ASSESSING ANTECEDENTS AND CONSEQUENCES OF ENTREPRENEURIAL ACTIVITIES OF ACADEMICS AT SOUTH AFRICAN UNIVERSITIES

By

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Declaration

I declare that the doctoral thesis, which I hereby submit for the degree PhD Entrepreneurship at the University of Pretoria, is my own work and has not been submitted by me for a degree at another university.

Magdalena Meusburger

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"It always seems impossible until it's done."
(Nelson Mandela)

A PhD thesis is a challenging task on its own, let alone when it has to be written while being a full-time entrepreneur. It was an exciting but demanding journey with several pivotal moments. I would like to express my gratitude to the wonderful people who supported me during this research process.

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Abstract

The knowledge economy is driven by entrepreneurship and, consequently, the entrepreneurial university becomes an important catalyst for regional economic and social development. Academics represent the key agents of knowledge and technology transfer from university to society. However, despite growing awareness and an emerging body of empirical evidence that academics' successful engagement in entrepreneurial activities, namely, consulting, sponsored research, licensing/assignment of intellectual property (IP) and spin-off creation, can positively contribute to the development of local society and economy, evidence on the antecedents and consequences of academic engagement and commercialisation is scarce.

Little is known about (1) whether aspects related to academics' human, physical and organisational capital resources influence their engagement in entrepreneurial activities; (2) whether academics' entrepreneurial activities have an impact on their research and teaching outcome parameters; and (3) whether the creation of entrepreneurial activity spin-off, licensing/assignment of IP, sponsored research and consulting complement or substitute each other. This research study aimed to fill this gap and contribute to the debate on the role of the individual academic in the process of multiple helix interactions within the South African national system of innovation. It sheds light on the question of who engages in entrepreneurial activities and what are the antecedents and consequences of these actions.

The theoretical part of the study contextualises and defines the entrepreneurial activities of academics in the field of Academic Entrepreneurship, which in turn is a subdivision of the research field of Entrepreneurship. The study outlines interacting economic, social and political developments in the South African national system of innovation. The theoretical framing for this study integrates resource-based research and the creativity of action theory. Based on the conceptual framework, the empirical part of the study used a fully structured online measurement instrument. The respondents were individual academic researchers affiliated to public South African universities, who, as on 28 February 2013, had been awarded a quality rating by South Africa's National Research Foundation (NRF).

These respondents were involved in the full spectrum of academic disciplines. Data analysis employed generalised linear models.

The results indicate that academics' engagement in entrepreneurial activities with industry, government and civil society is a complex process of a heterogeneous nature. The availability of resources influences the four entrepreneurial activities (consulting, sponsored research, licensing/assignment of IP and spin-off creation) differently. Resources can include the knowledge and abilities of the individual and the organisational system, the routines and relationships of the institution the academic is embedded in and the physical resources he or she can leverage. The major findings of this research include the fact that individual factors are more significant than institutional factors in determining entrepreneurial action and that academics' engagement in entrepreneurial activities is primarily determined by their prior experiences. In addition, the results of this study show that different research orientations relate significantly to different entrepreneurial activities.

Furthermore, the findings show that the activities of sponsored research and licensing/assignment of IP are positively related to academics' publication output. Also, the creation of firms and engagement in consulting activities do not occur at the expense of scientific productivity. In regard to teaching commitment, however, engagement in entrepreneurial activities proved to be negatively related. Complementarities were also found to exist between sponsored research and academics' consulting activities.

This research study provides theoretical insights and empirical evidence for scholars investigating academic entrepreneurship. In addition, it presents policy makers and university administrators with the key resource drivers of entrepreneurial action. It could also assist them in establishing an appropriate role for institutions and organisations in promoting entrepreneurial activities. With such knowledge they could provide academics with the resources required, foster their relevant abilities and get the most out of complementary effects, while acting with caution against potential trade-offs.

Table of contents

DECLARATION I

ACKNOWLEDGEMENTS II

ABSTRACT III

TABLE OF CONTENTS V

LIST OF TABLES X

LIST OF FIGURES XII

APPENDICES XIII

1. CHAPTER 1 ORIENTATION AND BACKGROUND 1

1.1 INTRODUCTION 1

1.2 PROBLEM STATEMENT 5

1.2.1 ENGAGEMENT BY ACADEMICS IN ENTREPRENEURIAL ACTIVITIES 8

1.2.2 INFLUENCE OF RESOURCES ON ENTREPRENEURIAL ACTIVITIES OF ACADEMICS 8

1.2.3 RELATIONSHIP BETWEEN ENTREPRENEURIAL ACTIVITIES AND TRADITIONAL ACTIVITIES 9

1.2.4 COMPLEMENTARITIES AND SUBSTITUTION EFFECTS OF ENTREPRENEURIAL ACTIVITIES 11

1.3 PURPOSE OF THIS STUDY 12

1.4 RESEARCH OBJECTIVES 14

1.5 MAIN THEORETICAL PERSPECTIVES 15

1.5.1 CONTRIBUTIONS OF THE RESOURCE-BASED VIEW TOWARDS THIS RESEARCH 16

1.5.2 CONTRIBUTIONS OF THE THEORY OF THE CREATIVITY OF ACTION TOWARDS THIS RESEARCH 18

1.6 THE RESEARCH DESIGN AND METHODOLOGY 19

1.6.1 RESEARCH DESIGN 19

1.7 IMPORTANCE OF STUDY 25

1.7.1 CONTRIBUTION TO RESEARCH 26

1.7.2 CONTRIBUTION TO PRACTICE 28

1.8 DEMARCATION OF CHAPTERS 30

1.8.1 OUTLINE OF CHAPTER TWO 30

1.8.2 OUTLINE OF CHAPTER THREE 31

1.8.3 OUTLINE OF CHAPTER FOUR 31

1.8.4 OUTLINE OF CHAPTER FIVE 31

1.8.5 OUTLINE OF CHAPTER SIX 32

1.9 CONCLUSION 32

2. CHAPTER 2 ACADEMIC ENTREPRENEURSHIP 33

2.1 INTRODUCTION 33

2.2 HISTORY AND DEFINITIONS OF ENTREPRENEURSHIP 34

2.2.1 PIONEERING THOUGHTS ON ENTREPRENEURSHIP 34

2.2.2 THE GROWTH PHASE OF ENTREPRENEURSHIP RESEARCH 36

2.2.3 ENTREPRENEURSHIPAS A LEGITIMATE SCHOLARLY DISCIPLINE.. 37

2.3 ENTREPRENEURSHIP IN THE FIELD OF HIGHER EDUCATION 41

2.3.1 THE ENTREPRENEURIAL UNIVERSITY 43

2.3.2 EVOLUTION OF THE ENTREPRENEURIAL UNIVERSITY 43

2.3.3 UNIVERSITY TECHNOLOGY TRANSFER 47

2.3.4 UNIVERSITY SPIN-OFFS 50

2.4 ENTREPRENEURIAL ACTIVITIES OF ACADEMICS 54
2.4.1 SPIN-OFF CREATION 59
2.4.2 LICENSING/ASSIGNMENT OF INTELLECTUAL PROPERTY (IP) 60
2.4.3 SPONSORED RESEARCH 61
2.4.4 CONSULTING 61
2.5 THEORETICAL FRAMING 62
2.5.1 JOAS' THEORY OF THE CREATIVITY OF ACTION 62
2.5.2 RESOURCE-BASED VIEW OF THE FIRM 66
2.6 ANTECEDENTS AND CONSEQUENCES 69
2.6.1 ANTECEDENTS 70
2.6.2 CONSEQUENCES: TEACHING AND RESEARCH OUTPUTS 80
2.6.3 RELATIONSHIPS BETWEEN THE ENTREPRENEURIAL ACTIVITIES OF ACADEMICS 84
2.7 CONCLUSION 89

3. CHAPTER 3 ACADEMIC ENTREPRENEURSHIP IN SOUTH AFRICA 91
3.1 INTRODUCTION 91
3.2 SOUTH AFRICA'S NATIONAL SYSTEM OF INNOVATION 92
3.3 TRANSFORMATION AT SOUTH AFRICAN UNIVERSITIES 99
3.4 CONCLUSION 103

4. CHAPTER 4 RESEARCH DESIGN AND METHODOLOGY 106
4.1 INTRODUCTION 106
4.2 HYPOTHESES 107
4.3 RESEARCH METHODOLOGY 113
4.3.1 RESEARCH DESIGN 113

4.3.2 SAMPLING 114

4.3.3 DATA COLLECTION 116

4.3.4 ANALYTICAL APPROACH 127

4.4 CONCLUSION 132

5. CHAPTER 5 DATA ANALYSIS AND FINDINGS 133

5.1 INTRODUCTION 133

5.2 DESCRIPTIVE STATISTICS 133

5.3 GENERALISED LINEAR MODELS 142

5.3.1 RESULTS: HYPOTHESES TESTING 146

5.3.2 GENERALISED LINEAR MODEL FOR SPIN-OFF CREATION 158

5.3.3 Generalised LINEAR MODEL FOR LICENS./ASSIGN.T OF IP 160

5.3.4 GENERALISED LINEAR MODEL FOR SPONSORED RESEARCH 162

5.3.5 GENERALISED LINEAR MODEL FOR CONSULTING 164

5.3.6 GENERALISED LINEAR MODEL FOR PUBLICATION OUTPUT 167

5.3.7 GENERALISED LINEAR MODEL FOR TEACHING COMMITMENT 169

5.4 CONCLUSION 171

6 CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS 173

6.1 INTRODUCTION 173

6.2 CONCLUSION ON EACH RESEARCH QUESTION 174

6.2.1 ENGAGEMENT BY ACADEMICS IN DIFFERENT ENTREPRENEURIAL ACTIVITIES 175

6.2.2 INVESTIGATING THE INFLUENCE OF RESOURCES ON ENTREPRENEURIAL ACTIVITIES OF ACADEMICS 176

6.2.3 EXAMINING THE RELATIONSHIP BETWEEN ENTREPRENEURIAL ACTIVITIES AND TRADITIONAL ACTIVITIES 179

6.2.4 TRADE-OFFS AND COMPLEMENTARITIES OF ENTREPRENEURIAL ACTIVITIES 181

6.2.5 SUMMARIZED OVERVIEW OF FINDINGS 181

6.3 IMPLICATIONS FOR RESEARCH 182

6.4 IMPLICATIONS FOR PRACTICE 184

6.5 LIMITATIONS OF THE STUDY 187

6.6 CONCLUSION 187

LIST OF REFERENCES 190

APPENDIX A QUESTIONNAIRE 231

APPENDIX B LETTER OF INTRODUCTION AND INFORMED CONSENT 241

APPENDIX C ODDS RATIOS AND INCIDENT RATE RATIOS 243

List of tables

Table 1.1: Hypotheses 22
Table 2.1: Clusters in Entrepreneurship Research 38
Table 2.2: Entrepreneurial activities of academics: definitions and dimensions 57
Table 2.3: Entrepreneurial Activities of Academics: Operational Definitions 59
Table 3.1: Knowledge Economy Index for South Africa 94
Table 3.2: Key indicators of the South African National Survey of Research and Experimental Development 95
Table 4.1: Operationalisation of the entrepreneurial activities of academics 118
Table 4.2: Operationalisation of applications-driven research 120
Table 4.3: Operationalisation of novelty of research 121
Table 4.4: Operationalisation of university's innovation infrastructure 122
Table 4.5: Operationalisation of university's IP managerial support 123
Table 4.6: Operationalisation of university's entrepreneurial culture 124
Table 4.7: Groupings of South African universities 125
Table 5.1: University affiliation – comparison of original population and respondents 134
Table 5.2: Faculty affiliation of respondents 135
Table 5.3: Academic position of respondents 136
Table 5.4: Gender of respondents 136
Table 5.5: Age of respondents 136
Table 5.6: Entrepreneurial activities of respondents (2011/2012) 137
Table 5.7: Academics' engagement in commercialization activities 2011/2012 138
Table 5.8: Joint research projects during 2011 and 2012 138
Table 5.9: Contract research projects during 2011 and 2012 139
Table 5.10: Consulting services during 2011 and 2012 140

Table 5.11: IP protection and invention disclosures during 2011 and 2012 140

Table 5.12: Abbreviations for GLM analysis.....143

Table 5.13: Estimated parameters of the multiple logistic regression for antecedents of entrepreneurial activities of academics 145

Table 5.14: Estimated parameters of the multiple logistic regression for consequences of entrepreneurial activities of academics 146

Table 5.15: Cross-tabulation of entrepreneurial activities.....157

Table 5.16: Generalized linear model for spin-off creation.....160

Table 5.17: Generalized linear model for licensing/assignment of IP.....161

Table 5.18: Generalized linear model for sponsored research 163

Table 5.19: Generalized linear model for consulting.....165

Table 5.20: Generalized linear model for publication output 167

Table 5.21: Generalized linear model for teaching commitment 169

Table 6.1: Summary of findings 181

List of figures

Figure 2.1: Conceptual framework: Entrepreneurial activities by academics 89
Figure 3.1: Major flows of R&D funding 97
Figure 3.2: Typical phasing of the value chain 102
Figure 5.1: Respondent's judgement of statements 142
Figure 5.2: GLM for spin-off creation 159
Figure 5.3: GLM for licensing/assignment of IP 161
Figure 5.4: GLM for sponsored research 162
Figure 5.5: Effect displays for sponsored research 164
Figure 5.6: GLM for consulting 165
Figure 5.7: Effect displays for consulting 166
Figure 5.8: GLM for publication output 167
Figure 5.9: Effect displays for publication output 168
Figure 5.10: GLM for teaching commitment 169
Figure 5.11: Effect displays for teaching commitment 170

Appendices

APPENDIX A: Questionnaire..... 231
APPENDIX B: Letter of introduction and informed consent 241
APPENDIX C: Odds ratios and incident rate ratios 243

CHAPTER 1
Orientation and background

1.1 INTRODUCTION

The title of this work, 'Assessing antecedents and consequences of entrepreneurial activities of academics at South African universities' may evoke various associations in the minds of different readers. Some may envision academic entrepreneurship and think of it as an oxymoron, others as a higher education axiom. Some may picture 'entrepreneur' and 'entrepreneurial' within this rhetoric and see these as either the marketisation of academia, or a driving force for innovation, growth and prosperity. In view of such perceptions, in what way should the title of this research actually be interpreted?

In an attempt to answer this question a number of illustrative real-life scenarios are given here.

Johannesburg, 06:30 in the morning on a cold autumn day. People are on their way to work. Cars hooting, a broad mix of music ranging from Kwaito to Boeremusiek booms out from car and taxi radios. The banter of street life rises with the sun every morning, with hundreds of citizens going about their busy daily lives.

Outside their office two colleagues enjoy a cup of coffee and chat about their weekend. Sibensile tells Marietta about the fantastic time she had at her gogo's (grandmother) place in the country. Among other things, she explains how she was able to stream educational videos for her cousins on her cellphone using the free Tuluntulu app, even though they were in a low bandwidth area. The Tuluntulu platform, Adaptive Real-Time Internet Streaming Technology (ARTIST), makes constant video streaming possible using algorithms to adjust the quality to the available bandwidth. The technology was developed by a group of researchers at the University of Cape Town, working in a consortium with developers from the Council for Scientific and Industrial Research (CSIR) and marketing experts from East Coast Access (University of Cape Town, 2014a; Tuluntulu, 2014).

While Sibensile and Marietta are absorbed in conversation, an ambulance speeds by. Inside is a patient who has lost most of his elbow in a car accident. Under normal circumstances amputation would be considered, but because of a new procedure that uses a selective laser melting technique, developed by researchers at the Central University of Technology in cooperation with industry and government, an implant produced directly from titanium alloys can be machined within a short period of time. The patient can hope to regain approximately 90% of the use of the injured arm within two months of the operation (Council on Higher Education, 2010:107; Campbell, De Beer & Pei, 2011:158).

Across the road, in a newly refurbished loft apartment, Vuyo reads the newspaper while eating his breakfast cereal. He is very conscious of healthy eating and the extruded rice crispy cereals are a standard item in his household. Directly expanded extrusion-cooked breakfast cereals are prepared using extrusion technology. The process to produce Vuyo's cereal may have used a twin-screw extruder developed at CFAM Technologies (Pty) Ltd. CFAM Technologies is a spin-off established at the North-West University in South Africa. Using reversed engineering it develops high-quality twin-screw extruders in Africa for the African industry (CFAM, 2014; Extruafrica, 2014).

As Vuyo browses the paper, an article on tea bag water filters catches his attention. AquaQure has launched the TBAG filter bottle, which uses a filter that resembles a tea bag and has a bacteria-killing compound spun into its fibres. AquaQure holds the licence for the patented disposable water filter bag innovation, which grew out of research conducted at Stellenbosch University. The TBAG filter bottle is of immeasurable value to people living in areas with no access to clean drinking water, as well as those in areas struck by natural disasters (Association of University Technology Managers, 2011; AquaQure, 2014).

Thinking of water, Vuyo remembers that he has to organise a bouquet of Iluba roses for his girlfriend's birthday dinner tomorrow. The roses, which are marketed under the name 'Iluba', last for six months without water and are a natural alternative to artificial flowers. The Iluba technique evolved at the Nelson Mandela Metropolitan University (NMMU), where scientists developed a chemical process in which some of the water in the cells and

tissue of the flower are replaced with natural preservatives. African Floralush (Pty) Ltd, the company that commercialised the new process for the preservation of roses and foliage, is an NMMU spin-off. The process is based on an NMMU patent that has been assigned to the company. African Floralush manufactures and sells to distributors and wholesalers both locally and internationally. Since its inception in 2009 it has created 90 direct jobs (Association of University Technology Managers, 2012; Iluba, 2014).

Vuyo turns up the volume on his iPod as Miriam Makeba's 'Pata Pata' starts to play. He loves her voice. She can sound bluesy and utterly exuberant but also light and pure. He just cannot imagine how life would be without Miriam Makeba's voice on his iPod. On a deeper level, he cannot picture how his life would be without his own voice – he is so used to saying anything he wants to say at any time, expressing how he feels and what he thinks. He remembers a conversation he had with Ian, an old school friend, a while ago. Ian is part of a professional team that works with people with disabilities. He explained that whenever they need additional support and guidance for people with complex communication needs they use the consulting services of the Centre for Augmentative and Alternative Communication (CAAC) at the University of Pretoria. He also told Vuyo about the Fofa Augmentative and Alternative Communication Youth Empowerment Project at the CAAC. This project has opened up a new world for young adults with little or no functional speech. During Fofa training young adults are given high tech communication tools that convert text into speech and are taught how to get the most out of these communication devices. During these get-togethers Fofa group members give speeches and share their dreams and their plans for reaching those dreams. Vuyo recalls that Ian mentioned that several young people have gained access to employment through the project and have become advocates for people with disabilities (Fofa, 2014).

Vuyo's phone rings. It is Tsepo, his workmate, who picks him up every morning on the way to work. Swiftly, Vuyo puts the empty bowl and the coffee cup into the dishwasher, slips on his fine leather shoes, takes his jacket and briefcase and rushes to the lift. It's going to be an exciting day in Johannesburg. The sky over the city is spectacular this morning, with wild cloud formations lit up by different colours.

These scenarios are examples of the *entrepreneurial activities of academics*, which form the focus of this research study. Academics are people who are typically focused on their personal careers, working to publish articles in high-impact journals and passing on their knowledge and expertise to their students. In addition, some academics take on a third role, one that is entrepreneurial in nature. By actively engaging with industry, government and civil society through consulting, sponsored research, the licensing/assignment of intellectual property (IP) and spin-off creation activities, they produce additional value that is tangible and has great meaning to many people. The purpose of this research was to assess these interactions and to understand which resources and resource bundles serve as antecedents to the entrepreneurial activities of academics. Resources in this sense can include the knowledge and abilities of the individual, the physical resources she or he can leverage, and the organisational system, the routines and the relationships in the institution in which the academic is embedded.

The analysis focused on the individual academic in relation to his or her environment. A number of factors may influence academics to engage in entrepreneurial activities. These factors may include aspects related to academics' human capital, such as their direct entrepreneurial experience or their academic seniority, or the novelty of their research, or the fact that it is applications-driven. Also of influence here are the physical capital resources they are able to leverage, for instance their university's innovation infrastructure, and aspects relating to the organisational capital of the university they are affiliated to, such as its entrepreneurial culture or the IP managerial support it offers.

As the title of this research indicates, the consequences of academics' entrepreneurial activities also formed part of this study. This research investigated the consequences of academics' engagement in entrepreneurial activities for their traditional tasks, namely, research and teaching, as well as the effects that activities such as consulting, sponsored research, the licensing/assignment of IP and spin-off creation have on each other, whether complementary or incompatible.

Overall, the study integrated resource-based research and the theory of the creativity of action with the aim of shedding light on the question of what the antecedents and

consequences of academics' entrepreneurial activities are within the multiple helix of the South African national system of innovation.

This chapter provides an introduction to the research. It outlines the research problem, the purpose of the study, the research objectives, the main theoretical perspectives, the research design and methodology, and illustrates the importance of the study. Additionally, it provides an outline of chapters 2 to 6 of this research study.

1.2 PROBLEM STATEMENT

Entrepreneurship, both as an activity and as discourse, is widely discussed in the higher education literature (Gibb, Haskins & Robertson, 2013:10). As the economy has evolved from being driven by physical capital to being driven by knowledge and, subsequently, to being driven by entrepreneurship, so has the role of the university (Audretsch, 2014:313). Accordingly, the entrepreneurial university has become an important catalyst for regional economic and social development, as it generates and exploits knowledge in the form of entrepreneurial opportunities (Urbano & Guerrero, 2013:40).

Within the global knowledge economy, countries need to continuously improve their capacity for new knowledge creation and innovation to support growth and development. It is therefore vital that academia, business, government and civil society work collaboratively to create enabling environments to foster innovation (World Economic Forum, 2013:9). This has led to a growing number of policies and initiatives aimed at promoting such interactions within countries' national systems of innovation (Aldridge & Audretsch, 2011:1059; Grimaldi, Kenny, Siegel & Wright, 2011:1047).

At present, South Africa is ranked 67 out of 145 countries in the World Bank's 2012 Knowledge Economy Index (KEI). South Africa has thus dropped fifteen positions compared to its position in 2000 (World Bank, 2014:2). In the context of the Global Innovation Index 2014, South Africa scored 38.2 out of 100 points and was ranked 53 out of 143 nations – low compared to the other BRICS countries (Global Innovation Index, 2014:256). An examination of South Africa's innovation profile reveals that the major

challenges facing the country include a shortfall in human capital development, low business expenditure on R&D, low triadic patents per million population, as well as low-level ICT penetration. The current inability to fully harness South Africa's innovation potential is what drove this study.

The national system of innovation proposed by the South African Science and Technology Policy (OECD, 2007:2; Kaplan, 2008:97) calls for a set of functioning institutions, organisations and policies to interact in pursuit of common social and economic goals. South Africa's National Development Plan (South Africa. National Planning Commission, 2012:326) states that the innovation system has a key role to play in improving the nation's global competitiveness.

The university, in common with all institutions, is in essence an accumulation of individuals, in this case predominantly academics. In this context, academics represent the key agents of knowledge and technology transfer from university to society. Although a common definition for the entrepreneurial activities of academics within the university context has not been established so far, scholars conceptualise such activities as all the undertakings that occur outside the traditional areas of academic work, that is, personal research and teaching (Klofsten & Jones-Evans, 2000:299). While the current focus of the academic literature dealing with entrepreneurial activities is mainly on licensing and spin-off creation, other commercial and non-commercial activities that are entrepreneurial in nature, such as sponsored research and consulting, should also be included (Abreu & Grinevich, 2013:408).

For the purpose of this study the entrepreneurial activities of academics were defined as the activities occurring beyond the traditional roles of teaching and research. These activities are primarily reflected in academics' interactions with industry, government and civil society via consulting, sponsored research, licensing/assignment of IP and spin-off creation. Spin-off creation in this context refers to the creation of a new firm to exploit commercially some knowledge, technology or research results developed within the university (Pirnay, Surlemont & Nlemvo, 2003:355; Shane, 2004:4; Visintin & Pittino, 2014:33). Licensing or the assignment of IP relates to the legal right to use or own a

specific piece of the university's intellectual property (Bercovitz & Feldmann, 2006:177; South Africa, 2008:4). Sponsored research takes the form of an agreement through which the university receives funding for conducting a research project (Bercovitz & Feldmann, 2006:177). This can be in the form of a joint-research or a contract research project with the private, the public or the third sector (Hall, Link & Scott, 2001:88; D'Este & Perkmann, 2011:318). Consulting in the context of academic entrepreneurship refers to the sale of personal scientific or technological expertise to solve a specific problem (Klofsten & Jones-Evans, 2000:300). This does not involve original research (Giuliani, Morrison, Pietrobelli & Rabellotti, 2010:758) and can be on a project basis or in the form of an ongoing role, such as membership of a scientific advisory board (Haeussler & Colyvas, 2011:44).

Academics have a long tradition of engaging in entrepreneurial activities (Wright, Mosey & Noke, 2012:430). To date, there is growing awareness and an emerging body of empirical evidence to show that the successful engagement of academic researchers in entrepreneurial activities can contribute positively to the development of both the local and the national economy (Mueller, 2006:1499; Teixeira & Mota, 2012:720; Sternberg, 2014:137). Most studies in the field of academic entrepreneurship at this point in time have been conducted in Europe or North America (Perkmann et al., 2013:428). In its Global Competitiveness Report 2013 to 2014 (World Economic Forum, 2013:11), the World Economic Forum categorised South Africa as an efficiency-driven economy. At the efficiency-driven stage of development, competitiveness is increasingly driven by higher education and training, efficient goods markets, well-functioning labour markets, developed financial markets, the ability to harness the benefits of existing technologies and a large domestic or foreign market (World Economic Forum, 2013:10). Accordingly, the examination of entrepreneurial activities in an efficiency-driven economy might provide different results and illustrate dissimilar requirements compared to studies conducted in countries classified by the World Economic Forum (2013:10) as innovation-driven economies.

1.2.1 Engagement by academics in entrepreneurial activities

While the transfer of innovations and knowledge generated by academics at universities is viewed as essential for economic growth, employment creation and international competitiveness in global markets, the systematic underreporting of these spillovers may lead to severe policy distortions (Aldridge & Audretsch, 2011:1059). In contrast to the traditional activities of academics, that is, teaching and research, academics' entrepreneurial activities are voluntary. Most published technology transfer studies focus on data reported by universities' technology transfer offices (TTOs) or by their liaison or research offices (e.g. Caldera & Debandre, 2010:1160; Huyghe, Knockaert, Wright & Piva, 2014:293), with the availability of comprehensive data sets compiled by the Association of University Technology Managers tending to favour this approach. However, the TTO's mandate is not to measure and document all the knowledge and technology transfer activities their academics engage in but rather to report the activities they are involved with (Aldridge & Audretsch, 2011:1059). This introduces an organisational focus on the formal mechanisms of transfer, such as patenting and licensing. This type of involvement is typically only a subset of the broader engagement and commercialisation activities taking place. Given this situation, structured data that include the ways in which academic researchers from different disciplines interact with both the private sector and the public sector (e.g. government departments and parastatals) and with the third sector (e.g. charity groups and community organisations), are mostly non-existent. This may concomitantly lead to policy misrepresentations, as the data reported and the impact measured refer only to a fraction of the actual entrepreneurial activities by academics taking place and are too incomplete for a wider interpretation.

1.2.2 Influence of resources on the entrepreneurial activities of academics

The reasons behind the entrepreneurial activities of academics and their consequences are largely underexplored, both theoretically and empirically (Van Looy, Landoni, Callaert, Van Pottelsberghe, Sapsalis & Debackere, 2011:554). In view of the fact that the quintessence of entrepreneurship is action (McMullen & Shepherd, 2006:132), and following the pragmatism-inspired line of situated creativity (Joas, 1996:133; Watson,

2013b:29), this study sees the participation of an academic researcher in an entrepreneurial activity as a creative act that goes beyond the habitual activities of teaching and research. The individual's entrepreneurial action is perceived to be resource-dependent (e.g. Schumpeter, 1934; Penrose, 1959; Baker & Nelson, 2005; Sarasvathy, 2008; Watson, 2013a) and anchored in their natural and social environment.

Based on these theoretical underpinnings, it is essential to develop further insight into which resources in terms of human capital, physical capital and organisational capital may serve as antecedents for the entrepreneurial activities of academics. Understanding that some resources play a more important role than others is thus crucial for the design of effective public policies, as instruments that build on different resources require substantially different approaches; for instance the support and facilitation of academics' human capital development as opposed to investment in the university's innovation infrastructure. Policies and incentive systems will only be fruitful if they place their focus on the resources that have been proven to be significant in influencing academics' likelihood to engage in entrepreneurial activities. Furthermore, different resources may influence consulting, sponsored research, licensing/assignment of IP and spin-off creation in different ways. For example, while a university's IP management support may be a vital resource to leverage when it comes to academics' licensing activities (Chang, Chen, Hua & Yang, 2006:209; Ambos, Mäkelä, Birkinshaw & D'Este, 2008:1438), it may have no influence on the individual's consulting activities. Hence, stimulating each of the entrepreneurial activities might require different approaches.

1.2.3 Relationship between entrepreneurial activities and traditional activities

The impact that entrepreneurial activities have on the traditional academic activities of teaching and research is unclear. The literature provides emerging evidence of a positive relationship between some entrepreneurial activities and scientific output in terms of publications (Larsen, 2011:9). Sponsored research, for example contract research, industry funding and research collaboration, has been shown to be positively associated with scientific productivity as measured by publications (Gulbrandsen & Smeby, 2005:932; Bonaccorsi, Daraio & Simar, 2006:389; Van Looy et al., 2011:558; Bonaccorsi, Secondi,

Setteducati & Ancaiani, 2014:189). On the other hand, the relationship between the consulting activities of researchers and their publication output has not been well investigated in the literature. One reason may be that there is very little quantitative data on consulting agreements (Wright, Clarysse, Mustar & Lockett, 2008:1216). Buenstorf (2009:290) did, however, find a positive relationship between the licensing of inventions and publishing. With regard to spin-off creation, some studies have revealed that the creation of firms does not occur at the expense of continued scientific productivity (Lowe & Gonzalez-Brambila, 2007:176; D'Este, Mahdi & Neely, 2009:27; Baldini, 2010:859).

In addition, little has been written about how less rigid boundaries between universities and organisations outside of academia may influence the teaching commitment of academics. In general, the impact academics' engagement in entrepreneurial activities has on teaching has not yet been well explored and no clear conclusions may be drawn (Perkmann et al., 2013:424). Some academics feel that engagement in commercialisation activities interferes with both their research and their teaching (Jain, George & Maltarich, 2009:928). Lee and Rhoads (2004:754) revealed a negative relationship between the use of funds for research and teaching commitment, although they also found that consulting positively affected the academic's commitment to teaching. With regard to spin-off creation, in their study of 1554 university researchers, Landry, Amara and Rherrad (2006:1611) did not find a statistically significant relation between teaching activities and spin-off creation.

Undoubtedly what is needed is clarity on whether it is possible for both the traditional and entrepreneurial visions of universities to co-exist successfully (Landry et al., 2006:1611) or whether a growing shift towards what Slaughter and Leslie (1997:9) term "academic capitalism" has a negative influence on the academic's commitment to teaching and publication output. This would enable decision-making bodies to adjust their university-level policies accordingly.

1.2.4 Complementarities and substitution effects of entrepreneurial activities

Compared to the vast amount of attention devoted to academic entrepreneurship and technology transfer channels, as illustrated in the reviews of Teixeira and Mota (2012:719) and Bozeman, Rimes and Youtie (2015:34), little is known about the relationships between academic engagement and commercialisation (Perkmann et al., 2013:429).

Licence agreements sometimes result from sponsored research, for example the product Peptosport® in terms of which the University of Cape Town licensed the formulation developed by one of its professors on an exclusive basis for commercial use by the nutrition products company which had sponsored the research (University of Cape Town, 2013). Similarly, North West University, together with an outside partner, developed a new generation automobile ignition system. Two patents on this variable spark ignition system were registered in Europe and the United States of America, as well as one on a low-noise amplifier and two more on a segmented core transformer (North West University, 2009:73; 2013:33). Thus, a project that starts as sponsored research may well result in a spin-off at a later stage (Shane, 2004:166). For example, in the beginning Hot Platinum (Pty) Ltd, a spin-off from the University of Cape Town, used funded research to develop its induction casting machine to the prototype phase (*Entrepreneur Magazine*, 2009:[1]; University of Cape Town, 2014b; Hot Platinum, 2014).

Another variation happens when spin-off companies become engaged in sponsored research activities together with their mother universities. Rasmussen (2011:460) cites a case in which as the university spin-off developed, the university became a research partner with the company that developed out of the spin-off. Students may also conduct research projects and may serve as a source of potential employees. In addition, the consulting activities of academics may provide an entry to external organisations (Wright et al., 2008:1208). Haeussler and Colyvas (2011:45) surveyed life scientists from the United Kingdom and Germany and found that 4% of their 2 294 respondents were involved in all three activities, namely, consulting, patenting and the founding of companies.

Despite several practical examples, the question as to whether consulting, sponsored research, licensing/assignment of IP and spin-off creation are complementary or in conflict with each other still remains unanswered. Just as the description of antecedents and consequences in the previous sections suggests that the four types of entrepreneurial activity may be driven by different underlying mechanisms, one may assume possible complementarities or contradictions between them. A deeper understanding of these relationships is therefore essential in order to elucidate whether more decisive approaches are needed (Perkmann et al., 2013:429). It is possible that focusing on one entrepreneurial activity may have detrimental effects on other activities (Van Looy et al., 2011:555).

There is, thus, a need for both the integration of the various perspectives that exist within the research stream of academic entrepreneurship and the development of a comprehensive understanding of the antecedences and consequences of the entrepreneurial activities of academics at South African universities.

1.3 PURPOSE OF THIS STUDY

The purpose of this study was to provide a framework that assists scholars investigating academic entrepreneurship, policy makers and university administrators to establish the appropriate role of institutions and organisations in promoting the entrepreneurial activities of academics in the South African context.

Firstly, the study measured the consulting, sponsored research, licensing/assignment of IP and spin-off creation activities carried out by academic researchers at South African universities. The resultant data set is the first of its kind and provides a solid baseline for further studies. The study aimed to countervail the systematic underreporting of the knowledge spillovers from academia to society and to shed light on the interactions taking place between the actors from academia and those from the private, public and third sector. The study adopted a wider focus and went beyond the activities which are termed *university–industry relationships* by Azagra-Caro (2007:708) and Ankrah, Burgess, Grimshaw and Shaw (2013:50), *industrial involvement* by Bozeman and Gaughan (2007:700), *university–industry interactions* by D'Este and Patel (2007:1301), *industry*

engagement by D'Este and Perkmann (2011:323), *institutionalised knowledge transfer activities* by Geuna and Muscio (2009:104), *university–industry linkages* by Perkmann and Walsh (2007:262) and Giuliani et al. (2010:758) and *commercial activities* by Haeussler and Colyvas (2011:46); and also included interactions with sectors outside of industry.

In a second step the study developed further insight into the resources in terms of the human capital, physical capital and organisational capital that may serve as antecedents for the entrepreneurial activities of academics. The study included the individual-level knowledge, abilities and resources of academics, as well as the resources and support that individuals have access to at the institutional level. The human capital-related aspects included (1) work experience outside of academia; (2) direct entrepreneurial experience; (3) exposure to entrepreneurship education; (4) academic seniority; (5) applications-driven research; and (6) novelty of research. The aspects related to physical capital resources comprised (7) intellectual property protection and (8) universities' innovation infrastructure; while the organisational capital-related aspects included (9) universities' IP managerial support and (10) universities' entrepreneurial culture. A deeper understanding of the importance and role of resources in enhancing the entrepreneurial activities of academics provides vital information for the design of effective public policies.

Thirdly, the study examined the consequences of the entrepreneurial activities of academics for their traditional activities of teaching and research. Accordingly, the study set out to establish the various relationships between consulting, sponsored research, licensing/assignment of IP and spin-off creation and the research output of academics in terms of publications and teaching commitment and also compared these relationships. Such knowledge is crucial for the implementation of successful technology and knowledge transfer measures to ensure that synergies may be used.

Finally, the study developed a basic understanding of the complementarities of the entrepreneurial activities in question. The key benefits of knowing whether consulting, sponsored research, licensing/assignment of IP and spin-off creation are either complementary or in conflict with each other include the ability to control and adjust current strategies. It is anticipated that such knowledge will enable policy makers and university

administrators to obtain the greatest possible benefit from the potential complementary effects and to act with caution against potential trade-offs.

1.4 RESEARCH OBJECTIVES

The study's primary research objective was to assess the antecedents and consequences of the entrepreneurial activities of NRF-rated academics at public South African universities. This main research purpose was underpinned by secondary objectives; these were categorised into theoretical objectives, which were achieved by means of a literature study, and empirical objectives, which were achieved through the empirical study.

The theoretical objectives included the following:

- To contextualise and define the entrepreneurial activities of academics within the field of Academic Entrepreneurship which is, in turn, a subdivision of the research field of Entrepreneurship
- To outline interacting economic, social and political developments within the South African national system of innovation
- To create the theoretical framework of the study which integrates resource-based research and the creativity of action theory
- To identify the relevant antecedents and consequences considered by prior research studies to have an impact on the entrepreneurial activities of academics.

Based on the literature study the research questions outlined below were formulated, with the empirical objective being to answer these questions by means of empirical data collection and analysis. The question guiding the empirical part of this research was: “Is it possible for academic entrepreneurial activities and their antecedents and consequences to be assessed in the South African university context?” Based on this research question, the following more specific research questions were formulated:

- To what extent do academics affiliated to South African universities engage in entrepreneurial activities with industry, government and civil society?

- To what extent do aspects related to the human, physical and organisational capital resources of academics influence their engagement in consulting and sponsored research activities, as well as commercialisation activities in terms of licensing/assignment of IP and spin-off creation?

- To what extent do the entrepreneurial activities of academics relate to the traditional academic activities of teaching and research?

- To what extent do the entrepreneurial activities of spin-off creation, licensing/assignment of IP, sponsored research and consulting coincide with each other?

The unit of investigation was the individual NRF-rated researcher who was affiliated to a public South African university at 28 February 2013 and covered the full spectrum of academic disciplines. The census conducted for the purposes of this study included all researchers rated by the National Research Foundation (NRF), as on 28 February 2013, and affiliated to a public South African university. South Africa's NRF evaluates and rates individuals based on the quality of their research outputs and impacts in the preceding eight years. Thus, the NRF-rating is an indicator of research excellence in South Africa (South Africa National Research Foundation, 2013). The choice of NRF-rated researchers as the population for the study was made based on the fact that it allowed the investigation of a wide spectrum covering all academic disciplines at all South African public universities in combination with a quality standard that ranges from promising young researchers to leading international researchers. Furthermore, it is anticipated that a deeper understanding at the micro level of individuals may yield novel insights into the phenomena of academic entrepreneurship (Markman, Siegel & Wright, 2008:1412; Foss, Husted & Michailova, 2010:457).

1.5 MAIN THEORETICAL PERSPECTIVES

This research study integrated resource-based research and the theory of the creativity of action with the aim of shedding light on the question as to what the antecedents and

consequences of entrepreneurial activities of academics are within the multiple helix of the South African national system of innovation. The concept of the multiple helix system of innovation is explained in chapter 3 of the study.

The major contributions made by the resource-based view and the theory of the creativity of action towards this research study are summed up in the following sections.

1.5.1 Contributions of the resource-based view towards this research

The resource-based view served as a theoretical anchor in terms of which to explore the individual and institutional resources and capabilities which may serve as antecedents in the processes involving the entrepreneurial activities of academics. Resource-dependent choices and actions are a recurrent theme in entrepreneurship research and range from their theoretical conceptualisation by Schumpeter (1934) and Penrose (1959) to emerging entrepreneurship theories, such as effectuation as a logic of entrepreneurial action (Sarasvathy, 1998) and entrepreneurial bricolage (Baker & Nelson 2005). Sarasvathy (2001:245) found that, in contrast to the causation processes, the effectuation processes take a set of means and contingent human aspiration as given and focus on choosing between the possible effects that may be produced with the set of means in question, thereby eliminating the assumption of predetermined goals. Baker and Nelson's (2005:334) theory of entrepreneurial bricolage focuses primarily on the resources an individual has at his disposal and that may be used to 'make do'. While effectuation builds on the decision theory literature, entrepreneurial bricolage rests on Penrose's (1959) concept of the social construction of resources (Fischer, 2012:1022). Edith Penrose (1959:24) was among the first scholars to view a firm as a bundle of productive resources. The central proposition of the resource-based view (RBV) of the firm is that for a firm to achieve a sustained competitive advantage, it must acquire resources and capabilities that are valuable, rare, inimitable and non-substitutable and also have an infrastructure in place that may absorb and apply such resources and capabilities (Kraaijenbrink, Spender & Groen, 2010:350). A modern resource-based logic is similar to a dynamic recipe that explains the process by which resources and capabilities that are rare, inimitable and non-

substitutable are utilised in order to realise a sustainable competitive advantage (Newbert, 2007:124).

