) that links OSS to innovation performance in Italian entrepreneurial ventures also uses the number of products and share of the firm's turnover to measure innovation performance.

2.3.4 *Open Innovation and Innovation Performance*

Inauen and Schenker-Wicki (2011) investigates the openness or R&D in stock-listed firms in the three German speaking countries, Germany, Switzerland and Austria, via a cross-sectional quantitative study. Specific focus is on effect of outside-in open innovation on innovation performance. In this case the independent variables measure the frequency of cooperation in the outside-in R&D process with a set of external stakeholders. The stakeholder cooperation intensity is then measured on a five-point Likert scale (Inauen & Schenker-Wicki, 2011). The research builds on the structure of this research in terms of the hypotheses and innovation performance measures.

Another study on the link between open innovation and innovation performance deals with high-technology SMEs in the inbound open innovation context (Parida et al., 2012). This is also a quantitative, cross-sectional study, but specifically looks at the following four inbound open innovation activities, viz. 1) technology scouting, 2) vertical technology collaboration, 3) horizontal technology collaboration and 4) technology sourcing. In this study, radical and incremental innovation performance is differentiated. The results of this research show a positive and significant effect inbound open innovation on innovation performance on both of these measures (Parida et al., 2012).

2.4 Open Source Software and Innovation Performance

The article by Piva et al. (2012) which researches the link between open source software and innovation of software entrepreneurial ventures is the primary basis for the business problem of the research. This is a cross-sectional quantitative study but it is comparative in nature in that it asks whether the innovation performance of OSS entrepreneurial ventures exhibit superior performance in comparison to non-collaborating firms (Piva et al., 2012). The dependent variable in this case is a measure of a composite of the innovation performance variables and collaboration is a dummy variable measuring 1 if the firm collaborates and 0 if not.

In this research, the focus was on the link between OSS adoption and innovation performance. The intention was to determine the *measure* of OSS adoption of the combinations by the contributions of the various adoption factors (independent variables) on the three stated innovation performance measures, namely number of new product innovations, number of new process innovations and percentage of sales contributed by new product innovations as dependent variables. It was asserted that adoption of OSS would positively influence innovation performance in the defined population of South African SMEs.

2.4.1 *Hypothesis 1*

The first hypothesis is based on the literature and asserts that the adoption of open source software as a form of open innovation has a positive effect on the innovation performance of SMEs in the ICT sector in South Africa that produce software products and services in terms of the number of new innovative products that are produced.

H1: There is a positive and significant relationship between the level of OSS adoption and the number of new products and services

2.4.2 *Hypothesis 2*

The second hypothesis is based on the literature and asserts that the adoption of open source software as a form of open innovation has a positive effect on the innovation performance of SMEs in the ICT sector in South Africa that produce software products and services in terms of the number of new innovative processes that are created.

H2: There is a positive and significant relationship between the level of OSS adoption and the number of new process innovations

2.4.3 *Hypothesis 3*

The third hypothesis is based on the literature and asserts that the adoption of open source software as a form of open innovation has a positive effect on the innovation performance of SMEs in the ICT sector in South Africa that produce software products and services in terms of percentage contribution to sales of new innovative products that are produced.

H3: There is a positive and significant relationship between the level of OSS adoption and the percentage of sales from new products and services

2.5 Conclusion of Literature Review

Seventeen adoption attributes were identified that are enablers or barriers to OSS adoption at firm level (Ellis & Van Belle, 2009).

The literature review indicates that open source software is an example of open innovation (West & Gallagher, 2006b), and that the measure of adoption of OSS should influence the innovation performance (Piva et al., 2012) of SMEs in the ICT sector in South Africa positively.

2.5.1 *Hypothesis 1:*

H1: There is a positive and significant relationship between the level of OSS adoption and the number of new products and services

2.5.2 *Hypothesis 2:*

H2: There is a positive and significant relationship between the level of OSS adoption and the number of new process innovations

2.5.3 *Hypothesis 3:*

H3: There is a positive and significant relationship between the level of OSS adoption and the percentage of sales from new products and services

3. CHAPTER 3: RESEARCH METHODOLOGY

This section describes the research methodology that was used to conduct this research. The first sub-section discusses the quantitative research methodology, followed by an explanation of the research design. A description of the population, sample and sampling method is then given. The research instrument is subsequently discussed. An overview of the data collection and analysis techniques that was used in this study is then given. Next, the procedure for data collection is outlined. An overview of the data analysis and interpretation techniques is given. This is followed by a discussion of the limitations of this study, as well as its validity and reliability.

3.1 Research methodology /paradigm

A quantitative research paradigm was used to conduct this research via a cross-sectional study. This is in accordance with a positivist worldview which holds a philosophy in which causes determine outcomes (Creswell, 2013). This is also a reductionist approach where ideas are reduced to discrete, small tests, using variables, for example, that can be used to validate research questions and hypotheses (Creswell, 2013). A characteristic of this approach is testing claims based on theory. Another is posing questions or hypotheses for explaining the causal relationships among variables. The data, evidence and relationships between variables were collected using instruments that were completed by participants or recorded by the researcher. Such a quantitative approach corresponds with analysing the relationship between the OSS adoption and innovation performance variables.

3.2 Research Design

A self-administered survey was used for data collection in the research. The advantages of using surveys, according to (Mouton, 2001), are: a) there is the potential of generalisation of the results to large populations if a suitable sampling

design has been applied, b) high reliability of measurements based on proper questionnaire design, c) high validity of constructs if the correct controls are implemented. Disadvantages of surveys (Mouton, 2001) are: a) lack of depth could lead to *surface level* analyses, b) data could be sample and context specific c) there are many sources of error which should be taken into consideration.

3.3 Population and sample

3.3.1 Population

The population comprised the employees/owners of small to medium enterprises (SMEs) in the Information Communications and Technology (ICT) sector in South Africa that produce software products and services. The ICT sector comprises around 8000 firms of which 85% have 50 or less employees (JCSE, 2013). SMEs are defined as firms with the following upper resource limits: 200 employees, R26million in turnover and R5million in fixed assets (Mahembe, 2011).

3.3.2 Sample and sampling method

The sample was extracted from various sources of firm contact information. Data sources included the Department of Trade and Industry's (DTI) Support Programme for Industrial Innovation (SPII) as administered by the Industrial Development Corporation (IDC) (IDC, 2013), the Companies and Intellectual Property Commission (CIPC) (Commission, 2013), Jo'burg Centre for Software Engineering(JCSE), Bizcommunity (Bizcommunity, 2013) and the Directory of South African Programming websites (Rainbownation, 2013). Firms from across South Arica were included in the sample, but the majority of the samples originated from Gauteng due to the relative economic size of this province. The number of respondents was expected to be greater than 80 in order for the sample to be significant (Saunders, Lewis, & Thornhill, 2009).

3.4 The research instrument

The research instrument was a self-administered and interviewer-administered questionnaire. The instrument was based on the Oslo Manual (Oecd, 2005) which contains commonly agreed definitions as used by Inauen and Schenker-Wicki (2011) for collecting technological innovation data. An odd numbered, seven point, Likert scale was used to ask questions around the independent variables (Adams, Khan, Raeside, & White, 2007).

A pilot survey was conducted with 5 respondents from the JCSE database first to determine if the questions in the research instrument are appropriate for the study. This was important to determine the content validity and to improve the format, scales and questions of the instrument (Creswell, 2013). Adjustments to the research instrument were then made before it was used on the main sample.

3.5 Procedure for data collection

In order to maximise the survey response rate, the initial contact with respondents was telephonic or via opt-in e-mail. The purpose of the study and survey methodology was explained in this initial contact. A respondent could then participate in the survey via a link sent by e-mail. Progress on the survey was monitored via the Internet. A follow-up e-mail or telephone call was used to increase the response rate.

3.6 Data analysis and interpretation

Exploratory factor analysis was used to establish a lower number of unobserved, uncorrelated variables that are called factors (Cramer, 2003) from the total of 22 questions that were answered by the respondents.

The survey data was analysed using descriptive statistics and regression analysis.

3.7 Limitations of the study

- Potential methodology weakness due to common method variance. This could produce an artificial covariance between the dependent and independent variables due to the fact that respondents are providing answer to these two at the same time (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Appropriate survey questionnaire design as well as following the guidelines set out by Podsakoff et al. (2003) was followed to minimise and check for this type of error.

- Potential sampling error due to the difference between the estimate and the population values (Adams et al., 2007). This is the combination of the sample bias, the location of the sampling distribution in relation to the population value and the sampling variance which measures the spread of the distribution. A decision about the relative importance of estimates was made to minimise this impact.

- Potential analysis weaknesses due to regression assumptions and distribution are deficiencies in model structure, multi-collinearity, non-linearity and outlier-effects as well as Homoscedasticity, the normality of residuals and autocorrelation (Lee, 2012). These potential weaknesses was addressed by the various remedies discussed in Lee (2012).

3.8 Validity and reliability

Validity refers to whether the findings are due to the suggested variables and not some other factors (Creswell, 2013). Reliability is the measure of consistency in past use of the instrument (Creswell, 2013).

The following two sub-sections describe the issues of external and internal validity relative to the research. The final sub-section discusses how the research meets reliability criteria and how maximisation of reliability was attempted.

3.8.1 External validity

The ability to generalised the research results to other settings is referred to as external validity (Adams et al., 2007). The potential threats to external validity could be due to the characteristics of the individuals selected, the specific settings or past and future situations (Creswell, 2013). To minimise the external validity threat of selection, the firms were chosen from the broadest population possible (Adams et al., 2007) by sourcing participants from every province in South Africa. The period of interest of the study to which quantitative questions refer was defined as the five years from 2007 and 2012. The study would have to be replicated over other periods to determine if the same results occur during a prior or future period.

3.8.2 Internal validity

Internal reliability refers to threats to the ability to draw correct inferences from data due to experimental procedures, treatments or experiences of the participants (Creswell, 2013). If a study has high internal validity, there is a high likelihood that changes in the dependent variable can only be attributed to changes in the independent variable and not to any other variables (Adams et al., 2007). According to Creswell (2013), these can be grouped into threats involving participants, those involving experimental treatment and those involving procedures used in the experiment. Specific threats related to the participant category for this research are regression and selection. This threat was minimised by respectively selecting participants who do not have extreme scores and choosing participants randomly from the sample population (Adams et al., 2007; Creswell, 2013). Threats to experimental treatment were not envisaged in the use of a survey instrument in this case.

3.8.3 Reliability

The reliability of the results is a measure of how consistent they are with past results. Previous studies on innovation performance using similar questions and

instruments have shown high reliability (Inauen & Schenker-Wicki, 2011; Oecd, 2005; Parida et al., 2012; Piva et al., 2012).

4. CHAPTER 4: PRESENTATION OF RESULTS

4.1 Introduction

In this chapter the results from the demographic profiles of the respondents is presented, followed by the results from a factor analysis of the independent variables. The results from the regression analysis of each of the three hypotheses are then presented.

4.2 Demographic profile of respondents

A total of 570 firms were contacted via e-mail and telephone and requested to complete an online survey. After validation of completed surveys to only including SMEs with employee counts of 200 or less a total 82 valid surveys were received, which represents a response rate of 14.3%.

The following demographic categories were included in the survey questionnaire: the number of employees, the number of development employees, turnover, firm age, Companies and Intellectual Property Commission (CIPC) business sector and product category.

Tables 2 and 3 show the distribution of employee numbers (Size) which is positively skewed (3.231) with positive kurtosis (10.685). The natural logarithm of the firm size was taken in order to improve the normality of the distribution with the new variable, LSIZE (Table 3) showing a skewness of 0.429 and a kurtosis of -0.395. This is within the 90% limit of normality for a sample size of n=80 (Doane & Seward, 2011). The maximum turnover is R360 million with an average of R19.61million.

Table 2 Firm size distribution by employee count

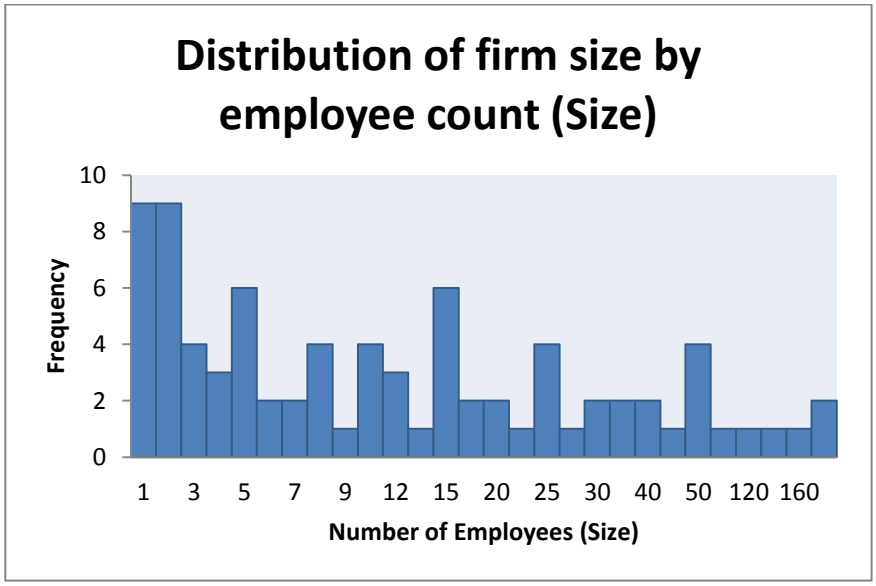


Table 3 Firm size descriptive statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Size	82	1.00	200.00	23.427	39.960	3.231	0.266	10.685	0.526
LSIZE	82	.69	5.30	2.419	1.203	0.429	0.266	-0.395	0.526
Valid N (listwise)	82								

The firm age was requested via a scale from seven options where option one represented firms that were less than one year old up to option seven which represents a firm age of more than 21 years. Table 4 shows the distribution of the firm age, which has a mean of eight to ten years and has a skewness of 0.193 and kurtosis of -0.337 which is within acceptable bounds of normality (Doane & Seward, 2011).

Table 4 Firm age distribution

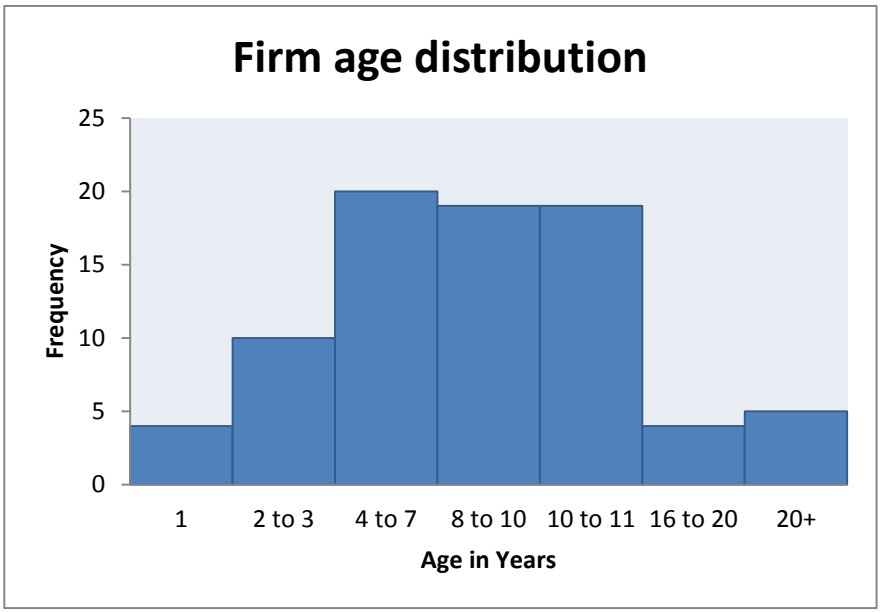


Table 5 Firm age descriptive statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Age	82	1.00	7.00	3.9146	1.50883	.193	.266	-.337	.526
Valid N (listwise)	82								

The CIPC business sectors in which the firms operated are depicted in Table 6 and comprise mostly Software Development at 50% with Business Services in 36.59% and "Other" at 11%.

Table 6 Distribution per CIPC business sector

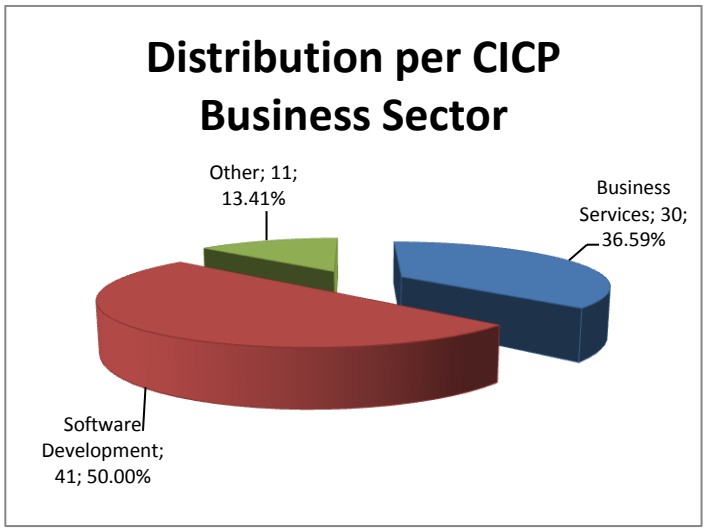
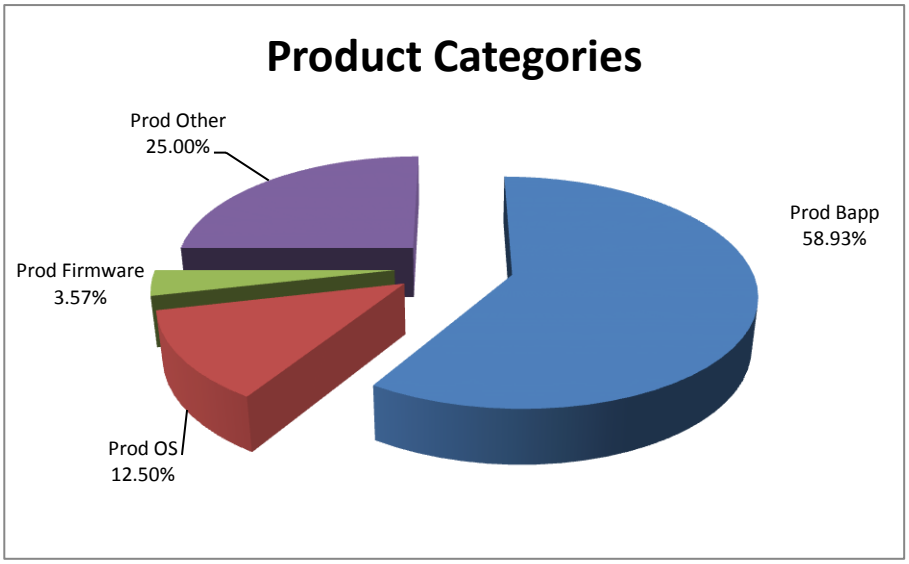


Table 7 shows that the products produced by the firms in the sample were mostly in the Business Applications category at a total of 58.93%. Operating Systems products made up 12.50% and Firmware Products only 3.57%. A quarter, 25.00%, of the respondents chose “Other” as their product category.