Resources may be classified into the following three dimensions, namely, human capital resources, physical capital resources and organisational capital resources (Barney 1991:101). In its original conceptualisation, human capital is a collective resource that comprises individual human assets (Becker, 1964; Nyberg, Moliterno, Hale & Lepak, 2014:319). Polyhart and Moliterno (2011:127) define the human capital resource as a unit-level resource that is created from the emergence of the knowledge, skills, abilities and other characteristics of individuals and which have their origins in the psychological attributes of individuals and are then transformed through unit-level processes. Physical capital resources were first conceptualised by Williamson (1975:13) and include technology, plant, equipment, geographic location and access to raw material (Barney, 1991:101, Blackhurst, Dunn & Craighead, 2011:376; Sedysheva, 2012:359). According to Tomer (1987:7), organisational resources are the systems, the routines and the relationships which are embedded in the company and are intangible, immobile and inherently difficult to imitate (Heirman & Clarysse, 2004:249; Blackhurst et al., 2011:376; Sedysheva, 2012:359).

The key contribution of the resource-based view of the firm to this study was the notion that an individual, like a firm, has access to a bundle of resources. Resources may refer to the knowledge and abilities of the individual and/or the organisational systems, routines and relationships of the institution of which the individual is part and the physical resources that may be leveraged. This study perceived an entrepreneurial activity in the context of academia as a resource-dependent action on the part of an individual. The aim of the study was to examine those resources that may serve as antecedents for the entrepreneurial activities of academics. Accordingly, the study examined the knowledge and abilities that the academic researcher has acquired through formal and informal education as well as training and experience; in addition, the organisational culture of the university for which he works, the intellectual property managerial support provided by the university and the physical resources he owns or to which he has access.

In the main, the resource-based view rests on the disciplinary tradition of economics and it may be positioned relative to the structure–conduct–performance paradigm found in economics, neoclassical microeconomics and evolutionary economic theory (Barney, 2001:644). In economic theory, definitely since the second half of the nineteenth century if not earlier, the abstract notion of a *homo oeconomicus* has become the fundamental point of departure of all discussions, with rational action principles constituting the paradigmatic core of the economic discipline (Joas, 1996:1). Within the limited confines of economic theory (e.g. Mintzberg, Simmons & Basu, 2002:67) humans are perceived to be engaged only in transactional, short-term oriented and self-interest based encounters designed to maximise their immediate utility (Pirson & Lawrence, 2010:554). All theories of action which proceed from a type of rational action presuppose (1) a teleological character of human action; (2) corporal control by the actor; and (3) autonomous individuality on the part of the actor. In empirically observable action, however, these preconditions are frequently not met (Joas, 1996:147). As an alternative, Hans Joas (1996) sought to establish the creative nature of all human action (Sarasvathy, Dew, Velamuri & Venkataraman, 2010:91; Weik, 2012:567) which intends to abrogate an ends–means model of human action (Spedale & Watson, 2014:763; Tanggaard, 2014:111). This study positioned the resource-based view relative to the theory of the creativity of action, reaching beyond the routinised conversations between the rationalist and normativist theories of action (Joas & Beckert, 2006:270). This is discussed in more detail in the next section.

1.5.2 Contributions of the theory of the creativity of action to this research

Joas's *creativity of action* theory (1996) contributed to this study by providing an advanced conception of action. By following the theory's pragmatism-inspired line of situated creativity, it is possible to interpret the participation of an academic in an entrepreneurial activity as a creative act that goes beyond the habitual, which, in this context, refers to the traditional activities of teaching and research and which is anchored in the individual's natural and social environment. Joas perceives human activity not as coincidental but, in a fundamental sense, as creative. Joas (1996:129) describes creativity as "performed within situations that call for solutions and not as an unconstrained production of something new

without any constitutive background in unreflected habits". In view of the fact that action is directed and redirected in its situational contexts, actors engage more in making retrospective sense of their actions than in acting that is based on causal rationality and predetermined goals and motives. Every situation contains numerous possibilities which, when action encounters unexpected obstacles, have to be rediscovered (Lombardo & Kvålshaugen, 2014:5). Creativity "being 'situated' means it will have different effects in different circumstances" (Watson, 2013b:29).

By following the pragmatism-inspired line of situated creativity (Joas, 1996:133; Watson, 2013b:29) and combining it with the resource-based view, this study regards the participation of an academic researcher in an entrepreneurial activity as a resource-dependent and creative act(ivity) that goes beyond the habitual activities of teaching and research.

1.6 THE RESEARCH DESIGN AND METHODOLOGY

The following section outlines the research design, sampling, data collection, hypotheses and data analysis procedure used in the study.

1.6.1 Research design

This research was designed as a formal study within the South African university context. The study consisted of both a literature review and an empirical study. The literature review provided insights into the field of academic entrepreneurship, its evolution and the connection between entrepreneurship and university innovation in both the global and the South African context. In addition, the literature review outlined the theoretical foundation of the study and identified relevant antecedents and consequences of the entrepreneurial activities of academics that were considered by various research studies. On this basis certain propositions were put forward.

The empirical component of the research study transformed the propositions into hypotheses and then tested these hypotheses. The data generated provided information

about the resources and abilities which influence the entrepreneurial activities of academics and how academic entrepreneurial activities complement or substitute for each other. In addition, the impact of these activities on research outputs and teaching commitment was tested. The research took the individual as the unit of investigation and analysed his engagement with the private, public and third sector via consulting, sponsored research, licensing/assignment of IP and spin-off creation. The time dimension of the empirical, cross-sectional study was seven weeks with the study starting on 4 June 2013 and ending on 24 July 2013. The study took place under field conditions at South African universities.

Sampling

For the purposes of the empirical study a census – a count of all the elements in a population (Cooper & Schindler, 2008:397) – was conducted. The population of interest comprised all academic researchers rated by the National Research Foundation (NRF), and affiliated with a public South African university. South Africa's NRF evaluates and rates individuals based on the quality of their research outputs and impacts in the preceding eight years. The evaluation committee consists of national and international reviewers who critically examine the research completed during the assessment period (South Africa National Research Foundation, 2013). The NRF also recognises output other than journal publications, for example artefacts, prototypes, patents and policy documents. In ascending order the NRF-rating categories are the following: late entrant into research; promising young researcher; established researcher; internationally acclaimed researcher; leading international researcher and president's awardee.

The census for this study included all researchers rated by the NRF on 28 February 2013 and affiliated with a South African public university. This population was chosen because it provided a wide spectrum of academic disciplines and included academics from all 23 public South African universities. Out of a total of 2 375 NRF-rated, university-affiliated researchers at the time the survey was conducted, 2 233 were contacted.

Data collection

The secondary data used for the purposes of this study was gathered from electronic databases that provided access to full-text academic journal articles, industry reports, trade journals, government documents and books.

In order to collect the empirical data, the study used a communication approach in the form of a fully structured web-based survey which was developed using Qualtrics Survey Software. The link to the self-administered survey was embedded in an invitation email, which was formulated as both a letter of introduction and a letter of informed consent for participation in an academic research study. A copy of the letter is contained in Annexure B. The invitation was sent to a total of 2 233 contacts and followed up by three reminders to non-respondents. The study intended to adhere to the ethical procedures and guidelines of the University of Pretoria. Accordingly, the anonymity of the respondents was guaranteed and their responses were kept confidential.

The measurement process consisted of construct development and scale measurement. The goal of a construct development process is to identify and define what is to be measured while the goal of scale development is to determine how to measure each construct (Hair, Bush & Ortinau, 2006:353). The process of operationalising variables for the purposes of this study is described in detail in section 4.3.3 in chapter 4. The full questionnaire is contained in Annexure A. In terms of scale measurements, Carifio and Perla (2007:107–109) point out that a clear distinction must be made between a scale and a response format. A response format may be a nominal, ordinal, interval or ratio data type. However, a measurement scale is more complex than the items that form the scale, as it attempts to assign designated degrees of intensity to the responses (Hair et al., 2006:356). In this study, different types of response format were chosen, namely, free responses, dichotomous, multiple choice, summated rating and constant-sum response formats.

Hypotheses

Hypotheses serve as a point of departure and may be regarded as the link between the theory and the research that leads to the broadening of knowledge. The hypotheses used in this study were based on the propositions formulated in chapter 2 of the study and are presented in the conceptual framework (fig. 2.1). Hypotheses are declarative statements about the relationship between two or more variables (Cooper & Schindler, 2008:64) and they give both structure and direction to a research study. The statistical hypotheses formulated for the purposes of this study are presented in table 1.1 below:

Table 1.1: Hypotheses

#	Human capital-related aspects in the context of academic entrepreneurship	
1	Work experience outside of academia	
$H_{0.1a}$	There is no significant relationship between work experience outside of academia and	spin-off creation
$H_{0.1b}$		licensing/assignment of IP
$H_{0.1c}$		sponsored research
$H_{0.1d}$		consulting
2	Direct entrepreneurial experience	
$H_{0.2a}$	There is no significant relationship between direct entrepreneurial experience and	spin-off creation
$H_{0.2b}$		licensing/assignment of IP
$H_{0.2c}$		sponsored research
$H_{0.2d}$		consulting
3	Exposure to entrepreneurship education	
$H_{0.3a}$	There is no significant relationship between exposure to entrepreneurship education and	spin-off creation
$H_{0.3b}$		licensing/assignment of IP
$H_{0.3c}$		sponsored research
$H_{0.3d}$		consulting
4	Academic seniority	
$H_{0.4a}$	There is no significant relationship between academic seniority and	spin-off creation
$H_{0.4b}$		licensing/assignment of IP
$H_{0.4c}$		sponsored research
$H_{0.4d}$		consulting
5	Applications-driven research	
$H_{0.5a}$	There is no significant relationship between applications-driven research and	spin-off creation
$H_{0.5b}$		licensing/assignment of IP
$H_{0.5c}$		sponsored research
$H_{0.5d}$		consulting
6	Novelty of research	
$H_{0.6a}$	There is no significant relationship between novelty of research and	spin-off creation
$H_{0.6b}$		licensing/assignment of IP
$H_{0.6c}$		sponsored research
$H_{0.6d}$		consulting

#	Physical capital-related aspects in the context of academic entrepreneurship	
7	Intellectual property protection	
$H_{0.7a}$	There is no significant relationship between intellectual property protection and	spin-off creation
$H_{0.7b}$		licensing/assignment of IP
$H_{0.7c}$		sponsored research
$H_{0.7d}$		consulting
8	University's innovation infrastructure	
$H_{0.8a}$	There is no significant relationship between a university's innovation infrastructure and	spin-off creation
$H_{0.8b}$		licensing/assignment of IP
$H_{0.8c}$		sponsored research
$H_{0.8d}$		consulting
#	**Organisational capital-related aspects in the context of academic entrepreneurship**	
9	University's intellectual property (IP) managerial support	
$H_{0.9a}$	There is no significant relationship between a university's IP managerial support and	spin-off creation
$H_{0.9b}$		licensing/assignment of IP
$H_{0.9c}$		sponsored research
$H_{0.9d}$		consulting
10	University's entrepreneurial culture	
$H_{0.10a}$	There is no significant relationship between a university's entrepreneurial culture and	spin-off creation
$H_{0.10b}$		licensing/assignment of IP
$H_{0.10c}$		sponsored research
$H_{0.10d}$		consulting
#	**Consequences for research and teaching**	
11	Publication output	
	There is no significant relationship between	
$H_{0.11a}$		spin-off creation
$H_{0.11b}$		licensing/assignment of IP
$H_{0.11c}$		sponsored research
$H_{0.11d}$		consulting
	and publication output	
12	Teaching commitment	
	There is no significant relationship between	
$H_{0.12a}$		spin-off creation
$H_{0.12b}$		licensing/assignment of IP
$H_{0.12c}$		sponsored research
$H_{0.12d}$		consulting
	and teaching commitment	
#	**Relationships between the entrepreneurial activities of academics**	
$H_{0.13}$	Sponsored research and licensing/assignment of IP do not coincide.	
$H_{0.14}$	Sponsored research and spin-off creation do not coincide.	
$H_{0.15}$	Licensing/assignment of IP and spin-off creation do not coincide.	
$H_{0.16}$	Sponsored research and consulting do not coincide.	
$H_{0.17}$	Licensing/assignment of IP and consulting do not coincide.	
$H_{0.18}$	Spin-off creation and consulting do not coincide.	

Source: Authors own compilation: H_0 = statistical hypothesis

Data analysis

In the first stage of the data analysis process descriptive statistics were used to analyse the profile of academics who engage in the entrepreneurial activities of spin-off creation, licensing/assignment of IP, sponsored research and consulting. In the second stage of the data analysis, generalised linear models (GLMs) were used to analyse the likelihood of engagement as a function of a set of explanatory variables derived from the hypotheses. The third stage of the process involved cross-tabulation. Four-dimensional contingency tables were used to determine whether the classification variables were independent of each other.

Generalised linear models (GLMs) are a class of statistical models that are generalised from classical linear regression. The basic principle originated with Nelder and Wedderburn (1972) and may be classified as a central breakthrough in statistics during the twentieth century (Fox & Weisberg, 2011:229). These models provide a systematic way in which to manage categorical response variables (Powers & Xie, 2008:290). The structure of a GLM consists of a response variable (y) and (m) predictors. The issue of concern lies in understanding how the mean of (y) varies as the values of the predictors change (Fox & Weisenberg, 2011:230).

As described in Fox and Weisenberg (2011:230), the following three components make up the GLM:

1) A *random component* which specifies the conditional distribution of the response variable (y), given the predictors.
2) A *linear predictor.* Similar to linear models, the predictors in a GLM are translated into a set of (k) regressor variables, $x = (x_1, \ldots x_k)'$. In a GLM, the response depends on the predictors only through a linear function of the regressors, termed the linear predictor, $\eta(x) = ß_0 + ß_1 x_1 + \ldots + ß_k x_k$.
3) In a GLM, because the mean of a binary random variable must be in the interval (0,1), an *invertible link function* is introduced, which translates from the scale of the mean response to the scale of the linear predictor.

As is the norm in GLMs, $\mu(x) = E(y|x)$ denotes the conditional mean of the response, while the link function may be written as: $g\,[\,\mu(x)\,] = \eta(x)$. Reversing this relationship produces the *inverse link function:* $g^{-1}\,[\,\eta(x)\,] = \mu(x)$.

Within a broad framework, generalised linear models (GLMs) unify several regression approaches with response variables that do not necessarily follow a normal distribution (Fahrmeir, Kneib, Lang & Marx, 2013:269). This study used the following two approaches for the hypothesis testing, namely, GLMs with regression models for binary responses and GLMs with regression models for count data. The specific details of the two approaches and the reasons for using them are discussed in detail in section 4.3.4 in chapter 4. The program R, version 3.1.0 (2014-04-10), was used to test the hypotheses formulated for the purposes of the study by means of generalised linear models.

1.7 IMPORTANCE OF STUDY

The global economy evolved from being driven by physical capital to being driven by knowledge and, now, to being driven by entrepreneurship. The role of the university has evolved in a similar way (Audretsch, 2014:313). In the entrepreneurial society the academic culture and environment has had to change in order to generate added value in terms of all activities (Urbano & Guerrero, 2013:51). The transfer of the innovations and knowledge generated by academics within universities is viewed as essential for economic growth, employment creation and international competitiveness in the global markets (Aldridge & Audretsch, 2011:1059). This notion has boosted the number of policies and programmes oriented towards promoting the entrepreneurial activities of academics (D'Este & Perkmann, 2011:317). While the design of effective policy measures requires a sound understanding of the factors related to this process, it would appear that there is little evidence on the antecedents and consequences of academic engagement and commercialisation (Van Looy et al., 2011:554). There is, thus, a clear need for the integration of various research streams and for the development of a comprehensive understanding of the phenomenon in question.

By assessing the antecedents and consequences of the entrepreneurial activities of academics at South African universities, it is anticipated that this study will be of scientific relevance to entrepreneurship research in the field of higher education. In addition, it is hoped that the study will be of practical benefit to academics, policy makers and university administrators. The remainder of this section will elaborate on the contribution of the study to research and practice in more detail.

1.7.1 Contribution to research

The study aimed to contribute to entrepreneurship research in the field of higher education in the following ways:

- *Taking the individual academic as the unit of investigation.* By taking the academic as the unit of investigation this study contributed to a deeper understanding at the micro level of individuals than would otherwise have been the case. The study perceives the academic as the key actor in the knowledge and technology transfer process. By bringing the 'entrepreneur' back into the 'entrepreneurial process' the study sheds light on the question of who interacts with outside organisations and who does not. This, in turn, may yield novel insights into the phenomenon of academic entrepreneurship, particularly in view of the fact that the research study (1) included the full spectrum of academic disciplines and (2) not only investigated the academics who were actively engaged in entrepreneurial activities but also those who were not.

- *Widening the focus of entrepreneurial activities.* While university–industry interactions have been the focus of scholarly attention in the last few years, there has been little investigation into the knowledge exchange between universities and government, or between universities and civil society. In South Africa, higher education serves together with industry, government and civil society as an innovation actor within the national system of innovation (South Africa, Department of Science and Technology, 2014:6). The fact that the study investigated the interactions of academics within this multiple helix network increases the

importance of the study as it offers an additional perspective compared to the various studies that investigate only university–industry relations.

- *Contextualising the research.* Scholars are increasingly emphasising the contextualisation aspect of entrepreneurship studies (Watson, 2013a:404; Wright, 2014:323). South Africa offers an interesting spatial context for a study of this nature. Most of the research in the field of academic entrepreneurship has taken place in the American or European context and there has been little published on the activities of entrepreneurial academics in the emerging economies (Perkmann et al., 2013:428). In its Global Competitiveness Report 2013–2014 (2013:11) the World Economic Forum categorises South Africa as an efficiency-driven economy. The examination of entrepreneurial activities in an efficiency-driven economy may therefore provide different results and illustrate dissimilar requirements compared to studies conducted in countries classified by the World Economic Forum (2013:10) as innovation-driven economies.

- *Advancing existing knowledge on the influence of resources on entrepreneurial action.* To the best of the researcher's knowledge this study represents the first attempt to measure and compare the influence of specific resources and resource bundles on the various entrepreneurial activities of academics. The primary data gathered for the purposes of the study enabled a statistical analysis of the relative influence of each of the ten human, physical and organisational capital-related aspects on the actual entrepreneurial activities. In addition, it permitted the extraction of actual resource drivers for consulting, sponsored research, licensing/assignment of IP and spin-off creation, as well as comparisons between such drivers. The results suggesting the resource type closely related to the entrepreneurial activities of academics may open up promising avenues for future research on academic entrepreneurship.

- *Combining resource-based research and the theory of the creativity of action.* This study regards the participation of an academic researcher in an entrepreneurial activity as a creative act that goes beyond the habitual activities of teaching and

research. In addition, the individual's entrepreneurial action is perceived to be resource-dependent (e.g. Schumpeter, 1934; Penrose, 1959; Baker & Nelson, 2005; Sarasvathy, 2008; Watson, 2013b) and anchored in the natural and social environment of the individual concerned. By following the pragmatism-inspired line of situated creativity (Joas, 1996:133; Watson, 2013b:29), the study investigated an ends–means model of the entrepreneurial activities of academics.

- *Clarifying the possibility of the coexistence of traditional and entrepreneurial activities.* By testing the influence of entrepreneurial activities on the academic's commitment to teaching and publication output, the results clarified whether it is possible for the traditional and entrepreneurial visions of universities to co-exist successfully (Landry et al., 2006:1611) or whether a growing shift towards what Slaughter and Leslie (1997:9) term "academic capitalism" is likely to occur.

1.7.2 Contribution to practice

This research study aimed to assist academics, policy makers and university administrators with practical insights into the following areas:

- *Knowledge on the key resource-drivers of the entrepreneurial activities of academics.* A deeper understanding of the importance and role of resources in enhancing the entrepreneurial activities of academics will provide vital information for the design of effective public policies. The policy instruments building on different resources entail substantially different approaches. The four types of entrepreneurial activity may be driven by different underlying mechanisms and one may assume possible complementarities or contradictions between them. Accordingly, a better understanding of these relationships is essential for deciding whether more decisive approaches are needed (Perkmann et al., 2013:429). In addition, focusing exclusively on one entrepreneurial activity may have detrimental effects on other activities (Van Looy et al., 2011:555). Thus, this knowledge should enable policy makers and university administrators to optimise the potential complementary effects and act with caution against potential trade-offs.

- *Inclusion of broader populations of academics*. This study aimed to assist policy makers to broaden their attention beyond the groups of academics who are engaged in university–industry interactions and to recognise the various interactions taking place between academia and government, as well as academia and civil society. In addition, the study proposed taking cognisance of groups of academics outside the most prevalent fields of interaction, namely, science and engineering. In the past, academics in fields such as the humanities, management studies or law have been largely overlooked by both theorists and practitioners.

- *Recommendations for university strategies and measures.* This study aimed to improve the existing knowledge on whether the investments made in human capital development and/or investments into physical capital or organisational capital are likely to lead to any results in terms of boosting the entrepreneurial activities of academics. Based on the results of this study, required adjustments may relate to incentive systems, organisational structures or the provision of specific training, services or facilities. The results may also influence the hiring strategies of universities. This study also aimed to provide a best practice model based on the empirical insights arising from the research results together with suggestions for university managers on how to bundle and allocate their resources. In addition, university managers will benefit from knowing why academics tend to engage in certain types of activity while avoiding others. With more extensive knowledge about how the entrepreneurial activities of academics influence, substitute or complement each other, focus points may be decided upon and appropriate measures taken. Ascertaining the various relationships between consulting, sponsored research, licensing/assignment of IP and spin-off creation and the research output of academics in terms of publications and teaching commitment means that the existing knowledge regarding the implementation of successful technology and knowledge transfer measures is enhanced, thus enabling synergies to be used and signals detected and rectified early.

- *Departure point for longitudinal studies*. The study also represents a sound departure point for longitudinal studies into academic entrepreneurship in South

Africa that investigate the impact on academic entrepreneurship of the Intellectual Property Rights from Publicly Financed Research and Development Act 51 of 2008 (IPR-PFRD Act), which was implemented in August 2010. The Act empowers universities and other organisations to control their inventions and other intellectual property that have resulted from government funding.

1.8 DEMARCATION OF CHAPTERS

A brief discussion of chapters 2 to 6 is given below.

1.8.1 Outline of chapter 2

Chapter 2 places the research study in context. 'Academic entrepreneurship' is an umbrella term referring to the efforts and activities on which universities and their stakeholders embark in order to commercialise research outcomes (Wood, 2011:153). Section 2.3 of chapter 2 explains how academic entrepreneurship is integrated as a distinct area of research within the field of entrepreneurship. The research field of entrepreneurship has a long tradition with diverse intellectual roots. The plurality of the theoretical and empirical perspectives within the field and how it emerged as a legitimate field of research with a large and continuously growing international body of entrepreneurship scholars is discussed in section 2.2 in chapter 2. The theoretical perspectives applied in entrepreneurship research cut across different levels of analysis, from the macro levels of society and nations to the micro levels that include industrial sectors, organisations and individual entrepreneurs (Mars & Rios-Aguilar, 2010:44). By integrating these multiple perspectives and by providing a comprehensive understanding of the field of Academic Entrepreneurship, chapter 2 provides the theoretical foundation for the assessment of academic entrepreneurial activities and their antecedents and consequences within the South African university context.

Chapter 2 firstly discusses the development of the field of entrepreneurship. Secondly, it illustrates the study of entrepreneurship in the field of higher education. Thirdly, the chapter presents a wider interpretation of Academic Entrepreneurship as a field of research that includes a range of entrepreneurial activities on the part of academics and

across different disciplines. Fourthly, the chapter defines the core dimensions representing entrepreneurial activities of the academics in the study. These dimensions relate to the interactions of academics with industry, government and the third sector via consulting, sponsored research, licensing/assignment of intellectual property (IP) and spin-off creation. The chapter then presents the theoretical framework of the study. This framework integrates resource-based research and the creativity of action theory. Finally, the chapter discusses antecedents and consequences of the entrepreneurial activities of academics and puts forward certain propositions.

1.8.2 Outline of chapter 3

Chapter 3 contextualises the setting of the study. It briefly characterises South Africa's national system of innovation, explores the transformation in South Africa's higher education sector and discusses several interacting economic, social and political developments impacting on the entrepreneurial activities of academics. In addition, the chapter highlights specific aspects that differentiate the setting of the study within the South African context from the settings of studies in advanced industrial societies.

1.8.3 Outline of chapter 4

Chapter 4 discusses the research methodology used in the study. The research design relates to the research problem and research objectives which were outlined in chapter 1. The chapter explains the sampling procedure and data collection approach followed as well as the empirical testing procedure used. The propositions outlined in chapter 2 are formulated as 18 hypotheses for empirical testing. The measurement instrument is introduced and the evaluation with generalised linear models (GLMs) for the data analysis explained.

1.8.4 Outline of chapter 5

Chapter 5 discusses both the data analysis and the interpretation of the research findings. Firstly, the descriptive statistics used in the study are outlined. Secondly, the hypotheses

formulated in chapter 4 are tested and then the cross-fertilisation and substitution effects of entrepreneurial activities are examined with the aid of cross-tabulation. Thirdly, the generalised linear models (GLMs) for spin-off creation, licensing/assignment of IP, sponsored research and consulting respectively are presented. Finally, the chapter analyses the relation between entrepreneurial activities and the traditional activities of academics is separate, generalised linear models.

1.8.5 Outline of chapter 6

In chapter 6 the research findings are linked back to the research problem which was presented in the introductory section of the study. The chapter starts by briefly revisiting the research problem and the research questions. The chapter then summarises the key findings pertaining to each research question and discusses the overall conclusion drawn. The implications of the study for both research and practice are then elaborated on and recommendations for future research made. Finally, the chapter discusses the limitations of this study.

1.9 CONCLUSION

This chapter provided an overview of the research study and described the background to the study. Firstly, the chapter provided an explanation of the key concepts used in the study and presented the theoretical framework used for the purposes of the study. The chapter then outlined the research problem and, based on the research problem, described the purpose of the study and the research objectives. The contributions of the two main theoretical perspectives of the study were then outlined. This was followed by a description of the research design and the research methodology used in the study. The importance of the study for research and practice was highlighted. Finally, an outline of chapters 2 to 6 of this study was provided.

The following chapter provides the theoretical foundation for the assessment of the antecedents and consequences of the entrepreneurial activities of academics at South African universities.

CHAPTER 2
Academic Entrepreneurship

2.1 INTRODUCTION

The purpose of this chapter is to describe the context of the study. The growing body of evidence which shows that economic growth is enhanced by the entrepreneurial activities of academics has resulted in a proliferation of national and international policies and programmes oriented towards promoting interactions between universities, industry, government and civil society (D'Este & Patel, 2007:1296; Aldridge & Audretsch, 2011:1059; Teixeira & Mota, 2012:720). Despite the central role played by academics in this process, there is little information available on the antecedents and consequences of academic engagement and commercialisation (Van Looy et al., 2011:554). By providing a comprehensive understanding of the field of Academic Entrepreneurship, this chapter provides the theoretical foundation for the assessment of academic entrepreneurial activities and their antecedents and consequences within the South African university context.

This chapter is divided into six main sections. Firstly, the development of the field of entrepreneurship is discussed, secondly, the study of entrepreneurship in the field of higher education is explained and, thirdly, a wider interpretation of Academic Entrepreneurship, as a field of research that includes a range of entrepreneurial activities on the part of academics across different disciplines, is provided. The core dimensions representing the entrepreneurial activities of academics in this study include interactions with industry, government and the third sector via consulting, sponsored research, licensing/assignment of intellectual property (IP) and spin-off creation. The fourth section defines the concepts used in the study and the fifth section presents the theoretical framework of the study. This framework integrates resource-based research and the creativity of action theory. In the final section, possible antecedents and consequences of the entrepreneurial activities of academics are discussed and propositions put forward.

2.2 HISTORY AND DEFINITIONS OF ENTREPRENEURSHIP

The function of entrepreneurship per se dates as far back as the time of exchange and trade between persons (Landström, Harirchi & Åström, 2012:1155). The term 'entrepreneur' is a French term and is derived from the verb *entreprendre*, which means to undertake, or to do. The term 'entrepreneur' can be divided into two parts, namely, *entre* meaning 'between' and *preneur*, which means 'taker'. Hence, translated literally an entrepreneur is a 'between-taker' or 'go-between' (Filion, 2011:42). Marco Polo (1254–1324) may be regarded as an example of a 'go-between' in the Middle Ages. He established trade routes to the Far East and exploited the entrepreneurial opportunity available at that time, namely, the demand for goods by people previously separated by distance and culture from those who possessed the goods (Hisrich, Peters & Shepherd, 2008:6).

2.2.1 Pioneering thoughts on entrepreneurship

During the Middle Ages, the term 'entrepreneur' expanded, as it was used to describe both an actor and a person who managed large production projects (Hisrich et al., 2008:6). In 1755, Richard Cantillon started taking an interest in the concept of entrepreneurship and, with his *Essai sur la Nature du Commerce en Général* (1755/2009), was the first to offer a clear description of the entrepreneurial function. His writings describe entrepreneurs as men who seek business opportunities as they "pay a certain price following that of the place where they purchase it, to resell, wholesale or retail at an uncertain price" (Cantillon, 2009:24).

In the late seventeenth and eighteenth centuries, classic economic theory was developed as a product of both the Industrial Revolution and the insights of the Enlightenment thinkers (Wickham, 2006:124). Adam Smith's *Inquiry into the nature and causes of the wealth of nations*, which was first published in 1776, may, to a great extent, be said to have laid the foundations for the analysis of the way in which the market economy functions (Landström et al., 2012:1155). Jean-Baptiste Say was a great admirer of Adam Smith's framework of thought and combined it with that of the physiocrats. With his writings (Say, 1803), Say is said to be the first thinker to have laid the foundation for the

field of entrepreneurship. He distinguished entrepreneurs from capitalists as he associated entrepreneurs with innovation and saw them as economic actors whose activities generated value-add (Filion, 2011:43). A century later, in his thesis *Risk, uncertainty and profit* (1916; revised 1921; 2006:289), Frank H. Knight argued that entrepreneurial returns result from activities that cannot be predicted and that entrepreneurial competence lies in the individual's ability to deal with uncertainty (Landström et al., 2012:1155).

In the early twentieth century, the economist, Joseph Alois Schumpeter, linked entrepreneurs with innovation and economic development. His notion, which he expounded in *The theory of economic development* (1934), was to develop a new economic theory based on change and newness, and it purposed entrepreneurship as an economically disruptive process. Schumpeter (1934; 2012:61) regarded the entrepreneur as the bearer of the mechanism of change.

Kirzner (1973:35) regards an entrepreneur as a person who is alert to imperfections and, in his words, one who is alert to "possible newly worthwhile goals and to possibly new available resources" in the market and who generates wealth by moving asymmetrical economies towards a greater state of equilibrium. Kirzner (2009:151) suggests that public policies that focus on the "alertness" aspect of entrepreneurship tend to promote that very Schumpeterian creativity. The creativity that drives entrepreneurs is a creativity that encompasses an alertness to future possibilities.

In the mid-twentieth century, economic science became more formalised and mathematically oriented than previously. The economists refused to accept non-quantifiable models and, hence, had been unable to create a science pertaining to the economic behaviour of entrepreneurs (Nieman & Nieuwenhuizen, 2009:6). As the stream of research lost momentum amongst economists, scholars from the fields of psychology and sociology, and referred to as behaviourists, started investigating entrepreneurship. Their interest was in the entrepreneur as an individual. David McClelland was one of the main contributors to the behavioural aspect of entrepreneurship. In his work, *The achieving society* (1961:65), he defined an entrepreneur as "someone who exercises control over production that is not just for his personal consumption" and pointed to the

need for achievement to be associated with more rapid economic development (1961:93). The behaviourists dominated the field of entrepreneurship from the 1960s to the early 1980s. A whole series of entrepreneurial characteristics were described. However, up to now, scholars have not managed to establish a scientific profile that enables them to identify potential entrepreneurs with any certainty (Nieman & Nieuwenhuizen, 2009:6).

2.2.2 The growth phase of entrepreneurship research

Since the 1980s entrepreneurship research has received increased attention. In 1981 the first Babson Research Conference dedicated to research in entrepreneurship was launched. In the following year the first *Encyclopedia of entrepreneurship* (Kent, Sexton & Vesper, 1982) was published. However, at that time, the vast majority of scholars with an interest in the field of entrepreneurship were from other disciplines. For example, there were scholars from the management sciences such as Drucker (1985, 2007) and Mintzberg (1973) and the humanities and administrative sciences such as Bygrave (1989), Gartner (1988) and Reynolds (1991).

The 1990s witnessed increased research aimed at enhancing the practice of entrepreneurship (Nieman & Nieuwenhuizen, 2009:7). For example, there was an increase in the entrepreneurship programmes and courses offered and an increased number of scientific journals and conferences relating to entrepreneurship (Landström et al., 2012:1156). With their seminal work entitled ‘Theorizing about entrepreneurship’, Bygrave and Hofer (1991:14) shifted the focus from the characteristics and functions of the entrepreneur as a person to the nature and characteristics of the entrepreneurial process. They referred to the *entrepreneurial process* as a process that involves "all the functions, activities, and actions associated with the perceiving of opportunities and the creation of organizations to pursue them". In order to enhance theory building in the field of entrepreneurship, they defined an entrepreneur as follows: "An *entrepreneur* is someone who perceives an opportunity and creates an organization to pursue it." They termed the creation of a new organisation for the pursuit of an opportunity an *entrepreneurial event* (Bygrave & Hofer, 1991:14). This perspective suggests that the entrepreneurial process is concerned primarily with the antecedents that lead to new venture creation and that the

culmination of the process is the new venture which has been created (DeTienne, 2010:206).

2.2.3 Entrepreneurship as a legitimate scholarly discipline

In the last decade the field of entrepreneurship research has seen a shift from the highly fragmented and mainly atheoretical empirical explorations of the phenomenon towards an increased theoretical focus on the phenomenon (Landström & Lohrke, 2010:32). The theoretical perspectives applied in entrepreneurship research cut across different levels of analysis, from the macro levels of society and nations to the micro levels that include industrial sectors, organisations and individual entrepreneurs (Mars & Rios-Aguilar, 2010:444).

In their seminal article entitled 'The promise of entrepreneurship as a field of research', Shane and Venkataraman (2000:217) point out that the field of entrepreneurship is a unique conceptual domain that requires a "conceptual framework that explains and predicts a set of empirical phenomena, that is not explained or predicted by conceptual frameworks already in existence in other fields". Thus, from their perspective, entrepreneurship research involves the study of (1) sources of opportunities, (2) the processes of discovery, evaluation and exploitation of opportunities and (3) the set of individuals who discover, evaluate and exploit opportunities.

Shane and Venkataraman's (2000:222) quest to create a systematic body of information about entrepreneurship sparked an intense debate regarding the boundaries, rigour, relevance and impact of its findings in entrepreneurship research. As highlighted by Landström, Harirchi and Åström (2012:1157), some scholars supported the distinct domain approach, for example Bruyat and Julien (2001:168), Busenitz, West, Shepherd, Nelson, Chandler and Zacharakis (2003:298), while others advocated an integrative approach in terms of which entrepreneurship should integrate with other fields of research, for example Alvarez (2003:248). A third subgroup argued for a multi-research approach and recommended that scholars should divide themselves into more homogeneous communities and study specific topic areas. Cornelius, Landström and Persson (2006:394) cite examples such as corporate entrepreneurship, venture capital and ethnic

entrepreneurship as emerging research areas. Gartner, Davidsson and Zahra (2006:321) highlight the need to develop communities of understanding in entrepreneurship research, as well as to enhance conversational skills between the research groupings.

Meyer, Libaers, Thijs, Grant, Glänzel and Debackere (2014:473) conducted a structural analysis based on the core documented approach of Thomson Reuters' Web of Science to map out the emergence and evolution of entrepreneurship as an independent field in the social science literature from early 1990 to 2009. They identified five large knowledge clusters. These knowledge clusters are summarised in the table below.

Table 2.1: Clusters in entrepreneurship research

Clusters	Topics	Prolific authors	Journals
Cognitive aspects of entrepreneurship	- Opportunity identification - Antecedents of opportunity recognition - Motivations relating to entrepreneurial activities - Measures of opportunities and opportunity recognition - Decision-making process of entrepreneurs	- Sarasvathy - Sheperd - Dew - Covin - Lumpkin - Wiklund - Kuratko	- *Entrepreneurship Theory and Practice* - *Journal of Business Venturing* - *Small Business Economics* - *Research Policy* - *Higher Education*
Demographic and personality determinants of entrepreneurship	- Demographic (human capital and social capital) and personality-related determinants of entrepreneurship - Role of entrepreneurship in the macro economy	- Baron - Wright - Westhead - Ram - Boyd - Shepherd	- *Small Business Economics* - *Journal of Business Venturing* - *Entrepreneurship Theory and Practice* - *International Small Business Journal*
Theoretical perspectives on entrepreneurship	- Origins, process and impacts of entrepreneurship - Aspects of entrepreneurship research - Institutional entrepreneurship research	- Zahra - Audretsch - Thurik - Acs	- *Entrepreneurship Theory and Practice* - *Journal of Business Venturing* - *Journal of Management* - *Organization Studies* - *Organization* - *Academy of*

			Management
Entrepreneurial and innovation finance	- Entrepreneurial finance - Governance issues with regard to new ventures and SMEs - Public policies to support the initiation, nurturing and growth of new ventures and SMEs	- Shepherd	- *Journal of Business Venturing*
Eclectic approaches to entrepreneurship	- Importance of networks, alliances, partnerships for the survival and growth of new ventures and for innovative and financial performance - Relations between resources/tactics/strategies and superior performance - Internationalisation patterns and strategies of new and small firms	- Wright - Shane - Fritsch - Acs - Chrisman - Chua	- *Research Policy* - *Regional Studies* - *Entrepreneurship and Regional Development* - *Journal of Technology Transfer*

Source: Adapted from Meyer et al. (2014:477–480)

Meyer et al. (2014:480) observed an extremely strong relationship between the cluster dealing with the cognitive aspects of entrepreneurship and the cluster comprising primarily conceptual papers that study the origins, processes and impacts of entrepreneurship. This finding emphasises the conceptual nature of the papers in both clusters. The table above highlights the fact that researchers from the Anglo-Saxon countries have dominated the field over the past 20 years, with a particularly strong presence of researchers from the United States. In recent years, the awareness of the differences between the European and American orientations in entrepreneurship research has grown (Kyrö, Hägg & Peltonen, 2013:289). A solidification of the distinctiveness of the European tradition in entrepreneurship research and one that adopts a "broader social-science (and humanities) perspective and is critical, reflexive and attentive to history" (Down, 2013:1) has emerged. In addition, a methodological openness sets the European tradition apart from the US-oriented research which follows the normative strand of science (Welter & Lasch, 2008:242; Brush, Manolova & Edelman, 2008:257). For example, under the umbrella of the European tradition, explorative research, which characterises an active and process-oriented approach, may gain ground in future, particularly as it is believed to offer a valuable methodological alternative for investigating complex situations and phenomena in entrepreneurship research (Kyrö et al., 2013:289).

It would appear that both creativity and contextualisation feature in the search for future directions in entrepreneurship research (Hjorth & Johannisson, 2008:348). Zahra and Wright (2011:81) argue for a fundamental “creative reconstruction” of the field of entrepreneurship. They stress the importance of investigating individual entrepreneurs in the context that surrounds them. To date, there has been limited focus on context in the entrepreneurial literature, while the concepts surrounding context are also not well understood (Welter, 2011:165). The inclusion of the temporal, institutional, social and spatial dimensions of context that shape entrepreneurship at the macro level could guide theory building and also enhance the predictive powers of such theories (Zahra & Wright, 2011:75). Nevertheless, it should be taken into account that, in the same way in which the context infuses the artefacts that entrepreneurs build with meaning and value, so the artefacts, per se, shape and give value to the context in which they occur (Venkataraman, Sarasvathy, Dew & Forster, 2013:164). The same principle applies to the entrepreneurial process. When opportunities are seen as the fixed endpoints of a process, they are related to discovery (e.g. Kirzner, 2009:148). On the other hand, when they are seen as path-dependent creations, they stem from a process of formation, development or design (Alvarez, Barney & Anderson, 2013:301). Dimov (2013:3) highlights the fact that it is not possible for both of these descriptions to be extended towards an, as yet, unknown future as they are inherently retrospective. He suggests that "viewing entrepreneurial opportunities as emergent social structures invites a self-organization perspective that redirects entrepreneurship enquiry towards the deep set of simple, recursive rules that drive the entrepreneurial process" (Dimov 2013:1). The exploration of what Dimov (2013:1) calls the "momentary operation of the flow" may be an exciting new avenue in entrepreneurship research and one that focuses on the perpetual expansion of the outcome space rather than on its ultimate destination.

In conclusion, this section has shown that the research field of entrepreneurship has a long tradition with diverse intellectual roots. It has emerged as a legitimate field of research with a large and continuously growing international body of entrepreneurship scholars (Carlsson, Braunerhjelm, McKelvey, Olofsson, Persson & Ylinenpää, 2013:926). Entrepreneurship uses a plurality of theoretical and empirical perspectives which reflects

the complexity and multidimensionality of the entrepreneurial process itself (Iversen, Gulbrandsen & Klitkou, 2007:15). However, for entrepreneurship to stand as a unique domain it should develop and test sufficient new theories that explain and test things that other disciplines have not explained or tested (Alvarez & Barney, 2013:156).

Based on the general perspective of entrepreneurship as a field of research outlined above, the next section focuses on academic entrepreneurship as a distinct area of research within the field of entrepreneurship.