Table 7 Distribution of product categories



4.3 Data Preparation

The dependent variables from the survey data (number of new products and services, number of new processes and percentage of sales from new products and services) were checked for normality and outliers in preparation for the factor and regression analysis. In order to perform linear regression the ordinal variables were recoded from the ordinal scale in the questionnaire to the actual product count represented by each ordinal value producing continuous variables NPROD and NPROC respectively. The lowest values of the ranges 11-20, 21-30, 31-40 and 41-50 were chosen in order to take the most conservative approach. After assessing the normality of NPROD and NPROC the natural logarithm was taken which produced skewness and kurtosis that were within acceptable limits as shown in Table 8 (Doane & Seward, 2011).

Table 8 Product and process count descriptive statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
NPROD	82	0.00	41.00	4.2683	5.35654	4.536	.266	27.859	.526
NPROC	82	0.00	51.00	7.3049	9.86287	3.039	.266	9.992	.526
LNPROD	82	0.00	3.74	1.3710	.74962	.062	.266	.523	.526

LNPROC	82	0.00	3.95	1.6726	.94009	.014	.266	.245	.526
Valid N (listwise)	82								

A z-score test showed only one case where the z-score was 3.157, which is more than 3 which indicates an outlier (Shiffler, 1988). This case was removed to produce a final sample size of n=81.

The independent variable representing the percentage of sales from new products and services was recoded from the survey answers in percentage via the arcsine-square root transformation method using the formula SALES = 2 * ARCSINE(SQRT(PSALES/100)) to produce the continuous variable SALES.

4.4 Factor Analysis

The factorability of the 22 adoption items was examined. Firstly, the Pearson correlation matrix (Appendix B) showed correlations of at least .3 for all the items with at least one of the other items which suggests reasonable factorability. Secondly, the internal consistency reliability of the all the independent variables had a cronbach alpha value of .885 (Appendix B) which is considered to be "Good" (Gliem & Gliem, 2003).

Thirdly, as shown in Table 9, the Kaiser-Meyer-Olkin (Kaiser, 1974) measure of sampling adequacy was .759, above the recommended value of .6, and Bartlett's test of sphericity was significant ($\chi^2(105)$ = 569.750, p < .001) which shows that the null hypothesis (that the variables are uncorrelated), can be rejected.

Table 9 KMO and Batlett's Test results

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.759
Bartlett's Test of Sphericity	Approx. Chi-Square	569.750
	df	105
	Sig.	.000

Exploratory factor analysis was performed on the 22 independent variables using principle component analysis and Varimax rotation. After including only factors with eigenvalues of greater than 1.0 a total of four factors were extracted (and new variables created by SPSS); this explains 67.615% of the total variance (Appendix C). The scree plot in Table 10 shows the marked cut off at four factors with the rest of the plot tapering off smoothly.

Table 10 Factor analysis scree plot

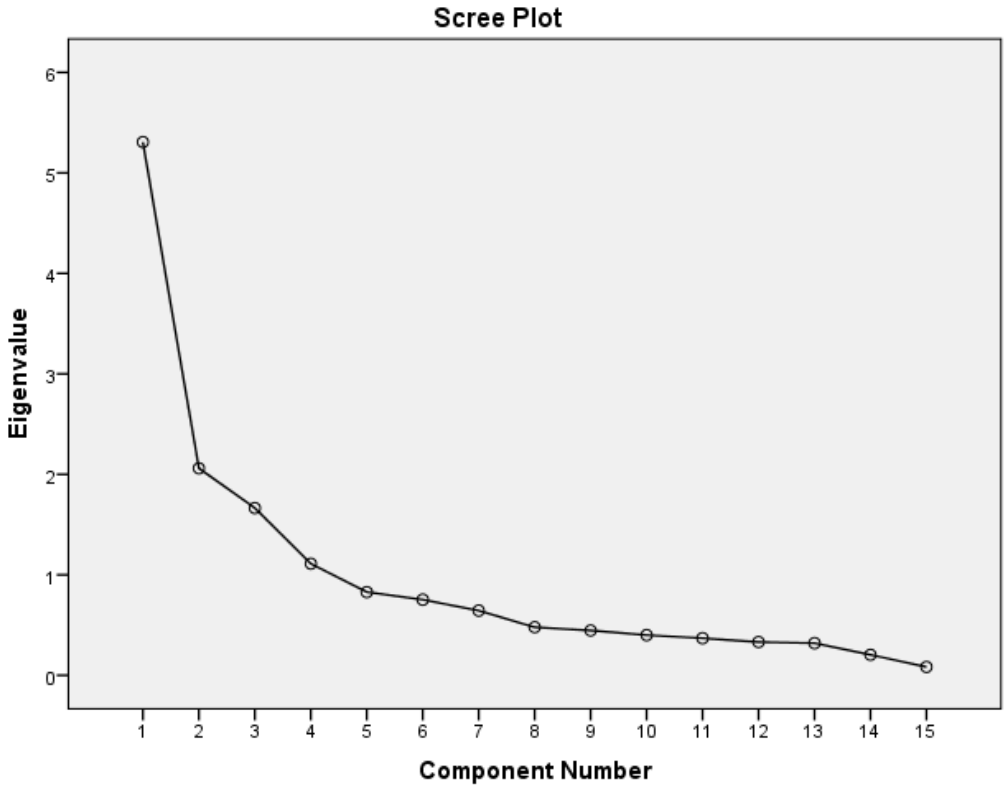


Table 11 shows the four extracted factors and their principle component loadings that were extracted via principle component analysis with Varimax rotation. From Table 11 can also be seen that only the variable Dev had a cross loading of .5 on factor two but was considered acceptable as the principle component loading was .628 on factor three. Factor four consisted of only two factors but was retained as it contributed more than 7% to the total variance and the two variables were clearly in their own grouping in terms of their high correlation of .880 with each other (Appendix B).

Table 11 Factor analysis results

Rotated Component Matrix[a]

	Component			
	1	2	3	4
Bloggs	**.809**	.249		
SuppGrp	**.783**			.248
Webinar	**.774**		.227	.112
Conf	**.756**	.126	.328	
Inits7	**.608**	.271		-.129
DB		**.760**	.141	.178
Source	.204	**.715**		
Exp	.287	**.653**	.417	-.118
OS	.286	**.631**	.184	.295
Bapps	.143		**.754**	.291
Desktop	.207		**.701**	.349
Collab	.350	.268	**.680**	-.123
Dev		.500	**.628**	
Stable		.121	.120	**.932**
Perf			.112	**.915**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 6 iterations.

The following new OSS Adoption variables were thus created related to the following survey questions:

Factor one: **OSS Boundary Spanner Usage (OSSBSPN)**

- Participation in OSS blogs
- Use of OSS support groups
- Participation in OSS webinars
- Attendance of OSS conferences (E.g. Software Freedom Day)
- OSS initiatives started/managed
- OSS source code contribution

Factor two: **OSS Technical Practices (OSSTECH)**

- Database Systems (E.g. MySQL, PostgreSQL)
- Use of Server operating systems (E.g. Linux, CentOS)
- Prior OSS experience of developers
- Importance of access to source code

Factor three: **OSS Business Tools Usage (OSSBTLS)**

- Use of Collaboration Tools (E.g. MediaWiki, WikkaWiki)
- Use of Software Development Tools (E.g. svn, jira, bamboo)
- Use of Business Applications (E.g. Gimp, OpenOffice)
- Desktop Operating Systems (E.g. Ubuntu, Gnome)

Factor four: **OSS Perceptions (OSSPCPT)**

- Linux is more stable than Microsoft Windows
- Linux performs better than Microsoft Windows

A Pearson correlation of the new factors was done to establish suitability for regression analysis. Table 12 shows the mean, standard deviation and Pearson correlation with significant correlations indicated at levels .01 and .05 for the variables. The number of new products and services has significant correlations with the use of business tools, OSSBTLS (.251, $p<.05$) and OSS perceptions, viz. OSSPCPT (-.350, $p<.001$). The number of new processes has a significant correlation with the firm size, LSIZE (.457, $p<.001$) and age, AGE (.325, $p<.001$). The percentage of sales contributed by new products and services, SALES is significantly correlated with the use of OSS business tools, viz. OSSBTLS (.225, $p<.05$).

Table 12 Pearson correlation of variables

	Mean	Std Dev	LNPROD	LNPROC	SALES	AGE	LSIZE	OSSBSPN	OSSTECH	OSSBTLS
LNPROD	1.342	0.706								
LNPROC	1.644	0.911	**.443****							
SALES	0.699	0.436	**.459****	.147						
AGE	2.427	1.208	.062	**.325****	-.113					
LSIZE	3.901	1.513	.206	**.457****	.071	**.286****				
OSSBSPN	-	1.000	.133	.062	.012	-.156	.202			
OSSTECH	-	1.000	-.035	.187	.139	-.094	.133	.000		
OSSBTLS	-	1.000	**.251***	.120	**.225***	.030	.077	.000	.000	
OSSPCPT	-	1.000	**-.350****	-.010	-.191	.044	**-.280***	.000	.000	.000

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

4.5 Results pertaining to Hypothesis 1:

There is a positive and significant relationship between the level of OSS adoption and the number of new products and services

The results of the regression analysis performed on the dependent variable, are presented in Tables 13, 14 and 15. The adjusted R square (Table 14) is low and signifies that only about 15% of the variance is explained by the model. The significance (Table 14) is less than .001. Table 15 shows that two of the OSS adoption variables, OSSBTLS (Beta = .245, $p < .05$) and OSSPCPT (Beta= -.339, $p < .05$) are significantly related to the independent variable LNPROD. The final equation yields a negative relationship due to the larger negative OSSPCPT factor. There is therefore no support for the hypothesis based on the regression results.

Table 13 Number of new products and services model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.463[a]	.214	.150	.65057

a. Predictors: (Constant), LSize, OSSBTLS, OSSTECH, OSSBSPN,

OSSPCPT, Age

Table 14 Number of new products and services regression

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.526	6	1.421	3.357	.006[b]
	Residual	31.320	74	.423		
	Total	39.846	80			

a. Dependent Variable: LNPROD

b. Predictors: (Constant), LSIZE, OSSBTLS, OSSTECH, OSSBSPN, OSSPCPT, AGE

Table 15 Number of new products and services coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.139	.224		5.076	.000
	OSSBSPN	.095	.077	.135	1.240	.219
	OSSTECH	-.025	.074	-.035	-.332	.741
	OSSBTLS	**.173**	**.073**	**.245**	**2.368**	**.021**
	OSSPCPT	**-.239**	**.077**	**-.339**	**-3.111**	**.003**
	AGE	.034	.053	.073	.649	.518
	LSIZE	.029	.070	.049	.407	.685

a. Dependent Variable: LNPROD

4.6 Results pertaining to Hypothesis 2:

There is a positive and significant relationship between the level of OSS adoption and the number of new process innovations

The results of the regression analysis performed on the dependent variable, are presented in Tables 16, 17 and 18 which show the model summary, ANOVA parameters and coefficients respectively. The adjusted R square (Table 17) is better than for the number of new products and service and signifies that 23.2% of the variance is explained by the model. The significance (Table 17) is less than .001. Table 18 shows that none of the OSS adoption variables, are significantly related to the independent variable LNPROC but that firm age, AGE (Beta = .225, $p < .05$) and firm size, LSIZE (Beta = .386, $p < .01$) are significantly related to the number of new processes introduced into the firm. There is therefore no support for hypothesis H2 based on these results.

Table 16 Number of new processes model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.538[a]	.290	.232	.79800

a. Predictors: (Constant), LSIZE, OSSBTLS, OSSTECH, OSSBSPN, OSSPCPT, AGE

Table 17 Number of new processes regression

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.205	6	3.201	5.026	.000[b]
	Residual	47.124	74	.637		
	Total	66.328	80			

a. Dependent Variable: LNPROC

b. Predictors: (Constant), LSIZE, OSSBTLS, OSSTECH, OSSBSPN, OSSPCPT, AGE

Table 18 Number of new processes coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.409	.275		1.487	.141
	OSSBSPN	.018	.094	.019	.186	.853
	OSSTECH	.143	.091	.157	1.566	.122
	OSSBTLS	.076	.090	.084	.851	.398
	OSSPCPT	.080	.094	.088	.848	.399
	AGE	**.136**	**.065**	**.225**	**2.095**	**.040**
	LSIZE	**.291**	**.086**	**.386**	**3.384**	**.001**

a. Dependent Variable: LNPROC

4.7 Results pertaining to Hypothesis 3:

There is a positive and significant relationship between the level of OSS adoption and the percentage of sales from new products and services

A stepwise regression analysis was performed on the dependent variable; SALES. The results are presented in Tables 19, 20 and 21 which show the model summary, ANOVA parameters and coefficients respectively. The adjusted R square (Table 19) is very low and indicates that only 3.8% of the variance is explained by the model. Table 21 shows the model that retains only one of the OSS adoption variables, OSSBTLS (Beta = .225, $p < .05$) is significantly related to the independent variable. Table 22 presents the statistics of the variables that were excluded from the final model via the step-wise regression process. There is therefore support for the H3, the significant positive relationship between OSS adoption and the percentage of sales from new products and services.

Table 19 Percentage of sales from new products and services model

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.225[a]	.050	.038	.42770	.050	4.199	1	79	.044

a. Predictors: (Constant), OSSBTLS

Table 20 Percentage of sales from new products and services model

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.768	1	.768	4.199	.044[b]
	Residual	14.451	79	.183		
	Total	15.219	80			

a. Dependent Variable: SALES

b. Predictors: (Constant), OSSBTLS

Table 21 Percentage of sales from new products and services model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.699	.048		14.702	.000	.604	.793					
	OSSBTLS	.098	.048	.225	2.049	.044	.003	.193	.225	.225	.225	1.000	1.000

a. Dependent Variable: SALES

Table 22 Percentage of sales from new products and services model

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	AGE	-.120[b]	-1.094	.277	-.123	.999	1.001	.999
	OSSBSPN	.012[b]	.111	.912	.013	1.000	1.000	1.000
	OSSTECH	.139[b]	1.277	.205	.143	1.000	1.000	1.000
	OSSPCPT	-.191[b]	-1.763	.082	-.196	1.000	1.000	1.000
	LSIZE	.054[b]	.488	.627	.055	.994	1.006	.994

a. Dependent Variable: SALES

b. Predictors in the Model: (Constant), OSSBTLS

4.8 Summary of the results

Descriptive statistical analysis, factor analysis and regression analysis were applied in this chapter in order to interpret the data collected during the survey.

The questions asked in the surveys pertained to the three dimensions of the TOE model as used in previous literature in OSS adoption context (Van Belle & Reed, 2012; Van Beulen et al., 2009). Exploratory factor analysis was used as a means of data reduction as well as determination of latent variables that are formed by combinations of the TOE components. The Varimax factor analysis produced four distinct factors that contribute 67.614% of the total variance. The loading of the factors were satisfactory and they could be grouped into the four areas of boundary spanners, technical practices, business tools usage and perceptions around the relative advantage of open source software.

Regression analysis found that the relationship between OSS adoption and the number of new products and services for hypothesis H1 is significant related to two OSS adoption variables, but one has a positive correlation *OSS Business Tool Usage* (OSSBTLS) and the other *OSS Perceptions* (OSSPCPT) has a stronger negative correlation thus there is only partial support for the hypothesis. Hypothesis H2 which postulates a relationship between OSS adoption and the number of new processes is only significant due to the moderating effect of firm size and age and shows no significant effect due to any of the OSS adoption variables thus there is no support for H2. Hypothesis H3 which states that OSS adoption is positively related to the percentage of sales contributed by new products and services found full support from the regression analysis on one variable, *OSS Business Tool Usage* (OSSBTLS).

5. CHAPTER 5: DISCUSSION OF THE RESULTS

5.1 Introduction

This chapter provides a discussion and interpretation of the results that were presented in Chapter 4. Validation of the literature review done in Chapter 2 against the empirical findings is also presented.

5.2 Demographic profile of respondents

The survey was conducted over a period of 2 months and multiple follow-up communications were sent in order to increase the response rate. The final response rate of 14.3% yielding a sample size of 82 (Which was reduced to 81 after removing an outlier) may be acceptable for online e-mail-solicited surveys of this nature (Sheehan & McMillan, 1999) but presents challenges to the analysis and interpretation of the results.

Firm size showed strong positive skewness which was compensated for by transforming the data via the natural logarithm. This strong skewness could indicate that the sample size is too small as a more normal distribution is expected on a sample of sufficient size (Stevens, 2009).

The distribution of age is near normal and indicates that most of the firms are older than five years. This is a good survival rate for the sample population of SMEs in an economy where the failure rate of all SMEs is between 70% and 80% (Fatoki & Smit, 2011).

The majority of firms operate in the CIPC Software Development sector which is expected as the sample population was chosen randomly but matching the criterion of selling software development related products and services. Business services as a CIPC category covers many of the respondents who create more services (such as web hosting, desktop publishing and OSS support and consulting) than software development products.

The predominance of Business Applications in the product categories is in line with the commercial nature of the SMEs in South Africa as many SMEs lack the resources to produce more complex and human resource intensive operating system and firmware products (Makoza & Chigona, 2012).

5.3 Discussion pertaining to the factor analysis

The factor analysis yielded groupings that match dimensions of the TOE model as was found by (Dedrick & West, 2003; Van Belle & Reed, 2012; Van Beulen et al., 2009). The first factor, viz. *OSS Boundary Spanners* relates to the use of inbound innovation to enhance the firm's capabilities (Chesbrough, Vanhaverbeke, & West, 2008; Parida et al., 2012). The inbound open innovation activity of technology sourcing (Parida et al., 2012) is covered by this factor.