2.3 ENTREPRENEURSHIP IN THE FIELD OF HIGHER EDUCATION

The role of universities in increasingly knowledge-based societies is changing as a result of several interacting economic, social and political developments (Etzkowitz, Webster, Gebhardt & Cantisano Terra, 2000:313; Cooke, 2005:1128; Novotny, 2008:71). The institutional transformation associated with the entrepreneurial university has broadened the role of academic researchers to accommodate their engagement in commercial activities. Thus, in addition to the two traditional tasks of 'research' and 'teaching', researchers are now expected to perform a third 'entrepreneurial' task as the regional engines of innovation and economic growth (Gibbons, Limoges, Nowotny, Schwartman, Scott & Trow, 1994:82; Etzkowitz & Leydesdorff, 2000:110; Leydesdorff & Meyer, 2006:1444; Geuna & Muscio, 2009:94).

Consequently, extensive literature that includes conceptualisations and discussions of entrepreneurship within the university setting has emerged (Mars & Rios-Aguilar, 2010:441). The working definition for the research concept "academic entrepreneurship" was adopted from Wood (2011:153) and refers to the efforts and activities on which universities and their stakeholders embark in order to commercialise their research outcomes. Louis, Blumenthal, Gluck and Stoto (1989:112) were among the first to conceptualise academic entrepreneurship. Based on their two surveys of life science faculty members, both conducted in 1985, they distinguished the following five types of academic entrepreneurship: (1) large-scale science which involves obtaining large, externally funded research projects; (2) earning supplemental income from outside the

university, primarily through consulting; (3) gaining industry support for university research; (4) obtaining patents or generating trade secrets; and (5) forming companies based on the results of research undertaken. Since 1985 then, academic entrepreneurship has been maturing as an area of both study and policy. There is now wide-ranging literature on academic entrepreneurship, technology transfer and research collaborations. Siegel, Wright and Lockett (2007), Grimaldi et al. (2011), Bozeman et al. (2014) and Wright (2014) have all provided detailed literature reviews and their reflections guide the review of academic entrepreneurship in this chapter.

Despite the maturation of research in this field, there are varied views on how academic entrepreneurship should be defined. There is the notion of the entrepreneurial university. This notion views entrepreneurial activity as a step in the natural evolution of a university system and emphasises economic development in addition to the traditional activities of universities, namely, research and teaching (e.g. Louis et al., 1989; Klofsten & Jones-Evans, 2000; Laukkanen, 2003; D'Este & Perkmann, 2011). Thus, the entrepreneurial university takes on the role of an important catalyst for regional economic and social development and generates and exploits knowledge as entrepreneurial opportunities (Urbano & Guerrero, 2013:40).

Another perspective, termed 'university technology transfer', refers primarily to the commercialisation of research, technology transfer and university spin-off activities (O'Shea, Allen, Chevalier & Roche, 2005; Markman et al., 2008; Feller & Feldman 2010; Clark, 2011). A third perspective encompasses a narrower focus on entrepreneurial activity in the form of new venture creation only (Shane, 2004; Siegel et al. 2007; Wright et al., 2012). The sections below briefly discuss these three different perspectives, namely, the entrepreneurial university, university technology transfer and university spin-offs and lay the foundation for a detailed discussion of the entrepreneurial activities of academics, which follows in section 2.4 of this chapter.

2.3.1 The entrepreneurial university

The perspective of what has been termed the 'entrepreneurial university' is not solely about the inclusion of entrepreneurship education and training as an offering, but also encompasses the expansion of the institutional scope of the university. The entrepreneurial university may be regarded as a natural incubator with the ability to innovate, recognise and create opportunities and respond to challenges (Urbano & Guerrero, 2013:43). Entrepreneurship, both as activity and discourse, features prominently in the higher education literature, with the concept of the entrepreneurial university embracing universities of all types, from those with a strong research tradition to newer organisations (Gibb et al., 2013:10).

The phrase entrepreneurial university dates back to Burton R. Clark's (1998) book, *Creating entrepreneurial universities: Organizational pathways of transformation*. Etzkowitz (1998:823) used the term 'entrepreneurial universities' to indicate express occasions on which universities have demonstrated themselves to be critical to economic development. The role of the university has evolved in the same way as the economy has evolved, from being driven by physical capital to being driven by knowledge and then to being driven by entrepreneurship (Audretsch, 2014:313). In an entrepreneurial society, both the academic culture and the academic environment have had to change in order to generate added value in all activities (Urbano & Guerrero, 2013:51).

In order to elucidate the concept of the entrepreneurial university, the evolution of the university over time will be explained in the following section.

2.3.2 Evolution of the entrepreneurial university

Universities are regarded as crucial generators of new knowledge and technological inventions in addition to their acknowledged important role as organisations of teaching and research (Göktepe-Hulten, 2008:1). Historically, universities were storehouses of knowledge. The University of Al Karaouine in Fez, which was founded in 859 by Princess Fatima al-Fihri, is recognised as the oldest, continuously operating, degree-granting

university in the world (*Guinness Book of World Records*, 1998). The first academic revolution in the nineteenth century made research a university function in addition to the traditional function of teaching (Hofstadter & Metzger, 1955:284; Veysey, 1965:175; Jencks & Reisman, 1968:252). The emergence of the 'classical' German research university is generally thought to have started with the founding of the University of Göttingen in 1737 (Universität Göttingen, 2014) and the University of Berlin in 1810 (Anderson, 2004:51). Wilhelm von Humboldt (1767–1835) was a German philosopher, linguist and governmental bureaucrat. He was also the driving force behind the educational system in Prussia and his name has been used as a symbol of the research university. The characteristics of the research university have been described quite differently in diverse contexts but the following four elements appear to be common to all the descriptions: (1) freedom of teaching and learning; (2) the unity of teaching and research; (3) the unity of science and scholarship; and (4) the primacy of 'pure' science over specialised professional training (Ash, 2006:246). The concept of the research university then spread to the United States of America, first to Johns Hopkins University in 1876, Clark University in 1890, Stanford University in 1891 and the University of Chicago in 1892 (Rogers, Takegami & Yin, 2001:257).

A second academic revolution subsequently transformed the university into a teaching, research and economic development enterprise. In 1892, the English biologist, Thomas Henry Huxley, wrote that while the medieval university looked backwards and professed to be a storehouse of old knowledge, the modern university looks forward and is a factory of new knowledge (Huxley, 2002:117). The university has now undergone a further transformation to become a knowledge hub, where technological innovation and economic development are advanced within its sphere of influence (Youtie & Shapira, 2008:1188). This transition into the entrepreneurial academic model with respect to industry initially took place at MIT which, in 1862, was founded as a "land grant" university (Etzkowitz, 2003:110). According to Scott (1993:4), "the university as an institution has escaped restriction by the university as an idea" and has, as a result, been able to adapt freely to radical shifts in science and intellectual culture to remain a powerful and pervasive institution. Accordingly, as an institution the university is able to meet the widespread need

to generate new ventures from knowledge resources in order to stimulate employment and productivity growth.

In view of the fact that the third mission of a university is economic and social development, its research produces economically important outputs in different forms which vary over time and across industries. Examples of such outputs include scientific and technological information, equipment and instrumentation, skills or human capital, networks of scientific and technological capabilities and prototypes for new products and processes (Sampat, 2006:773). In order to transfer these outputs, channels such as labour markets, consulting relationships between university faculty and ventures, publications, presentations at conferences, informal communications with industrial researchers, firm formation from faculty members and the licensing of patents by universities are needed.

Throughout most of the twentieth century, universities were reluctant to become directly involved in patenting and licensing activities in case such involvement compromised their commitment to open science. According to Merton (1973, in Edquist, 2005:72), the world of "open science" includes the notions of free pursuit and open disclosure of knowledge, accompanied by a reputational reward resource allocation system based on validated claims to priority in terms of either discovery or invention. In addition, the world of open science creates powerful incentives for academics to publish, to present at conferences and to share information. Shibayama (2012:508) defines the norm for open science as a norm for academic scientists to contribute openly and unconditionally to scientific advancement and to their peers. At this point, researchers who did become involved typically outsourced their patent management operations to third-party operations, such as the Research Corporation, which was set up by Berkeley's chemist, Frederick Gardner Cottrell, to administer his patents on the electrostatic precipitator – a pollution control device (Cottrell, 1912:865, in Mowery, Nelson, Sampat & Ziedonis, 2004:59).

In 1924, the Wisconsin Alumni Research Foundation (WARF) and the first technology transfer office (TT0) came into existence. Harry Steenbock, a researcher at the University of Wisconsin, demonstrated a means of fortifying the Vitamin D in food and drugs through a process termed 'irradiation'. He became concerned with how the technology would be

implemented as he recognised that unqualified individuals or organisations could use his invention, and possibly do harm, unless he brought it to the market with legal protection in the form of a patent. Together with other alumni, Steenbock created a separate entity that was university-affiliated and could accept patents, license them out, and disperse revenues back to the inventor and the university without exposing the university to potential financial and political liability (Sampat, 2006:776).

Factors such as the post-war growth of 'use-oriented' basic research, declining funds for university research, as well as changes in government patent policies, stimulated the patenting activities at universities. Both the Bayh-Dole Act passed in 1980 and its subsequent amendments effectively transferred ownership of intellectual property arising from federal research grants to universities (Valdivia, 2011:33). The stated purpose of the Bayh-Dole Act (1980) was to promote the transfer of technology based on inventions and discoveries arising from publicly funded academic research projects to the business sector. However, most universities placed more focus on the increased patenting of 'scientific' research outputs rather than on mere embryonic new technologies (Eisenberg & Nelson, 2002:91). The development of embryonic technologies in new markets is radically different from applying incremental innovations in current markets. IBM research director, James McGroddy (in Chesbrough, 2003:13), describes the difference as follows:

> When you're targeting your technology to your current business, it's like a chess game. You know the pieces, you know what they can and cannot do … In a new market, you have to plan your technology entirely differently. You're not playing chess anymore; now you're playing poker. You don't know all the information in advance. Instead, you have to decide whether to spend additional money to stay in the game to see the next card.

It is interesting to note that the evolution of the entrepreneurial university is thought to have been driven by legislative changes, such as the Bayh-Dole Act, and that institutional pressure has been exerted on political forces as a result of a belief in the "innovation paradox" among policy-makers (OECD, 2003:11). It would appear that, in Europe, it is the so-called 'European paradox' which is the main cause of a lack of university-owned

patents. However, the truth is that most of the university research that results in patents in Europe is not included in the relevant statistics because it is the academic inventor or his/her private firm that applies for the patent rather than the university. There is, thus, confusion between university-invented and university-owned patents and, in real terms, university patent output in Europe lags only marginally behind the output in the United States (Crespi, Geuna & Nesta, *2*007:24). In Europe, university patenting had generally increased since 1990, although with a significant slowdown after the early 2000s. This slowdown was accompanied by a switch in academic patent ownership in favour of the universities (Geuna & Rossi, 2011:1068).

There is currently a discourse between researchers in the field as to whether the phenomenon of the entrepreneurial university should be seen as either a positive or a negative evolution. Some researchers emphasise that the aggressive commercialisation of science may have a deleterious effect on the traditional "culture of open science" at universities (Sampat, 2006:776), while some scholars have found that scientists fear that entrepreneurial ways are leading to greater secrecy in science (Welsh, Glenna, Lacy & Biscotti, 2008:1854). On the other hand, other scholars have found no evidence that this is leading to the destruction of the open culture of science (Thursby & Thursby, 2011:29; Shibayama, 2012:508) and suggest that the traditional and entrepreneurial roles of universities may, in fact, complement and reinforce each other (Etzkowitz et al., 2000:314; Van Looy et al*.*, 2011:558).

2.3.3 University technology transfer

Universities may be regarded as knowledge producing and disseminating institutions which play a significant role in industrial innovation (Etzkowitz et al., 2000:314; Vinig & Van Rijsbergen, 2010:179). The term 'technology' refers to information that is put into use in order to accomplish some task or as "knowledge that is stored in millions of books, in hundreds of millions of human heads, and, to an important extent in the artifacts themselves" (Eveland, 1986:303, Simon, in Smith, 2006:44). Despite the fact that science and technology are related, technology involves how to do things while science involves

understanding (Smith, 2006:45). McGinn (1991:18) makes the following distinction between technology and science:

> Technology is the human activity, which is devoted to the production of techniques [material products of human making or fabrication] – or technic-related products – and whose root function is to expand the realm of practical human possibility.

While:

> Science is that form of human activity which is devoted to the production of theory-related knowledge of material phenomena whose root function is to attain an enhanced understanding of nature.

It is scientific advances and breakthroughs that stimulate the developments in technology, which, in turn, give rise to the innovations which are defined as “doing something in a way which is new, different and better” (Wickham 2006:7) and are brought to the market (Smith, 2006:45). Thus, innovation is not a synonym for invention but is based on new knowledge, and new combinations of existing knowledge and technologies introduced on the market (Valente, 2014:7). Baregheh, Rowley and Sambrook (2009:1334) define innovation as "the multi-stage process whereby organisations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace". For universities this means that the mere generation of knowledge does not ensure that knowledge will spill over for commercialisation, thus driving innovative activities and economic growth. In addition to the production of knowledge, universities also need to alter their activities and values in such a way as to facilitate the transfer of technology and knowledge spillovers (Audretsch, 2014:314).

Technology transfer may be regarded as "the process of transferring scientific findings from one organization to another for the purpose of further development and commercialization" (Association of University Technology Managers, 2014:[1]). Thus, referring back to the definition of innovation cited above, technology transfer may be seen as a critical component of the nurturing and fostering of innovation in universities and their

partners from industry, government and the wider community. However, the raison d'être of universities is not to produce commercial goods or services (Pries & Guild, 2011:151) and, thus, the process of university technology transfer is, as noted by McAdam, Miller, McAdam and Teague (2012:57), "neither easy nor smooth". Instead it is a complex, non-linear and highly interactive process in which several stakeholders are involved. It may be divided into three distinct stages with each stage involving multiple inputs. The inputs during the first stage include research funding, the research work, the individual researcher or research team and the technology transfer office (TTO) personnel (University of Cape Town, 2010:6). The output of this first stage is invention disclosure, followed by evaluation. During the evaluation, the commercial and social benefits of the disclosed invention are assessed, primarily with the help of a technological audit (Łącka, 2012:71).

If the possible benefit of the invention is affirmed, the strategy for commercialising the invention is set out in order to determine how the potential of the invention may be realised. During this process both the scholarly value and the prospective economic benefit of the invention are taken into consideration. This requires the ability to assess the potential of emerging and breakthrough technologies and future markets (Łącka, 2012:71). The TTO will then apply for intellectual property rights protection on those inventions which have been deemed to be suitable. This signals the start of the next stage, which includes the marketing and managing of the new solution, the search for prospective receivers and the negotiating of contract conditions.

The patenting and licensing of research are only one of several ways of transferring new knowledge from universities to the market and different types of transaction may occur sequentially to reinforce the commercialisation process (Bercovitz & Feldmann, 2006:176). These transactions include the mechanisms of sponsored research support, the hiring of research students, new start-up ventures and simple serendipity, which is an informal mechanism that may be used to initiate a relationship which then develops through another mechanism. The commercialisation methods of spin-off creation, licensing/assignment of IP, sponsored research and consulting are described in detail in section 2.4 of this chapter. However, independent of the selected method of

commercialisation, once the solution has been commercially implemented, the monitoring and benefit sharing process commences.

The calculation of a numerical direct return on investment for technology transfer is a complex and difficult task because, besides the generation of revenue, intangible benefits, such as increased opportunity for funding, promotion of a culture of entrepreneurship and innovation, student success, public benefit and economic development, are also involved (McDevitt et al., 2014:76).

In the United States, academic entrepreneurship is reflected directly in the creation of new ventures – the so-called university spin-offs (Shane, 2004:4). This narrow notion of academic entrepreneurship is evident in the American literature (Łącka, 2012:71) and is described in the next section of this chapter.

2.3.4 University spin-offs

Compared to the perspectives, *entrepreneurial university* and *university technology transfer*, scholars focusing on entrepreneurial activity in the form of new venture creation appear to exhibit a similar understanding of their research perspective (Rothaermel, Agung & Jiang, 2007:749). In addition, the venture creation aspect of academic entrepreneurship has become the focus of increased attention (Wright et al., 2012:430). In his book titled *Academic entrepreneurship university spinoffs and wealth creation* (2004:4), Shane defines a university spin-off as “a new company founded to exploit a piece of intellectual property created in an academic institution”.

University spin-offs are a new type of firm that generates considerable hopes for policymakers and technology transfer institutions, as they are perceived as an economically powerful division to transfer new technological knowledge to business and society (Sternberg, 2014:137). University spin-offs occur in many different forms, including firms formed by the university, faculty or staff; firms formed around a university licence of intellectual property; start-up firms that have joint research projects with the university; and

firms started by students or post-doctoral students based on research conducted at the university (Bercovitz & Feldmann, 2006:179).

Governments have a significant interest in increasing the number and quality of university spin-offs because these serve as a source of skilled labour, specialised facilities and expertise (Sternberg, 2014:137). For example, the Association of University Technology Managers (AUTM, 2010) reported in its FY2009 US Licensing Activity Survey that 596 new companies had been formed based on university technology, with 435 (73%) operating in the licensing institution's home state. Smith, Chapman, Wood, Barnes and Romeo (2014:341) explored spin-offs from London universities and found that nearly two-thirds of the primarily small and medium-sized enterprises operated in the London region. University spin-offs are seen as an important direct channel through which new science and technology reach the wider market sphere (Goethner, Obschonka, Silbereisen & Cantner, 2011:629). However, there is mixed evidence regarding their performance and impact, especially compared to other non-university-related technology start-ups (Djokovic & Souitaris, 2008:41; Wennberg, Wiklund & Wright, 2011:1137; Bolzani, Fini, Grimaldi & Sobrero, 2014:2).

Over the previous decade considerable research has been conducted to investigate university spin-offs. The following three different themes dominate this research stream: (1) influence of university's ecosystem on spin-off creation, (2) quality of the university's intellectual property and spin-off policies, and (3) resources and capabilities as key drivers of spin-off performance.

The first theme investigates the impact of university systems on spin-off creation and includes university policy, incubation models and research environments. Researchers refer increasingly to a university ecosystem that is a community of organisms, in this case professors, researchers, students, external practitioners and so forth “interacting with one another and with other organisms in the external environment that are pulled into its sphere of influence” (Curley & Formica, 2013:11). Clarysse, Wright, Bruneel and Mahajan (2014:1174) point out that in knowledge ecosystems that include players such as universities and public research institutions, the players are not in direct competition with

each other and the value creation flows from upstream to downstream players. On the other hand, in business ecosystems, the key players are large, established corporations that provide both resources and commercial infrastructure. These are characterised by a non-linear value-creation process. In order to successfully establish a university ecosystem, visible promotion, recognition, support for collaboration and entrepreneurship, as well as adequate success measures, are needed (Curley & Formica, 2013:12).

Entrepreneurial boot camps aimed at stimulating specific venture initiatives (Clarysse, Mosey & Lambecht, 2009:427) and university incubators that support spin-off creation (Hess & Siegwart, 2013:33; Caiazza, 2014:1067) are examples which are targeted at the early stages of the venture creation life cycle. Wright, Piva, Mosey and Lockett (2009:584) advocate internal knowledge flows between business schools, TTOs and the science departments of universities. In addition, the availability of social and financial capital within the region (Fini, Grimaldi, Santoni & Sobrero, 2011:1125), as well as the functioning of technology parks (Link & Scott, 2007), have a positive effect on the ability of universities to launch new spin-off ventures.

University spin-offs are heterogeneous and differ in terms of their institutions, TTOs, entrepreneurial teams, the dynamics of venture development and their objectives and, hence, the need for diverse policy measures (Mustar, Wright & Clarysse, 2008:79). Sternberg (2013:146) analysed two different government support programmes in two regional contexts in terms of their impact on the start-up success of university spin-offs over a period of eleven years. He found that the fact that the founder had received government support had a lesser impact on start-up success, while the site-specific factors of the regional context in which an individual had started a firm were important.

The second theme focuses on the impact of the intellectual property policies of universities on university spin-offs (e.g. Ambos et al*.,* 2008; Philpott, Dooley, O'Reilly & Lupton, 2011). In the main, it is the university TTOs that are the gatekeepers of intellectual property at universities. They play a role as protector, propagator and influencer of the new technology (Jain & George, 2007:556) within the institution. Some researchers investigating this theme found that the activities of the TTO play a marginal role only in

driving academics to start new ventures (e.g. Clarysse, Tartari & Salter, 2011:1084), while others have indicated that patent regulations and the existence of a TTO have a significant impact on the spin-off productivity of universities (Fini et al., 2011:1125).

It sometimes happens that spin-off ventures do not build on the formal, codified knowledge embodied in patents but, instead, enter via the back door (Fini, Lacetera & Shane, 2010:1061). These spin-off ventures draw on either non-intellectual property or the tacit knowledge of the scientists who work in academic or corporate settings (Markman et al., 2008:1408) or simply start with an unprotected invention or a body of unpatented expertise (Perkman et al., 2013:424). Close ties with the parent university (Johansson, Jacob & Hellstrom, 2005:271, Bolzani et al., 2014:13) and with investors (Shane & Stuart, 2002:157) are fruitful for spin-offs. However, the strength of the ties to the university may also make it difficult to replace these ties. This dependency may lead to the spin-offs being more vulnerable to shifts in national innovation and science policy trends (Johansson et al., 2005:284).

The third theme explores resources and capabilities as key drivers of spin-off performance. Prior research has attributed the success of university spin-offs to the quality of the human resources involved in terms of faculty (Clarysse et al., 2011:1084), founding team (e.g. Colombo, Mustar & Wright, 2010:10; Visintin & Pittino, 2014:31), surrogate entrepreneurship (Lundqvist, 2014:93) and technology transfer personnel (Siegel & Phan, 2005). In the main, the founding team of university spin-offs arise primarily from the confluence of business and academic roles (Colombo et al., 2010:9). For example, Visintin and Pittino's (2014:40) analysis of 103 Italian universities showed that, when founding teams are composed of academic and non-academic members who promote differentiation and integration simultaneously, the university spin-off exhibits superior levels of performance in terms of growth. In order to balance the continuously changing needs of the stakeholders involved, Rasmussen, Mosey and Wright (2011:1339; 2014:98) propose the evolution of competencies to allow for the repeated reconfiguration of the necessary resources.

External conditions, such as industry research and development revenues, opportunities in the market and the attractiveness of industry (Shane & Stuart, 2002:162; Powers & McDougall, 2005:305), have also been highlighted by researchers. In the view of Brennan and McGowan (2006:159), academic entrepreneurs switch between the two modes of knowledge production using opportunity, novelty and advantage-seeking processes. They also modelled the relationship between the individual academic, academic field and discipline domain.

The above section of the chapter discussed the field of Academic Entrepreneurship and its perspectives on the *entrepreneurial university*, *university technology transfer* and *university spin-offs*. In sum, like its mother domain of Entrepreneurship, which has been described by Zahra (2005:254) as a loosely connected field with a mosaic of issues to be explored, the research field of Academic Entrepreneurship is somewhat fragmented. The majority of research studies tend to address very particular elements of the field.

2.4 ENTREPRENEURIAL ACTIVITIES OF ACADEMICS

The preceding section outlined the main perspectives of academic entrepreneurship. Wright et al. (2012:430) state that “[a]cademics have a long established tradition of being entrepreneurial”. However, there is an ongoing discourse between researchers in the field as to the way in which the entrepreneurial activities of academics should be defined. The following paragraphs discuss various perspectives highlighted in the literature.

From a general perspective entrepreneurial activities are specific types of organisational activity that involve creative action, innovative exchanges and deal-making (Greenman, 2012:116). Watson (2013a:407) states that “to act entrepreneurially is to innovate, to deal with social and economic circumstances, with those very circumstances constraining as well as enabling the shaping of entrepreneurial actions and their outcomes”. Although a common definition of entrepreneurial activities within the university context has not yet been formulated, scholars conceptualise such activities as all undertakings outside of the traditional areas of academic work, namely, personal research and teaching (Klofsten & Jones-Evans, 2000:299). While the current focus of the academic literature on

entrepreneurial activities is primarily on licensing and spin-off creation, other commercial and non-commercial activities that are entrepreneurial in nature, such as sponsored research and consulting, should also be included (Abreu & Grinevich, 2013:408).

According to Louis et al. (1989:113), the varying degrees of academic entrepreneurial activities may be distinguished by the amount of knowledge-related external contact on the part of the academic researcher with industry and other organisations outside academia. Perkmann et al. (2013:424) differentiate between "academic engagement", which involves consulting, collaborative research, contract research and informal knowledge transfer relationships, and "commercialisation", which is defined as intellectual property creation and academic entrepreneurship. The main aim of academic engagement in entrepreneurial activities should not be defined entirely in economic terms (Slaughter & Leslie, 1997:217; Fini et al., 2010:1061; Larsen, 2011:6) but rather as initiative aimed at contributing to society and economic development as a whole (Yokoyama, 2006:528; Shattock, 2009:4; South Africa, 2012:8). This point of view is reflected in a recent study by Abreu and Grinevich (2013:408), in which they state that "financial rewards can occur directly or indirectly via an increase in reputation, prestige, influence or societal benefits".

In a similar vein, Etzkowitz and Zhou (2008:630) maintain that academic entrepreneurship goes beyond simple knowledge capitalisation, as the university interacts with actors from outside of academia in order to promote regional growth. It is important to note that the entrepreneurial activities of academics do not involve interactions with the private sector only, for example private companies, but also include interactions with the public sector, for example government departments, parastatal companies, and the third sector, for example charity groups, community organisations and not-for-profit organisations. As will become more apparent in chapter 3 of this study, especially in the South African context, besides the university–industry interactions, many academic links are with both the public sector and the third sector. Accordingly, this study uses a wider focus, going beyond the activities referred to as *university–industry relationships* by Azagra-Caro (2007:708) and Ankrah et al. (2013:50), *industrial involvement* by Bozeman and Gaughan (2007:700), *university–industry interactions* by D'Este and Patel (2007:1301), *industry engagement* by D'Este and Perkmann (2011:323), *institutionalised knowledge transfer activities* by Geuna

and Muscio (2009:104), *university–industry linkages* by Perkmann and Walsh (2007:262) and Giuliani et al. (2010:758) and *commercial activities* by Haeussler and Colyvas (2011:46), to include interactions with sectors outside of industry.

In addition to the various definitions, the literature also provides evidence of the wide-ranging dimensions of the academic's entrepreneurial activities. The majority of these dimensions are focused on the following modes of transfer:

- Sponsored research, which includes research collaborations, contract research, research funds from industry and large-scale science (Louis et al., 1989:113; Shibayama, 2012:517; Abreu & Grinevich, 2013:408)

- Spin-off creation (Bird & Allen, 1989:589; Renault, 2006:232; Clarysse et al., 2011:1089)

- Transaction of intellectual property (IP), including licensing and assignment of IP (Klofsten & Jones-Evans, 2000:300; Fini et al., 2010:106; Yang & Chang, 2010:410)

- Consulting (Etzkowitz & Zhou, 2008:629; Boardman & Ponomariov, 2009:143; Abreu & Grinevich, 2013:408).

In addition, some researchers include commercial output measures such as patents, copyrights, royalties, licensing income or invention disclosures (Louis et al., 1989:113; Fini et al., 2010:1064; Yang & Chang, 2010:410) or other measures such as researcher mobility, external teaching and public lectures (Klofsten & Jones-Evans, 2000:300; Abreu & Grinevich, 2013:408). Table 2.2 summarises the various definitions and dimensions of the entrepreneurial activities in academia.

Table 2.2: Entrepreneurial activities of academics: definitions and dimensions

Author, Year	Definitions relating to entrepreneurial activities of academics	Dimensions
Abreu and Grinevich (2013:408)	We define as entrepreneurial any activity that occurs beyond the traditional academic roles of teaching and/or research, is innovative, carries an element of risk, and leads to financial rewards for the individual academic or his/her institution. These financial rewards can occur directly or indirectly via an increase in reputation, prestige, influence or societal benefits.	- Licence - Spinout - Consultancy business - Contract research - Informal advice - Public lectures
Shibayama (2012:517)	Entrepreneurial activities	- Commercial activity: • Negotiation with industry • Planning of a new business • Foundation of start-ups • Development and marketing of new technologies • Earning licence income - Patent applications - Collaboration with industry - Research funds from industry
Clarysse et al. (2011:1089)	Entrepreneurial activities	- Company creation
Fini et al. (2010:1064, 1061)	An accurate understanding of academic entrepreneurship requires researchers to capture the entire range of efforts by academics to profit commercially from their scholarly activities.	- Disclosures - US patents issued - Licences - New business started - New business started on patent
Yang and Chang (2010:409, 410)	Entrepreneurial activities	- Patent grant - Licence creation - Licensing income
Boardman and& Ponomariov (2009:143)	Entrepreneurial activities	- Paid consulting - Technology transfer and commercialisation - Patents - Copyrights
Etzkowitz and Zhou (2008:630, 629)	Academic entrepreneurship transcends simple knowledge capitalisation as the university interacts with innovative actors from other institutional spheres to promote regional growth.	University-level: - Technology patent and licensing - Consultation for industry - Spin-offs: firm formation - Entrepreneurship education - Provision of rare facilities for R&D
Renault (2006:232)	Entrepreneurial actions by faculty	- Collaboration with industry - Patent/Discovery - Spin-off creation
Klofsten and Jones-Evans (2000:300)	Academic entrepreneurship activities are all commercialisation activities outside of the normal university duties of basic research and teaching.	- Large scale science projects - Contracted research - Consulting - Patenting/licensing

		- Spin off firms - External teaching - Sales - Testing
Bird and Allen (1989:589)	Entrepreneurial activity	- Start up a firm based on their own or others' research activity
Louis et al. (1989:113)	Academic entrepreneurship	- Large-scale science - Consulting - Industrial support for university science - Patenting - Direct commercial involvement, e.g. ownership of firms

Source: Author's own compilation.

In the same vein as Shane (2004:4), who stated that "[t]o investigate a topic, researchers must first define it", the following definition is proposed for the purpose of this study:

> The entrepreneurial activities of academics are the activities occurring beyond the traditional academic roles of teaching and/or research. These activities are reflected primarily in the interactions of academics with industry, government and the third sector via consulting, sponsored research, licensing/assignment of intellectual property (IP) and spin-off creation.

The core dimensions representing the entrepreneurial activities of academics in this study include interactions with industry, government and civil society via consulting, sponsored research, licensing/assignment of IP and spin-off creation. Table 2.3 presents the operational definitions of the entrepreneurial activities of academics used in this study.

Table 2.3: Entrepreneurial activities of academics: operational definitions

Entrepreneurial Activity	Operational Definitions
Spin-off creation	New firm created to commercially exploit some knowledge, technology or research results developed within a university. (Pirnay et al., 2003:355; Shane, 2004:4; Visintin & Pittino, 2014:33)
Licensing/assignment of intellectual property	Legal right to use or own a specific piece of university intellectual property (Bercovitz & Feldmann, 2006:177; South African IPR-PFRD Act of 2008, 2008:4).
Sponsored research	Agreement by which the university receives funding for conducting a research project (Bercovitz & Feldmann, 2006:177). This may be in the form of a joint-research or a contract research project with industry, government or the third sector (Hall et al. 2001:88; D'Este & Perkmann, 2011:318).
Consulting	The sale of personal scientific or technological expertise to solve a specific problem (Klofsten & Jones-Evans, 2000:300; Giuliani et al., 2010:758; Haeussler & Colyvas, 2011:44).

Source: Author's own compilation.

The concepts cited in the table above are explained in more detail in the following paragraphs.

2.4.1 Spin-off creation

University spin-offs operate at the intersection of academia and the market. They are a phenomenon that has proved to be a successful method for bringing inventions or scientific discoveries carried out within university laboratories to market by finding appropriate applications for such inventions or scientific discoveries or by establishing entirely new markets (Visintin & Pittino, 2014:33). In general, the definitions of the phenomenon of university spin-off vary substantially (Clarysse et al., 2011:1423). For the purpose of this study, spin-off creation is defined as the creation of new entities set up to commercially exploit some knowledge, technology or research results developed within a university (Pirnay et al., 2003:355; Shane, 2004:4). The individual concerned 'who' participates in spin-off creation activities is the academic researcher who is affiliated to a university. The 'what' constitutes knowledge, technology or research results developed within a university. There are, however, no restrictions concerning the 'how' the academic participates in this activity. The academic may create the spin-off himself or the university may create the spin-off on his behalf. The essential feature is that a new entity is created and that this new entity brings the intellectual property to the market and to society at

large. The variety of issues explored in the research focusing on university spin-offs is described in section 2.3.4 of this chapter.

2.4.2 Licensing/assignment of intellectual property (IP)

The South African IPR-PFRD Act of 2008 (2008:4) defines an intellectual property transaction as "any agreement in respect of intellectual property emanating from publicly financed research and development, and includes licensing, assignment and any arrangement in which the intellectual property rights are transferred to a third party". Similarly, the Bayh-Dole Act, which was enacted by the US Congress in 1980, together with amendments in 1984 and augmentation in 1986, empowers universities and small businesses to control both their inventions and the other intellectual property that results from government funding (Aldridge & Audretsch, 2011:1059). Several European countries, including Denmark, Germany, Austria and Norway (Grimaldi et al., 2011:1047), as well as Asian countries such as Japan (Kodama, 2008:1224), have adopted similar legislation.

Licensing has traditionally been the most popular mode for assigning IP (Chapple, Lockett, Siegel & Wright, 2005:3, Aldridge & Audretsch, 2011:1059). Licences provide the right for companies and others to use the university's IP in codified form. Licensing agreements differ in terms of their specifications and scope but, essentially, they involve selling an organisation the rights to use a university's inventions in return for revenue in the form of up-front fees at the time of closing the deal and ongoing royalty payments (Bercovitz & Feldmann, 2006:178). A patent-protected technology may, for example, be commercialised through one of three main licensing strategies: (1) licensing in exchange for sponsored research, (2) licensing in exchange for equity in a company, and (3) licensing for cash (Markman, Gianiodis & Phan, 2005:242).

Selling intellectual property usually involves the buyer taking ownership of the IP in return for either a lump sum payment or instalment payments over a period of time. A written deed of assignment confirms the change in ownership. The assignment of university IP confers on the receiving organisation absolute discretion as to how it uses the enabling asset, which may be presented by patent, trademark, copyright, plant breeder right,

registered design or in the form of specialised know-how, trade secrets and confidential information. In the majority of cases, universities prefer to licence the IP as this enables them to profit through royalty streams and also to retain some control over the use of the IP. In terms of the new South African IPR-PFRD Act, provisions must be included in the agreements for the IP to revert back to the university should the licensing or buying company cease to exist or fail to commercialise the IP (Southern African Research and Innovation Management Association, 2009:60).

2.4.3 Sponsored research

Sponsored research encompasses an agreement in terms of which the university receives funding for conducting a research project (Bercovitz & Feldmann, 2006:177). There are two main forms of sponsored research, namely, joint research, which refers to formal collaborative arrangements aimed at cooperation on research and development projects (Hall et al. 2001:88), and contract research, which is explicitly commissioned by an organisation and where the work is usually more applied than in joint research projects (D'Este & Perkmann, 2011:318). However, irrespective of the form chosen, both parties usually negotiate upfront the legal specifications of the research agreement and the ownership of the resulting intellectual property. The reasons for partners outside of academia to sponsor research include the opportunity to absorb and develop state-of-the-art knowledge, as well as the access to graduates provided (Wright et al., 2008:1207). The degree of support for research provided by industry varies considerably between countries and research fields (Bekkers & Bodas Freitas, 2008:1844; Giuliani & Arza, 2009:917).

2.4.4 Consulting

Consulting refers to the sale of personal scientific or technological expertise to solve a specific problem (Klofsten & Jones-Evans, 2000:300). Consulting does not involve original research (Giuliani et al., 2010:758) and may be on a project basis or an ongoing basis, such as membership of a scientific advisory board (Haeussler & Colyvas, 2011:44). Consulting agreements are typically made on a bilateral basis with the individual academic and the university only formulating policies about the acceptable amount of time to be

devoted to consulting, conflicts of interest and the use of university resources in the consulting (Bozeman & Gaughan, 2007:695). In referring to consulting, Jacobson, Butterill and Goering (2005:316) state that when knowledge users are actively involved, it helps to ensure the relevance and utility of the knowledge generated in the process. In addition, it may furnish the academic involved with new research leads and insights into practical problems (Bercovitz & Feldmann, 2006:178).

The next section describes the theoretical setting of the study. This is followed by a discussion of possible antecedents and consequences of the entrepreneurial activities of academics. Propositions are then put forward and the conceptual framework presented.

2.5 THEORETICAL FRAMING

This research study integrates resource-based research and Joas's theory of the creativity of action (Joas, 1996:144). The following sections briefly describe both perspectives and then summarise their contributions to the framework guiding this research study.

2.5.1 Joas's theory of the creativity of action

In his book entitled *The creativity of action,* Hans Joas (1996) presents a non-teleological interpretation of the intentionality of action and emphasises the creative character of human action. Joas's (1996:144) revised action theory is based primarily on the pragmatist understanding of human action as situated creativity, which was developed by George Herbert Mead and John Dewey. Joas sees creativity in the continuous reorganisation of the habits and institutions of human beings, maintaining that creativity may be perceived as the liberation of capacity for new action (Lombardo & Kvålshaugen, 2014:5). Thus, habit and creativity are both essential elements of all human activity and also coeval dimensions of human action and, therefore, not mutually exclusive (Spedale & Watson, 2014:764).

Joas's theory of the creativity of action intends to abrogate an ends–means model of human action (Spedale & Watson, 2014:763; Tanggaard, 2014:111). The creativity of

action model overarches the two predominant models of action, namely, 'rational action' and 'normatively oriented action'. By defining human action as creative action, Joas avoids the problem of a residual category to which the other two models allocate the major part of human action. Joas points out the reason why one should not follow theories rooted in economics, sociology, psychology and analytical philosophy that take rational action as their starting point by shedding light on the three tacit assumptions that lie behind the notions of rational action (Weik, 2012:567). All theories of action that proceed from a type of rational action presuppose (1) a teleological character to human action, (2) corporal control by the actor and (3) the autonomous individuality of the actor. In empirically observable action, however, these preconditions which are assumed by the model of rational action are frequently not to be found (Joas, 1996:147).

As an alternative to a teleological interpretation of action, the theory of creative action suggests that thought and action are not preceding actions but emerge in situational contexts (Fisher & Mwaipopo, 2013:81; Hoffman, 2013:264). Situation, sociality and corporality are the three dimensions for every form of action. Sociality means that action and actors are inherently integrated within social groups (Fisher & Mwaipopo, 2013:81). On the other hand, corporality characterises human action by taking the body to be one of the pillars of agency and according it equal weight and autonomy vis-à-vis the mind (Weik, 2012:569).

Joas's notion of creativity incorporates a strong pre-reflexive component and is a mixture of body, will and action. Joas (1996:161) states that “according to this view, our perceptions of the world appear to be structured by our capacities for, and experiences of, action”. The realisation that situation-relatedness is constitutive of all action then no longer essentially presupposes motives and plans for action. For example, constraint handling has a clear role in the definition of creative action. Constraint shattering involves problem solving and, hence, originates creative action (Lombardo & Kvålshaugen, 2014:2). When actors find themselves confronted with new situations, they have to come up with creative solutions (Joas & Knôbl, 2009:522). This means that the experience of resistance in the environment may prompt creative action to arise when the actor begins to give by working

with the resistance rather than trying to overcome it (Joas, Sennett & Gimmler, 2006:11; Tanggaard, 2014:114).

In short, Joas's creativity of action theory contributed to this study by providing an advanced conception of action. By following its pragmatism-inspired line of situated creativity it is possible to interpret the participation of an academic in an entrepreneurial activity as a creative act that goes beyond the habitual, which, in this context, comprises the traditional activities teaching and research, and which is anchored in the individual's natural and social environment. Joas regards human activity not as coincidental but, in a fundamental sense, as creative. Joas (1996:129) describes creativity as "performed within situations that call for solutions and not as an unconstrained production of something new without any constitutive background in unreflected habits". In view of the fact that action is directed and redirected in its situational contexts, actors engage more in making retrospective sense of their actions than in acting based on causal rationality and predetermined goals and motives. Every situation contains several possibilities which, when action encounters unexpected obstacles, have to be rediscovered (Lombardo & Kvålshaugen, 2014:5). The fact of creativity "being 'situated' means it will have different effects in different circumstances" (Watson, 2013b:29).

While Joas's theory of the creativity of action is useful for outlining the fundamentals of a theory of creative action, it does not put forward concrete elements and definitions which could be applied in order to analyse the individual and his actions within his situational context. Joas (1996:161) refers to capacities for, and experiences of, action but does not elaborate on these concepts in any great detail. It is for this reason that this study uses the resource-based view as the second theoretical anchor in its exploration of the individual and the institutional resources and capabilities that may serve as antecedents in the processes involving the entrepreneurial activities of academics. Resource-dependent choices and actions are a recurrent theme in entrepreneurship research and range from their theoretical conceptualisation by Schumpeter (1934) and Penrose (1959) to emerging entrepreneurship theories, such as effectuation as the logic of entrepreneurial action of Sarasvathy (1998) and the entrepreneurial bricolage of Baker and Nelson (2005). Effectuation and entrepreneurial bricolage are discussed briefly in the following

paragraphs, while the resource-based view of the firm is described in section 2.5.2 of the study.