The second factor, *OSS Technical Practices*, combines the use of the technical aspects of OSS such as integration and prior development resource experience (Dedrick & West, 2003; Ellis & Van Belle, 2009) with the more direct OSS aspects of the importance of source code and the use of specific OSS operating systems and database management systems. The use of Open Systems Databases and Operating Systems are congruent with ease of integration, *compatibility* as per Dedrick and West (2003) and the importance of source code, *trialability* in the context of more OSS-experienced developers (Dedrick & West, 2003).

The third factor, *OSS Business Tools Usage*, encapsulates the replacement of commercial business applications and tools with their open source equivalents. This is also, possibly, the area where the greatest financial saving can be made in an SME. Use of OSS Business Tools had very clear loading on Desktop Application and Business Application usage as well as the use of Collaboration and Software Development Tools.

The fourth factor that combines OSS perceptions, OSSPCPT shows the importance of perceptions in the adoption of open source software. However, as per Dedrick and West (2003) there are mixed views on the area of reliability.

5.4 Discussion pertaining to Hypothesis 1

> *There is a positive and significant relationship between the level of OSS adoption and the number of new products and services*

The regression result for hypothesis one, H1, shows significant correlation where the *OSS Business Tools* and *OSS Perception* variables, stability and performance are retained. However the *OSS Perception* variable is negative which yields an overall negative influence due to the relative size of that coefficient and the hypothesis is therefore not supported.

Although the TOE model notes positive as well as negative correlation for reliability as a factor from qualitative study by Dedrick and West (2003) the negative nature of stability and performance is unexpected in the context of other open innovation research around the value of open source (Chesbrough et al., 2008; Gassmann et al., 2010; West, Gallagher, Chesbrough, & Vanhaverbeke, 2005) and warrants further investigation. One possible explanation could be that the “commercial” South African open source software market has reached a certain level of maturity where the ability to modify source code is of less importance than cost. In that case the later adopters in a more mature market are mostly free-riding on the existing work of the open source community (Dedrick & West, 2003; Rogers, 1983) which may be relevant to the South African context of low levels of financial and human resources for SMEs.

The results from the positive influence of *OSS Business Tools* suggest that the use of open source desktop operating systems like Ubuntu, for instance, as well as the replacement of commercial (with associated licensing and purchase costs) with their open source (no licensing or purchase costs) equivalents is supported for the purpose of enhancing innovation performance. Furthermore, making use

of supporting business tools in the areas of collaboration and information management (e.g. Wiki) as well as the more direct OSS code development sphere (e.g. svn – A source code management system) is correlated with producing more product and service innovations.

The *OSS Technical Usage* factor is not significant so there is no evidence that the use of technical aspects of OSS has a significant effect on the new products and services components of innovation performance. This result may seem like a blow to the business case for open source software but could be a reflection of the strong influence of the open source ethos which is counter to commercialization and exploitation of resources for financial gain (Perens, 1999; Stallman, 2009). Lack of significance of this factor also seems to suggest support for the notion from Van Belle and Reed (2012) that South African SMEs mainly engage with open source software at the levels of 1) simple use and 2) modification of products without sharing.

Of note is the lack of significance of the *OSS Boundary Spanner* factor (OSSBSPN) which encapsulates some of the best practices related to open source software adoption such as the sharing of knowledge and electronic communication across firm boundaries. Again the possible tension between the open source ethos and need for secrecy of competitive information in the commercial environment could be a contributing factor. However, the ratio of the response sample size to the sample population that was contacted (14.3%) could have an influence on the significance of this factor and may be found to play a role in further, larger studies.

5.5 Discussion pertaining to Hypothesis 2

> *There is a positive and significant relationship between the level of OSS adoption and the number of new process innovations*

Support for hypothesis two is from the correlation with firm size and age. Correlation with firm size is in agreement with considerable previous evidence that

suggests that firm size has a positive influence on the innovation performance (Cohen & Klepper, 1996; Kafouros, Buckley, Sharp, & Wang, 2008; Lichtenberg & Siegel, 1991). Dedrick and West (2003) have also noted that the lack of documentation and defined processes is a salient feature in the open source community.

The link between process innovation and firm age is more indirect. According to Vaona and Pianta (2008), while product innovation is explained by a growth-orientated strategy, process innovation is more associated towards the acquisition of new machinery and the restructuring of production. As firms age they find it more optimal to shift innovation focus from product to process innovation which provides more maximal value extraction from innovation (Balasubramanian & Lee, 2008).

Based on the results there is therefore no evidence of support for significant positive correlation of hypothesis two with any of the OSS factors that were analysed.

5.6 Discussion pertaining to Hypothesis 3

> *There is a positive and significant relationship between the level of OSS adoption and the percentage of sales from new products and services*

Hypothesis 3 is fully supported with a standardised Beta of 0.225 on the *OSS Business Tools* factor that is significant at a level of $p < 0.05$. This shows that there is a positive correlation between the use of supporting business applications and tools and having a larger percentage of overall sales derived from new products and services. This confirms that the use of collaboration and development tools as well as the replacement of commercial business applications and desktop operating systems with their “free” open source equivalents has a positive influence on the percentage of turnover of SME firms.

Based on the low R squared of 3.8%, the near marginal significance of p = .044 and the final regression equation that contains only one OSS adoption factor the existence of other factors should not be discounted. This may be particularly relevant to surveys with larger sample sizes as the sample size of n=81 for this research is deemed adequate but not good.

5.7 Conclusion

In this chapter the results presented in chapter 4 was discussed in terms of the theoretical background of the literature study. Factors created by exploratory factor analysis produced recognisable new underlying groupings with good internal validity. The exclusion of three of the original dimensions via the factor analysis, viz. complexity, the attitude of senior management towards OSS, and the ease of obtaining external OSS support is in line with lack of significant correlation with any of the innovation performance dependent variables. However the importance of the ethos of OSS and the perception of the firm's own innovativeness show some level of significant correlation (> .23) and the influence of the small sample size may be a contributor.

Linear regression analysis showed negative significant support for *H1 - There is a positive and significant relationship between the level of OSS adoption and the number of new products and services.* This result is in line with Ellis and Van Belle (2009) and Dedrick and West (2003) that there are mixed views on the reliability and performance of OSS platforms.

Linear regression analysis of *H2 - There is a positive and significant relationship between the level of OSS adoption and the number of new process innovations* showed support for the hypothesis only in the presence of the firm size and age control variables, which is in agreement with previous studies (Balasubramanian & Lee, 2008; Cohen & Klepper, 1996; Kafouros et al., 2008; Lichtenberg & Siegel, 1991)).

Linear regression analysis of *H3 - There is a positive and significant relationship between the level of OSS adoption and the percentage of sales from new products and services* showed full support for the hypothesis. The conclusion is that there is a positive correlation between the use of supporting business applications and tools and having a larger percentage of overall sales derived from new products and services.

The lack of a significant influence related to OSSBSPN which encapsulates contribution of source code back the community as well as the initiation or management of open source software projects shows support for the suggestion from the literature study that SMEs in South Africa mainly engagement with open source software at levels 1) simple use of OSS products and 2) modification of products without sharing.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusions of the study, recommendations to the stakeholders (as defined in the introduction) based on the empirical results and theory and suggestions for further research and improvements.

6.2 Conclusions of the study

Factor analysis produced new underlying variables that are supported by previous qualitative literature and the TOE model of technological adoption as applied to open source software (Dedrick & West, 2003; Ellis & Van Belle, 2009). Exclusion of highly correlated variables showed the possibility that the sample size may be too small to make general inferences that apply to the larger population.

Support was found for significant positive correlation between OSS adoption and innovation performance related to the percentage of sales from these new products and services. Negative support was found for significant correlation between OSS adoption and innovation performance related to number of new products and services that were introduced. Although supported by the literature this result is surprising in light of previous notions on open source perceptions (Stallman, 2009). No support was found for OSS adoption and the number of new process innovations in the firm although the relationships between firm size and age and innovation performance were confirmed (Cohen & Klepper, 1996; Kafouros et al., 2008; Lichtenberg & Siegel, 1991).

However, the percentage of the variance that is explained by the correlations is low at 15% and 3.8% for H1 and H3 respectively, which also may indicate that a larger sample size may produce higher percentages.

6.3 Recommendations

The outcome of this research suggests that there is merit in the adoption of *OSS Business Supporting Applications and Tools* in terms of the positive influence on the percentage of sales derived from new products and services. It is recommended that owners and managers of SMEs consider replacing commercial business support applications and tools with their open source equivalents. Of particular interest is the positive correlation with the use of OSS desktop operating systems (such as Ubuntu) as this could have a positive influence on the further adoption of OSS into the SME due to its visibility and cost saving, once adopted by a large percentage of its employees. It is suggested that this is the area where the highest initial cost saving can be in an SME when adopting OSS and can thus form part of a suitable business case.

The negative correlation of perceptions around the stability and performance of open source software which translates into higher OSS adoption and subsequent better innovation performance in terms of the number of new products and services give food for thought on the OSS perceptions of SMEs. This result seems to be at odds with the notion that the value of open source software to firms lies in the access to source code (Dedrick & West, 2003). In the context of a more mature open source software market this finding may suggest that cost savings is one of the biggest drivers of adoption, even overruling other “technical” factors.

6.4 Suggestions for further research

The design and confirmation of TOE OSS adoption survey questions and factors as well as the creation of a more formal model specific to OSS adoption is suggested. This could bring to light other latent factors that influence OSS adoption. A mixed research method with structured interviews will help to explain factor groupings and the reasons behind responses.

Negative perceptions from the sample population around the stability and performance of OSS server operating systems can provide an avenue for further investigation with either quantitative study with larger sample sizes or more focused qualitative study on the detailed aspects of perceptions around OSS adoption. This also presents an area for cross-functional research on the more psychological aspects around OSS perceptions and their drivers. If larger sample sizes can be obtained comparisons of groupings via cluster analysis could prove to be insightful.

The non-normality of the distributions of the number of products and service as well as the number of new processes should be investigated further. It may be that the spread of these two variables are non-linear in the South African environment due to specific socio-economic factors. In that case more sophisticated non-parametric analysis techniques may provide areas of new research.

Comparative studies of the innovation performance of OSS adopters vs non-adopters could provide support for the research by Piva et al. (2012) in the South African context of SMEs.

A further suggested area of study is the comparative analysis of various new popular modes of open source software such as mobile smart phones, the Raspberry Pi platform R. P. Foundation (2014) and other smart “connected” devices, and the impact that these new technology platforms have on innovation.

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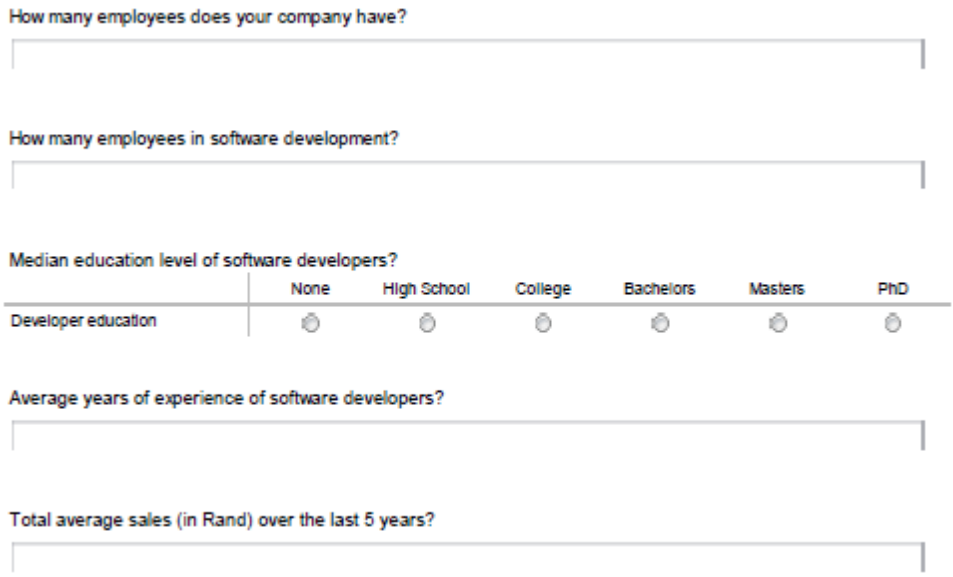
APPENDIX A: SURVEY QUESTIONNAIRE

Survey Questionnaire

Instructions

This section comprises 5 sub-sections. The first section asks demographic questions and the next three have questions on the adoption of open source software in your firm related to technology, organisational and environmental factors. The final section contains questions on the innovation performance of your firm.

Section 1: Demographic Questions



Age of company?

- One year or less
- 2 to 3 years
- 4 to 7 years
- 8 to 10 years
- 10 to 15 years
- 16 to 20 years
- More than 20 years

CIPC Business Sector

- Business services
- Software Development
- Other

Distribution Policy

- Business to business
- Business to consumer

Section 2: Questions on Adoption of OSS in the Technology Dimension

How much do you use any of the following groups of OSS platforms and applications in your organisation?

	Never	Rarely	Occasionaly	Sometimes	Frequently	Usually	All the time
Server operating systems (E.g. Linux, CentOS)							
Database Systems (E.g. MySQL, PostgreSQL)							
Business Applications (E.g Gimp, OpenOffice)							
Software Development Tools (E.g. cvs, jira, bamboo)							
Collaboration Tools (E.g. MedaiWiki, WikkaWIki)							
Desktop Operating Systems (E.g. Ubuntu, Gnome)							

To what extent do you agree/disagree with these statements?

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
Linux is more stable than Microsoft Windows.	○	○	○	○	○	○	○
Linux performs better than Microsoft Windows.	○	○	○	○	○	○	○

To what extent do OSS operating systems and applications integrate to your existing hardware and software infrastructure?

	Not at all	Hardly	Somewhat	Average	More than average	Very	Completely
OSS Integration to existing	○	○	○	○	○	○	○

How complex do you perceive OSS to be?

	Not complex at all	Slightly complex	Less than average	Average	More than average	Very Complex	Highly Complex
Click to write Statement 1	○	○	○	○	○	○	○

How important is access to software source code to your organisation?

	Not at all Important	Very Unimportant	Somewhat Unimportant	Neither Important nor Unimportant	Somewhat Important	Very Important	Extremely Important
Importance of access to source code	○	○	○	○	○	○	○

How important is the level of maturity of OSS to your organisation?

	Not at all important	Low importance	Slightly important	Neutral	Moderately important	Very important	Extremely important
OSS Maturity Importance	○	○	○	○	○	○	○

Section 3: Questions on Adoption of OSS in the Organisation Dimension

How much do you make use of the following in your organisation?

	Never	Rarely	Occasionally	Sometimes	Frequently	Often	All the time
Participation in OSS blogs	○	○	○	○	○	○	○
Use of OSS support groups	○	○	○	○	○	○	○
Participation in OSS webinars	○	○	○	○	○	○	○
Attendance of OSS conferences (E.g. Software Freedom Day)	○	○	○	○	○	○	○

What is the attitude of your senior management towards OSS?

	Strongly Negative	Negative	Somewhat negative	Neutral	Somewhat positive	Positive	Strongly positive
Senior management attitude to OSS	○	○	○	○	○	○	○

How much slack time does your organisation have?

	None	Little	Less than average	Average	More than average	A lot	As much as developers want
Slack time	○	○	○	○	○	○	○

How important is the ethos of OSS to your organisation?

	Not at all	Low importance	Somewhat important	Neutral	Moderately important	Very important	Extremely important
Importance of OSS ethos	○	○	○	○	○	○	○

How innovative do you perceive your organisation to be?

	Not at all	Slightly	Moderately	Average	More than average	Very	Extremely
Innovativeness of organisation	○	○	○	○	○	○	○

How much prior OSS experience do your developers have?

	None	Little	Some	Average	More than average	A lot	Extensive
Prior OSS experience of developers	○	○	○	○	○	○	○

Section 4: Questions on Adoption of OSS in the Environment Dimension

What is your level of familiarity to the following documentation?

	None	Have heard of	Slightly familiar	Somewhat familiar	Moderately familiar	Assimilation into firm polcies	Contributed
Government OSS policy	○	○	○	○	○	○	○
Open Source Definition	○	○	○	○	○	○	○

How often do you access the Free Software Foundation www.fsf.org?

	Never	Less than Once a Month	Once a Month	2-3 Times a Month	Once a Week	2-3 Times a Week	Daily
www.fsf.org access frequency	○	○	○	○	○	○	○

How easy is it to find external OSS support?

	Very Difficult	Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Easy	Very Easy
External OSS support	○	○	○	○	○	○	○

How often do your developers collaborate in OSS communities?

	Never	Less than Once a Month	Once a Month	2-3 Times a Month	Once a Week	2-3 Times a Week	Daily
Developer OSS community collaboration	○	○	○	○	○	○	○

Frequency of source code contribution back to OSS community.

	Never	Once	More than once	Often	All of the Time
OSS source code contribution	○	○	○	○	○

How many OSS initiatives have you managed/started?

	None	One	Two	3 to 5	More than 5
OSS initiatives started/managed	○	○	○	○	○

Section 5: Questions on Innovation Performance

In which categories do your software products fall?

- [ ] Business Applications
- [ ] Operating Systems
- [ ] Firmware
- [ ] Other

Have you introduced any new products and/or services into your market in the last 5 years?

- ○ Yes
- ○ No

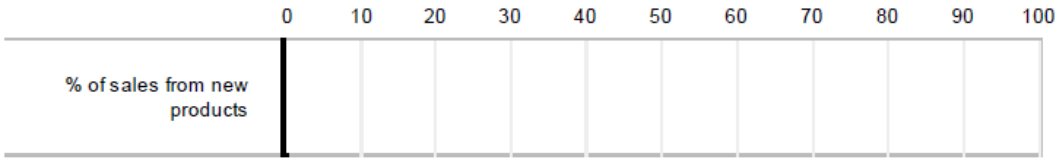
How many new products have you introduced into your market in the last 5 years?

	None	1	2	3	4	5-10	11-20	21-30	31-40	41-50	More than 50
Number of new products	○	○	○	○	○	○	○	○	○	○	○

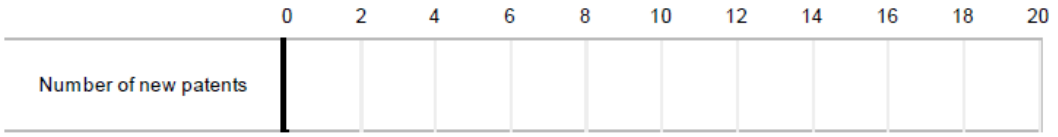
How many new processes have been introduced into your organisation in the last 5 years?