Sarasvathy (2001:245) contrasted effectuation processes with the causation processes in venture creation. She found that the effectuation processes take a set of means and contingent human aspiration as given and focus on selecting between the possible effects that may be produced with that set of means, thereby eliminating the assumption of predetermined goals. The three means are articulated as: (1) 'Who I am' – referring to individual-level traits, tastes and abilities, physical resources on the firm level and demographics on the level of the economy. (2) 'What I know' – related to knowledge corridors on the individual level, human resources on the level of the firm and technology regimes on the level of economy. (3) 'Whom I know' – represented by individual-level social networks, firm-level organisational resources and socio-political institutions of the level of the economy (Sarasvathy, 2001:253). A dynamic decision environment is assumed in terms of which both means and aspirations change over time. The question "What kinds of entrepreneurial activities could I pursue and what kind of enterprises could I create?" (Sarasvathy, 2008:267) is a function of the level of loss or risk acceptable and the degree of control over the future which is achieved by strategic partnerships (Sarasvathy, 2001:253).

Similar to Sarasvathy's theory of effectuation, Baker and Nelson's (2005:334) theory of entrepreneurial bricolage focuses primarily on the resources an individual has on hand and that may be used to 'make do'. However, effectuation builds on the decision theory literature while entrepreneurial bricolage rests on Penrose's (1959) concept of the social construction of resources (Fischer, 2012:1022). Edith Penrose (1959:24) was among the first scholars to view a firm as a bundle of productive resources and argued that these resources may contribute to a firm's competitive position only once they are exploited in such a manner that they benefit the firm. She further pointed out that firms may find different value in seemingly identical resources but did not provide a model of the way in which firms come to construct their idiosyncratic resource environments (Baker & Nelson, 2005:330).

In order to fill this gap, Baker and Nelson (2005:333) used the concept of bricolage which they defined as "making do by applying combinations of resources at hand to new problems and opportunities". The concept of 'bricolage' was introduced by the anthropologist, Lévi-Strauss, (1966) in his book *The savage mind*. He used the concept to describe the actions of a 'bricoleur', best translated as a professional do-it-yourself man or 'Jack of all trades' as compared to the actions of an engineer. "The 'bricoleur' is adept at performing a large number of diverse tasks, but, unlike the engineer, he does not subordinate each of them to the availability of raw materials and tools conceived and procured for the purpose of the project" (Lévi-Strauss, 1966:17). The process of entrepreneurial bricolage, as described by Baker and Nelson (2005:353), starts in an impoverished environment, an environment that provides new challenges without providing new resources. In such an environment, firms have the following three options: (1) seek resources from outside, (2) avoid the challenge or (3) engage in bricolage by making do with the resources at hand and creating something from nothing.

Those firms that enact entrepreneurial bricolage may do so in five domains: (1) physical input – materials with new use value, (2) skills inputs – use of amateur and self-taught skills that would otherwise be unapplied, (3) labour inputs – involving suppliers, customers and 'hanger-ons', (4) regulatory and institutional environment – refusing to enact limitations with regard to standards and (5) customers – provision of products and services that would otherwise be unavailable (Fischer, 2012:1027; Baker & Nelson, 2005:353).

2.5.2 Resource-based view of the firm

The central proposition of the resource-based view of the firm is that for a firm to achieve a sustained competitive advantage, it must acquire resources and capabilities that are valuable, rare, inimitable and non-substitutable and also have an infrastructure in place that may absorb and apply them (Kraaijenbrink et al., 2010:350). Hence, differences with respect to resources and capabilities impact on an organisation's behaviour and performance (Lockett & Wright, 2005:1004).

Within the disciplinary tradition of economics, the resource-based view of the firm may be positioned relative to at least three different theories: (1) a structure-conduct-performance (SCP) paradigm in economics, (2) neoclassical microeconomics and (3) evolutionary economics (Barney, Wright & Ketchen, 2001:643). The three theories share the following two common assumptions. Firstly, resources and capabilities may be heterogeneously distributed across firms and, secondly, these differences may be long lasting. Furthermore, the three theories all emphasise *why* some firms outperform others (Barney et al*.,* 2001:644). They differ, however, in terms of the implications of these assumptions. The first two theories suggest either a competitive equilibrium model or a static conceptualisation of the resource-based view (e.g. Demsetz, 1973:4; Lippman & Rumelt, 1982:419; Barney, 1991:1010; Conner, 1991:124; Peteraf, 1993:180; Peteraf & Barney, 2003:309).

On the other hand, when the resource-based view was developed relative to evolutionary economic theory, a dynamic, innovative stance was adopted. This stance is associated with heterodox economists, such as Joseph Alois Schumpeter (1934), Edith Penrose (1959), George Richardson (1972) and Thorstein Veblen (in Foss, 2010; Foss & Stieglitz, 2012:256). The notion that competitive advantage arises from the continuous development, exploitation and protection of assets has a long tradition, dating back to Schumpeter's theory of economic development (1934). This is the mechanism underlying continuous industrial evolution and revolution with evolutionary theorising investigating how the routines by which resources are deployed change over time (e.g. Teece, Pisano & Shuen, 1997:509; Teece, 2007:1341).

Routines are identifiable patterns of activity which are embodied in capital or human assets (Nelson & Winter, 1982:134). Routines may be regarded as similar to capabilities, as they represent the ability to integrate, build and reconfigure resources to generate a competitive advantage in rapidly changing environments (Teece et al., 1997:516; Barney, 2001:647).

A modern resource-based logic is similar to a dynamic recipe that explains the process by which resources and capabilities, which are valuable, rare, inimitable and non-

substitutable, are utilised to realise a sustainable, competitive advantage (Newbert, 2007:124). Vohora et al. (2004:151), for example, describe how university spin-offs go through five distinctive phases of development, namely, (1) research phase; (2) opportunity framing phase; (3) pre-organisation phase; (4) re-orientation stage; and (5) sustainable returns phase. Every phase requires a different bundle of resources while certain critical junctures have to be overcome in order to move from one phase to the next.

Barney (1991:101) classifies the resources of a firm into three dimensions: physical capital resources (based on Williamson, 1975:13), human capital resources (based on Becker, 1964:15) and organisational capital resources (based on Tomer, 1987:7). Physical capital resources include technology, plan, equipment, geographic location and access to raw material (Barney, 1991:101). Human capital resources refer to the knowledge and abilities people acquire through formal and informal education, training and experience. In addition, they include judgement, intelligence, relationships and the insights of individuals (Barney, 1991:101). In its original conceptualisation, human capital is a collective resource that comprises individual human assets (Becker, 1964; Nyberg et al., 2014:319). As early as the seventies, Cooper and Bruno (1977:21) had hypothesised that “for a new, high technology firm, the primary assets are the knowledge and skills of the founders”. Ployhart and Moliterno (2011:127) define the human capital resource as a unit-level resource that is created from the emergence of individuals’ knowledge, skills, abilities and other characteristics that have their origins in the psychological attributes of individuals and are transformed through unit-level processes. Finally, organisational resources are the systems, the routines and the relationships embedded in the company and are intangible, immobile and inherently difficult to imitate (Heirman & Clarysse, 2004:249). Helfat and Peteraf (2003:999) refer to organisational capabilities as “the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources for the purpose of achieving a particular end result”.

The key contribution of the resource-based view of the firm to this study was the following: The notion that an individual, like a firm, has access to a bundle of resources. Such resources may be the knowledge and abilities of the individual and the organisational systems, routines and relationships of the institution of which the individual is part, as well

as the physical resources that may be leveraged. This study sees an entrepreneurial activity within the context of academia as a resource-dependent action of an individual. The aim of the study is to look at those resources that may serve as antecedents for the entrepreneurial activities of academics. Consequently, the study examines the knowledge and abilities of the academic researcher that he/she has acquired through formal and informal education, training and experience, the organisational culture of the university and the intellectual property managerial support provided by the university of which he/she is part, as well as the physical resources he/she owns or to which he/she has access. The following section of the chapter outlines the antecedents and consequences of the entrepreneurial activities of academics and formulates propositions.

2.6 ANTECEDENTS AND CONSEQUENCES

Based within the theoretical setting outlined in section 2.5 of this chapter, this section presents the concepts which have been identified as the antecedents of the entrepreneurial activities of academics. In addition, the consequences of the entrepreneurial activities of academics for the two traditional activities of teaching and research are explored, while the relationship between consulting, sponsored research, licensing/assignment of IP and spin-off creation is investigated to establish possible complementarities or substitution effects between them. Propositions are outlined and are transformed into hypotheses for empirical testing (chapter 4). Finally, the conceptual framework used in the study is presented. The unit of investigation is the individual academic researcher within his/her contextual setting. South Africa's National Research Foundation (NRF) evaluates and rates individuals based on the quality of their research outputs and impacts in the previous eight years. The NRF rating is a South African indicator of research excellence (South Africa. National Research Foundation, 2013). The study includes all NRF-rated researchers who were affiliated to a public South African university as at 28 February 2013 and covers the full spectrum of academic disciplines. It is hoped that building a deeper understanding at the micro level of individuals may yield novel insights into the phenomena of academic entrepreneurship (Markman et al., 2008:1412; Foss et al., 2010:457).

2.6.1 Antecedents

The study also covers the knowledge, abilities and resources of individuals, as well as the resources and support to which the individual has access on the institutional level. The antecedents are divided into the following three major aspects. Firstly, human capital-related aspects which include: (1) work experience outside of academia, (2) direct entrepreneurial experience, (3) exposure to entrepreneurship education, (4) academic seniority, (5) applications-driven research and (6) novelty of research; secondly, aspects related to physical capital resources which include (7) intellectual property protection and (8) universities' innovation infrastructure; and thirdly, aspects related to organisational capital and which include (9) universities' IP managerial support and (10) universities' entrepreneurial culture.

Human capital-related aspects

(1) Work experience outside of academia

Academics are often characterised by their life-long careers in the university setting. In the past, the traditional academic career path resembled a ladder with little opportunity to gain work experience in the private sector (Jones-Evans, 1995:26). Studies addressing the question of those academics that are likely to engage in entrepreneurial activities often highlight the importance of work experience in the private, public or third sector. Dietz and Bozeman (2005:363) associate intersectional job changes by researchers from industry with the spillover of industry-specific human capital into the academic field. Jones-Evans's (1995:10) study of the entrepreneurial activities of academics in Europe revealed that previous employment outside the university sector or previous small business experience has a positive effect on the likelihood of academics engaging with industry. On the other hand, Lubango and Pouris (2007:795) found that the industrial experience of university scientists in South Africa appeared to be an effective mechanism that increased the universities' inventive activities in terms of patent applications. Similarly, Göktepe-Hulten (2008:139) points out that the serial inventors at Lund University often have work

experience from industry which enables them to broadly assess the potential outcomes of their research results. These findings led to the following proposition:

Proposition 1. Work experience outside of academia influences the likelihood of the academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

(2) Direct entrepreneurial experience

In addition to work experience outside of academia, experience in other similar situations may serve as the basis for knowledge relating to the entrepreneurial activities of academics. Studies on habitual and serial entrepreneurs have identified entrepreneurial experience as an effective facilitator of both opportunity identification (Ucbasaran, Westhead & Wright, 2006:200) and the likelihood of venture capital funding (Hsu, 2007:722). Shane and Khurana's (2001:24) study on the patents assigned to MIT between 1980 and 1996 found a strong correlation between inventors with more start-up experience and the commercialisation of IP through licensing to a new company. Abreu and Grinevich (2013:417) found the ownership of a small company in the past to be positively associated with licensing, spinout, consultancy business and contract research, as well as providing informal advice and giving public lectures. It is, thus, possible to assume that, in the main, the personal experiences gained while running a new venture, being involved in the creation of a new venture or owning a new venture lead to the accumulation of a large store of prior knowledge. Such prior knowledge provides the individual with a portfolio of potentially relevant information on which to draw (Dew, Read, Sarasvathy & Wiltbank, 2011:246). Thus, the knowledge gained from direct entrepreneurial experience is likely to influence the academic researcher's engagement in consulting, sponsored research, licensing/assignment of IP and/or spin-off creation. On this basis the following proposition is put forward:

Proposition 2. Direct entrepreneurial experience influences the likelihood of the academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

(3) Entrepreneurship education

Siegel and Phan (2005:2) advise entrepreneurial universities to provide education and training for the researchers in academia on the specifics of the entrepreneurial process, the role of entrepreneurs and how to interact with the business and entrepreneurial community. Abreu and Grinevich (2013:417) found that the entrepreneurship training provided by the institution increases the individual's involvement in non-commercial activities such as providing informal advice and giving public lectures. They did not, however, find entrepreneurship training to have any effect on licensing, spinout, consultancy business and contract research. In addition, the fact that the institution offers entrepreneurial training does not necessarily mean that the individual academic researcher would attend such training. In addition, it is not known what type of entrepreneurship education is provided. In entrepreneurship education, a distinct set of competencies that are critical for entrepreneurial action should ideally be developed together with more general business competencies (Rasmussen et al*.,* 2011:1316). However, educational programmes in entrepreneurship have tended to emphasise the skills required for the day-to-day operations of a business and have not addressed the unique requirements of the entrepreneurial context (Morris, Webb, Fu & Singhal, 2013:352). Blank and Dorf (2012:1) maintain that "a startup is not a small version of a big company".

Haeussler and Colyvas (2011:49) found that management training, which they measured as an indicator variable equal to one if the life scientist had a degree in management in addition to a scientific degree, had a significant effect on the academic's engagement in the founding activities of companies, but no effect on the consulting and patenting activity. It would appear that growing up in a family business provides a de facto business education which may be positive, negative or merely different (Krueger, 2007:128).

Existing research has found that individuals who had grown up in a family business reported a positive view of their family's business experience, while they regarded entrepreneurship as more feasible and had a better perception of entrepreneurship compared to those who had not grown up in a family business (Delmar & Gunnarsson, 2000:20). However, it is equally important to note that negative experiences arising from a family business may, in turn, have negative consequences for attenuating entrepreneurial attitudes and intentions (Krueger, 2007:128). In addition, in terms of academia, findings suggest that when a parent or sibling is a company founder, this has a significant effect on the founding, consulting and patenting activity of life scientists (Haeussler & Colyvas, 2011:47).

The entrepreneurship-related knowledge acquired from a course during which the individual learns how to transform opportunities into profitable businesses, or from a course during which the individual learns how to run and manage businesses or else a family business, may provide the academic with relevant information that results in his/her engaging in consulting, sponsored research, licensing/assignment of IP or spin-off creation. On this basis the following proposition is put forward:

Proposition 3. Exposure to entrepreneurship education influences the likelihood of the academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

(4) Academic seniority

While prior research indicates a strong relationship between the academic researcher's career status and entrepreneurial activities, the direction of such a relationship is questionable. One may assume that academic seniority facilitates interactions with industry, government and the third sector. In addition, it makes sense that established researchers are more likely to be approached by actors outside academia than less

established researchers. Boardman and Ponomariov (2009:149) approximated seniority and reputation by tenure status and found that it positively affected the likelihood of the academic to engage in consulting. With regard to either working on a patent or co-authoring publications with industrial partners, Boardman and Ponomariov (2009:149) found no discernible effect. Ambos et al. (2008:1442) found that projects with younger, less senior and higher-cited principal investigators produced the highest proportion of patents, licences, spin-out companies or a combination thereof. Landry, Amara and Saihi (2006:1610) did not find researcher seniority, as measured by academic rank, to have a significant impact on the likelihood of the researcher in question creating university spin-offs. Similarly, Haeussler and Colyvas (2011:50) suggest that founding is independent of laboratory size and seniority. Overall, it would appear that engagement in consulting and sponsored research is associated with higher seniority, while for the commercialisation activities, licensing/assignment of IP and spin-off creation the results are more ambiguous (Perkmann et al*.,* 2013:427). This study assumes a relationship between academic seniority and entrepreneurial activities, and therefore proposes:

Proposition 4. Seniority influences the likelihood of the academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

(5) Applications-driven research

In the face of the developments towards a more market-oriented approach within universities (Lam, 2010:7), researchers are assumed to pay more attention to commercially oriented research knowledge and spot commercial opportunities for their particular expertise than would otherwise have been the case (Landry et al*.,* 2006:1604). Smith (2006:121) states that “[t]echnology enhances the state of knowledge within the broader scientific and technological community, while the market works to express wider consumer needs and expectations”. Studies in Canada and the United Kingdom have found that academics working on user-inspired or applied research are more likely to

engage in entrepreneurial activities than academics engaged in basic research (Landry, Amara & Ouimet, 2007:581; Abreu & Grinevich, 2013:418). In South Africa, the Department of Education, in its Education White Paper 3 (1997:31-32), states that South Africa's research system must "keep abreast with the emerging global trends, especially the development of participatory and applications-driven research addressing critical national needs which requires collaboration between knowledge producers, knowledge interpreters and knowledge managers and implementers". Similarly, in their paper on academic freedom, institutional autonomy and the corporatised university in contemporary South Africa, Habib, Morrow and Bentley (2008:151) emphasise the importance of academic engagement with the immediate concerns of the local society. In line with both previous studies and the approach that participatory and applications-driven research is a resource that, when mobilised, will increase the academic's participation in entrepreneurial activities, the following is proposed:

Proposition 5. The degree to which her/his research is applications-driven influences the likelihood of the academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

(6) Novelty of research

The degree of novelty of the research findings increases the likelihood of spin-off creation (Landry et al., 2006:1611) and also impacts positively on knowledge transfer in engineering and the earth sciences (Landry et al., 2007:581). Bernardos Barbolla and Casar Corredera (2009:606) analysed the degree of innovation of successful and unsuccessful projects and pointed out that the majority of successful projects were aimed at enhancing existing products with the objective of developing a just about ready-to-use product or process. In line with this, in 80% of the unsuccessful projects in their study, the integration processes constituted stumbling blocks. This study regards the novelty of research findings as an asset and proposes:

Proposition 6. The novelty of her/his research influences the likelihood of the academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

Aspects related to physical capital

(7) Intellectual property protection

At a time when universities are becoming increasingly aware of the value of their IP, protected IP represents an asset that may be used as a resource for entrepreneurial activity (Landry et al., 2006:1602). The protection of IP via patents, registered designs, trademarks or plant breeder rights generates original and distinctive assets that cannot be legally imitated for a certain period of time. As part of their employment terms, academic researchers agree to assign the IP generated during their employment to the academic institution in question. In return, they are entitled to a percentage of the royalties or equity spawn from the commercialisation of their IP. IP may also be protected by common law, for example through the keeping of a trade secret or a copyright. Feller (2005:201) highlights the importance of protective formal mechanisms when academics collaborate with partners from outside of academia. A positive relationship between a researcher's protected IP and the commercialisation thereof via licensing/assignment of IP or spin-off creation appears to be parsimonious, although there seems to be relevant empirical evidence. The relationship between a protected IP as a physical resource and academic engagement in consulting and sponsored research remains unexplored. This study proposes the following:

Proposition 7. The protection of IP influences the likelihood of an academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

(8) University's innovation infrastructure

It would appear that the university's innovation infrastructure, which includes its supportive infrastructure and networks, plays a crucial role in the diffusion of knowledge and value to society at large. Nilsson, Rickne and Bengtsson (2010:632) emphasise the importance of an active support system consisting of organised networks of knowledge exchange. The participating actors in such an open innovation system may include, inter alia, venture capitalists, university alumni, legal advisors and business developers. New innovation infrastructures have increasingly been allied with the emergence of science and technology parks (Sleuwaegen & Boiardi, 2014:1512). Mohannak (2008:3) views the principal purpose of technology parks as dealing with "innovation in terms of research, development and design, conceiving new products and developing them to the market stage". Thus, such technology parks are a core element of smart innovation infrastructure. In South Africa, over 30 incubators exist in various critical sectors of the economy, ranging from high-technology to high-growth sectors, for example construction (Tshabangu, 2009:54), while the SEDA Technology Programme (2009:6) regards business incubation as "one to the most effective, albeit expensive, tools for supporting small enterprise development".

Clarysse, Mosey and Lambrecht (2009:439) recommend a link between business schools and schools of engineering and the sciences, other technology-orientated organisations, as well as science-based business incubators and science parks. Incubators, leased access to laboratories and equipment and in-kind product development assistance are all examples of subsidy programmes created by universities to enhance the development of their inventions (Shane, 2002:547). In the realisation that merely transferring technology to established, large corporations was not always the best vehicle for bringing early-stage technologies to the market, universities embarked on technology commercialisation efforts and went on to set up business incubation programmes (National Business Incubation Association, 2010). Both the increase in university–entrepreneurial company interaction by lowering the cost of technology development for cash strapped ventures (Shane, 2002:547) and the provision of 'low-cost' entrepreneurship services by universities have played an important role in the success of university spin-offs (Hayter, 2010:100).

Similar to the subsidy programmes, applied science conducted by the universities in the form of buffer institutions is intended to enhance the transfer of research inventions to local industry. An example of such a buffer institution is the African Centre for Gene Technologies (2014:[1]), a cooperative venture between the Council for Scientific and Industrial Research, the University of Pretoria and the University of the Witwatersrand. In addition, South Africa's universities of technology have set up technology stations and institutes for advanced tooling in order to foster the transfer. Based on the above one may assume that the individual researcher who has access to an innovation network at the university to which he/she is affiliated is more likely to engage in entrepreneurial activities than would otherwise be the case. This leads to the following proposition:

Proposition 8. A university's innovation infrastructure influences the likelihood of an academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

Organisational capital-related aspects

(9) University's intellectual property managerial support

The new IPR-PFRD Act of 2008 allows South African universities to fully claim and commercialise the titles of IP derived from government-funded research and reap the economic benefits of such. Technology transfer offices (TTOs) are often regarded as the formal gateway between the university and industry, government and the third sector. Existing literature has highlighted the importance of having well-defined strategies and policies in place, as well as an appropriate mix of expertise and experience in the TTO, in order to provide adequate support for entrepreneurial activities (O'Shea et al*.,* 2005:998; Lockett & Wright, 2005:1048; Rothaermel et al*.,* 2007:140; Abreu & Grinevich, 2013:413). Chang et al. (2006:209) found a positive relationship between a university's IP managerial capability and licensing creation, as well as firm incubation. In addition, Ambos et al.

(2008:1438) found that universities with a specialised TTO have a higher likelihood of a commercial output from the project than would otherwise be the case.

The provision of adequate support for entrepreneurial activities by the university's TTO may enhance the likelihood of the academic participating in consulting, sponsored research, licensing/assignment of IP and spin-off creation.

Proposition 9. The university's intellectual property managerial support influences the likelihood of the academic engaging in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

(10) University's entrepreneurial culture

The creation of an entrepreneurial university is an evolutionary process without end and it is, thus, not a stage that may be passed through once only (Clark, 2001:17). Faculty members are key suppliers in the process of innovation creation (Chang et al*.,* 2006:203). According to Siegel, Waldman and Link (2003:27), the most critical organisational factors in innovation creation include faculty reward systems, TTO staffing/compensation practices and cultural barriers between universities and firms. The organisational policies of universities regarding faculty incentives for entrepreneurial activities, acceptable publication delays and the charter of TTOs influence the comparative cost of academic entrepreneurial activities (Bercovitz & Feldmann, 2006:181). It is assumed that researchers who have been socialised in a non-entrepreneurial university environment are less likely to adopt new unfamiliar entrepreneurial activities compared to those socialised in an entrepreneurial university environment (Renault, 2006:227; Bercovitz & Feldman, 2008:69). Bercovitz and Feldman (2008:69) examined the backgrounds, work environment and engagement in academic entrepreneurship of 1 780 faculty members and found that individuals were more likely to participate in entrepreneurial activities if they had been trained at institutions that had adopted an entrepreneurial culture and been active in

technology transfer. In South Africa, the newly promulgated Intellectual Property Rights from Publicly Funded Research and Development Act (Act 51 of 2008) only came into force on 2 August 2010. In addition, the current academic promotion system in South Africa generally gives very little recognition for the "innovation output" of researchers, despite the fact that patenting activity was recently included in the NRF's rating of researchers (Bailey, 2010:[1]).

Davies (2001:330) cites the following instruments which an entrepreneurial university may use to enhance entrepreneurial activities among its researchers: (1) Provision of structured quality time for entrepreneurial activities (e.g. flexible timetabling of teaching, introduction of a semester-based system and funds for the buy-out of staff from regular teaching activities). (2) Sensitive and explicit reward and incentive structures (e.g. reasonable share of intellectual property income and recognition of entrepreneurial activities for the purposes of promotion and career advancement). (3) Development and training opportunities for academic and administrative faculty to ensure that they obtain competence and familiarity with existing institutional task and, thus, preparing them for highly innovative areas. (4) Flexible contractual arrangements to cope with non-traditional work patterns. (5) Provision of external staff specialists as change agents in the entrepreneurial domains. This study, therefore, proposes the following:

Proposition 10. The university's entrepreneurial culture influences the likelihood of the academic to engage in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

2.6.2 Consequences: teaching and research outputs

It is essential that the impact of the various entrepreneurial activities within the context of the university's other missions, namely, teaching and research, be considered (Perkmann et al., 2013:428). A researcher's engagement in consulting, sponsored research,

licensing/assignment of IP and spin-off creation activities may either enhance or hinder his/her research output in terms of publications and teaching commitments.

(11) Publications

Publications are the outputs of research activities where research is defined as a systematic study performed with the objective of developing or creating knowledge (Halilem, Amara & Landry, 2011:432). The bulk of the new scientific knowledge produced by university researchers contributes to the existing pool of open science (Landry et al., 2006:1603). Despite issues raised about trade-offs between academic productivity and entrepreneurial activities (Fabrizio & Di Minin, 2008:914), the majority of the empirical literature has shown that there is no resultant substitution or crowding-out effect. There may, however, be differences between spin-off creation, licensing/assignment of IP, sponsored research and consulting activities in their impact on scientific research outputs measured in terms of publications.

While several researchers report a positive relationship between patenting and publications (Geuna & Nesta, 2006:801; Van Looy, Callaert & Debackere, 2006:596; Carayol, 2007:119; Stephan, Gurmu, Sumell & Black, 2007:92; Fabrizio & Di Minin, 2008:914; Buenstorf, 2009:290; Lubango & Pouris, 2009:315), there is limited literature available on the relationship between the commercialisation of patents and the publishing of research results. This may, however, be a result of the fact that the complementarities between spin-off creation and scientific productivity are less clear-cut (Van Looy et al., 2011:555). Buenstorf (2009:290) found a positive relationship between the licensing of inventions and publishing. However, with regard to spin-off activities, no specific positive impact of such activities on research productivity has been found. D'Este et al. (2009:27) measured scientific quality in terms of citations to the publication and found no positive relation between spin-off involvement and scientific quality. On the other hand, Lowe and Gonzalez-Brambila (2007:176) showed that the creation of firms does not occur at the expense of continued scientific productivity. At the level of the university, Van Looy et al. (2011:558) reported that the number of scientific publications normalised by the number of academic staff coincides positively with the number of spin-offs established.

Sponsored research, including contract research, industry funding and research collaboration, has been shown to be positively associated with scientific productivity as measured by publications (Gulbrandsen & Smeby, 2005:932; Bonaccorsi et al., 2006:389; Van Looy et al., 2011:558). It would appear that the relationship between the consulting activities of researchers and their publication output has not been well investigated in the literature. One reason for this may be that quantitative data on consulting agreements is extremely scarce (Wright et al., 2008:1216).

There is emerging evidence of a positive relationship between certain entrepreneurial activities and scientific output in terms of publications (Larsen, 2011:9). However, this evidence does not allow for definite conclusions with respect to the direction of causality, as to whether the entrepreneurial activity influences the scientific output or vice versa. For example, in their study, Haeussler and Colyvas (2011:27) found that the number of publications positively drives the level of consulting, patenting and founding. Ambos et al. (2008:1441) tested 207 Research Council-funded projects in the United Kingdom and found that the faculty with the highest levels of citations to the work of its researchers was also the faculty most likely to achieve commercial outcomes from its research projects. In addition, for enhanced university spin-off activity it is critical that a faculty generates world-class research (Di Gregorio & Shane, 2003:222) and that "breakthroughs with natural excludability" are transferred to industry by top academics working in or with ventures (Zucker, Darby & Armstrong, 2002:629). Accordingly, this study proposes a relationship between entrepreneurial activities and publication output:

Proposition 11. The publication output of an academic is influenced by the academic's engagement in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

(12) Teaching

Certain scholars assume that the growing shift towards "academic capitalism" (Slaughter & Leslie, 1997:9), in terms of which researchers increase their own prestige and that of the universities based on their success in generating revenue, has a negative influence on a faculty's commitment to teaching (Lee & Rhoades, 2004:739). There has, however, been little written about how the thinning boundaries between universities and organisations outside academia influence the education of university students (Stephan, 2001:203).

Holmén and Ljungberg (2015:208) investigated the perception of academics regarding the way their experiences arising from societal interactions inform their teaching and vice versa. They found both a positive and a bidirectional relationship. Lee and Rhoads (2004:754) used a United States national database of four-year college faculty and tested the teaching commitment of academics with respect to various forms of entrepreneurial activities. They revealed a negative relationship between the use of funds for research and teaching commitment although, on the other hand, they found that consulting enhanced the commitment of researchers to teaching in positive ways. In addition, Grant and Wakelin (2009:133) found a perceived positive influence of consulting on teaching activities. Stephan (2001:200–202) points out that faculty interaction with industry has the potential to affect the curriculum in both positively and negatively. It may lead to an update of the curriculum to make it more responsive to the needs of society, enhance the integration of new programmes, facilitate the job placements of students and provide funds for students as well as resources for programmes. However, it may also divert the faculty's focus away from the students and the curriculum towards seeking financial benefits. The relationship of trust between faculty and students may be compromised when inventions involve a considerable amount of money.

With regard to spin-off creation, in their study of 1 554 university researchers, Landry, Amara and Rherrad (2006:1611) did not find a statistically significant relationship between teaching activities and spin-off creation. Accordingly, they suggested that "the traditional and entrepreneurial visions of universities and university research can successfully co-exist in the same milieu without harming each other". Jain et al. (2009:928) interviewed

scientists who had been involved in some form of commercialisation activity and who had interacted with their universities' TTO. The researchers point out that certain of their interviewees felt that engagement in entrepreneurial activities interfered with their research and teaching effort. In general, the impact of the engagement of academics in entrepreneurial activities on teaching is not yet well explored and it is not possible to draw any clear conclusions (Perkmann et al., 2013:428). However, this study assumes a relationship and proposes the following:

Proposition 12. The teaching commitment of academics is influenced by his/her engagement in

a) spin-off creation
b) licensing/assignment of IP
c) sponsored research
d) consulting.

2.6.3 Relationships between the entrepreneurial activities of academics

Previous literature has highlighted that potential trade-offs and complementarities on the level of the entrepreneurial activities of academics remain a black box and require further investigation (Van Looy et al., 2011:560; Perkmann et al., 2013:429). In the same way in which the description of antecedents and consequences in the previous sections suggests that the four types of entrepreneurial activity may be driven by different, underlying mechanisms, one may assume possible complementarities or contradictions between such activities. An enhanced understanding of these relationships would also benefit policy debates in terms of clarifying whether more focused policy approaches are required (Perkmann et al., 2013:429), as focusing on one entrepreneurial activity may impact negatively on the other activities (Von Looy et al., 2011:555).

(13) Relationship between sponsored research and licensing/assignment of IP

One may assume a temporal relationship between sponsored research and licensing or assignment of IP, with a prior involvement in either contract or collaboration research eventually resulting in commercial output (Perkmann et al., 2013:429). A practical example of such a situation is the sports nutrition product, "PeptoSport®". In this case, sponsored research led to the development of a formulation and later resulted in a licence agreement between the University of Cape Town and DSM Nutritional Products South Africa (Pty) Ltd (University of Cape Town, 2010:65). It may thus be assumed that a prior transfer of IP, for example the licensing of a patent, could prompt a new sponsored research agreement between the university and the licensee in view of the fact that additional research in the area surrounding the patent is needed. Thursby and Thursby (2011:20) investigated the research and invention disclosure of academic researchers at eleven major universities in the United States over a period of 17 years and found that recent disclosure by academics has had a positive effect on industry and government funding. However, they also established that if academics disclosed multiple times, the effect on government funding may be negative.

On the other hand, the university's commitment to generating IP, such as patents and registered designs, may jeopardise the willingness of firms to engage with such universities in contract research (Van Looy et al., 2011:556). In cases in which the university's TTO has created excessive expectations in terms of royalties, firms may decide to stop the collaboration with IP issues becoming a real barrier to sponsored research (Wright et al., 2008:1217). The same scenario applies to the individual researcher. At some universities in Europe and also in South Africa, research groups have to co-finance part of the patent application costs and thus, if the chances of royalty income are perceived as somewhat small, they may see this as a disincentive (Wright et al., 2008:1215). This study assumes a relationship between sponsored research and the licensing/assignment of IP and proposes:

Proposition 13. Sponsored research and the licensing/assignment of IP coincide.

(14) Relationship between sponsored research and spin-off creation

A project that started as sponsored research may result in a spin-off at a later stage. Shane (2004:166) describes the process of university spin-off creation and places the "use of funded research" at the forefront of university technology development. In the United States of America, the federal government provides more than two-thirds of the funding for research in science and engineering while the rest is underwritten by private firms. These funds enable new scientific knowledge to be produced. This may sometimes lead to the production of a technology invention that can be commercialised in various ways, including spin-off creation (Shane, 2004:167–168).

The presence of university spin-offs and/or the academic researcher's involvement in spin-off creation may have either a positive or a negative effect on sponsored research. Institutions outside academia may anticipate unintended knowledge spillovers between the contract or collaboration research project and the university spin-off. These anticipations may be either positive or negative, thus either enhancing or compromising sponsored research. Van Looy et al. (2011:559) found a significant positive relationship between spin-off activity and contract research at the university level and suggested complementarities rather than substitution effects. Thus:

Proposition 14. Sponsored research and spin-off creation coincide.

(15) Relationship between licensing/assignment of IP and spin-off creation

Prior research suggests that university spin-offs are often established after efforts to license the invention in question to established companies have failed (Arvanitis, Kubli & Woerter, 2008:1867) or when the knowledge related to the invention is highly tacit (Lowe, 2006:416). Regardless of whether spin-off creation may be seen as an alternative to licensing or the sale of IP, it is clear that in most cases the presence and transfer of university IP is a prerequisite for the very same spin-off. It is important to note that, for the purpose of this study, university spin-offs are regarded as new entities which have been created to commercially exploit some knowledge, technology or research results

developed within a university (Pirnay et al., 2003:355). University start-ups are defined as new ventures where the university has been involved in their formation in some way, but that do not have any formal intellectual property agreement with the founders of the start-up (Wright et al., 2008:1207). They are therefore beyond the scope of this study. The following proposition is put forward:

Proposition 15. Licensing/assignment of IP and spin-off creation coincide.

(16) Relationship between consulting and other entrepreneurial activities of academics

The impact of consulting is often overlooked as a result of the unavailability of relevant data (Ding & Choi, 2011:70) and because it is more difficult to track such data compared to publications, patents or licences (Thursby et al., 2009:24). Gulbrandsen and Smeby (2005:944) report that researchers who receive funding from external organisations are in possession of more frequent consulting contracts than researchers with no external funding. Haeussler and Colyvas (2011:45) surveyed life scientists in Germany and the United Kingdom and found that 9% of their 2 294 respondents were involved in consulting and patenting, while 4% were involved in all three activities, namely, consulting, patenting and the founding of a company. This finding corresponds with Rothaermel and Thursby (2005:1079), who point out that when spin-offs are created based on university research, it is common for the academic researcher to retain ties with the new venture either informally via consulting contracts or as a member of the senior management team. In addition, the consulting activities of academics may provide an entry route into external organisations (Wright et al., 2008:1208). Even in the eighties, Bird and Allen (1989:586) pointed out that consulting may result from, as well as lead to, sponsored research arrangements and the commercialisation of a product or service. On the other hand, when Ding and Choi (2011:69) analysed a sample of 6 138 university life scientists, they established that scientists who are academic advisors to firms are less likely to become founders of firms than would otherwise be the case. Their results suggest a trade-off effect rather than the view that one is a stepping-stone to another. In general, it would appear that the

relationships between consulting and the other entrepreneurial activities of academics are nuanced. For the purposes of this study the following propositions are formulated:

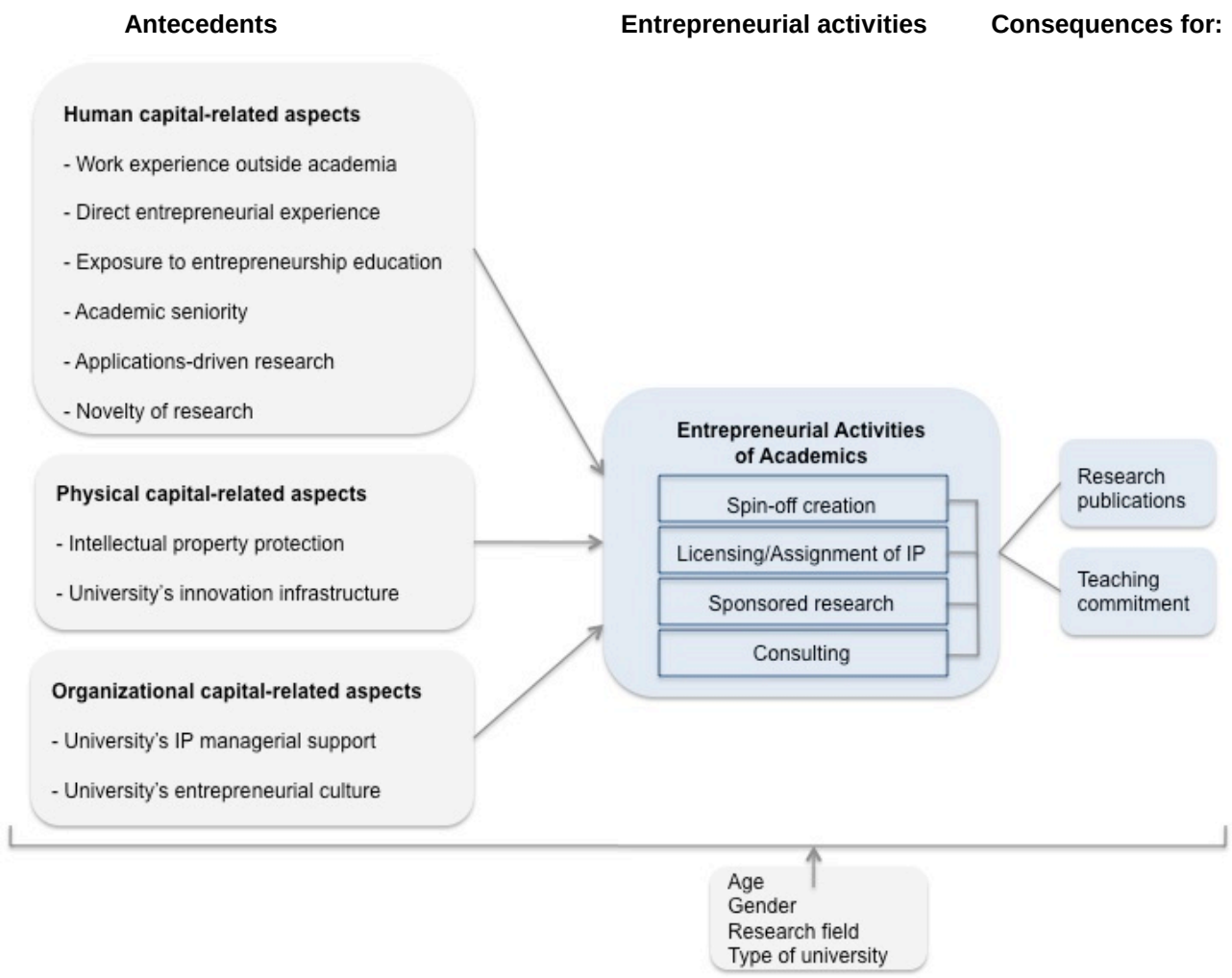
Proposition 16. Sponsored research and consulting coincide.

Proposition 17. Licensing/assignment of IP and consulting coincide.

Proposition 18. Spin-off creation and consulting coincide.

The conceptual framework presented in figure 2.1 illustrates in visual form the propositions outlined above. In addition, the framework also indicates both antecedents and consequences as well as the classification and co-variables of age, gender, research field and type of university.

Figure 2.1: Conceptual framework: entrepreneurial activities by academics



Source: Author's own compilation.

2.7 CONCLUSION

The purpose of this chapter was to contextualise the entrepreneurial activities of academics within the field of Academic Entrepreneurship, which is in turn a subdivision of the research field of Entrepreneurship. For the purposes of this study the entrepreneurial activities of academics are defined as the activities occurring beyond the traditional academic roles of teaching and/or research. These activities are reflected primarily in the interactions of academics with industry, government and civil society via consulting, sponsored research, licensing/assignment of intellectual property and spin-off creation.

The core dimensions representing the entrepreneurial activities of academics in this study include interactions with industry, government and the third sector via consulting, sponsored research, licensing/assignment of IP and spin-off creation. As a theoretical anchor, this research study integrated resource-based research and Joas's theory of the creativity of action. Firstly, the antecedents of the entrepreneurial activities of academics, as indicated in the existing literature, were categorised into aspects related to human capital, physical capital and organisational capital resources and then described. For the purposes of this study the human capital-related aspects include: (1) work experience outside of academia, (2) direct entrepreneurial experience, (3) exposure to entrepreneurship education, (4) academic seniority, (5) applications-driven research and (6) novelty of research; the aspects related to physical capital resources include (7) intellectual property protection and (8) the university's innovation infrastructure; while the aspects related to organisational capital include (9) the university's IP managerial support and (10) the university's entrepreneurial culture.

Secondly, relevant literature on the possible consequences of academics' involvement in entrepreneurial activities may have for research and teaching, and mixed results were discussed. This was followed by an explanation of the relationship between the various entrepreneurial activities based on which certain propositions were put forward. The next chapter contextualises the setting of the study. As such, the chapter provides a brief overview of the South African national system of innovation and highlights several interacting economic, social and political developments that may impact on the entrepreneurial activities of academics at South African universities.

CHAPTER 3
Academic Entrepreneurship in South Africa

3.1 INTRODUCTION

The previous chapter provided the theoretical foundation for the assessment of the entrepreneurial activities of academics and their antecedents and consequences in the South African university context. The chapter illustrated the development of the field of entrepreneurship and presented the current state of research into entrepreneurship in the field of higher education. Based on research into entrepreneurship the chapter then discussed a wider interpretation of Academic Entrepreneurship as a field of research that includes a range of entrepreneurial activities conducted by academics across different disciplines. In addition, the core dimensions of consulting, sponsored research, licensing/assignment of intellectual property (IP) and spin-off creation were defined. The theoretical framework of the study, which integrates resource-based research and the creativity of action theory was discussed, possible antecedents and consequences of the entrepreneurial activities of academics expounded upon and propositions put forward.

There is increasing recognition that the study of entrepreneurial activities should include an analysis of these activities in their wider context (Watson, 2013a:404; Wright, 2014:323). This chapter contextualises the setting of the study; it also briefly characterises South Africa's national system of innovation, explores the transformation in South Africa's higher education sector and highlights several interacting economic, social and political developments which impact on the entrepreneurial activities of academics. Referring back to chapter 2 of the study, it must be remembered that entrepreneurship in the academic world is fundamentally different from entrepreneurship in the business world (Yang, 2012:399). For the purpose of this study the entrepreneurial activities of academics are defined as those activities which occur beyond the traditional academic roles of teaching and/or research.

The following analyses are not intended to be comprehensive but rather attempt to expose some features that will assist to specify aspects that differentiate the setting of this study in the South African context from study settings in advanced industrial societies.

3.2 SOUTH AFRICA'S NATIONAL SYSTEM OF INNOVATION: AN OVERVIEW

The term 'national system of innovation' has become widely used among policy makers and scholars throughout the world. The concept was developed at the beginning of the 1980s by Christopher Freeman (1987) and the IKE group in Aalborg (Lundvall, 1985). The national system of innovation is an aggregate of elements, including organisations and institutions involved in searching, exploring, diffusing, absorbing and using innovation (Lundvall, 2007:101; Marxt & Brunner, 2013:1035). In addition to the local integration of the system of innovation, the international dimension should also be accounted for (Leydesdorff & Strand, 2013:1891). South Africa's innovation system has been shaped by the infrastructure, assets and distortions inherited from the apartheid era (OECD, 2012:380). The national system of innovation proposed in the South African Science and Technology Policy (OECD, 2007:2; Kaplan, 2008:97) calls for a set of functioning institutions, organisations and policies to interact in pursuit of common social and economic goals. The introduction of innovation is seen as a key promoter of change in the country, while South Africa's National Development Plan (South Africa. National Planning Commission, 2012:326) states that the system of innovation has a key role to play in improving the nation's global competitiveness.

The central policy intention of South Africa's National Development Plan (South Africa. National Planning Commission, 2012:262) is to focus the nation's energies both on addressing poverty and on expanding a robust, entrepreneurial and innovative economy. At the beginning of the higher education section it states that:

> Universities are key to developing a nation. They play three main functions in society. Firstly, they educate and train people with high-level skills for the employment needs of the public and private sectors. Secondly, universities are the dominant producers

> of new knowledge, and they critique information and find new local and global applications for existing knowledge. Universities also set norms and standards, determine the curriculum, languages and knowledge, ethics and philosophy underpinning a nation's knowledge-capital. South Africa needs knowledge that equips people for a society in constant social change. Thirdly, given the country's apartheid history, higher education provides opportunities for social mobility and, simultaneously, strengthens equity, social justice and democracy. In today's knowledge society, higher education underpinned by a strong science and technology innovation system is increasingly important in opening up people's opportunities.

This statement reflects that the National Development Plan regards universities as major development drivers towards a knowledge-based economy. South Africa is an emerging economy with the capacity to innovate (Wolson, 2007:343). The country is undergoing a transformation process towards a knowledge-based economy in which the production and dissemination of knowledge leads to economic benefits and enriches all fields of human endeavour (South Africa. Department of Science and Technology, 2007:1). The same focus is echoed in South Africa's New Growth Path (South Africa, 2011:13), which targets 100 000 new jobs by 2020 in the knowledge-intensive sectors of ICT, higher education, health care, mining-related technologies, pharmaceuticals and biotechnology.

The knowledge-based economy has four pillars: (1) The Economic Incentive and Institutional Regime, (2) Education and Human Resources, (3) The Innovation System, and (4) Information and Communication Technology (World Bank, 2014). According to the World Bank's 2012 Knowledge Economy Index (KEI), South Africa ranked 67 out of 145 countries, fifteen positions down from the year 2000 (World Bank, 2012:2). South Africa had fallen back primarily because of large reversals in its ICT pillars. Table 3.1 depicts the index for the four pillars of the Knowledge Economy Index (KEI).

Table 3.1: Knowledge Economy Index for South Africa

Description	Index
Economic Incentive and Institutional Regime	5.49
Education	4.87
Innovation	6.89
ICT	3.58
Knowledge Economy Index	5.21

Source: Adapted from World Bank (2012:2)

In the context of the Global Innovation Index 2014, South Africa scored 38.2 out of 100 points and was ranked 53 out of 143 nations (Global Innovation Index, 2014:256). This is a low score compared to the scores of the other BRICS countries which all qualified as 'efficient innovators' in 2014. This means that these countries obtained innovation efficiency scores – calculated as total innovation outputs over total innovation inputs – which are greater than or equal to the average of 0.76 (Global Innovation Index, 2014:12). The Innovation Efficiency Ratio looks at the ratios of input factors and output factors and shows how much innovation output a nation is obtaining in return for its innovation input. South Africa has an Innovation Efficiency Index of 0.7. Input factors are made up of institutions, human capital and research, infrastructure, market sophistication and business sophistication, while output factors include knowledge and technology outputs and creative outputs (Global Innovation Index, 2014:7). Competitiveness problem areas which are contributing to South Africa's somewhat low innovation performance have been identified as the education system, especially the pupil–teacher ratio at secondary schools, ratio of gross capital formation to GDP, ratio of GDP per unit of energy use, venture capital deals and patent families filed in more than three offices, communication, computer and information services, imports and exports as a percentage of total trade, foreign direct investment net inflows, national feature films produced and video uploads on YouTube. Market sophistication was designated as South Africa's strength (Global Innovation Index, 2014:256).

Overall, South Africa's gross expenditure on research and development (GERD) was R22.2 billion in the period 2011/12. The GERD covers all expenditures for research and development carried out on national territory in a given year. Compared to 2010/2011, in

2011/12 South Africa invested R2 billion more in research and development (R&D) and maintained the level of GERD at 0.76% of the country's GDP (South Africa. Department of Science and Technology, 2014:3). As a comparison, the European Union's (EU) average GERD was 1.94% and the OECD's average 2.37% in 2011/12. Among the BRICS countries, R&D intensity was above 1% in Brazil, China and the Russian Federation and below 1% in India and South Africa. The key indicators of the South African National Survey of Research and Experimental Development 2011/2012 are presented in table 3.2. The survey uses the Organisation for Economic Co-operation and Development (OECD) definition as per the Frascati Manual (Organisation for Economic Co-operation and Development, 2002:30) for research and experimental development as comprising "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new application."

Table 3.2: Key indicators of the South African National Survey of Research and Experimental Development

Key Indicator	Value		
	2011/12	2010/11	2009/10
Gross domestic expenditure on R&D (GERD) (Rand million)	22'209	20'254	20'955
Gross domestic product (GDP) at current prices (Rand million)	2'917'539	2'664'269	2'395'967
GERD as percentage of GDP	0.76	0.76	0.87
Civil GERD as percentage of GDP	0.72	0.71	0.82
Basic research (Rand million)	5 440	4 848	5 553
Total R&D personnel (FTE[1])	30 978.4	29 486.4	30 891.3
Total researchers[2] (FTE[1])	20 115.1	18 719.6	19 793.1
Total researchers[2] (FTE[1]) per 1000 in total employment	1.5	1.4	1.5
Total R&D personnel (FTE[1]) per 1000 in total employment	2.3	2.2	2.3
Total researchers (headcount)	40 653	37 901	40 797
Female researchers (headcount) as % of total researchers[2]	42.3	41.7	40.8

[1] FTE= full-time-equivalent

[2] following OECD practice doctoral students and post-doctoral fellows are included as researchers.

Source: Adapted from the South African National Survey of Research and Experimental Development – Main Analysis Report 2011/12 (South Africa. Department of Science and Technology, 2014:2)

Civil GERD stands for civil gross expenditure on R&D and is the sum of all expenditure by socioeconomic objective, minus expenditure on defence R&D. Table 3.2 shows that South

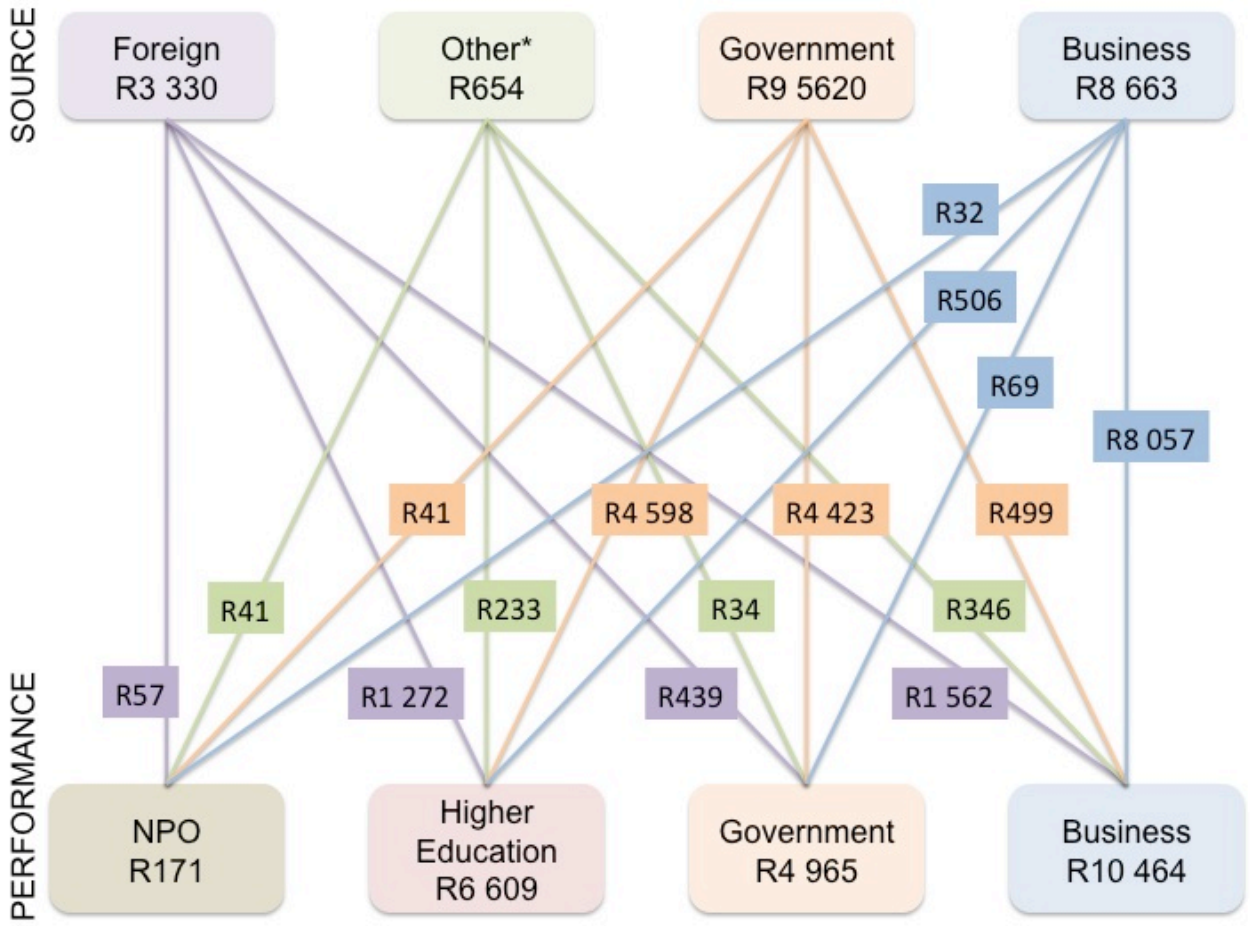
Africa's Civil GERD, as a percentage of GDP, decreased from 0.82 % in 2009/10 to 0.72% in 2011/12. In the 2011/12 period, a total of R5 440 million was invested in basic research. The pattern towards increased expenditure on applied research continued and consolidated the shift in the overall composition of GERD by type of research. The share of GERD for basic research was 24.5%, the proportion of applied research was 42.3% while experimental development accounted for 33.2% in 2011/12 (South Africa. Department of Science and Technology, 2014:11).

Full-time equivalent R&D personnel increased by 5% between 2010/11and 2011/12. The increase came from the higher education sector, with the key driver being doctoral students and post-doctoral fellows (South Africa. Department of Science and Technology, 2014:20). Female researchers made up over 40% of total researchers. All sectors increased their nominal R&D expenditure in 2011/2012 with a robust increase in the higher education sector. Higher education expenditure on R&D in current rand value grew by 22% from R5.425 billion in 2010/11 to R6.609 billion in 2011/12. The business sector is, traditionally, the largest performer of R&D in South Africa, with an expenditure of R10.464 billion in 2011/12. Government, science councils and not-for-profit organisations had expenditures of R1.236 billion, R3.730 billion and R171 million respectively in 2011/12 (South Africa. Department of Science and Technology, 2014:5).

The nature of how and where research is conducted has changed. There are now multiple sites of research and knowledge production and it is essential that all these sites of research and innovation are coordinated and function coherently. The research and innovation system should take advantage of new modes of knowledge production, economies of scale and opportunities by working across disciplines (South Africa. National Planning Commission, 2012:326).

The overarching innovation framework in South Africa involves the higher and further education system, state-owned enterprises, science councils, government, not-for-profit organisations and private industries. The major flows of R&D funding within this framework are presented in figure 3.1.

Figure 3.1: Major flows of R&D funding (million), 2011/12



'Other' includes contributions from higher education, not-for-profit organisations and individual donations.

** Government includes science councils.

Source: South African National Survey of Research and Experimental Development – Main Analysis Report 2011/12 (South Africa. Department of Science and Technology, 2014:6)

Higher education institutions and science councils receive the bulk of the R&D funded by government. In South Africa, publicly financed research institutions, which include 23 higher education institutions, as per the Higher Education Act, 1997 (Act No. 101 of 1997) and five science councils, form the largest concentration of skills and human resources in the area of knowledge generation (Sibanda, 2009:113). There are a number of strong linkages in place between industry and these research organisations (Wolson, 2007:344). The way in which these interactions take place has not yet been well explored and, thus, the empirical component of this research study aims to shed some light on the intensity

and form of interaction between academic researchers and industry, government and civil society.

Over the previous two decades, universities throughout the industrial world have been exposed to or infiltrated by market relations with movements such as *massification*, *marketisation* and *managerialism* taking place (Bundy, 2005:86). These movements include a major shift away from the public funding of higher education towards greater revenue from entrepreneurial activities than before, the promotion of university–industry research agendas and the routine use of entrepreneurship-related terminology (Mautner, 2005:102). The impact of neoliberal influences is related to the redefinition of knowledge as commodity (Bundy, 2006:4). In addition to the endogenous pressures on universities emanating from both the state and the market, exogenous changes relating to the production, consumption, circulation and conservation of knowledge are pressing in on universities (Bundy, 2006:7).

The debate about the entrepreneurial university and its unique position both within and outside of society underlines Zahra and Wright's (2011:67) premise of contextualisation as found in their entrepreneurship studies. They state that "[e]ntrepreneurial contexts exhibit considerable novelty, given that they are in the early stages of emergence". In addition, the boundaries of these contexts also change constantly because of the dynamism of the actors and processes involved (Zahra & Wright, 2011:72).

In South Africa today, the context surrounding the entrepreneurial activities of academics appears to differ from that of academics in other countries. South Africa's history of colonialism and apartheid has left a legacy not only of complexity and diversity but also of a unique evolution of academic freedom, institutional autonomy and public accountability in higher education in the country. This evolution is explained further in the following section.

3.3 TRANSFORMATION AT SOUTH AFRICAN UNIVERSITIES

In the mid-1990s the transformation, restructuring and mergers within the South Africa's higher education system had to correspond with a newly established democracy while also addressing the social and economic deficits inherited from the apartheid system (Lange, 2003:1). However, the major reconfiguration of South Africa's higher education landscape took place from 2004 onwards. Through a process of mergers and renaming, South Africa's 36 higher education institutions were trimmed down to eleven traditional universities, six comprehensive universities and six universities of technology. The public universities in post-apartheid South African are based on the British model. The senate of each university is responsible for academic matters and the university councils are in charge of internal governance (Krüger, 2013:7). In referring to the South African context, Du Pré (2009:14) describes a university as

> … an academic institution at which research is conducted and teaching and learning are offered within the organised cadre of the contact between lecturer and student, and supported by networking, cooperation and collaboration with external academic partners to create, develop and transmit new knowledge.

As an academic institution, the university has to overcome the restrictions faced by the identification of a university as an idea, and the following three principles apply: academic freedom, institutional autonomy and public accountability. These are interlocking concepts and, ideally, academic freedom and institutional autonomy should not merely be constrained by public accountability but be firmly grounded in democratic accountability (Jonathan, 2006:10). The South African Constitution explicitly lists academic freedom in its Bill of Rights under the heading "freedom of expression" (1996b, 2014:section 16[1d]), and states the following: "Everyone has the right to freedom of expression, which includes – (d) academic freedom and freedom of scientific research." Thus, those responsible for drafting the South African Constitution were clearly reacting to the infringements of academic freedom which had occurred in the past. Examples of such infringements include state-controlled admission at the supposed racial-group level, deep inequalities relating to funding, resources, content of curricula and pedagogy, as well as undue restrictions of any

critical analysis of governmental actions and policies (Jonathan, 2006:61; Krüger, 2013:24).

The last decade has seen the introduction of several policies, programmes and institutions designed to bridge the chasm between society and the knowledge developed by universities and science councils. In 1996, the White Paper on Science and Technology created a framework based on the national system of innovation concept. The National Research and Technology Foresight (2000) and the National Research and Development Strategy (2002) followed the White Paper. In 2007, the Department of Science and Technology released its Ten-Year Plan for South Africa. This plan was called "Innovation towards a knowledge-based economy" and it presented the principal challenges which had been identified by the Department of Science and Technology, while also providing core projections for 2018.

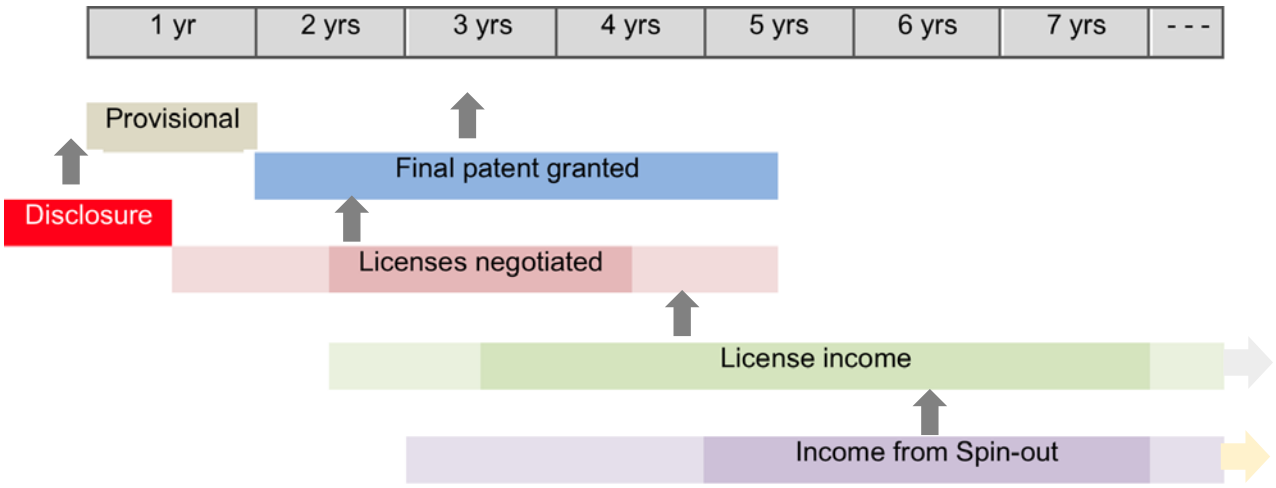
South Africa's Department of Science and Technology aims to drive progress towards a knowledge-based economy and is applying a problem-solving, multidisciplinary, partnership approach to innovation as a mechanism of growth and development (2012:326). In its Ten-Year Innovation Plan (2007:6), the Department of Science and Technology places the focus on the following four elements: (1) human capital development, (2) knowledge generation and exploitation, (3) knowledge infrastructure, and (4) enablers to address the 'innovation chasm' between research results and socioeconomic outcomes. The 'innovation chasm' is a concept which describes the gap that exists between the knowledge generators, in particular universities and research institutions, and the market. South Africa's Department of Science and Technology (2007:8) intends to foster the commercialisation of the results of scientific research, generate more knowledge workers capable of building a globally competitive economy and form working partnerships between intellectual property holders and industry.

A major milestone in this initiative was the passing of the Intellectual Property Rights from Publicly Financed Research and Development Act 51 (IPR-PFRD Act) in 2008. The Act was proclaimed in the *Government Gazette* on 30 July 2010 and came into operation on

2 August 2010. The act calls for the introduction of a uniform approach to the protection of intellectual property developed with public financing and based on good practice globally, while remaining responsive to the local context. It is the responsibility of every institution to seek protection for its intellectual property in exchange for the right to own and exploit such intellectual property (Wolson, 2007:357). In addition, the legislation requires institutions to establish a designated office of technology transfer (TTO) to undertake institutional obligations which include a reporting duty to a designated government agency on intellectual property management activity and the obligation to share the revenues earned from intellectual property exploitation with the individual inventors or creators of the intellectual property concerned. The government reserves the right to a 'free licence' if this is in the national interest, while preference should be given to the people of the Republic of South Africa in the licensing of small enterprises as defined in section 1 of the National Small Enterprise Act, 1996 (Act No. 102 of 1996) (South Africa, 1996a); and BBBEE, as defined in section 1 of the Broad-Based Black Economic Empowerment Act, 2003 (Act No. 53 of 2003) (South Africa, 2003a). In addition, it introduces the establishment of a technology innovation agency (TIA) whose purpose it is to help to close the financing gap between research and commercialisation by means of new creative funding mechanisms and the establishment of a network of competence centres focused on market opportunities and in partnership with industry and public research institutions (Department of Science and Technology, 2007:26).

In the main, the typical phasing of the value chain (see figure 3.2) from disclosure to licence income is between three and seven years (Heher, 2006:405).

Figure 3.2: Typical phasing of the value chain



Source: Adapted from Heher (2006:405)

These long time delays mean that it is extremely difficult to collect and interpret innovation system benchmark data. In addition, a sound understanding of the origins and structure is necessary in order to avoid misuse of the data. Heher (2006:407) developed a model which uses international benchmark data from the AUTM annual surveys and from similar surveys conducted elsewhere, including in the United Kingdom, Europe and Australia, which attempts to normalise values in an effort to obtain comparable data for different national systems. Heher (2006:412) concluded that if South Africa were to attain innovation performance similar to comparable institutions elsewhere and operate at international norms of efficiency, its entire education system could be expected to generate between 200 and 300 invention disclosures a year. After a period of seven to 10 years this number of invention disclosures should lead to a portfolio of approximately 500 active licences.

Although these outlooks are promising, there are nevertheless constraints in the current system and serious efforts are required to overcome such constraints. The government funding pattern has implications for IP generation and ownership. As explained in section 3.2 of this chapter, in South Africa approximately 70% of the higher education funds come

from government while the rest is sourced elsewhere. Further constraints include few invention disclosures, the high costs associated with international patenting, the limited capacity of technology transfer practitioners, unclear expectations and objectives for TTOs, and limited licensing opportunities (Wolson, 2007:361).

Licensing opportunities for existing local ventures are rare as these local ventures often do not have the markets or distribution channels for viable exploitation. At the same time, despite the fact that the IPR-PFRD Act of 2008 favours IP transfer to small enterprises, start-up opportunities for new businesses are limited as it is not easy to raise finance from risk-averse financial institutions and venture capitalists or business angels (Wolson, 2007:364). On the one hand, universities are under pressure to generate revenues from their IP and, on the other, they also need adequate funding to enable them to engage in the international marketing of their research output through commercialisation.

3.4 CONCLUSION

The purpose of this chapter was to briefly contextualise the setting of the study. South Africa's history of colonialism and apartheid has left a legacy not only of complexity and diversity but also of a unique evolution of academic freedom, institutional autonomy and public accountability in higher education in South Africa. Together with the private sector, government and civil society, higher education serves as innovation actor within the context of the South African national system of innovation. The system of innovation has a key role to play in improving South Africa's global competitiveness. However, its existence alone is not sufficient to guarantee scientific or technological breakthroughs or social innovations. Innovation is prompted by encouraging conditions in which both actors and society are open to new approaches and apply creative, critical and entrepreneurial thinking.

At present South Africa is in position 67 out of 145 countries in the World Bank's 2012 Knowledge Economy Index (KEI). South Africa has dropped fifteen positions relative to its position in 2000 (World Bank, 2014:2). In the context of the Global Innovation Index 2014,

South Africa scored 38.2 out of 100 points and was ranked 53 out of 143 nations – low compared to the other BRICS countries (Global Innovation Index, 2014:256). An examination of the innovation profile of South Africa reveals that the major challenges facing the country include a shortfall in human capital development, low business expenditure on R&D, low triadic patents per million population, as well as low-level ICT penetration.

South Africa performs relatively well in its ability to attract foreign research funding and in university–industry research collaborations (see table 3.1). For example, business funding accounts for a larger share of university research and development than in many other countries (OECD, 2007:10, South Africa. Department of Science and Technology, 2014:6) with South Africa attracting R&D funding from multinational companies through its participation in global R&D programmes and through joint R&D programmes with multinationals (OECD, 2012:380). In terms of the Equity Equivalent (EE) Investment Programme for multinationals, the code of good practice requires that all entities operating in the South African economy make a contribution towards the objective of Broad Based Black Economic Empowerment (BBBEE) (OECD, 2014:34). Among other essential criteria, the objectives of an EE must include "infrastructure investment with an emphasis on developing the country's research and development infrastructure" (OECD, 2014:35). Between 2010/11 and 2011/12 the foreign funding of higher education R&D increased by nearly R800 million. However, this increase was primarily the result of a confirmed spike in foreign funding at one university (South Africa. Department of Science and Technology, 2014:10).

The National Development Plan 2030 calls for greater investment in research and development and more innovation efficiency. The National Roadmap on Innovation Infrastructure is currently being developed. South Africa has made structural investments in large-scale facilities (OECD, 2012:382). An example of such structural investments is the South African National Research Network (SANReN), a high-speed network dedicated to research traffic, as well as research into networking and broadband infrastructure (SANReN, 2014). Significant investments in scientific equipment include the Karoo Array

Telescope (MeerKAT), a precursor to the Square Kilometre Array (SKA) telescope. The SKA project is an international effort to build the world's largest radio telescope (SKA Project, 2014). The Technology and Innovation Agency (TIA) has been established in order to strengthen links to science, technology and innovation policies. The National Development Plan 2030 further stresses the importance of enhanced cooperation between the actors in the national innovation system. There are several possible strands of action to raise innovation performance, including the IPR-PFRD Act of 2008 described in this chapter. A specific strand of action is the support and retention of top innovators with strong patent portfolios and productive entrepreneurial academics with a desire to follow through on their inventions.

The next chapter addresses the question, “Is it possible for academic entrepreneurial activities and their antecedents and consequences to be addressed in the South African university context?” from an empirical perspective. The chapter outlines the research methodology used in the study.

CHAPTER 4
Research Design and Methodology

4.1 INTRODUCTION

Chapter 2 discussed the main resource determinants of the entrepreneurial activities of academics in terms of spin-off creation, licensing/assignment of IP, sponsored research and consulting. For the purposes of this study, human capital-related aspects consist of work experience outside of academia, direct entrepreneurial experience, exposure to entrepreneurship education, academic seniority, applications-driven research and novelty of research. Physical capital related aspects in the context of academic entrepreneurship are powered by IP protection and the university's innovation infrastructure, while organisational capital-related aspects include the university's IP managerial support as well as the university's entrepreneurial orientation. The research setting in the innovation system of the emerging economy South Africa was explained in chapter 3.

The question guiding this research is: "Is it possible for academic entrepreneurial activities and their antecedents and consequences to be assessed in the South African university context?" Based on this research question, the following more specific research questions were formulated:

- To what extent do academics affiliated to South African universities engage in entrepreneurial activities with industry, government and civil society?

- To what extent do aspects related to the human, physical and organisational capital resources of academics influence their engagement in consulting and sponsored research activities, as well as commercialisation activities in terms of licensing/assignment of IP and spin-off creation?

- To what extent do the entrepreneurial activities of academics relate to the traditional academic activities of teaching and research?

- To what extent do the entrepreneurial activities of spin-off creation, licensing/assignment of IP, sponsored research and consulting coincide with each other?

This chapter discusses the hypotheses which were formulated in order to address the research questions from an empirical perspective. The chapter then explains the research methodology used in the study in detail. The research methodology includes the research design, sampling procedures, data collection and data analysis approaches used for the purposes of this study.

4.2 HYPOTHESES

Propositions were formulated in chapter 2 of this study. Once propositions are formulated for empirical testing, they are transformed into hypotheses (Cooper & Schindler, 2008:64). Hypotheses serve as a point of departure for empirical research and are the link between the theory and the research that leads to the broadening of existing knowledge. Hypotheses are based on the secondary research conducted and are presented visually in the conceptual framework for this study. Hypotheses are declarative statements about the relationship between two or more variables (Cooper & Schindler, 2008:64) and provide structure and direction to a research study.

An alternative hypothesis is the complement of the null hypothesis. A null hypothesis is a statement that asserts the status quo, which means that there is no difference between the group means (Hair, Bush & Ortinau, 2006:518). Exploratory hypotheses postulate the existence of a difference only but without any a priori expectations as to the direction of the difference(s), while directional hypotheses also indicate the direction of the difference (Diamantopoulos & Schlegelmilch, 2000:133). The hypotheses formulated for the purposes of this study were derived from the main purpose of the study, namely, to assess entrepreneurial activities and their individual-level antecedents and consequences in the South African university context.

The following statistical hypotheses were formulated for the purposes of the study:

Human capital-related aspects in the context of academic entrepreneurship

(1) Work experience outside of academia

$H_{0.1a}$ There is no significant relationship between work experience outside of academia [WEO] and spin-off creation [SPC].

$H_{0.1b}$ There is no significant relationship between work experience outside of academia [WEO] and licensing/assignment of IP [LAI].

$H_{0.1c}$ There is no significant relationship between work experience outside of academia [WEO] and sponsored research [SPR].

$H_{0.1d}$ There is no significant relationship between work experience outside of academia [WEO] and consulting [CON].

(2) Direct entrepreneurial experience

$H_{0.2a}$ There is no significant relationship between direct entrepreneurial experience [DEE] and spin-off creation [SPC].

$H_{0.2b}$ There is no significant relationship between direct entrepreneurial experience [DEE] and licensing/assignment of IP [LAI].

$H_{0.2c}$ There is no significant relationship between direct entrepreneurial experience [DEE] and sponsored research [SPR].

$H_{0.2d}$ There is no significant relationship between direct entrepreneurial experience [DEE] and consulting [CON].

(3) Exposure to entrepreneurship education

$H_{0.3a}$ There is no significant relationship between exposure to entrepreneurship education [EEE] and spin-off creation [SPC].

$H_{0.3b}$ There is no significant relationship between exposure to entrepreneurship education [EEE] and licensing/assignment of IP [LAI].

$H_{0.3c}$ There is no significant relationship between exposure to entrepreneurship education [EEE] and sponsored research [SPR].

$H_{0.3d}$ There is no significant relationship between exposure to entrepreneurship education [EEE] and consulting [CON].

(4) Academic seniority

$H_{0.4a}$ There is no significant relationship between academic seniority [SEN] and spin-off creation [SPC].

$H_{0.4b}$ There is no significant relationship between academic seniority [SEN] and licensing/assignment of IP [LAI].

$H_{0.4c}$ There is no significant relationship between academic seniority [SEN] and sponsored research [SPR].

$H_{0.4d}$ There is no significant relationship between academic seniority [SEN] and consulting [CON].

(5) Applications-driven research

$H_{0.5a}$ There is no significant relationship between applications-driven research [ADR] and spin-off creation [SPC].

$H_{0.5b}$ There is no significant relationship between applications-driven research [ADR] and licensing/assignment of IP [LAI].

$H_{0.5c}$ There is no significant relationship between applications-driven research [ADR] and sponsored research [SPR].

$H_{0.5d}$ There is no significant relationship between applications-driven research [ADR] and consulting [CON].

(6) Novelty of research

$H_{0.6a}$ There is no significant relationship between novelty of research [NOR] and spin-off creation [SPC].

$H_{0.6b}$ There is no significant relationship between novelty of research [NOR] and licensing/assignment of IP [LAI].

$H_{0.6c}$ There is no significant relationship between novelty of research [NOR] and sponsored research [SPR].

$H_{0.6d}$ There is no significant relationship between novelty of research [NOR] and consulting [CON].

Aspects related to physical capital in the context of academic entrepreneurship

(7) Intellectual Property protection

$H_{0.7a}$ There is no significant relationship between intellectual property protection [IPP] and spin-off creation [SPC].

$H_{0.7b}$ There is no significant relationship between intellectual property protection [IPP] and licensing/assignment of IP [LAI].

$H_{0.7c}$ There is no significant relationship between intellectual property protection [IPP] and sponsored research [SPR].

$H_{0.7d}$ There is no significant relationship between intellectual property protection [IPP] and consulting [CON].

(8) University's innovation infrastructure

$H_{0.8a}$ There is no significant relationship between the university's innovation infrastructure [UII] and spin-off creation [SPC].

$H_{0.8b}$ There is no significant relationship between the university's innovation infrastructure [UII] and licensing/assignment [LAI].

$H_{0.8c}$ There is no significant relationship between the university's innovation infrastructure [UII] and sponsored research [SPR].

$H_{0.8d}$ There is no significant relationship between the university's innovation infrastructure [UII] and consulting [CON].

Organisational capital-related aspects in the context of academic entrepreneurship

(9) University's intellectual property managerial support

$H_{0.9a}$ There is no significant relationship between the university's IP managerial support [UIM] and spin-off creation [SPC].

$H_{0.9b}$ There is no significant relationship between the university's IP managerial support [UIM] and licensing/assignment of IP [LAI].

$H_{0.9c}$ There is no significant relationship between the university's IP managerial support [UIM] and sponsored research [SPR].

$H_{0.9d}$ There is no significant relationship between the university's IP managerial support [UIM] and consulting [CON].

(10) University's entrepreneurial culture

$H_{0.10a}$ There is no significant relationship between the university's entrepreneurial culture [UEC] and spin-off creation [SPC].

$H_{0.10b}$ There is no significant relationship between the university's entrepreneurial culture [UEC] and licensing/assignment of IP [LAI].

$H_{0.10c}$ There is no significant relationship between the university's entrepreneurial culture [UEC] and sponsored research [SPR].

$H_{0.10d}$ There is no significant relationship between the university's entrepreneurial culture [UEC] and consulting [CON].

Consequences for teaching and research

(11) Publication output

$H_{0.11a}$ There is no significant relationship between spin-off creation [SPC] and publication output [PUB].

$H_{0.11b}$ There is no significant relationship between licensing/assignment of IP [LAI] and publication output [PUB].

$H_{0.11c}$ There is no significant relationship between sponsored research [SPR] and publication output [PUB].

$H_{0.11d}$ There is no significant relationship between consulting [CON] and publication output [PUB].

(12) Teaching commitment

$H_{0.12a}$ There is no significant relationship between spin-off creation [SPC] and teaching commitment [TEC].

$H_{0.12b}$ There is no significant relationship between licensing/assignment of IP [LAI] and teaching commitment [TEC].

$H_{0.12c}$ There is no significant relationship between sponsored research [SPR] and teaching commitment [TEC].

$H_{0.12d}$ There is no significant relationship between consulting [CON] and teaching commitment [TEC].

Relationships between the entrepreneurial activities of academics

$H_{0.13}$ Sponsored research [SPR] and licensing/assignment of IP [LAI] do not coincide.

$H_{0.14}$ Sponsored research [SPR] and spin-off creation [SPC] do not coincide.

$H_{0.15}$ Licensing/assignment of IP [LAI] and spin-off creation [SPC] do not coincide.

$H_{0.16}$ Sponsored research [SPR] and consulting [CON] do not coincide.

$H_{0.17}$ Licensing/assignment of IP [LAI] and consulting [CON] do not coincide.

$H_{0.18}$ Spin-off creation [SPC] and consulting [CON] do not coincide.

The program R, version 3.1.0 (2014-04-10), was used to test the hypotheses. The procedures followed and the properties of testing are outlined in section 4.3.4 – Analytical approach.

4.3 RESEARCH METHODOLOGY

The following sections discuss the research design, sampling, data collection and data analysis approaches used in the study.

4.3.1 Research design

This research study adopted the view of the positivist. Positivism argues that only phenomena that you can observe will lead to the production of credible data. Existing theory is used to develop hypotheses and these hypotheses are tested and either confirmed or refuted. This leads to further development of theory (Saunders, Lewis & Thornhill, 2009:113). In positivist studies the researcher's view of the nature of reality is external, objective and independent of social actors. Focus on causality and law-like generalisations reduce the phenomena to their simplest elements. Highly structured data collection methods are most often used and the researcher is independent of the data (Saunders et al., 2009:119). For the empirical analysis this study emphasised a deductive–objective–generalising approach.

This research study was designed as an experimental study to analyse the entrepreneurial activities of academic researchers at South African universities. The study included a literature review and an empirical study. The literature review provided insights into the field of academic entrepreneurship, its evolution and the connection between entrepreneurship and university innovation in both the global and the South African context. In addition, the literature review outlined the theoretical foundation of the study and identified relevant antecedents and consequences of the entrepreneurial activities of academics that have been investigated by various prior research studies. Based on this, propositions were put forward.

The empirical component of the research study transformed the propositions into hypotheses and tested the hypotheses. The data generated provided information about the resources and abilities which influence the entrepreneurial activities of academics and how academic entrepreneurial activities may complement or substitute for each other. In

addition, the impact of these activities on research outputs and teaching commitment was tested.

The time dimension of the empirical, cross-sectional study was seven weeks, as the empirical study started on the 4th of June and ended on the 24th of July 2013. The study took place under field conditions at South African universities. Respondents were guaranteed the confidentiality of their responses and they were assured that there were no correct or incorrect answers.

4.3.2 Sampling

For the purposes of the empirical study, a census, that is, a count of all the elements in a population (Cooper & Schindler, 2008:397), was conducted. The population of interest comprised all academic researchers rated by the National Research Foundation (NRF), who were affiliated to a public South African university.

The NRF evaluates and rates individuals based on the quality of their research outputs and impacts in the recent past, namely, the preceding eight years. The evaluation committee includes national and international reviewers who critically examine the research completed during the assessment period (South Africa National Research Foundation, 2013). The NRF also recognises output other than journal publications, such as artefacts, prototypes, patents and policy documents. In ascending order, the NRF-rating categories are: late entrant into research; promising young researcher; established researcher; internationally acclaimed researcher; leading international researcher; and president's awardee.

The census conducted for the purposes of this study included all researchers rated by the NRF, as on 28 February 2013, and affiliated to a public South African university. This population was chosen given that it provided a wide spectrum of academic disciplines and included all 23 South African public universities. Private higher education institutions were beyond the scope of this study.

As a first step, a list of all 2 637 NRF-rated researchers, as on 28 February 2013, was downloaded from the NRF webpage (South Africa National Research Foundation, 2013). The list included surnames, initials, titles, rating categories, institutions and specialisation of the researchers. The list was cleared of researchers not currently affiliated to any of the 23 South African universities. Based on the amended list of 2 375 NRF-rated researchers affiliated to a South African university, contact details were obtained from the web pages of the various South African universities. A total of 2 233 valid email addresses was obtained. The process of creating and cleaning the sample database took two months.

In total, 2 233 contacts were made with 415 fully completed questionnaires being received by the researcher. The data from 17 respondents was removed as a result of contradictory information. Thus, the final response size was 398 completed surveys. According to the RR1 method of the American Association for Public Opinion Research (2011:44), the response rate was 17.5%. The Response Rate 1 refers to the number of complete interviews divided by the number of interviews plus the number of non-interviews (refusal, break-off, non-contacts and others, plus all cases of unknown eligibility) (American Association for Public Opinion research, 2011:44). The response rate is consistent with other studies in this field of research conducted by, inter alia, Fini et al. (2011:1062) and Abreu and Grinevich (2013:414). Table 5.1 in the data analysis and findings chapter of this study compares the number of respondents per university to the total number of NRF-rated researchers that were affiliated to a certain university at the time the survey was conducted. Even though it does not proportionally reflect the variability and composition of the original population, it still provides solid insights into the topic.