	None	1	2	3	4	5-10	11-20	21-30	31-40	41-50	More than 50
Number of new processes	○	○	○	○	○	○	○	○	○	○	○

On average what percentage of total sales is contributed by the new products that you have introduced in the last 5 years?



How many patents have you registered in the last 5 years?



This concludes the questionnaire.

Thank you for your participation and contribution towards the research. If you have any further question please contact me, Barry Greyling, at barry.greyling@lightyear.co.za.

APPENDIX B: SUMMARY DATA

Cronbach alpha and Pearson correlation of all survey independent variables

Cronbach's Alpha	N of Items
.885	22

Correlations

	LNPROD	LNPROC	SALES	LSIZE	AGE	OS	DB	Bapps	Dev	Collab	Desktop	Stable	Perf	Integr	Source	Complex	AttSenior	Ethos	Innov	Exp	Bloggs	SuppGrp	Webinar	Conf	ExtSupp	Contrib7
LNPROD																										
LNPROC	.443**																									
SALES	.459**	.147																								
LSIZE	.206	.457**	.071																							
AGE	.062	.325**	-.113	.286**																						
OS	-.026	.046	.130	.033	-.186																					
DB	-.166	.165	.041	.164	-.082	.525**																				
Bapps	.132	.107	.062	-.076	.043	.376**	.293**																			
Dev	.094	.133	.234*	.216	.043	.311**	.405**	.357*																		
Collab	.239*	.202	.225*	.235*	-.061	.318**	.239*	.423**	.500**																	
Desktop	.076	.045	.127	-.041	-.097	.415**	.225*	.600**	.332**	.432**																
Stable	-.278*	.082	-.079	-.201	.073	.266*	.223*	.290**	.095	.072	.396**															
Perf	-.273*	.053	-.193*	-.211	.025	.291**	.192	.313**	.075	.080	.313**	.880**														
Integr	.053	.225*	.094	.157	.012	.597**	.386**	.542**	.342**	.388**	.395**	.276*	.301**													
Source	.135	.240*	.195	.012	.000	.426**	.336**	.169	.309*	.329**	.197	.162	.094	.234*												
Complex	.134	.153	.133	-.043	.090	-.009	-.117	-.200	-.166	-.136	.058	-.012	-.099	-.192	.205											
AttSenior	-.011	.116	.016	.100	-.169	.585**	.435**	.483**	.292**	.337**	.428**	.376**	.347**	.657**	.300**	-.193										
Ethos	.063	.239*	.028	.020	-.045	.342**	.230*	.430**	.055	.274*	.267*	.421**	.397**	.476**	.405**	-.017	.613**									
Innov	.348**	.374**	.299**	.247*	.100	.083	.193	.086	.199	.309**	.045	-.093	-.206	.244*	.282*	.126	.233*	.186								
Exp	.183	.197	.178	.206	-.137	.426**	.485**	.315**	.560**	.555**	.335**	.057	.089	.510**	.451**	-.041	.521**	.326**	.363**							
Bloggs	.090	.006	-.012	.182	-.169	.353**	.260*	.232*	.138	.365**	.242*	.018	.066	.314**	.302**	-.076	.359**	.401**	.208	.409*						
SuppGrp	-.084	-.008	-.093	.134	-.061	.325**	.143	.174	.085	.271*	.278*	.242*	.231*	.286**	.181	-.037	.273*	.258*	.197	.281*	.592**					
Webinar	.079	.099	.150	.172	-.174	.329**	.177	.315**	.175	.361**	.228*	.118	.171	.295**	.141	-.093	.256*	.417**	.049	.291**	.561**	.561**				
Conf	.291**	.223*	.156	.246*	.009	.305**	.197	.302**	.225*	.497**	.365**	.067	.142	.335**	.338**	-.073	.266*	.417**	.187	.420**	.602**	.462**	.693**			
ExtSupp	.031	.102	-.105	.038	.048	.182	.126	.294**	.070	.124	.112	.158	.188	.322**	.089	-.290**	.411**	.350**	.057	.257*	.197	.233*	.198	.181		
Contrib7	.133	.093	.157	.083	-.098	.292**	.253*	.227*	.256*	.469**	.177	-.100	-.070	.286**	.463**	-.165	.348**	.300**	.351**	.454**	.559**	.300**	.374**	.515**	.286**	
Initis7	.162	.160	.043	.169	-.186	.324**	.136	.162	.115	.374**	.258*	-.033	-.003	.300**	.279*	-.005	.333**	.379**	.180	.395**	.488**	.428**	.278*	.403**	.217	.425**

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

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

APPENDIX C: FACTOR ANALYSIS

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.759
Bartlett's Test of Sphericity	Approx. Chi-Square	569.750
	df	105
	Sig.	.000

Communalities

	Initial	Extraction
OS	1.000	.601
DB	1.000	.631
Bapps	1.000	.680
Dev	1.000	.655
Collab	1.000	.672
Desktop	1.000	.664
Stable	1.000	.897
Perf	1.000	.863
Source	1.000	.555
Exp	1.000	.696
Bloggs	1.000	.722
SuppGrp	1.000	.683
Webinar	1.000	.663
Conf	1.000	.695
Inits7	1.000	.468

Extraction Method: Principal Component Analysis.

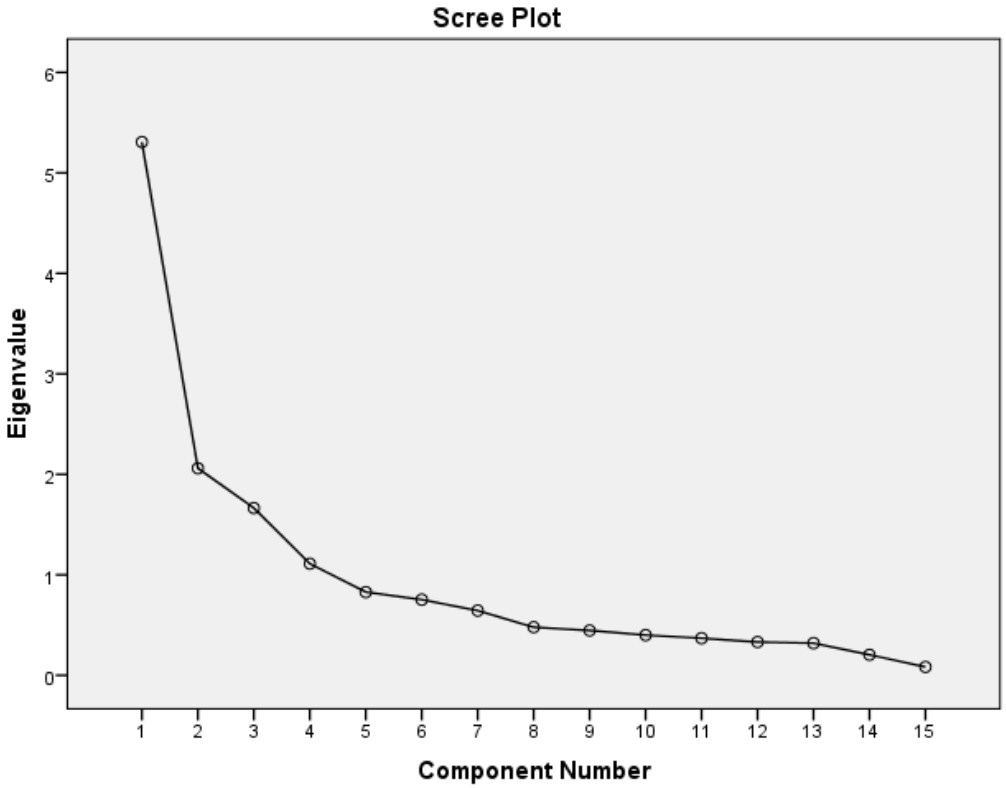
Total Variance Explained

Factor analysis total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.307	35.379	35.379	5.307	35.379	35.379	3.208	21.385	21.385
2	2.061	13.737	49.116	2.061	13.737	49.116	2.431	16.208	37.592
3	1.664	11.095	60.212	1.664	11.095	60.212	2.343	15.622	53.214
4	1.111	7.404	67.615	1.111	7.404	67.615	2.160	14.402	67.615
5	.828	5.521	73.136						
6	.753	5.020	78.156						
7	.644	4.294	82.450						
8	.478	3.190	85.640						
9	.446	2.973	88.613						
10	.400	2.668	91.281						
11	.369	2.461	93.742						
12	.331	2.208	95.950						
13	.320	2.134	98.084						
14	.204	1.361	99.445						
15	.083	.555	100.000						

Extraction Method: Principal Component Analysis.

Scree plot



Rotated component matrix

	Component			
	1	2	3	4
Bloggs	**.809**	.249		
SuppGrp	**.783**			.248
Webinar	**.774**		.227	.112
Conf	**.756**	.126	.328	
Inits7	**.608**	.271		-.129
DB		**.760**	.141	.178
Source	.204	**.715**		
Exp	.287	**.653**	.417	-.118
OS	.286	**.631**	.184	.295
Bapps	.143		**.754**	.291
Desktop	.207		**.701**	.349
Collab	.350	.268	**.680**	-.123
Dev		.500	**.628**	
Stable		.121	.120	**.932**
Perf			.112	**.915**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 6 iterations.