The population size criterion deemed appropriate for this study was dictated by the data analysis technique used in the study. Myers, Montgomery, Vining and Robinson (2010:102) point out that, with generalised linear models, the large-sample theory generally applies for both type of response variables, namely, normally and non-normally distributed response variables. In the main, for multiple regressions, a conventional sample size rule of a minimum of five observations per item is recommended (Tabachnick & Fidell, 1996:329) and this study conforms to this ratio.

4.3.3 Data collection

The sources of data structures required to solve the research problem may be classified as either secondary or primary (Hair et al., 2006:64). The secondary data used for the purposes of this study was gathered from electronic databases that provided access to full-text academic journal articles, industry reports, trade journals, government documents as well as books.

Primary data may be collected either by means of surveys or observations (Hair et al., 2006:64). This study followed a communication approach in the form of a fully structured web-based survey which was developed using Qualtrics Survey Software. The link to the self-administered survey was embedded in an invitation email which was formulated as a letter of introduction and informed consent for participation in the academic research study in question. A copy of the letter is attached as Annexure B. The invitation was sent to a panel of 2 233 contacts and followed by three reminders to non-respondents. The anonymity of the respondents was guaranteed as was the confidentiality of their responses.

The measurement process consisted of both construct development and scale measurement. Well-constructed measurement procedures are vital to the process of collecting primary data. The goal of the construct development process is to identify and define what is to be measured, while the goal of scale development is to determine how to measure each construct (Hair et al., 2006:353). Cooper and Schindler (2008:57–59) define a construct as “an image or abstract idea specifically invented for a given research and/or theory-building purpose” and a concept as a “generally accepted collection of meanings or characteristics associated with certain events, objects, conditions, situations, and behaviours”. For each variable in the model, be it construct or concept, there must be at least one, but preferably multiple, specific measures, which are referred to as indicators (Garson, 2013:121). The process of operationalising the variables in this study is described in the following section. The full questionnaire is attached as Annexure A.

Operationalisation of variables

The variable of spin-off creation [SPC] was operationally defined as the activity of creating a new firm specifically to exploit some knowledge, technology or research results developed within a university for commercial purposes (Pirnay et al., 2003:355). The variable was captured as a numerical estimate through the question presented in table 4.1 and subsequently coded as binary and as one (TRUE) if the individual, or the university on his/her behalf, had created one or more university spin-offs during the calendar years 2011 and 2012, and as zero (FALSE) otherwise.

Licensing/assignment of IP [LAI] was operationally defined as the activity of transferring a legal right to use or own a specific piece of university intellectual property (Bercovitz & Feldmann, 2006:177; South Africa, 2008:4). In order to capture the variable two questions were asked (see table 4.1). The numerical estimates acquired were transformed into a binary variable coded as one (TRUE) if the academic researcher had stated he/she had engaged at least once during the calendar years 2011 and 2012 in the sale and/or licensing of IP created during a university research project. The variable was coded as zero (FALSE) if he/she had not so engaged.

The variable of sponsored research [SPR] was operationally defined as involvement in an agreement in terms of which the university receives funding for conducting a research project (Bercovitz & Feldmann, 2006:177). This research project may be in the form of a joint research or a contract research project with industry, government or the third sector. The variable was captured from six questions which are presented in table 4.1. The numerical estimates were subsequently coded as binary and as one (TRUE) if the individual had engaged in either a joint research or a contract research project with industry, government or the third sector during the calendar years 2011 and 2012, and as zero (FALSE) otherwise.

The variable of consulting [CON] was operationally defined as the sale of personal scientific or technological expertise in order to solve a specific problem (Klofsten & Jones-Evans, 2000:300). The academic researchers were questioned about their involvement in consulting activities for industry, government or the third sector during the calendar years

2011 and 2012. The three questions are presented in table 4.1. The numerical estimates were subsequently coded as binary and as one (TRUE) if the individual had so engaged, and as zero (FALSE) otherwise.

Table 4.1: Operationalisation of the entrepreneurial activities of academics

Variable name	Variable label	Indicators (column numbers)	Questions		Coding
SPC	Spin-off creation	V19	Think about your last two years as a researcher [calendar years 2011 and 2012]. How many times did you, or the university on your behalf …?	– create a university spin-off? (A new firm created to exploit some knowledge, technology or research results developed within a university for commercial purposes)	If V19 >= 1: TRUE 0 = FALSE
LAI	Licensing/ assignment of IP	V17		– sell intellectual property created during a university research project?	If V17 and or V18 >= 1: TRUE 0 = FALSE
		V18		– licensed intellectual property created during a university research project?	
SPR	Sponsored research	V11	Think about your last two years as a researcher [calendar years 2011 and 2012]. How many times have you been involved in a JOINT RESEARCH PROJECT with …?	– industry? (e.g. private sector company)	If V11- V16 >= 1: TRUE 0 = FALSE
		V12		– government? (e.g. parastatal, government department)	
		V13		– any other entity outside academia, industry and government? (e.g. civil society, non-governmental organisation (NGO), not-for-profit organisation (NPO), community group)	
		V14	Think about your last two years as a researcher [calendar years 2011 and 2012]. How many times have you been involved in a CONTRACT RESEARCH PROJECT for …?	– industry?	
		V15		– government?	
		V16		– any other entity outside academia, industry and government?	
CON	Consulting	V20	Think about your last two years as a	– in industry.	If V20- V22 >= 1: TRUE
		V21		– in government.	

		V22	researcher [calendar years 2011 and 2012]. To how many clients did you provide CONSULTING services?	– outside academia, industry and government.	0 = FALSE

Source: Author's own compilation.

The variable of work experience outside of academia [WEO] was measured according to the respondent's number of years of professional work experience outside of academia. The numerical estimates were re-coded as one (TRUE) if the respondent indicated one or more than one year of professional work experience outside of academia and zero (FALSE) if otherwise (V69).

The variable of direct entrepreneurial experience [DEE] was operationalised as the entrepreneurship-related knowledge acquired while running a new venture, being involved in the creation of a new venture or owning a new venture. It was measured using the responses to three questions (V64–V66). The Likert response format for the questions used anchor labels where 1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree. If the respondent indicated experience in at least one of the three questions the variable was coded as equal to one and otherwise zero. The same procedure applied for the variable of entrepreneurship education [EEE], which was measured using the responses to three questions (V63, V67, V68). The variable of entrepreneurship education was operationalised as knowledge related to entrepreneurship and acquired through the individual's involvement in a family business, during a course where the individual learned how to transform opportunities into profitable businesses, or during a course where the individual learned how to run and manage businesses.

The variable of academic seniority [SEN] referred to the participant researcher's academic position and was captured according to the South African academic career structures with "1" for lecturer/researcher, "2" for senior lecturer/senior researcher, "3" for associate professor, "4" for full professor, "5" for emeritus professor, "6" for head of department and "7" for dean. For the purposes of the data analysis this variable was transformed into a

dummy variable, labelled NOT PROFESSOR when the value was one, two or three and labelled PROFESSOR when the respondent was either a full professor or higher (V3).

Variable applications-driven research [ADR] consisted of the academic researcher's assessment regarding the extent to which the respondent's research projects were participatory and applications-driven. The response format for the four questions (V23-V26) used anchor labels where 1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree. The final measure was an average of the four scores obtained and was tested using a Cronbach's alpha. The four statements were constructed by the researcher. The statements used to capture ADR are presented in table 4.2.

Table 4.2: Operationalisation of applications-driven research

Variable name	Variable label	Indicators	Statements	Mean	Sd	Corrected item – total correlation	Alpha if item deleted
ADR	Applications-driven research	V23-V26	How do each of the following statements describe your research projects?				
		V23	My research projects are focused mainly on end-user needs.	2.34	0.93	0.64	0.85
		V24	Existing problems in the market place form the major focus of my research projects.	2.36	0.93	0.88	0.74
		V25	Most of my research addresses issues that affect society.	3.06	0.86	0.46	0.91
		V26	My research projects involve the active participation of end-users.	2.36	0.93	0.88	0.74
			Cronbach's α = .86 n = 398				

Source: Author's own compilation.

In line with Landry et al. *(*2006:1604), novelty of research [NOR] was measured by using four questions (V27–V30) and a four-point response format with the following anchor labels 1 = almost never, 2 = sometimes, 3 = often and 4 = almost always. The final

measure was an average of the four scores obtained and was tested using a Cronbach's alpha. The results are presented in table 4.3.

Table 4.3: Operationalisation of novelty of research

Variable name	Variable label	Indicators	Questions	Mean	Sd	Corrected item – total correlation	Alpha if item deleted
NOR	Novelty of research	V27-V30	For your research results to be used in the development of new or improved products, processes or services, to what extent is the following required?				
		V27	Use of new materials	1.77	0.93	0.62	0.78
		V28	Use of radical new technology	1.83	0.90	0.68	0.75
		V29	Use of new production techniques	1.66	0.84	0.71	0.74
		V30	Significant financial investment	2.16	1.03	0.56	0.81
			Cronbach's α = .82 n = 398				

Source: Author's own compilation.

The variable of intellectual property protection [IPP] was measured in terms of the number of IP protections the academic researcher or her/his university on her/his behalf had filed during the preceding two years (V75–V80). Next, the numerical values were coded as binary variables equal to one (TRUE) when the respondent had filed at least one application of the following protection methods for the IP emanating from research and development: (1) international patent application, (2) local patent application, (3) trademark application, (4) registered design application, (5) plant breeder right application or (f) protected IP emanating from R&D by means of the common law (e.g. trade secret or copyright, excluding publications). The variable was coded zero (FALSE) when the respondent had not protected IP by any of the means stated above.

The university's innovation infrastructure [UII] was measured on a five-item scale with 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree and 5 = I don't know and using eight statements constructed by the researcher (V55–V62). The subject matter of the statements was based on the work of Shane and Stuart (2002:168) and Chang et al.

(2006:203). The varying degree of the university's innovation infrastructure was measured by the sum of the scores of the items corresponding to the responses to these eight statements and tested using Cronbach's alpha. Table 4.4 presents the statements used to capture UII.

Table 4.4: Operationalisation of the university's innovation infrastructure

Variable name	Variable label	Indicators	Statements	Mean	Sd	Corrected item – total correlation	Alpha if item deleted
UII	University's innovation infrastructure	V55-V62	Regarding the innovation infrastructure of the university to which you are currently affiliated, what is your opinion on each of the statements below? The university provides:				
		V55	– links to a network of alumni.	2.79	0.70	0.49	0.88
		V56	– innovation infrastructure.	2.62	0.70	0.66	0.87
		V57	– seed funding for entrepreneurial activities.	2.43	0.69	0.69	0.87
		V58	– connections to funding institutions.	2.59	0.72	0.71	0.86
		V59	– access to buffer institutions.	2.44	0.62	0.68	0.87
		V60	– access to legal advisers.	2.94	0.69	0.55	0.88
		V61	– access to business developers.	2.49	0.65	0.72	0.86
		V62	– links to industrial partners.	2.52	0.68	0.73	0.86
			Cronbach's α = .88 n = 398				

Source: Author's own compilation.

The university's IP managerial support [UIM] was measured by the researcher's responses to five statements (V50-V54) and used anchor labels where 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree and 5 = I don't know. The final measure was an average of the scores obtained and was tested using Cronbach's alpha. The statements were constructed by the researcher using concepts from Rothaermel et al. (2007:140). Table 4.5 presents the statements.

Table 4.5: Operationalisation of university's IP managerial support

Variable name	Variable label	Indicators	Statements	Mean	Sd	Corrected item – total correlation	Alpha if item deleted
UIM	University's IP managerial support	V50–V54	Moving on to your university's intellectual property (IP) managerial support, please rate each of the following statements:				
		V50	The university's technology transfer office has expertise in facilitating entrepreneurial activities.	2.71	0.74	0.73	0.81
		V51	The university's technology transfer office has the capacity to facilitate entrepreneurial activities.	2.61	0.7	0.68	0.82
		V52	The university has a clear process for conducting due diligence on intellectual property rights.	2.81	0.68	0.64	0.83
		V53	I have been informed about the new IPR-PFRD Act 51 of 2008 by the university.	2.20	0.87	0.41	0.88
		V54	The university has established procedures for collaboration with industry.	2.80	0.71	0.72	0.81
			Cronbach's α = .85 n = 398				

Source: Author's own compilation.

The university's entrepreneurial culture [UEC] was measured by the responses to seven statements (V45–V49) on a five-item scale from 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree and 5 = I don't know. The researcher used pointers from Davies (2001:330) to construct the statements. The responses to the statements were summed up and tested with Cronbach's alpha. Table 4.6 presents the statements used to capture the university's entrepreneurial culture.

Table 4.6: Operationalisation of university's entrepreneurial culture

Variable name	Variable label	Indicators	Statements	Mean	Sd	Corrected item – total correlation	Alpha if item deleted
UEC	University's entrepreneurial culture	V45–-V49	Thinking about your university's entrepreneurial culture, please indicate your opinion of each of the following statements.				
		V45	The structure of the university's incentive system encourages entrepreneurial activities.	2.38	0.77	0.64	0.78
		V46	The university recognises entrepreneurial activities for promotion.	2.29	0.77	0.69	0.76
		V47	There are role models who are entrepreneurially active within the university.	2.63	0.73	0.53	0.81
		V48	The university provides structured, quality time for entrepreneurial activities.	2.14	0.73	0.63	0.78
		V49	The university provides training opportunities for researchers to obtain competence in entrepreneurial activities.	2.27	0.73	0.60	0.79
			Cronbach's α = .82 n = 398				

Source: Author's own compilation.

The continuous variable of the publication productivity [PUP] of the participants was measured as the total number of (1) articles published in international accredited journals and (2) academic books published during the calendar years 2011 and 2012 (V73 & V74). Both items (V73 & V74) were scaled between 0 and 1 and summed together. Teaching commitment [TEC] was measured as the percentage of the participant's time spent on teaching activities (V81) out of a total of 100.

Bibliographical information related to university affiliation (V1), field of research (V2), gender (V4) and year of birth (V5) served as classification variables and co-variables.

The variable of university affiliation was grouped into three categories, namely, traditional university [U], university of technology [UT] and comprehensive university [CU] (see table 4.7 below). The group of traditional universities served as the reference group.

Table 4.7: Groupings of South African universities

Traditional University (U)	Labels	University of Technology (UT)	Labels	Comprehensive University (CU)	Labels
North-West University	6	Cape Peninsula University of Technology	1	Nelson Mandela Metropolitan University	5
Rhodes University	7	Central University of Technology	2	University of Johannesburg	14
Stellenbosch University	8	Durban University of Technology	3	University of South Africa	17
University of Cape Town	10	Mangosuthu University of Technology	4	University of Venda	20
University of Fort Hare	11	Tshwane University of Technology	9	University of Zululand	21
University of the Free State	12	Vaal University of Technology	22	Walter Sisulu University	23
University of KwaZulu-Natal	13				
University of Limpopo	15				
University of Pretoria	16				
University of the Western Cape	18				
University of the Witwatersrand	19				

Source: Author's own compilation based on Centre for Higher Education Transformation (2013).

The eleven research fields were merged into the following five blocks: Block Ent consisted of engineering and information technology and served as a reference category, Block Hlt included medical and health science, Block Nrt included natural science, agricultural and veterinarian science, Block Hmt consisted of the humanities and education, while Block Mng included law, economics and management sciences, research office and military sciences. This procedure enabled sufficient observations to enable the researcher to conduct the comparative analyses.

The questionnaire also enquired about the number of invention disclosures the participants had made to the university's TTO during the calendar years 2011 and 2012 (V72). In addition, in order to gauge the prevailing perspectives of NRF-rated academic researchers at South African universities on academic entrepreneurship they were asked their opinions on the following five statements: (V6) Academic research topics should be determined by the private sector's needs. (V7) Academia-industry collaborations are important. (V8) I actively seek interactions with entities outside of academia. (V9) Increased attention to the commercialisation of intellectual property will improve the quality of research. (V10) Starting up a venture is a career option for me. The anchor labels were 1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree.

Scale measurements

As regards scale measurements, Carifio and Perla (2007:107–109) point out that a clear distinction needs to be made between a scale and a response format. A response format may be in a nominal, ordinal, interval or ratio data type, while a measurement scale is more complex than the items that form the scale as it attempts to assign designated degrees of intensity to the responses (Hair et al., 2006:356). For the purposes of the study different types of response formats were chosen, namely, free responses, dichotomous, multiple choice, summated rating and constant-sum response formats.

The most frequently used variation of the summated rated scale is the Likert-type scale (Cooper & Schindler, 2008:308). The scale was developed by Rensis Likert (1932:14) and is used to measure the participant's degree of attitudinal favourableness. The optimum number of scale points in the Likert scale/response format has not been agreed upon in literature. This study uses the four-point response categories. This is classified as a "forced-choice scale" which means that it requires the respondent to choose one of the categories (Cooper & Schindler, 2008:304). Four-point response formats are usually applied in the field of entrepreneurship research and have, in fact, been applied by, for example, Ponomariov and Boardman (2008:309), Jansen, Curseu, Vermeulen, Geurts and Gibcus (2011:203) and Lam (2011:1361). For the questions which were asked relating to the university's innovation infrastructure, IP managerial support and entrepreneurial culture

an “I don’t know” option was added. It was assumed and confirmed during the pre-test that some of the participants would not have an answer to the three university-related topics.

Pre-testing of measurement instrument

After the questionnaire had been pre-piloted, reviewed and refined in its design, it was pre-tested by seven reputable researchers from diverse disciplines to ensure that the syntax did not generate confusion for their peers. During the pre-test the amount of time the respondents would require to complete the survey was also determined. In addition, any unclear wording or semantics were highlighted and it was established whether more instructions should be added. After the collection of all the feedback, the modifications required were incorporated and a revised questionnaire was sent back to the respondents for review. This process was repeated until consensus was obtained.

Characteristics of the measurement instrument

The following three major criteria were used to evaluate a measurement instrument, namely, validity, reliability and practicality (Cooper & Schindler: 2008:289). Practicality refers to the operational requirements of the study and calls for the measurement process to be economical, convenient and interpretable. Validity is the extent to which a measure is free from both systematic and random measurement error while reliability is indicated by the absence of random error. Systematic error, also known as bias, occurs in a consistent manner every time the measurement is taken, while random error on the other hand does not manifest itself every time a measurement is taken and tends to be self-compensating (Diamantopoulos & Schlegelmilch, 2000:33).

4.3.4 Analytical approach

In the first stage of the data analysis process descriptive statistics were used to analyse the profile of the participating academics who were engaged in the entrepreneurial activities of spin-off creation, licensing/assignment of IP, sponsored research and consulting. In the second stage, generalised linear models (GLMs) were used to analyse

the likelihood of engagement as a function of a set of explanatory variables derived from the research hypotheses. The third stage involved cross-tabulation. Using four-dimensional contingency tables, it was determined whether the classification variables were independent of each other.

GLMs were chosen because they provide a systematic way in which to manage categorical response variables (Powers & Xie, 2008:290) and can be applied for response variables that do not necessarily follow a normal distribution (Fahrmeir, Kneib, Lang & Marx, 2013:269).

GLMs are a class of statistical models generalised from the classical linear regression. The next section first provides an overview of the use of linear regression in general and then describes GLMs specifically.

Linear regression

A fundamental basis of regression analysis is the assumption of a straight-line relationship between the explanatory and the response variables. A response variable, which is also termed the dependent, outcome or endogenous variable, represents a population characteristic of interest which is being explained in a study. Explanatory variables, which are also termed independent, predetermined or exogenous variables, are variables that are used to explain the variation in the response variable. In regression-type statistical models, it is assumed that the response variable depends on, is explained by, or is a function of the explanatory variables (Powers & Xie, 2008:2). The general formula for a straight line is:

$$Y = a + bX + e_i$$

where

Y = the response variable.
a = the intercept. This is the point where the straight line intersects the y-axis when $X = 0$.
b = the slope. It denotes the change in Y for every 1-unit change in X.
X = the explanatory variable used to predict Y.

e_i = the error for the prediction (Hair et al., 2006:560).

In order to examine the relationship between the explanatory and the response variable, the known values of X and Y and the computed values of a and b were used. With the least squares procedure the best-fitting line is determined by minimising the vertical distances of all the points from the line. Any point that does not fall on the best-fitting line, which is the regression line, is an unexplained variance (Hair et al., 2006:560). This procedure uses the criterion of minimising the total squared errors of estimate. When values of Y are predicted for each X_i, the difference between the actual Y_i and the predicted Y is the error. The error is squared and then summed (Cooper & Schindler, 2008:523). After the values of a and b have been computed, their statistical significance must be tested. The calculated a (intercept) and b (slope) are sample estimates of the true population parameters of α (alpha) and β (beta). In order to determine whether the computed intercept and slope are significantly different from zero, a t-test is applied.

Multiple regression analysis is the appropriate technique to analyse the linear relationship between a response variable and multiple explanatory variables. Multiple explanatory variables are entered into the same type of regression equation. For each variable a separate regression coefficient is calculated that describes its relationship with the response variable (Hair et al., 2006:566).

Linear models are appropriate for regression-type analysis when the response variable is continuous and, at least, approximately normal. However, in many applications the response variable is not continuous but rather a binary, a categorical or a count variable (Fahrmeir et al., 2013:269). Categorical variables are variables that can be measured using a limited number of categories only (Powers & Xie, 2008:1). Powers and Xie (2008:2) explain regression-type statistical models as models that predict either the expected value of the response variable or some other characteristic of the response variable as a regression function of the explanatory variables. In the main, the term regression is used to denote the problem of predicting conditional means. Regression is

one of the most widely used statistical techniques for analysing observational data (Powers & Xie, 2008:11).

As mentioned above, the elegant and well-understood linear regression models are appropriate for continuously measured response variables. In this study, however, the response variables were binary. Unlike the methods used for continuous variables, the methods used for categorical data require close attention to the type of measurement of the response variable. A binary variable may be discrete, ordinal, or nominal, depending on the researcher's interpretation (Powers & Xie, 2008:5). In this study, y was coded so that $y = 0$ if an academic researcher did not engage in the entrepreneurial activity and coded as $y = 1$ if he/she did engage in entrepreneurial activity. In this case the response variable may be interpreted as nominal, meaning compliance versus non-compliance. The extension of the linear model to problems in which the response is either categorical or discrete was made possible with the development of GLMs.

Generalised linear models

The basic principle of GLMs originated with Nelder and Wedderburn (1972) and may be classified as one of the central breakthroughs in statistics during the twentieth century (Fox & Weisberg, 2011:229).

GLMs are a class of statistical models which was generalised from the classical linear regression. They provide a systematic way in which to manage categorical response variables (Powers & Xie, 2008:290). The structure of a GLM consists of a response variable (y) and (m) predictors. The focus lies in understanding how the mean of (y) varies as the values of the predictors change (Fox & Weisberg, 2011:230).

As described in Fox and Weisberg (2011:230), GLMs are made up of the following three components:

1) A *random component* which specifies the conditional distribution of the response variable (y), given the predictors.

2) A *linear predictor.* Similar to linear models, the predictors in a GLM are translated into a set of (k) regressor variables, $x = (x_1, \ldots x_k)'$. In a GLM the response depends on the predictors only through a linear function of the regressors and termed linear predictors $\eta(x) = ß_0 + ß_1 x_1 + \ldots + ß_k x_k$.
3) In GLM, because the mean of a binary random variable must be in the interval (0, 1), an *invertible link function* is introduced, which translates from the scale of the mean response to the scale of the linear predictor.

As is the norm in GLMs, one writes $\mu(x) = E(y|x)$ for the conditional mean of the response. The link function may be written as: $g[\mu(x)] = \eta(x)$. Reversing this relationship produces the *inverse link function:* $g^{-1}[\eta(x)] = \mu(x)$.

Within a broad framework, GLMs unify many regression approaches with response variables that do not necessarily follow a normal distribution (Fahrmeir et al*.,* 2013:269). The next section describes GLMs with regression models for binary responses. This is followed by a description of GLMs with regression models for count data.

Binary regression models

The general assumption is that data on n objects or individuals is given in the form $(y_i, x_{i1}, \ldots, x_{ik})$, $i = 1, \ldots, n$, with the binary response y coded by 0 and 1 and the covariates denoted by $x_1, \ldots, x_k$. Similar to the linear and logit models, $x_1, \ldots, x_k$. may have been derived from an appropriate transformation or coding of the original covariates. Thus, the main goal of a binary regression analysis is to model and estimate the effects of the covariates on the conditional probability $\pi_i = P(y_i = 1) = E(y_i)$, for the outcome $y_i = 1$ and given values of the covariates $x_{i1}, \ldots, x_{ik}$. Specified in this way the response variables are assumed to be (conditionally) independent (Fahrmeir et al*.,* 2013:270).

Count data regression

Count data regression is used when the numbers of certain events within a fixed time frame or frequencies in a contingency table have to be analysed. This was the case for hypotheses $H_0$11a-d and $H_0$12a-d in this study. Discrete distributions that recognise the specific properties of count data are the most appropriate option. The simplest and most widely used choice of count data is the Poisson distribution. Fahrmeir et al. (2013:293) describe the Poisson distribution in this way: "The log-linear Poisson model connects the rate $\lambda_i = E(y_i)$ of the Poisson distribution with the linear predictor $\eta_i = x'_i \beta = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_{k1} x_{ik}$ via

$$\lambda_i = \exp(\eta_i) = \exp(\beta_0)\exp(\beta_1 x_{i1}) \ldots \exp(\beta_{k1} x_{ik})$$

or in log-linear form through

$$\log(\lambda_i) = \eta_i = x'_i \beta = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_{k1} x_{ik} .$$

The effect of covariates on the rate λ is, thus, exponentially multiplicative, similar to the effect on the odds $\pi / (1 - \pi)$ in the logit model."

4.4 CONCLUSION

This chapter discussed the research methodology used in the study. The research design was decided based on the research problem and the research objectives. The chapter also explained the sampling procedure and data collection approach used in the study as well as the empirical testing procedure used. In short, the study used a census of all NRF-rated researchers affiliated to a South African university as on 28 February 2013. Via a communication approach in the form of an online-based survey a total of 398 usable interviews were obtained. The propositions outlined in chapter 2 were formulated as 18 hypotheses for empirical testing. In addition, the measurement instrument was described, as was the evaluation process using GLMs which was employed in the data analysis.

The next chapter contains the data analysis and interprets the research findings.

CHAPTER 5
Data Analysis and Findings

5.1 INTRODUCTION

The previous chapters provided an overview of the entrepreneurial activities of academics in general in the South African context in particular. The human, physical and organisational resources which influence the entrepreneurial activities of academics were described, as was the data analysis procedure using GLMs.

The focus of this chapter is the data analysis and the interpretation of the findings. Firstly, the descriptive statistics used in this study are discussed. Secondly, the hypotheses outlined in chapter 4 are tested and the co-fertilisation and substitution effects of entrepreneurial activities examined using cross-tabulation. Thirdly, the generalised linear models (GLMs) are presented for spin-off creation, licensing/assignment of IP, sponsored research and consulting respectively. Finally, the relationship between the entrepreneurial activities and the traditional activities of academics is analysed in separate GLMs.

5.2 DESCRIPTIVE STATISTICS

Descriptive analysis is a valuable first step in data analysis. It provides insights into the distribution of values for each variable, helps to detect errors in the coding process and presents data in an eye-catching way by using tables and graphs (Diamantopoulos & Schlegelmilch, 2000:73). Frequency distributions provide a summary of the number of times each possible raw response to a scale question was recorded by the total group of respondents (Hair et al., 2006:685). The biographical information captured in the questionnaire, relating to university affiliation, faculty, academic position, gender and year of birth, is presented below while the respondents' engagement in different entrepreneurial activities is discussed. In addition, the respondents' means of IP protection, disclosures to universities' TTOs and their general attitude towards academic entrepreneurship are described.

The first question related to the university to which the respondents were affiliated. The majority of the respondents, 85%, worked for a traditional university (traditional universities offer theoretically oriented degrees), 12% for a comprehensive university (comprehensive universities offer a combination of academic and vocational diplomas and degrees) and 3% for a university of technology (universities of technology focus on vocationally oriented education). The majority of the respondents (72) were from the University of Pretoria. This was followed by 57 from Stellenbosch University, 55 from the University of Cape Town, 39 from the University of the Witwatersrand and 30 from the University of KwaZulu-Natal. The statistics are presented in table 5.1 and the number of respondents per university is compared to the total number of NRF-rated researchers that were affiliated to a certain university at the time the survey was conducted.

Table 5.1: University affiliation: comparison of original population and respondents

Type of University	University	Total number of respondents	Total number of NRF-rated researchers	%
Traditional University	North-West University	27	140	19.29
	Rhodes University	20	70	28.57
	Stellenbosch University	57	311	18.33
	University of Cape Town	55	409	13.45
	University of Fort Hare	3	18	16.67
	University of the Free State	23	107	21.50
	University of KwaZulu-Natal	30	209	14.35
	University of Limpopo	1	8	12.50
	University of Pretoria	72	334	21.56
	University of the Western Cape	13	94	13.83
	University of the Witwatersrand	39	248	15.73
	Total: Traditional university	340	1948	17.45
University of Technology	Cape Peninsula University of Technology	2	23	8.70
	Central University of Technology	1	7	14.29
	Durban University of Technology	2	11	18.18
	Mangosuthu University of Technology	0	2	0.00
	Tshwane University of Technology	6	43	13.95
	Vaal University of Technology	0	7	0.00
	Total: University of technology	11	93	11.83
Comprehensive University	Nelson Mandela Metropolitan University	9	60	15.00
	University of Johannesburg	18	111	16.22
	University of South Africa	19	130	14.62

	University of Venda	0	15	0.00
	University of Zululand	1	11	9.09
	Walter Sisulu University	0	7	0.00
	Total: Comprehensive University	47	334	14.07
Total		398	2375	16.76

The second question referred to the respondents' fields of research. As summarised in table 5.2, 43% of the respondents were in the field of natural science, which includes agricultural and veterinarian sciences, nearly 20% of the respondents were in the humanities and education, over 14% of the participants were in the field of medical and health science, 14% were in management-related fields, which include law, economics and management sciences, research offices and military sciences while less than 10% were in engineering and information technology.

Table 5.2: Faculty affiliation of respondents

Faculty	Frequency (n)	Percentage (%)	Block	(n) per block	(%) per block
Engineering	31	7.79	ENG	37	9.30
Information Technology	6	1.51			
Medical/Health Science	57	14.32	HLT	57	14.32
Natural Science	153	38.44	NTR	171	42.96
Agricultural/Veterinarian Sciences	18	4.52			
Humanities	56	14.07	HMT	76	19.10
Education	20	5.03			
Law	20	5.03	MNG	57	14.32
Economics and Management Sciences	34	8.54			
Research Office	2	0.50			
Military Sciences	1	0.25			
Total	398	100		398	100

The third question addressed the academic position of the respondents. It emerged that 41% of the respondents were not in full professorship positions, in other words, they were in positions such as lecturer, researcher, senior lecturer, senior researcher and associate professor. On the other hand, the majority of the respondents, 59%, were at the level of a full professorship, such as full professor, emeritus professor, head of department or dean.

Table 5.3: Academic position of respondents

Academic position	Frequency (n)	Percentage (%)	Seniority		
				(n)	(%)
Lecturer/researcher	16	4.02	Not Full Prof.	165	41.46
Senior lecturer/senior researcher	52	13.07			
Associate professor	97	24.37			
Full professor	166	41.71	Full Prof.	233	58.54
Emeritus professor	13	3.27			
Head of department	45	11.31			
Dean	9	2.26			
Total	398	100		398	100

Table 5.4 presents the gender of the respondents. One-third of the respondents was female and two-thirds male.

Table 5.4: Gender of respondents

Gender	Frequency (n)	Percentage (%)
Female	128	32.16
Male	270	67.84
Total	398	100

As far as age was concerned, the majority of the respondents were between 40 and 59 years old. The youngest respondent had been born in 1984 and the oldest in 1936. Table 5.5 summarises the details of the ages of the respondents. The year 2014 was used as the reference category.

Table 5.5: Age of respondents

Age range	Frequency (n)	Percentage (%)
30–39 years	42	10.55
40–49 years	114	28.64
50–59 years	136	34.17
60–69 years	86	21.61
70+ years	18	4.52
No answer	2	0.50
Total	398	100

The respondents' engagement in different entrepreneurial activities was the next topic to be addressed. As a general observation, sponsored research and consulting were significantly more widespread than licensing/assignment of IP and spin-off creation. It emerged that 80% of the respondents had entered into at least one sponsored research agreement with industry and/or government and/or any other entity outside of academia, industry and government during the calendar years 2011 and 2012. During the same period, two-thirds of the respondents had provided consulting service to clients in industry, government or the third sector. With regard to licensing/assignment of IP, 13% of the respondents stated that, during the calendar years 2011 and 2012 they, or the university on their behalf, had sold or licensed intellectual property created during a university research project, while 8% of the respondents declared that they, or the university on their behalf, had created a university spin-off in the period 2011/2012. Table 5.6 summarises the details of the respondents' entrepreneurial activities.

Table 5.6: Entrepreneurial activities of respondents, 2011/2012

Entrepreneurial activity	Frequency (n)	Percentage (%)	Total (n)
Spin-off creation	33	8	398
Licensing/assignment of IP	52	13	398
Sponsored research	317	80	398
Consulting	268	67	398

Table 5.7 shows that 24 of the 398 respondents had created one spin-off during 2011 and 2012, while nine respondents had created more than one spin-off. Of the 398 respondents, 27 had sold some sort of IP during the period 2011 to 2012 with 4% having done this once and 3% having done it more than once. On the other hand, 10% of the 398 respondents had licensed IP resulting from research projects, while 18 of them had entered into more than one licensing agreement during the two years in question.

Table 5.7: Academics' engagement in commercialisation activities, 2011/2012

Spin-off creation	Frequency (n)	Percentage (%)	Total (n)
Never	365	92	398
Once	24	6	
More than once	9	2	
Sale of IP			
Never	371	93	
Once	17	4	
More than once	10	3	
Licensing of IP			
Never	360	90	
Once	20	5	
More than once	18	5	

It was found that 50% of the NRF-rated researchers who responded to the survey had participated in a joint research project with industry during the calendar years 2011 and 2012, while as many had engaged in a joint research project with government. State-owned enterprises such as Eskom, South African Airways, Telkom SA (Ltd) and Transnet (Ltd) fall into this category. More than 40% of the respondents had collaborated in a joint research project with the third sector in the period in question. The third sector constitutes all organisations outside of academia, industry and government, for example non-governmental organisations and community groups. A total of 49 respondents indicated that they had engaged in more than three joint research projects with the third sector during 2011 and 2012. The results are summarised below.

Table 5.8: Joint research projects during 2011 and 2012

Joint research project with industry	Frequency (n)	Percentage (%)	Total (n)
Never	200	50	398
1–3 times	122 (55,42,25)	31	
More than three times	76	19	
Joint research project with government			
Never	191	48	
1–3 times	149 (63,58,28)	37	
More than three times	58	15	
Joint research project with the third sector			
Never	223	56	
1-3 times	126 (65,40,21)	32	
More than three times	49	12	

Table 5.9 shows that, during 2011 and 2012, 42% of the respondents had entered into a contract research project with industry, 36% with government and 29% with the third sector. The figures for contract research projects are slightly higher than the ones for joint research projects.

Table 5.9: Contract research projects during 2011 and 2012

Contract research project with industry	Frequency (n)	Percentage (%)	Total (n)
Never	231	58	398
1–3 times	105 (43,46,16)	26	
More than three times	62	16	
Contract research project with government			
Never	256	64	
1–3 times	100 (50,34,16)	25	
More than three times	42	11	
Contract research project with the third sector			
Never	282	71	
1-3 times	86 (47,24,15)	22	
More than three times	30	7	

The participants' engagement in consulting services is presented in table 5.10. More than half of the respondents had not offered consulting services to clients in industry during the calendar years 2011 and 2012. Of the 181 respondents who had offered consulting services to clients in industry, 57 had had more than five clients during the two-year period 2011/12, while nearly half of the respondents had provided consulting services to government and about one-third to clients in the third sector.

Table 5.10: Consulting services during 2011 and 2012

Consulting services to clients in industry	Frequency (n)	Percentage (%)	Total (n)
None	217	55	398
1–5 clients	124 (41,37,18,16,21)	31	
More than five clients	57	14	
Consulting services to clients in government			
None	244	61	
1–5 clients	140 (57,45,16,8,14)	35	
More than five clients	14	4	
Consulting services to clients in the third sector			
None	266	67	
1–5 clients	110 (51,30,15,5,9)	28	
More than five clients	22	5	

Table 5.11 shows that 13% of the respondents had disclosed one or more inventions to the TTOs of their universities during 2011 and 2012, with the respondents disclosing a total of 91 inventions in that period. It was found that 9% had applied for one or more local patents, and 7% had filed international patent applications. On the other hand, four respondents had filed one trademark application each, three registered design applications were reported but no applications for plant breeder rights. In addition, 14 respondents reported that they had protected their IP by means of common law.

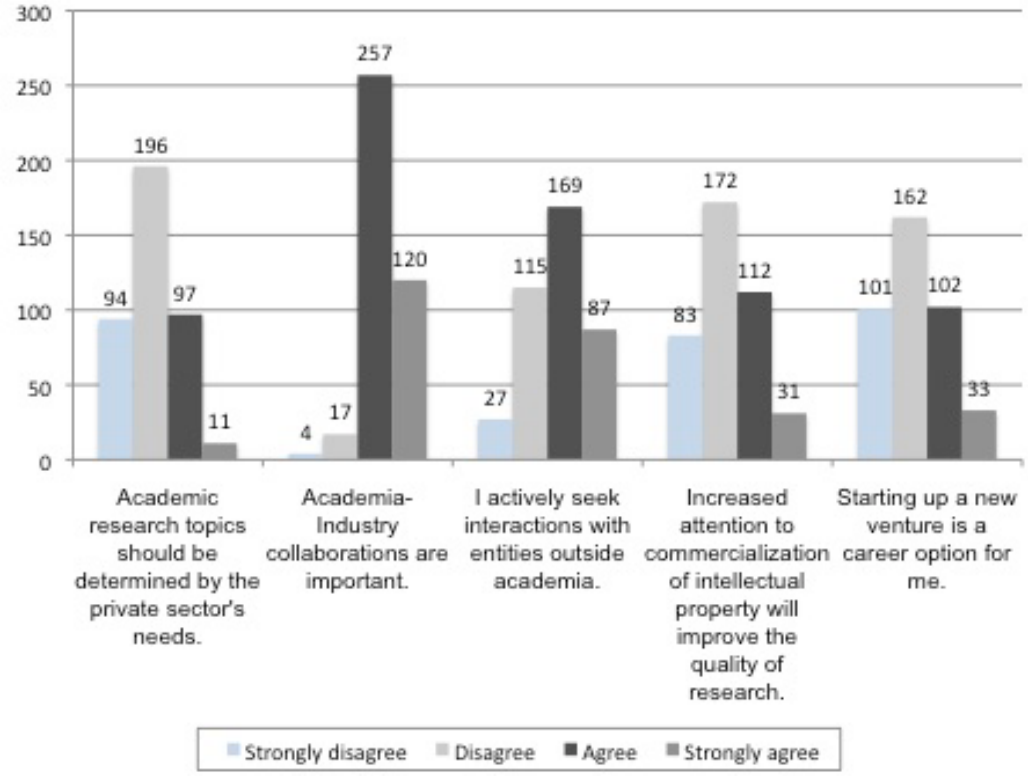
Table 5.11: IP protection and invention disclosures during 2011 and 2012

	Number of respondents (n = 398)		Total number of protection	
International patent applications	27	7%	49	12%
Local patent applications	37	9%	63	16%
Trademark applications	4	1%	4	1%
Registered design applications	2	0.5%	3	0.7%
Plant breeder right applications	0	0%	0	0%
Protection of IP by means of common law (e.g. trade secret, copyright)	14	3.5%	29	7%
Invention disclosures to university's technology transfer office	50	13%	91	23%

In order to gauge the prevailing attitude of the NRF-rated academic researchers at South African universities that participated in the study towards academic entrepreneurship, their

opinions of three statements were sought. More than 70% of the respondents either strongly disagreed or disagreed with the notion that academic research topics should be determined by private sector needs, a total of 95% of the respondents viewed academia–industry collaborations as important, while more than one-third of the participants were of the opinion that increased attention to the commercialisation of IP would improve the quality of research. In questioning the proactiveness of the participants in terms of entrepreneurial activities, it was found that 64% of the respondents had actively sought interactions with entities outside of academia. Starting up a new venture was regarded as a career option by one-third of the NRF-rated researchers who participated in the survey. Figure 5.1 presents the participants' responses. The findings illustrate that the general attitude of the participants towards entrepreneurial activities was positive and that the respondents were fairly open towards the concept of the entrepreneurial university. On the other hand, the participants appeared to view the notion of increased attention to the commercialisation of IP and the determination of research topics by industry in a rather sceptical light.

Figure 5.1: **Respondents' opinions of statements relating to academic entrepreneurship** (n = 398)



The next section presents the inferential statistics. This includes the estimation of population values and the testing of the statistical hypotheses.

5.3 GENERALISED LINEAR MODELS

As outlined in section 4.5.4, this study used GLMs to test the 12 hypotheses formulated for the purposes of the study. The program R, version 3.1.0 (2014-04-10), was used to analyse the models. The following settings of the program were applied: mean = 0 and standard deviation = 1. Table 5.12 summarises the abbreviations of the concepts and constructs used in the analysis in alphabetical order.