Descriptive statistics from factor analysis results

	Mean	Std. Deviation	N
LNPROD	1.3418	.70575	81
LNPROC	1.6445	.91055	81
SALES	.6987	.43616	81
LSIZE	2.4266	1.20837	81
AGE	3.9012	1.51332	81
OSSBSPN	.0000000	1.00000000	81
OSSTECH	.0000000	1.00000000	81
OSSBTLS	.0000000	1.00000000	81
OSSPCPT	.0000000	1.00000000	81

Pearson correlations

Correlations

		LNPROD	LNPROC	SALES	LSIZE	AGE	OSSBSPN	OSSTECH	OSSBTLS	OSSPCPT
LNPROD	Pearson Correlation	1	.443**	.459**	.206	.062	.133	-.035	.251*	-.350**
	Sig. (2-tailed)		.000	.000	.065	.582	.235	.754	.024	.001
	N	81	81	81	81	81	81	81	81	81
LNPROC	Pearson Correlation	.443**	1	.147	.457**	.325**	.062	.187	.120	-.010
	Sig. (2-tailed)	.000		.190	.000	.003	.581	.094	.286	.929
	N	81	81	81	81	81	81	81	81	81
SALES	Pearson Correlation	.459**	.147	1	.071	-.113	.012	.139	.225*	-.191
	Sig. (2-tailed)	.000	.190		.530	.315	.914	.214	.044	.088
	N	81	81	81	81	81	81	81	81	81
LSIZE	Pearson Correlation	.206	.457**	.071	1	.286**	.202	.133	.077	-.280*
	Sig. (2-tailed)	.065	.000	.530		.010	.070	.237	.497	.012
	N	81	81	81	81	81	81	81	81	81
AGE	Pearson Correlation	.062	.325**	-.113	.286**	1	-.156	-.094	.030	.044
	Sig. (2-tailed)	.582	.003	.315	.010		.165	.405	.791	.697
	N	81	81	81	81	81	81	81	81	81
OSSBSPN	Pearson Correlation	.133	.062	.012	.202	-.156	1	.000	.000	.000
	Sig. (2-tailed)	.235	.581	.914	.070	.165		1.000	1.000	1.000
	N	81	81	81	81	81	81	81	81	81
OSSTECH	Pearson Correlation	-.035	.187	.139	.133	-.094	.000	1	.000	.000
	Sig. (2-tailed)	.754	.094	.214	.237	.405	1.000		1.000	1.000
	N	81	81	81	81	81	81	81	81	81
OSSBTLS	Pearson Correlation	.251*	.120	.225*	.077	.030	.000	.000	1	.000
	Sig. (2-tailed)	.024	.286	.044	.497	.791	1.000	1.000		1.000
	N	81	81	81	81	81	81	81	81	81
OSSPCPT	Pearson Correlation	-.350**	-.010	-.191	-.280*	.044	.000	.000	.000	1
	Sig. (2-tailed)	.001	.929	.088	.012	.697	1.000	1.000	1.000	
	N	81	81	81	81	81	81	81	81	81

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

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

APPENDIX D: REGRESSION ANALYSIS

Regression analysis of the number of new products and services - LNPROD:

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.463[a]	.214	.150	.65057

a. Predictors: (Constant), LSIZE, OSSBTLS, OSSTECH, OSSBSPN, OSSPCPT, AGE

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.526	6	1.421	3.357	.006[b]
	Residual	31.320	74	.423		
	Total	39.846	80			

a. Dependent Variable: LNPROD

b. Predictors: (Constant), LSIZE, OSSBTLS, OSSTECH, OSSBSPN, OSSPCPT, AGE

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.139	.224		5.076	.000
	OSSBSPN	.095	.077	.135	1.240	.219
	OSSTECH	-.025	.074	-.035	-.332	.741
	OSSBTLS	**.173**	**.073**	**.245**	**2.368**	**.021**
	OSSPCPT	**-.239**	**.077**	**-.339**	**-3.111**	**.003**
	AGE	.034	.053	.073	.649	.518
	LSIZE	.029	.070	.049	.407	.685

a. Dependent Variable: LNPROD

Regression analysis of the number of new processes - LNPROC:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.538[a]	.290	.232	.79800

a. Predictors: (Constant), LSIZE, OSSBTLS, OSSTECH, OSSBSPN, OSSPCPT, AGE

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.205	6	3.201	5.026	.000[b]
	Residual	47.124	74	.637		
	Total	66.328	80			

a. Dependent Variable: LNPROC

b. Predictors: (Constant), LSIZE, OSSBTLS, OSSTECH, OSSBSPN, OSSPCPT, AGE

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.409	.275		1.487	.141
	OSSBSPN	.018	.094	.019	.186	.853
	OSSTECH	.143	.091	.157	1.566	.122
	OSSBTLS	.076	.090	.084	.851	.398
	OSSPCPT	.080	.094	.088	.848	.399
	AGE	**.136**	**.065**	**.225**	**2.095**	**.040**
	LSIZE	**.291**	**.086**	**.386**	**3.384**	**.001**

a. Dependent Variable: LNPROC

Regression analysis of the percentage of sales contributed by the number of new products and services - SALES:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.225[a]	.050	.038	.42770	.050	4.199	1	79	.044

a. Predictors: (Constant), OSSBTLS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.768	1	.768	4.199	.044[b]
	Residual	14.451	79	.183		
	Total	15.219	80			

a. Dependent Variable: SALES

b. Predictors: (Constant), OSSBTLS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.699	.048		14.702	.000	.604	.793					
	OSSBTLS	.098	.048	.225	2.049	.044	.003	.193	.225	.225	.225	1.000	1.000

a. Dependent Variable: SALES

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	AGE	-.120[b]	-1.094	.277	-.123	.999	1.001	.999
	OSSBSPN	.012[b]	.111	.912	.013	1.000	1.000	1.000
	OSSTECH	.139[b]	1.277	.205	.143	1.000	1.000	1.000
	OSSPCPT	-.191[b]	-1.763	.082	-.196	1.000	1.000	1.000
	LSIZE	.054[b]	.488	.627	.055	.994	1.006	.994

a. Dependent Variable: SALES

b. Predictors in the Model: (Constant), OSSBTLS

APPENDIX E: CONSISTENCY MATRIX

The consistency matrix is shown on the next page.

Table 23: Consistency matrix

The main problem of the research is to establish the relationship between the adoption attributes of OSS and the innovation performance of SMEs in South Africa.					
Sub-problem	**Literature Review**	**Hypotheses**	**Source of data**	**Type of data**	**Analysis**
The link between OSS adoption and product innovation	(Chesbrough, 2003; Crowston et al., 2012; Dahlander & Magnusson, 2008; Dedrick & West, 2003; Ellis & Van Belle, 2009; Feller & Fitzgerald, 2000; Inauen & Schenker-Wicki, 2011; Parida et al., 2012; Piva et al., 2012; Tornatzky et al., 1990; Van Belle & Reed, 2012; Van Beulen et al., 2009; West & Gallagher, 2006b)	*There is a positive and significant relationship between the level of OSS adoption and the number of new products and services*	Have you introduced and new products in your market in the last 5 years? How many new products have you introduced into your market in the last 5 years? Questions from sections 2, 3 and 4 of the survey.	Ratio	Ordinary Least Squares Regression

The main problem of the research is to establish the relationship between the adoption attributes of OSS and the innovation performance of SMEs in South Africa.					
Sub-problem	**Literature Review**	**Hypotheses**	**Source of data**	**Type of data**	**Analysis**
The link between OSS adoption and process innovation	(Chesbrough, 2003; Crowston et al., 2012; Dahlander & Magnusson, 2008; Dedrick & West, 2003; Ellis & Van Belle, 2009; Feller & Fitzgerald, 2000; Inauen & Schenker-Wicki, 2011; Parida et al., 2012; Piva et al., 2012; Tornatzky et al., 1990; Van Belle & Reed, 2012; Van Beulen et al., 2009; West & Gallagher, 2006b)	*There is a positive and significant relationship between the level of OSS adoption and the number of new process innovations*	How many new processes into your organisation in the last 5 year? Questions from Sections 2, 3 and 4 of the survey.	Ratio	Ordinary Least Squares Regression

The main problem of the research is to establish the relationship between the adoption attributes of OSS and the innovation performance of SMEs in South Africa.					
Sub-problem	**Literature Review**	**Hypotheses**	**Source of data**	**Type of data**	**Analysis**
The link between OSS adoption and sales percentage of product innovations	(Chesbrough, 2003; Crowston et al., 2012; Dahlander & Magnusson, 2008; Dedrick & West, 2003; Ellis & Van Belle, 2009; Feller & Fitzgerald, 2000; Inauen & Schenker-Wicki, 2011; Parida et al., 2012; Piva et al., 2012; Tornatzky et al., 1990; Van Belle & Reed, 2012; Van Beulen et al., 2009; West & Gallagher, 2006b)	*There is a positive and significant relationship between the level of OSS adoption and the percentage of sales from new products and services*	What percentage of total sales is contributed by the new products that you have introduced in the last 5 years? Questions from Sections 2, 3 and 4 of the survey.	Ratio	Ordinary Least Squares Regression