Table 5.12: Abbreviations for the GLM analysis

Abbreviation	Description
ADR	Applications-driven research
Block Hlt	Block Medical/Health Sciences
Block Hmt	Block Humanities and Education
Block Mng	Block Economics and Management Sciences, Law, Research Office and Military Sciences
Block Ntr	Block Natural Sciences and Agricultural/Veterinarian Sciences
CON	Consulting
DEE	Direct entrepreneurial experience
EEE	Exposure to entrepreneurship education
Gen	Gender
IPP	Intellectual property protection
LAI	Licensing/assignment of IP
NOR	Novelty of research
PUB	Publication output
SEN	Academic seniority
SPC	Spin-off creation
SPR	Sponsored research
TEC	Teaching commitment
UEC	University's entrepreneurial culture
UIM	University's IP managerial support
UII	University's innovation infrastructure
UniUT	University of technology
UniCU	Comprehensive university
WEO	Work experience outside of academia

The GLM relates the explanatory variables of WEO, DEE, EEE, SEN, ADR, NOR, IPP, UII, UIM and UEC to the response variables of spin-off creation (SPC), licensing/assignment of IP (LAI), sponsored research (SPR) and consulting (CON). In addition, the model includes the co-variables of age, gender, type of university and field of research. The evaluation criteria used include Akaike's information criterion (AIC), the Bayesian information criterion (BIC) and the deviance. AIC is one of the most widely used criteria for the choice of model within the scope of likelihood-based inference (Fahrmeir et al*.,* 2013:148). In order to compensate for the likelihood of model complexity, the AIC includes the number of parameters as a form of penalisation (Fahrmeir et al*.,* 2013:481). Formally, the BIC is similar to the AIC. The factor 2 multiplying the number or parameters in the AIC is replaced by log(n). However, BIC selects less complex models than AIC, as its penalisation of parameters is stronger (Fahrmeir et al*.,* 2013:678). An additional evaluation criterion is the deviance statistic. The deviance is a goodness-of-fit statistic which is often used. It requires that the data be grouped as far as is possible. The deviance compares the log-

likelihood of the estimated model with the value of the log-likelihood of the saturated model (Fahrmeir et al., 2013:288). Sections 5.3.2 to 5.3.7 discuss the use of Akaike's information criterion (AIC) in this study to compare the block GLM to the full generalised model. The use of AIC is recommended for moderate sample sizes and several parameters. For the model, the one with the smaller AIC was chosen (Fahrmeir et al*.,* 2013:664).

The study used *p*-values in order to compute the test statistic and either reject or not reject the null hypothesis. Under weak regularity conditions, the critical values or *p*-values are calculated using an asymptotic distribution. "The p-value is the probability of observing a sample value as extreme as, or more extreme than, the value actually observed, given that the null hypothesis is true" (Cooper & Schindler, 2008:478). The *p*-value is compared to the significance level. When the *p*-value is less than the significance level, the null hypothesis is rejected. On the other hand, if *p i*s greater than or equal to the significance level, the null hypothesis is not rejected. The lower the *p*-value the stronger is the evidence against the null hypothesis (Diamantopoulos & Schlegelmilch, 2000:146). In view of the fact that this study used exploratory hypotheses, the *p*-values related to a two-tailed test. The significance level was set as $\alpha = 0.05$.

The following sections explore the validity of the hypotheses outlined in chapter 4, using GLMs to control for individual and institutional variables. The regression results for the antecedents of entrepreneurial activities are presented in table 5.13. Each column represents a specific entrepreneurial activity of academics, starting with spin-off creation, followed by licensing/assignment of IP, sponsored research and consulting. The cells show the estimated regression coefficient, the confidence interval in brackets and the indication of the *p*-value. The actual *p*-values for spin-off creation are presented in figure 5.2 in section 5.3.2, for licensing/assignment of IP in figure 5.3, for sponsored research in figure 5.4 and for consulting in figure 5.5. The tables depicting the odds and odds-ratios are contained in Annexure C.

Table 5.13: Estimated parameters of the multiple logistic regression for the antecedents of the entrepreneurial activities of academics

	SPC	LAI	SPR	CON
(Intercept)	-9.55 (2.41)***	-4.88 (1.79)**	-1.60 (1.49)	-0.64 (1.15)
BlockHlt	-1.38 (0.79)	-0.21 (0.70)	-1.01 (0.91)	-0.72 (0.57)
BlockNtr	-1.10 (0.64)	-0.14 (0.61)	-1.37 (0.83)	-0.75 (0.51)
BlockHmt	-0.54 (0.82)	-0.11 (0.77)	-1.79 (0.86)*	-0.95 (0.56)
BlockMng	-2.14 (1.04)*	0.52 (0.74)	-1.76 (0.88)*	-0.46 (0.60)
WEO (TRUE)	0.02 (0.48)	-0.39 (0.39)	0.20 (0.31)	0.05 (0.25)
DEE (TRUE)	1.68 (0.51)**	1.12 (0.39)**	0.47 (0.37)	0.77 (0.29)**
EEE (TRUE)	0.46 (0.48)	-0.68 (0.43)	0.42 (0.38)	0.60 (0.31)*
SEN (Prof.)	0.93 (0.61)	-0.64 (0.44)	0.73 (0.36)*	0.07 (0.29)
ADR	-0.03 (0.39)	0.44 (0.30)	0.92 (0.24)***	0.62 (0.19)**
NOR	0.93 (0.36)**	-0.03 (0.28)	0.28 (0.23)	-0.17 (0.19)
IPP (TRUE)	1.27 (0.53)*	2.73 (0.48)***	0.95 (0.80)	0.86 (0.49)
UII	0.05 (0.65)	-0.29 (0.50)	-1.00 (0.38)**	-0.38 (0.31)
UIM	0.48 (0.52)	0.46 (0.40)	0.57 (0.34)	0.28 (0.28)
UEC	0.48 (0.52)	0.19 (0.41)	0.61 (0.33)	-0.30 (0.27)
Gender (m)	0.31 (0.60)	0.02 (0.42)	-0.10 (0.33)	0.51 (0.27)
Age	0.02 (0.03)	0.01 (0.02)	0.02 (0.02)	0.02 (0.01)
UniUT	-14.85 (1037.01)	-16.85 (997.91)	-1.43 (0.84)	-0.49 (0.77)
UniCU	1.43 (0.66)*	0.25 (0.60)	-0.66 (0.42)	-0.34 (0.37)
AIC	191,61	264,99	354,08	472,3
BIC	267,36	340,73	429,82	548,04
Log Likelihood	-76,81	-113,49	-158,04	-217,15
Deviance	153,61	226,99	316,08	434,3
Num. obs.	398	398	398	398
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$				

The regression results relating to the consequences of entrepreneurial activities are presented in table 5.14. The columns represent publication output and teaching commitment while the cells show the estimated regression coefficient, the confidence interval in brackets and the indication of the *p*-value. The actual *p*-values for publication output are presented in figure 5.6 in section 5.3.2 and for teaching commitment in figure 5.7. The tables depicting the incident rate ratios for the Poisson regression are contained in Annexure C. The dispersion parameter for the Poisson family was taken to be 1.

Table 5.14: Estimated parameters of the multiple logistic regression for the consequences of the entrepreneurial activities of academics

	PUP	TEC
Intercept	1.85 (0.10)***	4.01 (0.06)***
BlockHlt	0.74 (0.07)***	-0.41 (0.04)***
BlockNtr	0.60 (0.06)***	-0.08 (0.03)*
BlockHmt	0.44 (0.07)***	-0.14 (0.04)***
BlockMng	0.48 (0.07)***	-0.24 (0.04)***
SPCTRUE	-0.07 (0.05)	-0.12 (0.04)**
LAITRUE	0.08 (0.04)*	-0.25 (0.03)***
SPRTRUE	0.23 (0.04)***	-0.11 (0.02)***
CONTRUE	0.02 (0.03)	-0.13 (0.02)***
Age	-0.01 (0.00)***	0.00 (0.00)*
Gender (m)	0.16 (0.03)***	0.04 (0.02)
SEN (Prof)	0.32 (0.03)***	-0.22 (0.02)***
UniUT	0.58 (0.07)***	0.04 (0.05)
UniCU	-0.10 (0.05)*	0.01 (0.03)
AIC	5461,1	6680,09
BIC	5516,92	6735,91
Log Likelihood	-2716,55	-3326,05
Deviance	3862,54	4730,82
Num. obs.	398	398
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$		

5.3.1 Results: Hypotheses testing

Human capital-related aspects in the context of academic entrepreneurship

(1) Work experience outside of academia

In chapter 2 of the study a relationship between the work experience of academics outside of academia and their engagement in entrepreneurial activities was supposed. However, such a relationship is not supported by the data analysis. No significant difference could be found for academics who had work experience outside of academia compared to academics who had no work experience outside of academia in regard to the likelihood of

their engaging in entrepreneurial activities. For example, the likelihood that an academic would engage in consulting activities was 1.02 if the academic had work experience outside of academia and 0.98 for the academic with no work experience outside of academia. Thus, in revisiting the hypotheses it was possible to deduce the following.

Hypothesis $H_{0.1a}$ cannot be rejected: There is no significant relationship between work experience outside of academia [WEO] and spin-off creation [SPC].

Hypothesis $H_{0.1b}$ cannot be rejected: There is no significant relationship between work experience outside of academia [WEO] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.1c}$ cannot be rejected: There is no significant relationship between work experience outside of academia [WEO] and sponsored research [SPR].

Hypothesis $H_{0.1d}$ cannot be rejected: There is no significant relationship between work experience outside of academia [WEO] and consulting [CON].

(2) Direct entrepreneurial experience

The statistical analysis supported the existence of a relationship between direct entrepreneurial experience and spin-off creation and licensing/assignment of IP, as well as consulting. However, the relationship between direct entrepreneurial experience and sponsored research was not significant. In chapter 2 of the study, it was argued that previous experience in the sense of having acquired entrepreneurship-related knowledge through running a new venture, being involved in the creation of a new venture or owning a new venture is likely to be associated with entrepreneurial activities on the part of academics. The likelihood of an academic engaging in spin-off creation was 5.15 for an academic with direct entrepreneurial experience and 0.19 for an academic with no direct entrepreneurial experience. This may be interpreted as follows: For academics with direct entrepreneurial experience, the probability that they will engage in spin-off creation is approximately five times higher than the probability that the academic will not engage in such spin-off creation. On the other hand, for academics with no direct entrepreneurial

experience, the probability that they will engage in spin-off creation is about 1/5 (~0.19) only as compared to the probability that they will not engage in such spin-off creation.

The probability of engagement in licensing/assignment of IP by an academic with direct entrepreneurial experience was 2.86 as compared to 0.35 for an academic without direct entrepreneurial experience. With regard to engaging in consulting, the probability was 1.23 for academics with direct entrepreneurial experience and 0.81 for those without direct entrepreneurial experience. In addition, academics who had acquired entrepreneurial experience were not more likely to engage in sponsored research activities compared to their counterparts with no direct entrepreneurial experience. This led to the following deduction:

Hypothesis H_{02a} is rejected and H_{A2a} is accepted: There is a significant relationship between direct entrepreneurial experience [DEE] and spin-off creation [SPC].

Hypothesis $H_{0.2b}$ is rejected and $H_{A.2b}$ is accepted: There is a significant relationship between direct entrepreneurial experience [DEE] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.2c}$ cannot be rejected: There is no significant relationship between direct entrepreneurial experience [DEE] and sponsored research [SPR].

Hypothesis $H_{0.2d}$ is rejected and $H_{A.2d}$ is accepted: There is a significant relationship between direct entrepreneurial experience [DEE] and consulting [CON].

(3) Exposure to entrepreneurship education

This study found no evidence that exposure to entrepreneurship education has a significant effect on spin-off creation, licensing/assignment of IP and sponsored research. On the other hand, the study found that exposure to entrepreneurship education significantly influenced the consulting activities of academics. For the purposes of the study, entrepreneurship education was operationalised as knowledge related to entrepreneurship and acquired through involvement in the individual's family business,

during a course where the individual learned how to transform opportunities into profitable businesses or during a course where the individual learned how to run and manage businesses. The probability that an academic without exposure to entrepreneurship education will engage in consulting activities is 0.85 and 1.17 for an academic with exposure to entrepreneurship education. From the statistical analysis the following was deduced:

Hypothesis $H_{0.3a}$ cannot be rejected: There is no significant relationship between exposure to entrepreneurship education [EEE] and spin-off creation [SPC].

Hypothesis $H_{0.3b}$ cannot be rejected: There is no significant relationship between exposure to entrepreneurship education [EEE] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.3c}$ cannot be rejected: There is no significant relationship between exposure to entrepreneurship education [EEE] and sponsored research [SPR].

Hypothesis $H_{0.3d}$ is rejected and $H_{A.3d}$ is accepted: There is a significant relationship between exposure to entrepreneurship education [EEE] and consulting [CON].

(4) Academic seniority

The analysis showed a significant relationship between full professorship and sponsored research activities. As regards full professors, the probability that they would engage in sponsored research activities was approximately one and one-tenth times higher than the probability that they would not. For their less senior colleagues the probability of their engaging in sponsored research was 0.9. The study found no significant relationship between the entrepreneurial activities other than sponsored research and seniority. This led to the following deductions:

Hypothesis H_{04a} cannot be rejected: There is no significant relationship between academic seniority [SEN] and spin-off creation [SPC].

Hypothesis $H_{0.4b}$ cannot be rejected: There is no significant relationship between academic seniority [SEN] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.4c}$ is rejected and $H_{A.4c}$ is accepted: There is a significant relationship between academic seniority [SEN] and sponsored research [SPR].

Hypothesis $H_{0.4d}$ cannot be rejected: There is no significant relationship between academic seniority [SEN] and consulting [CON].

(5) Applications-driven research

The study found the relationship between applications-driven research and sponsored research to be significant, with a *p*-level of 0.000103. For the purposes of the study, applications-driven research was conceptualised as research that pays attention to the needs of end-users, focuses on existing problems in the marketplace, addresses issues that affect society and involves the active participation of end-users. The odds-ratio for the variable sponsored research was estimated to be 2.518. This implies that the probability of engagement in sponsored research was two and a half times greater for those researchers whose research tended to be applications-driven as compared to researchers whose research was less applications-driven. There was a similar scenario for consulting. The *p*-level was 0.001039 and the odds-ratio 2.159. Thus, the probability that academics would consult to industry, government or the third sector was twice as much for those academics whose research tended to be applications-driven as compared to those whose research was less application driven. The analysis indicates no significant relationship between ADR and SPC, as well as between ADR and LAI. This led to the following deductions:

Hypothesis $H_{0.5a}$ cannot be rejected: There is no significant relationship between applications-driven research [ADR] and spin-off creation [SPC].

Hypothesis $H_{0.5b}$ cannot be rejected: There is no significant relationship between applications-driven research [ADR] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.5c}$ is rejected and $H_{A.5c}$ is accepted: There is a significant relationship between applications-driven research [ADR] and sponsored research [SPR].

Hypothesis $H_{0.5d}$ is rejected and $H_{A.5d}$ is accepted: There is a significant relationship between applications-driven research [ADR] and consulting [CON].

(6) Novelty of research

For the purposes of the study, research was classified as novel when the research results were to be used in the development of new or improved products, processes or services, the use of new materials, radical new technology and new production techniques, and significant financial investment was required. The statistical analysis showed a significant relationship between novelty of research and spin-off creation with a *p*-level of 0.009168. The probability that the academic researcher was active in spin-off creation was two and a half times greater when he/she classified his/her research as novel with an odds-ratio of 2.5. It was not possible to establish a significant relationship between the other three entrepreneurial activities and novelty of research. This led to the following deduction:

Hypothesis $H_{0.6a}$ is rejected and $H_{A.6a}$ is accepted: There is a significant relationship between novelty of research [NOR] and spin-off creation [SPC].

Hypothesis $H_{0.6b}$ cannot be rejected: There is no significant relationship between novelty of research [NOR] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.6c}$ cannot be rejected: There is no significant relationship between novelty of research [NOR] and sponsored research [SPR].

Hypothesis $H_{0.6d}$ cannot be rejected: There is no significant relationship between novelty of research [NOR] and consulting [CON].

Aspects related to physical capital in the context of academic entrepreneurship

(7) Intellectual property protection

The significance of the relationship between IP protection and the licensing/assignment of IP was parsimonious. It is, however, interesting to note that the relationship between IP protection and spin-off creation was statistically significant. When an academic filed an international or local patent application, trademark application, registered design application, plant breeder right application or protected their IP by means of common law, the probability that the researcher also engaged in spin-off creation was 3.4 times greater than the probability that he or she did not also engage in spin-off creation. No significant relationship was established between either IP protection and sponsored research or IP protection and consulting. This led to the following deduction:

Hypothesis $H_{0.7a}$ is rejected and $H_{A.7a}$ is accepted: There is a significant relationship between intellectual property protection [IPP] and spin-off creation [SPC].

Hypothesis $H_{0.7b}$ is rejected and $H_{A.7b}$ is accepted: There is a significant relationship between intellectual property protection [IPP] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.7c}$ cannot be rejected: There is no significant relationship between intellectual property protection [IPP] and sponsored research [SPR].

Hypothesis $H_{0.7d}$ cannot be rejected: There is no significant relationship between intellectual property protection [IPP] and consulting.

(8) University's innovation infrastructure

The statistical analysis did not show any significant relationships between the university's innovation infrastructure and the entrepreneurial activities of spin-off creation, licensing/assignment of IP and consulting. However, it was interesting to note a statistically

significant negative relationship between the university's innovation infrastructure and sponsored research. The *p*-value was 0.007752 and the odds-ratio 0.366. In other words, those academics who indicated that their universities provided innovation infrastructure in terms of links to a network of alumni, links to science parks, business incubators and technology networks, seed funding for entrepreneurial activities, connection to funding institutions, access to buffer institutions, access to legal advisors and business developers and links to industrial partners were less likely to engage in sponsored research than those who reported that their universities did not provide such innovation structure. One explanation for this phenomenon may be that universities with a high level of innovation infrastructure are more likely to have their own pool of funds available for research compared to those with a low level of innovation structure. Based on the statistical analysis the following was deduced:

Hypothesis $H_{0.8a}$ cannot be rejected: There is no significant relationship between the university's innovation infrastructure [UII] and spin-off creation [SPC].

Hypothesis $H_{0.8b}$ cannot be rejected: There is no significant relationship between the university's innovation infrastructure [UII] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.8c}$ is rejected and $H_{A.8c}$ is accepted: There is a significant relationship between the university's innovation infrastructure [UII] and sponsored research [SPR].

Hypothesis $H_{0.8d}$ cannot be rejected: There is no significant relationship between the university's innovation infrastructure [UII] and consulting [CON].

Organisational capital-related aspects in the context of academic entrepreneurship

(9) The university's intellectual property managerial support

The study found that the university's IP management support did not significantly influence any of the entrepreneurial activities of academics. From the statistical analysis the following was deduced:

Hypothesis $H_{0.9a}$ cannot be rejected: There is no significant relationship between the university's IP managerial support [UIM] and spin-off creation [SPC].

Hypothesis $H_{0.9b}$ cannot be rejected: There is no significant relationship between the university's IP managerial support [UIM] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.9c}$ cannot be rejected: There is no significant relationship between the university's IP managerial support [UIM] and sponsored research [SPR].

Hypothesis $H_{0.9d}$ cannot be rejected: There is no significant relationship between the university's IP managerial support [UIM] and consulting [CON].

(10) University's entrepreneurial culture

The literature review in chapter 2 of this study highlighted the importance of an entrepreneurial culture for the emergence of entrepreneurial activities in academia. However, the statistical analysis conducted in this study does not support the relationship between the university's entrepreneurial culture and the engagement of academics in entrepreneurial activities. Thus, the following was deduced:

Hypothesis $H_{0.10a}$ cannot be rejected: There is no significant relationship between the university's entrepreneurial culture [UEC] and spin-off creation [SPC].

Hypothesis $H_{0.10b}$ cannot be rejected: There is no significant relationship between the university's entrepreneurial culture [UEC] and licensing/assignment of IP [LAI].

Hypothesis $H_{0.10c}$ cannot be rejected: There is no significant relationship between the university's entrepreneurial culture [UEC] and sponsored research [SPR].

Hypothesis $H_{0.10d}$ cannot be rejected: There is no significant relationship between the university's entrepreneurial culture [UEC] and consulting [CON].

Consequences: Teaching and research outputs

(11) Publication output

As described in chapter 2, the relationship between the publication output of academics and their entrepreneurial activities is a hotly debated topic in the literature. The statistical analysis conducted in this study found that sponsored research and publication output were significantly related, with a *p*-value of 0.00000004. Thus, academics who engage in sponsored research may be expected to have a publication output rate 1.26 times greater than that of academics who do not engage in sponsored research. The relation between licensing/assignment of IP and publication output was also significant, with a *p*-value of 0,04. In other words, the publication output rate of an academic who engages in licensing/assignment of IP may be expected to be 1.09 times than that of an academic who does not engage in licensing/assignment of IP. On the other hand, the study found that spin-off creation and consulting were not significantly related to publication output. Based on the statistical analysis the following was deduced:

Hypothesis $H_{0.11a}$ cannot be rejected: There is no significant relationship between spin-off creation [SPC] and publication output [PUB].

Hypothesis $H_{0.11b}$ is rejected and $H_{A.11b}$ is accepted: There is a significant relationship between licensing/assignment of IP [LAI] and publication output [PUB].

Hypothesis $H_{0.11c}$ is rejected and $H_{A.11c}$ is accepted: There is a significant relationship between sponsored research [SPR] and publication output [PUB].

Hypothesis $H_{0.11d}$ cannot be rejected: There is no significant relationship between consulting [CON] and publication output [PUB].

(12) Teaching commitment

The effects of entrepreneurial activities on teaching commitment were interesting. The statistical analysis showed a significant negative relationship between all four of the entrepreneurial activities and teaching commitment. For example, the teaching commitment rate of an academic who engages in spin-off creation may be expected to decrease by a factor of 0.89. It must, however, be noted that the percentage of weekly time allocation to teaching is not a reflection of the quality of teaching or of the number and workload of courses taught. The results of the statistical analysis led to the following deductions:

Hypothesis $H_{0.12a}$ is rejected and $H_{A.12a}$ is accepted: There is a significant relationship between spin-off creation [SPC] and teaching commitment [TEC].

Hypothesis $H_{0.12b}$ is rejected and $H_{A.12b}$ is accepted: There is a significant relationship between licensing/assignment of IP [LAI] and teaching commitment [TEC].

Hypothesis $H_{0.12c}$ is rejected and $H_{A.12c}$ is accepted: There is a significant relationship between sponsored research [SPR] and teaching commitment [TEC].

Hypothesis $H_{0.12d}$ is rejected and $H_{A.12d}$ is accepted: There is a significant relationship between consulting [CON] and teaching commitment [TEC].

Relationships between the entrepreneurial activities of academics

The study used cross-tabulation in order to test the relationships between the entrepreneurial activities of academics. Table 5.15 illustrates the patterns of engagement. Nearly half of the participants, 47%, had engaged in sponsored research and consulting during the calendar years 2011 and 2012 but had not engaged in spin-off creation and the licensing/assignment of IP during the same period, while 16% of the respondents had participated in sponsored research activities with industry, government or the third sector only but not in other entrepreneurial activity. The study also found that 15% of the participants had not been active in any of the four entrepreneurial activities and 8% had been active in consulting, sponsored research and the licensing/assignment of IP. It was interesting to note that 12 of the 398 academic researchers (3%) had participated in all four of the entrepreneurial activities.

Table 5.15: Cross-tabulation of entrepreneurial activities

			CON	FALSE	TRUE
SPC	**LAI**	**SPR**			
FALSE	FALSE	FALSE		58	20
		TRUE		62	187
	TRUE	FALSE		2	1
		TRUE		3	32
TRUE	FALSE	FALSE		0	0
		TRUE		3	16
	TRUE	FALSE		0	0
		TRUE		2	12

The variability between the four variables of spin-off creation, licensing/assignment of IP, sponsored research and consulting was too small for the data to be tested using a non-parametric correlation coefficient. Accordingly, it was also not possible to test the null hypotheses 13 to 18 using inferential statistics. However, the descriptive findings strongly support the suggestion that sponsored research and consulting activities coincide, as nearly half of the respondents had participated in both of those activities.

Hypothesis $H_{0.13}$ cannot be rejected: Sponsored research [SPR] and licensing/ assignment of IP [LAI] do not coincide.

Hypothesis $H_{0.14}$ cannot be rejected: Sponsored research [SPR] and spin-off creation [SPC] do not coincide.

Hypothesis $H_{0.15}$ cannot be rejected: Licensing/assignment of IP [LAI] and spin-off creation [SPC] do not coincide.

Hypothesis $H_{0.16}$ cannot be rejected: Sponsored research [SPR] and consulting [CON] do not coincide.

Hypothesis $H_{0.17}$ cannot be rejected: Licensing/assignment of IP [LAI] and consulting [CON] do not coincide.

Hypothesis $H_{0.18}$ cannot be rejected: Spin-off creation [SPC] and consulting [CON] do not coincide.

The following section focuses on graphical illustrations of the GLMs for all four of the entrepreneurial activities of academics, as well as for publication output and teaching commitment. The graphs illustrate the influences of both the explanatory variables and the co-variables on the response variable, while the tables compare the block model to the full model and also show the standard error and z-value. Effect displays are shown for the response variables of sponsored research, consulting, publication output and teaching commitment. However, effect displays for spin-off creation and licensing/assignment of IP are not included. Based on the results provided by the effect displays for spin-off creation and licensing/assignment of IP, it was not possible to draw additional conclusions.

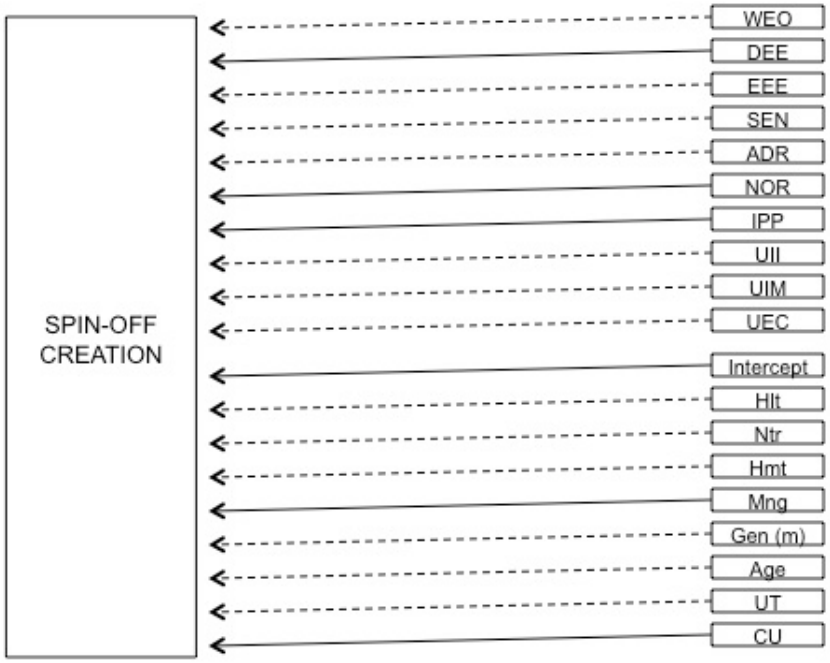
5.3.2 Generalised linear model for spin-off creation

Figure 5.2 and table 5.16 summarise the GLM for spin-off creation. It may be seen that direct entrepreneurial experience, novelty of research and IP protection have a statistically significant impact on spin-off creation. In table 5.16, the block model, which includes the

research fields only, is compared to the full model. Compared to the block model, which shows an AIC of 230, the full model shows a better fit, with a smaller AIC of 192.

Relative to the reference category of 'Engineering and information technology', the probability for academics in the Mng-block to be involved in spin-off creation decreases. Additionally, in relation to the reference category of 'Traditional university', the probability that academics affiliated to a comprehensive university do engage in spin-off creation is estimated to be higher.

Figure 5.2: GLM for spin-off creation



Estimate	Conf. Int.	p-value
0.02	0.48	0.972568
1.68	0.51	0.001049
0.46	0.48	0.346383
0.93	0.61	0.124055
-0.03	0.39	0.945366
0.93	0.36	0.009168
1.27	0.53	0.016400
0.05	0.65	0.942548
0.48	0.52	0.353806
0.48	0.52	0.352854
-9.55	2.41	0.000072
-1.38	0.79	0.083514
-1.10	0.64	0.085831
-0.54	0.82	0.508142
-2.14	1.04	0.040656
0.31	0.60	0.602942
0.02	0.03	0.449548
-14.85	1037.01	0.988578
1.43	0.66	0.030034

Table 5.16: GLM for spin-off creation

	Block-Model	all DV	Std. Error	z value
Intercept	-1.46	-9.55	2,40	-3,96
BlockHlt	-0.89	-1.38	0,79	-1,73
BlockNtr	-0.89	-1.10	0,63	-1,71
BlockHmt	-1.44	-0.54	0,82	-0,66
BlockMng	-1.86	-2.14	1,04	-2,04
WEOTRUE		0.02	0,48	0,03
DEETRUE		1.68	0,51	3,27
EEETRUE		0.46	0,48	0,94
SENProfessor		0.93	0,60	1,53
ADR		-0.03	0,38	-0,06
NOR		0.93	0,35	2,60
IPPTRUE		1.27	0,53	2,39
UII		0.05	0,65	0,07
UIM		0.48	0,52	0,92
UEC		0.48	0,51	0,92
Genderm		0.31	0,59	0,52
Age		0.02	0,02	0,75
UniUT		-14.85	1037,01	-0,01
UniCU		1.43	0,66	2,16
AIC	230,1	191,61		
BIC	250,03	267,36		
Log Likelihood	-110,05	-76,81		
Deviance	220,1	153,61		
Num. obs.	398	398		

5.3.3 Generalised linear model for licensing/assignment of IP

The GLM for the licensing/assignment of IP is summarised in figure 5.3 and table 5.17. It can be seen that, in addition to IP protection, direct entrepreneurial experience also has a statistically significant impact on licensing or assignment of IP. Compared to the block model, which shows an AIC of 313, the full model shows a better fit, with a smaller AIC of 265.

Figure 5.3: GLM for licensing/assignment of IP

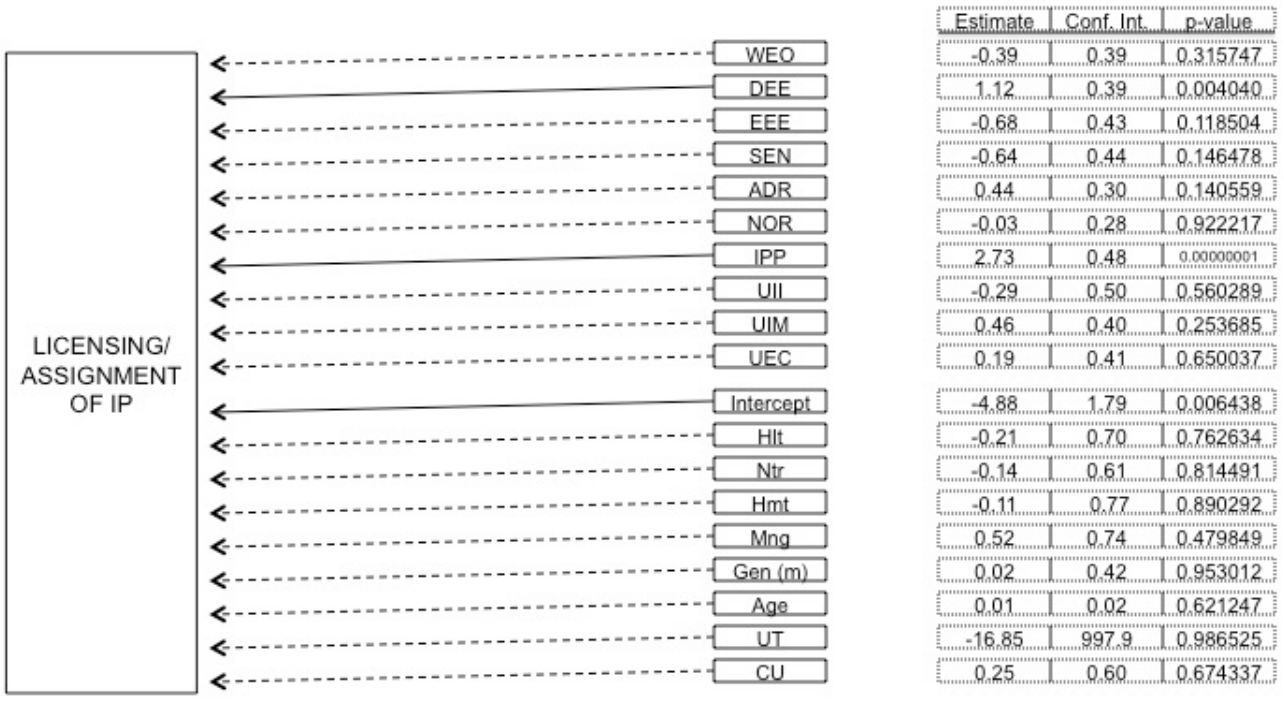


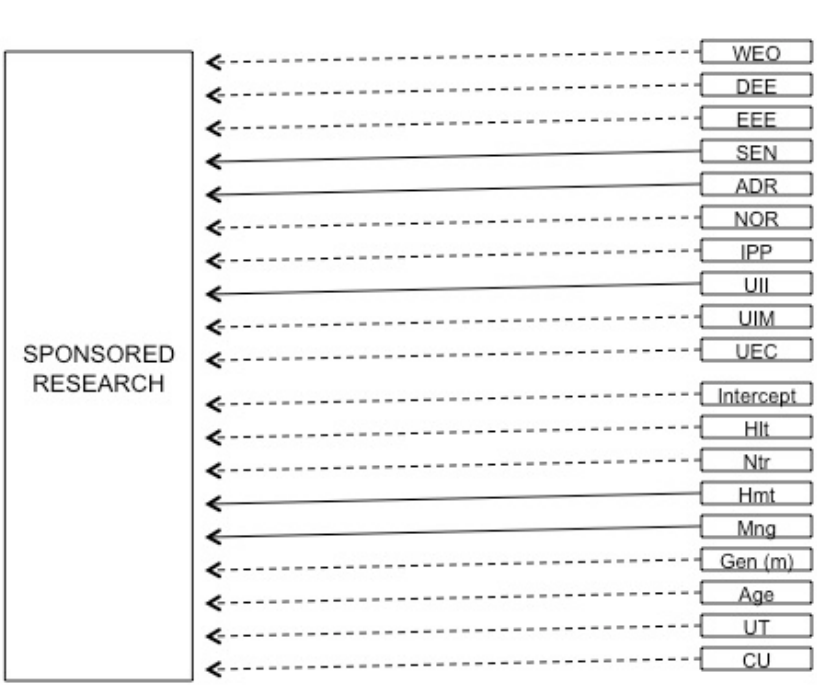
Table 5.17: GLM for licensing/assignment of IP

	Block-Model	all DV	Std. Error	z value
Intercept	-1.46	-4.88	1,79	-2,72
BlockHlt	-0.09	-0.21	0,70	-0,30
BlockNtr	-0.46	-0.14	0,60	-0,23
BlockHmt	-1.20	-0.11	0,77	-0,13
BlockMng	-0.36	0.52	0,73	0,70
WEOTRUE		-0.39	0,38	-1,00
DEETRUE		1.12	0,39	2,87
EEETRUE		-0.68	0,43	-1,56
SENProfessor		-0.64	0,44	-1,45
ADR		0.44	0,30	1,47
NOR		-0.03	0,27	-0,09
IPPTRUE		2.73	0,47	5,71
UII		-0.29	0,49	-0,58
UIM		0.46	0,40	1,14
UEC		0.19	0,41	0,45
Genderm		0.02	0,42	0,05
Age		0.01	0,02	0,49
UniUT		-16.85	997,91	-0,01
UniCU		0.25	0,59	0,42
AIC	313,22	264,99		
BIC	333,15	340,73		
Log Likelihood	-151,61	-113,49		
Deviance	303,22	226,99		
Num. obs.	398	398		

5.3.4 Generalised linear model for sponsored research

The GLM for sponsored research is presented in figure 5.4 and table 5.18. It is clear that there is a statistically significant positive relationship between the two explanatory variables of seniority and applications-driven research and sponsored research. The influence of the university's innovation infrastructure on sponsored research is negative and statistically significant. Figure 5.5 presents the effect displays for the interaction of the explanatory variables and the response variable of sponsored research in the logit model fit to the data of this study. The vertical axis is labelled on the probability scale, and a 95% point-wise confidence interval is drawn around the estimated effect. This exemplifies a 90% likelihood that senior academics will engage in sponsored research, while there is an 80% likelihood of their less senior colleagues engaging in such research. It also illustrates the positive slope for applications-driven research and the negative slope for the university's innovation infrastructure. Relative to the reference category of 'Engineering and information technology', academics in the Hmt and Mng-block are less likely to be involved in sponsored research. Compared to the block model, which shows an AIC of 399, the full model shows a better fit, with a smaller AIC of 354.

Figure 5.4: GLM for sponsored research

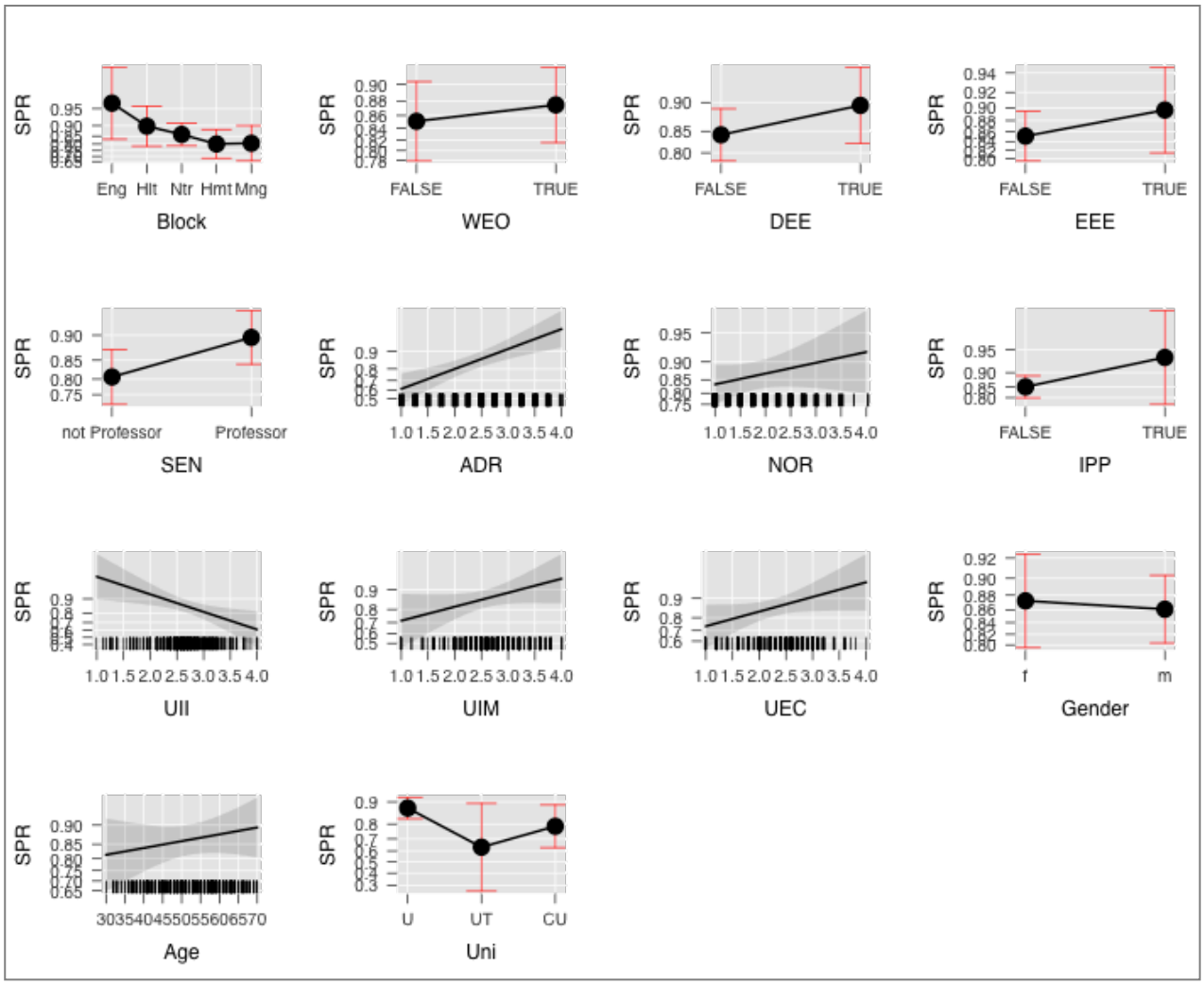


Estimate	Conf. Int.	p-value
0.20	0.31	0.518329
0.47	0.37	0.197648
0.42	0.38	0.274317
0.73	0.36	0.041958
0.92	0.24	0.000103
0.28	0.23	0.233825
0.95	0.80	0.233859
-1.00	0.38	0.007752
0.57	0.34	0.090331
0.61	0.33	0.065049
-1.60	1.49	0.282262
-1.01	0.91	0.267019
-1.37	0.83	0.099227
-1.79	0.86	0.037815
-1.76	0.88	0.046385
-0.10	0.33	0.754259
0.02	0.02	0.365283
-1.43	0.84	0.090723
-0.66	0.42	0.112253

Table 5.18: GLM for sponsored research

	Block-Model	all DV	Std. Error	z value
Intercept	2.86	-1.60	2,40	-3,96
BlockHlt	-1.05	-1.01	0,79	-1,73
BlockNtr	-1.50	-1.37	0,63	-1,71
BlockHmt	-2.09	-1.79	0,82	-0,66
BlockMng	-1.54	-1.76	1,044	-2,04
WEOTRUE		0.20	0,48	0,03
DEETRUE		0.47	0,51	3,27
EEETRUE		0.42	0,48	0,94
SENProfessor		0.73	0,60	1,53
ADR		0.92	0,38	-0,06
NOR		0.28	0,35	2,60
IPPTRUE		0.95	0,53	2,39
UII		-1.00	0,65	0,07
UIM		0.57	0,52	0,92
UEC		0.61	0,51	0,92
Genderm		-0.10	0,59	0,52
Age		0.02	0,02	0,75
UniUT		-1.43	1037,01	-0,01
UniCU		-0.66	0,66	2,16
AIC	398,6	354,08		
BIC	418,53	429,82		
Log Likelihood	-194,3	-158,04		
Deviance	388,6	316,08		
Num. obs.	398	398		

Figure 5.5: Effect displays for sponsored research



5.3.5 Generalised linear model for consulting

Figure 5.6 and table 5.19 present the GLM for consulting. There is a positive and statistically significant relationship between direct entrepreneurial experience, exposure to entrepreneurship education and applications-driven research and consulting. Figure 5.7 depicts the effect displays for consulting in the GLM model. There is an 80% probability that an academic with direct entrepreneurial experience will participate in consulting but a 65% probability that an academic with no direct entrepreneurial experience will do so. In addition, those participants who stated that they had had exposure to entrepreneurship education were 10% more likely to engage in consulting activities compared to their

colleagues with no exposure to entrepreneurship education. The more applications-driven an academic's research is, the more likely he/she is to engage in consulting with industry, government or the third sector. The block model shows an AIC of 501. The full model shows a comparatively better fit, with a smaller AIC of 472.

Figure 5.6: GLM for consulting

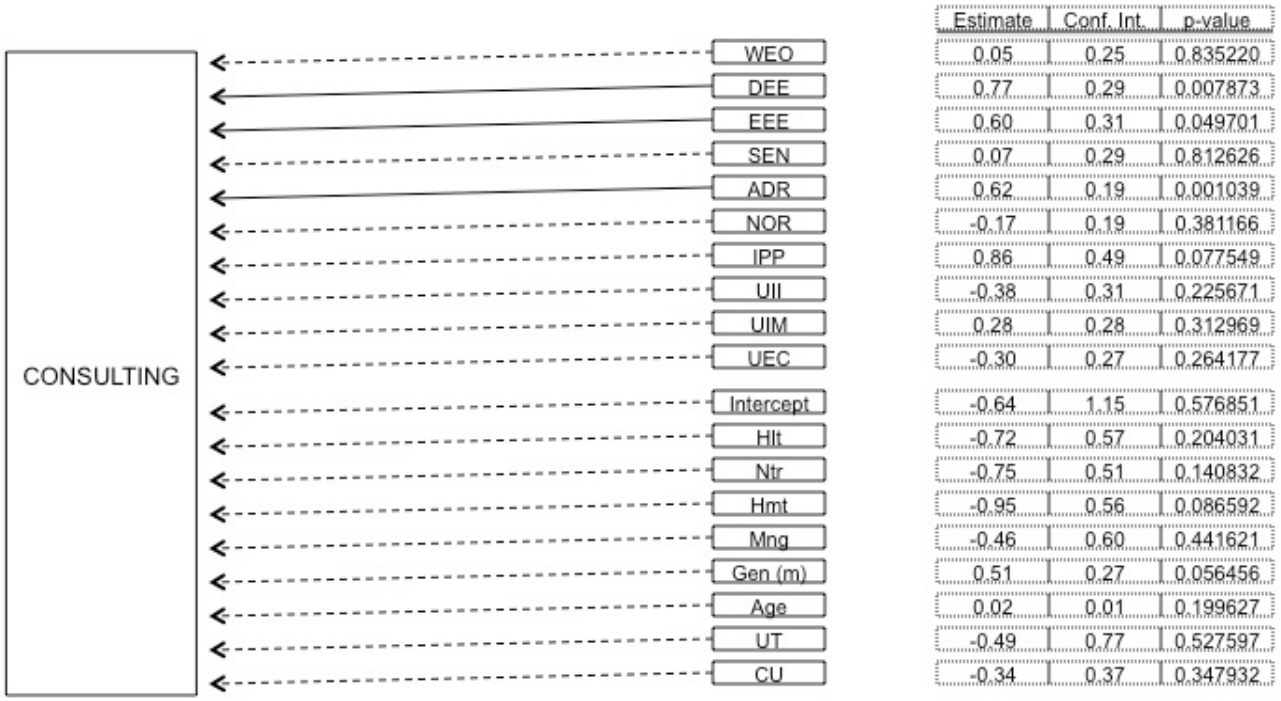
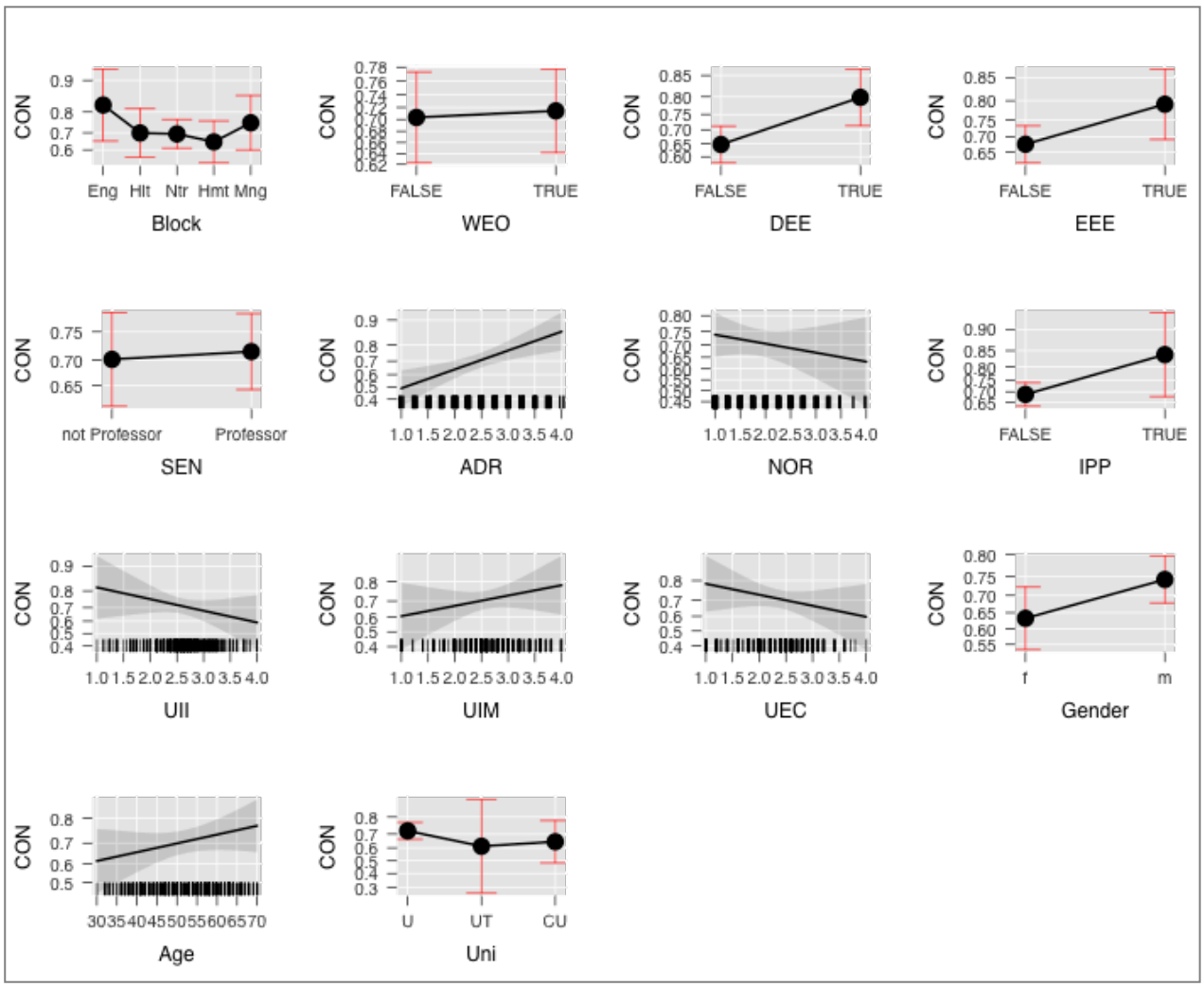


Table 5.19: GLM for consulting

	Block-Model	all DV	Std. Error	z value
Intercept	1.64	-0.64	1,14	-0,55
BlockHlt	-0.95	-0.72	0,56	-1,27
BlockNtr	-1.00	-0.75	0,50	-1,47
BlockHmt	-1.38	-0.95	0,55	-1,71
BlockMng	-0.42	-0.46	0,59	-0,76
WEOTRUE		0.05	0,25	0,20
DEETRUE		0.77	0,28	2,65
EEETRUE		0.60	0,30	1,96
SENProfessor		0.07	0,29	0,23
ADR		0.62	0,18	3,27
NOR		-0.17	0,18	-0,87
IPPTRUE		0.86	0,48	1,76
UII		-0.38	0,31	-1,21
UIM		0.28	0,28	1,00
UEC		-0.30	0,27	-1,11

Genderm		0.51	0,26	1,90
Age		0.02	0,01	1,28
UniUT		-0.49	0,77	-0,63
UniCU		-0.34	0,36	-0,93
AIC	500,97	472,3		
BIC	520,9	548,04		
Log Likelihood	-245,48	-217,15		
Deviance	490,97	434,3		
Num. obs.	398	398		

Figure 5.7: Effect displays for consulting



5.3.6 Generalised linear model for publication output

Figure 5.8 and table 5.20 present the GLM for publication output. It is interesting to note that all the co-variables have a significant impact on publication output. The study found that those academic researchers who engage in sponsored research or licensing/assignment of IP are more likely to produce more publication output compared to their colleagues who do not engage in either sponsored research or licensing/assignment of IP. This is illustrated in figure 5.9. The block model shows an AIC of 5685. The full model shows a comparatively slightly better fit, with an AIC of 5461.

Figure 5.8: GLM for publication output

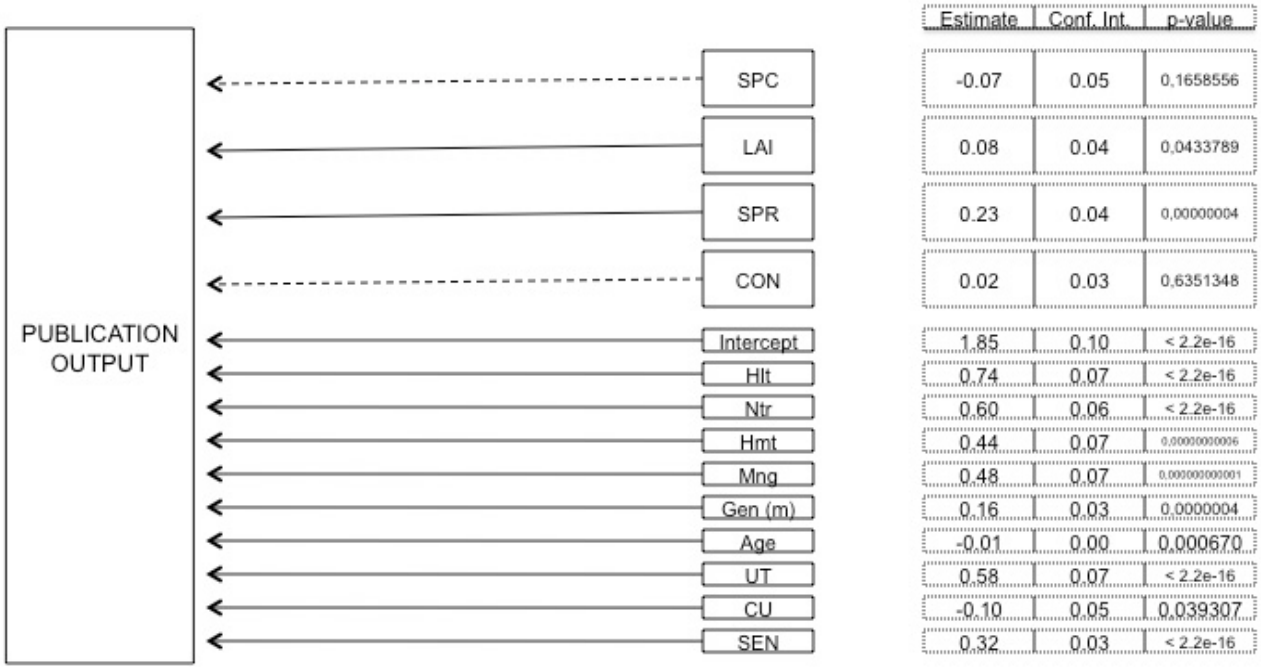
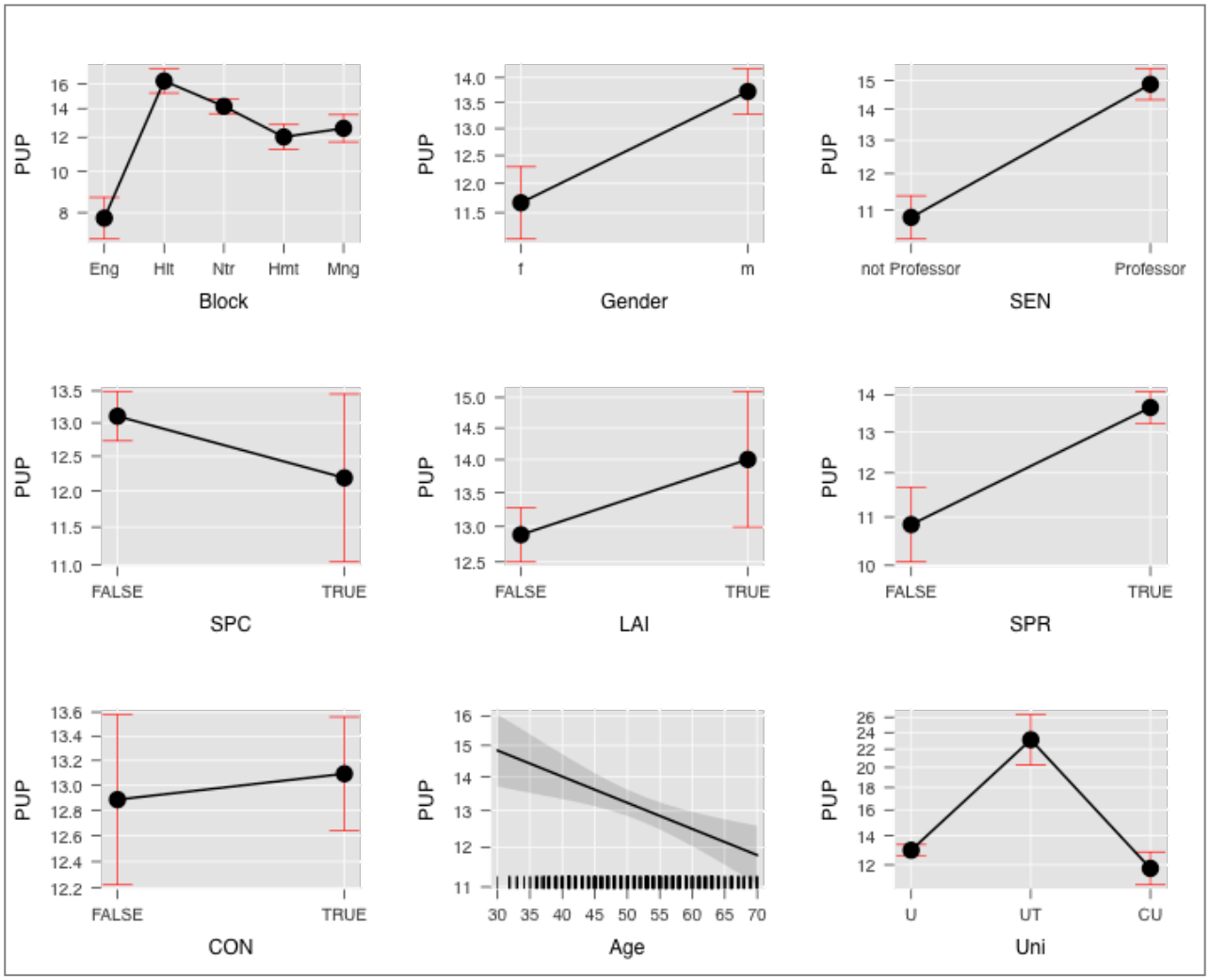


Table 5.20: GLM for publication output

	Block-Model	all DV	Std. Error	z value
(Intercept)	2.15	1.85	0,10	18,29
BlockHlt	0.63	0.74	0,06	11,21
BlockNtr	0.54	0.60	0,05	10,04
BlockHmt	0.29	0.44	0,06	6,52
BlockMng	0.41	0.48	0,06	7,08
Genderm		0.16	0,03	5,05
SENProfessor		0.32	0,03	9,16
SPCTRUE		-0.07	0,05	-1,38

LAITRUE		0.08	0,04	2,02
SPRTRUE		0.23	0,04	5,47
CONTRUE		0.02	0,03	0,47
Age		-0.01	0,00	-3,40
UniUT		0.58	0,06	8,34
UniCU		-0.10	0,04	-2,06
AIC	5684,78	5461,1		
BIC	5704,72	5516,92		
Log Likelihood	-2837,39	-2716,55		
Deviance	4104,22	3862,54		
Num. obs.	398	398		

Figure 5.9: Effect displays for publication output



5.3.7 Generalised linear model for teaching commitment

The GLM for publication output is portrayed in figure 5.10 and table 5.21. All four of the entrepreneurial activities had a negative impact on the weekly time the academic allocates for teaching. In addition, the relationship between the co-variables of age, seniority, field of research and teaching commitment is statistically significant and negative. Figure 5.11 illustrates these findings with effect displays for teaching commitment in the Poisson model fit. A 95% point-wise confidence interval is drawn around the estimated effect. The block model shows an AIC of 7136. The full model shows a comparatively better fit, with a smaller AIC of 6680.

Figure 5.10: GLM for teaching commitment

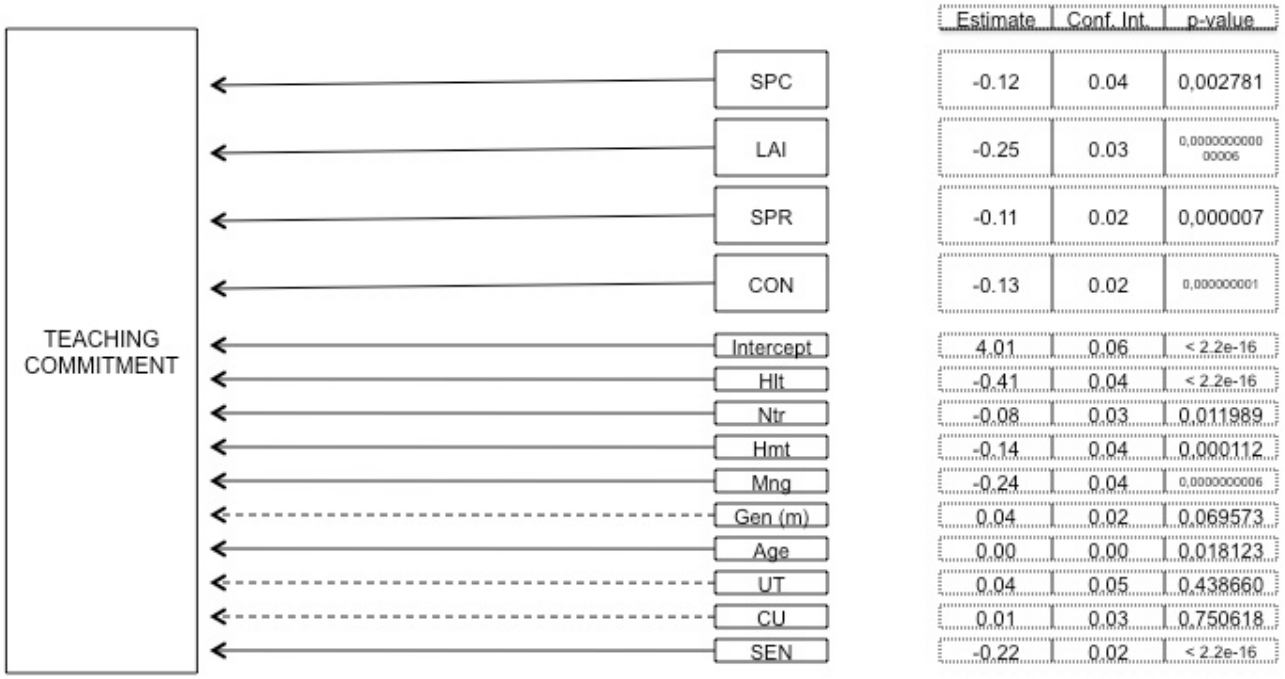
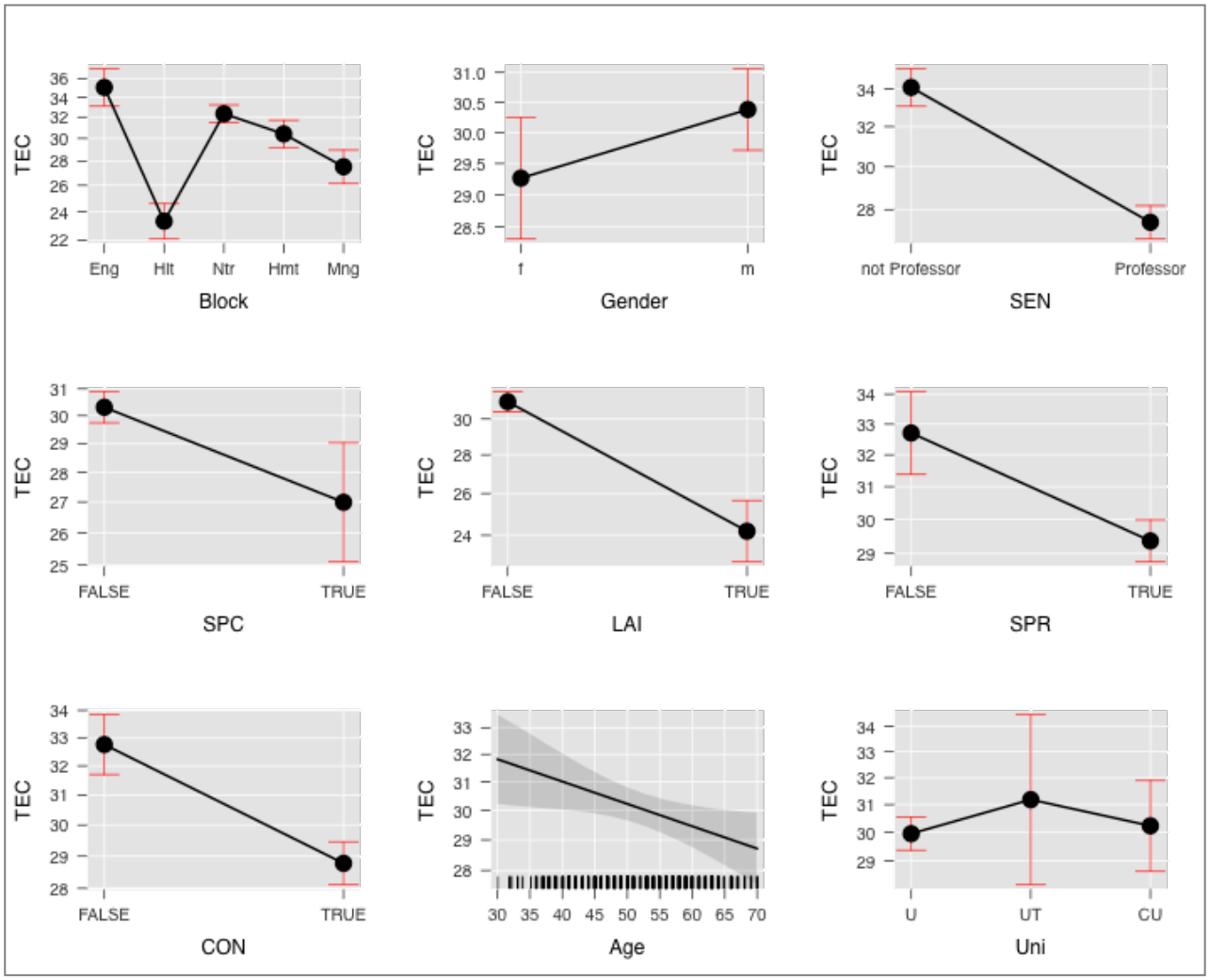


Table 5.21: GLM for teaching commitment

	Block-Model	all DV	Std. Error	z value
(Intercept)	3.51	4.01	0,05	67,85
BlockHlt	-0.34	-0.41	0,03	-10,20
BlockNtr	0.00	-0.08	0,03	-2,51
BlockHmt	-0.04	-0.14	0,03	-3,86
BlockMng	-0.21	-0.24	0,03	-6,18
Genderm		0.04	0,02	1,81

SENProfessor		-0.22	0,02	-9,75
SPCTRUE		-0.12	0,03	-2,99
LAITRUE		-0.25	0,03	-7,79
SPRTRUE		-0.11	0,02	-4,46
CONTRUE		-0.13	0,02	-6,07
Age		0.00	0,00	-2,36
UniUT		0.04	0,05	0,77
UniCU		0.01	0,02	0,31
AIC	7135,84	6680,09		
BIC	7155,77	6735,91		
Log Likelihood	-3562,92	-3326,05		
Deviance	5204,56	4730,82		
Num. obs.	398	398		

Figure 5.11: Effect displays for teaching commitment



5.4 CONCLUSION

This chapter discussed the descriptive and inferential statistics used in the study. The chapter first presented the biographical information of the respondents and then it discussed the use of GLMs for hypothesis testing. The influence of the explanatory variables on the entrepreneurial activities was analysed. The variables were subdivided into three categories. Human capital-related variables included work experience outside of academia, direct entrepreneurial experience, exposure to entrepreneurship education, academic seniority, applications-driven research and novelty of research, while physical capital-related variables included IP protection and the university's innovation infrastructure. Organisational capital-related variables included the university's IP managerial support and the university's entrepreneurial culture.

The chapter then examined the influence of spin-off creation, licensing/assignment of IP, sponsored research and consulting on the traditional academic activities of publication and teaching. In addition, the co-relations between the entrepreneurial activities were illustrated using cross-tabulation. The GLM for each entrepreneurial activity as well as for teaching and publication activities were presented and explained.

In short, based on the statistical analysis, the following significant positive (+) and negative (-) relationships were detected:

(+) Direct entrepreneurial experience [DEE] and spin-off creation [SPC]
(+) Direct entrepreneurial experience [DEE] and licensing/assignment of IP [LAI]
(+) Direct entrepreneurial experience [DEE] and consulting [CON]
(+) Exposure to entrepreneurship education [EEE] and consulting [CON]
(+) Academic seniority [SEN] and sponsored research [SPR]
(+) Applications-driven research [ADR] and sponsored research [SPR]
(+) Applications-driven research [ADR] and consulting [CON]
(+) Novelty of research [NOR] and spin-off creation [SPC]
(+) Intellectual property protection [IPP] and spin-off creation [SPC]
(+) Intellectual property protection [IPP] and licensing/assignment of IP [LAI]

(-) University's innovation infrastructure [UII] and sponsored research [SPR]
(+) Licensing/assignment of IP [LAI] and publication output [PUB]
(+) Sponsored research [SPR] and publication output [PUB]
(-) Spin-off creation [SPC] and teaching commitment [TEC]
(-) Licensing/assignment of IP [LAI] and teaching commitment [TEC]
(-) Sponsored research [SPR] and teaching commitment [TEC]
(-) Consulting [CON] and teaching commitment [TEC]

It was deemed to be a remarkable finding that 47% of the participants had engaged in sponsored research and consulting during the calendar years 2011 and 2012 but had not engaged in spin-off creation and licensing/assignment of IP during the same period. It was, however, not possible to test this finding using inferential statistics as a result of the small variability between the variables. However, based on the descriptive results, it was possible to accept the proposition that sponsored research and consulting activities coincide.

The following chapter summarises the main research purpose and the research findings. Recommendations for future research and the conclusions drawn will be presented. Finally, the limitations of the study and its contribution to the field of research are discussed.

CHAPTER 6
Conclusions and recommendations

6.1 INTRODUCTION

In this chapter the research findings are linked back to the research problem which was presented in the introductory section to the study. The chapter starts by briefly recalling the research problem and the research questions. The chapter then summarises the key findings for each research question and derives the overall conclusion to the study. The implications of the study for both research and practice are elaborated upon and suggestions for future research put forward. Finally, the limitations of the study are discussed.

With the advancements of the knowledge economy, the production and exchange of knowledge are dominating the globe and there is a need for economies to generate well-educated, highly-skilled human capital that produces technological innovations (Reichelt, 2010:3). The ability of economies to create new value-added products, processes and business models through innovation will be of particular importance in the world (World Economic Forum, 2013:xiii). However, disparities among countries in their capacity to create and use technology for development are likely to play a major role in global development and poverty alleviation in the twenty-first century. It is, therefore, vital that academia, business, government and civil society work collaboratively to create enabling environments that foster innovation (World Economic Forum, 2013:9). The transfer of the innovations and knowledge generated by academics within universities is viewed as essential for economic growth, employment creation and international competitiveness in the global markets (Aldridge & Audretsch, 2011:1059).

Despite growing awareness and an emerging body of empirical evidence to show that the successful engagement of academics in entrepreneurial activities, namely, consulting, sponsored research, licensing/assignment of IP and spin-off creation may make a positive contribution to the development of local society and economy (Mueller, 2006:1499; Teixeira & Mota, 2012:720), there appears to be little evidence regarding the antecedents

and consequences of academic engagement and commercialisation (Van Looy et al., 2011:554).

The following questions guided this research study, namely, 'Can academic entrepreneurial activities and their antecedents and consequences be assessed in the South African university context?' Based on the question above, the following, more specific research questions were formulated:

- To what extent do academics affiliated to South African universities engage in entrepreneurial activities with industry, government and civil society?

- To what extent do aspects related to the human, physical and organisational capital resources of academics influence their engagement in consulting and sponsored research activities as well as commercialisation activities in terms of licensing/assignment of IP and spin-off creation?

- To what extent do entrepreneurial activities relate to the traditional academic activities of teaching and research?

- To what extent do the entrepreneurial activities of spin-off creation, licensing/assignment of IP, sponsored research and consulting coincide with each other?

Thus, this research study represents a multidimensional analysis of the antecedents and consequences of the entrepreneurial activities of academics. The next session summarises the conclusions drawn in relation to each of the research questions cited above.

6.2 CONCLUSION TO EACH RESEARCH QUESTION

This section starts with a brief description of the respondents' engagement in the entrepreneurial activities of consulting, sponsored research, licensing/assignment of

intellectual property (IP) and spin-off creation. It then summarises the conclusions drawn regarding the extent to which the human, physical and organisational capital resources of academic researchers influence their engagement in entrepreneurial activities. The section presents the conclusions regarding the impact of entrepreneurial activities on the traditional academic activities of teaching and research. This is followed by a review of the conclusions drawn regarding the question of how the entrepreneurial activities of consulting, sponsored research, licensing/assignment of IP and spin-off creation relate to each other. Finally, table 6.1 presents a summarised overview of the findings.

6.2.1 Engagement by academics in different entrepreneurial activities

The study addressed the lack of systematic, quantitative evidence on the interactions of academics from a wide range of disciplines with external organisations via consulting, sponsored research, licensing/assignment of IP and spin-off creation activities. The data collected provided a picture of the entrepreneurial activities of academics at South African universities and their engagement with industry, government and civil society. The key observations included the following:

- As a general observation, it appeared that participation in sponsored research and consulting activities was a fairly common practice among the respondents. These interactions with a wide range of partners included academics from all disciplines, not only from the science and technology based disciplines but also the humanities and the social sciences. The study found that 80% of the 398 respondents had entered into at least one sponsored research agreement with external organisations during the calendar years 2011 and 2012. Sponsored research agreements may be in the form of either joint research projects or contract research projects. Two-thirds of the respondents had provided consulting services outside of academia. When providing consulting services, academics engage with a range of partners, particularly with the private business sector although interactions with both the public sector and the third sector are common. For example, one-third of the respondents indicated that they had provided consulting services to clients outside of academia, industry or government during 2011 and 2012.

- These findings suggest the existence of dynamic knowledge transfer within the multiple helix of the South African system of innovation.

- The study found that the other two entrepreneurial activities, namely, licensing/assignment of IP and spin-off creation, appeared to be less widespread among academics at South African universities. During the two-year period (2011 and 2012), 8% of the respondents had created spin-offs while 13% had either sold or licensed their IP. However, future potential exists as one-third of the respondents indicated starting up a new venture as a possible career option.

- The general attitude of the respondents towards entrepreneurial activities was positive and they were clearly open-minded about the concept of the entrepreneurial university. They did, however, appear to be somewhat sceptical about both increased attention to the commercialisation of IP and the determination of research topics by industry.

6.2.2 Investigating the influence of resources on the entrepreneurial activities of academics

With regard to the influence of resources on the entrepreneurial activities of academics, the study investigated the extent to which ten specific resources, as cited in the literature as relating to human, physical and organisational capital, are significantly related to the academic's entrepreneurial activities of spin-off creation, licensing/assignment of IP, sponsored research and consulting. The human capital-related aspects included (1) work experience outside of academia, (2) direct entrepreneurial experience, (3) exposure to entrepreneurship education, (4) academic seniority, (5) applications-driven research and (6) novelty of research. The aspects related to physical capital resources included (7) intellectual property protection and (8) university's innovation infrastructure. The organisational-capital related aspects included (9) university's IP managerial support and (10) university's entrepreneurial culture.

The key conclusions relating to the research question: 'To what extent do aspects related to the human, physical and organisational capital resources of academics influence their

engagement in consulting and sponsored research activities as well as commercialisation activities in terms of licensing/assignment of IP and spin-off creation?' include the following.

- The influence of the resources varies for all four entrepreneurial activities.

- The direct entrepreneurial experience that the academic may have acquired while running a new venture, being involved in a new venture or owning a new venture positively influences his or her spin-off creation, licensing/assignment of IP and consulting activities. This result confirms the conclusion of Abreu and Grinevich (2013:417), who found that ownership of a small company in the past is positively associated with the entrepreneurial activities of academics. This prior knowledge provides the individual with a portfolio of information on which to draw (Dew et al., 2011:224) and also enables the individual academic to engage in a creative act that goes beyond the habitual (Joas, 1996:129). It is also worth noting that, while direct entrepreneurial experience is related to the consulting activities of academics, it does not influence their sponsored research activities.

- The study found a positive relationship between exposure to entrepreneurship education and consulting activities. Those academics who had gained entrepreneurship-related knowledge either during a course where they learned how to transform opportunities into profitable businesses, a course where they had learned how to run and manage businesses, or in a family business, are more likely to provide consulting services to external organisations than those without such knowledge. However, the results did not show an association between exposure to entrepreneurship education and spin-off creation, licensing/assignment of IP and sponsored research.

- Academic seniority and sponsored research activities are positively related. As regards full professors, the probability that they will engage in sponsored research activities is approximately 1.1 times higher than the probability that they will not engage in such activities. It is feasible that research productivity has cumulative

features and that professors with tenure are more likely to be approached by actors from outside of academia than those without tenure. However, while seniority was associated with engagement in sponsored research, it did not have a significant influence on consulting, licensing/assignment of IP and spin-off creation. These findings are in line with the findings of Haeussler and Colyvas (2011:50) to the effect that founding activities are independent of seniority.

- The relationship between applications-driven research and the activities of sponsored research and consulting is both positive and significant. On the other hand, there is no significant relationship between applications-driven research and the commercialisation activities of spin-off creation and licensing/assignment of IP. This distinction between the more knowledge-transfer related activities and the more commercialisation-related activities is in line with the research results of Boardman and Corley (2008:911), who found industry-funded research to be more applied and more collaborative with both private and public partners.

- In keeping with previous studies (e.g. Landry et al., 2006:1611), this study established that novelty of research and IP protection are positively related to spin-off creation. Academics who rate their research as novel are more likely to engage in spin-off creation compared to those who do not rate their research as such. This also confirms the role that the protection of IP plays in spin-off creation.

- The innovation infrastructure provided at the university to which the academic is affiliated did not prove to be significant in influencing her or his spin-off creation, licensing/assignment of IP and consulting activities. It is, however, worth noting the statistically significant, negative relationship between the university's innovation infrastructure and the sponsored research activities of academics. One explanation for this phenomenon may be that universities with a high level of innovation infrastructure are more likely to have their own pool of funds available for research. These findings are not in line with prior research that emphasised the importance of supportive infrastructure and networks (e.g. Shane & Stuart, 2002:168; Nilsson et al., 2010:632).

- None of the two organisational capital-related aspects proved to have a significant effect on the entrepreneurial activities of academics, with no proof being found that either the university's IP managerial support or the university's entrepreneurial culture were significantly related to spin-off creation, licensing/assignment of IP, sponsored research or consulting activities. This is a rather surprising finding in view of the fact that the literature had highlighted the importance of the experience and expertise of the TTO (Chang et al., 2006:209; Rothaermel et al., 2007:140; Ambos et al., 2008:1438; Abreu & Grinevich, 2013:413), as well as the positive influence of an entrepreneurial university environment (Bercovitz & Feldman, 2008:69).

6.2.3 Examining the relationship between entrepreneurial activities and traditional activities

The study investigated the influence of the various entrepreneurial activities on the university's other missions, namely, teaching and research. Key conclusions with regard to the research question on the extent to which entrepreneurial activities relate to the traditional academic activities of teaching and research include the following:

- The activities of sponsored research and licensing/assignment of IP proved to be positively related to publication output. These findings are in line with previous studies which emphasised the cross-fertilisation effect between the licensing of inventions and publishing (e.g. Buenstorf, 2009:290), as well as between sponsored research, including contract research and research collaborations, and scientific productivity as measured by publications (e.g. Van Looy et al., 2011:558). Lubango and Pouris (2009:315) reported a positive relationship between patenting and the publication activities of academics at South African universities. In addition, this research study showed that academics who engage in the transfer of their IP by licensing or by assignment are likely to have a higher publication output rate than those who do not so engage.

- This study did not find a statistically significant relationship between publication output and spin-off creation or consulting. In other words, it would appear that the creation of firms and the engagement in consulting activities do not occur at the expense of scientific productivity as measured by publication output.

- The co-variables of age, gender, field of research and type of university to which the researcher is affiliated were significantly related to the academic's publication output. The study found that age related negatively to the academic's publication output with younger academics publishing significantly more papers and books during the years 2011 and 2012 than their older counterparts. On the other hand, being male and more senior was positively related to publication output. Affiliation to a traditional university was used as a reference category. Compared to this reference category, affiliation to a comprehensive university was negatively related to publication output, while affiliation to a university of technology was positively related to publication output. The block variable Eng (Engineering and Information Technology) formed the reference category when the academic's field of research was investigated. Compared to this variable, the block variables Hlt (Medical/Health Sciences), Hmt (Humanities and Education), Mng (Economics and Management Sciences, Law, Research Office and Military Sciences), Ntr (Natural, Agricultural and Veterinarian Sciences) showed a statistically significant positive relationship with publication output.

- Teaching commitment, as measured by the percentage of weekly time allocation to teaching activities, was shown to be negatively related to all four of the entrepreneurial activities of academics. For example, the teaching commitment rate of an academic who engaged in spin-off creation may be expected to decrease by a factor of 0.89. However, this finding must be approached with caution as the percentage of weekly time allocation to teaching does not provide information about either the quality of teaching or the number and workload of courses taught.
- In addition, the study found a significant negative relationship between teaching commitment and the co-variables of age and seniority. This implies that the younger and less senior academics allocate more of their weekly time to teaching activities.

6.2.4 Trade-offs and complementarities of entrepreneurial activities

Finally, the study aimed to establish whether consulting, sponsored research, licensing/assignment of IP and spin-off creation are either complementary or in conflict with each other. The variability between the four entrepreneurial activities was, however, too small to enable the data to be tested using inferential statistics. Nevertheless, the descriptive findings led to the following conclusions:

- Sponsored research and consulting activities often coincide. Almost half of the participants engaged in sponsored research and consulting activities although they were not active in spin-off creation and licensing/assignment of IP.

- The study did not detect substitution effects between the four types of entrepreneurial activity.

6.2.5 Summarised overview of findings

Table 6.1 presents a summary overview of the effects observed. Overall, the findings confirmed some of the hypothesised antecedents and consequences of entrepreneurial activities. However, the relationships differed depending on the activity being considered.

Table 6.1: Summary of findings

	Spin-off creation	Licensing/ assignment of IP	Sponsored research	Consulting
Human capital-related aspects				
Work experience outside academia	/	/	/	/
Direct entrepreneurial experience	++	++	/	++
Exposure to entrepreneurship education	/	/	/	+
Academic seniority	/	/	+	/
Applications-driven research	/	/	+++	++
Novelty of research	++	/	/	/
Physical capital-related aspects				
Intellectual property protection	+	+++	/	/
University's innovation infrastructure	/	/	- -	/
Organisational capital-related aspects				

University's IP managerial support	/	/	/	/
University's entrepreneurial culture	/	/	/	/
Research publications	/	+	+++	/
Teaching commitment	- -	- - -	- - -	- - -
Spin-off creation		/	/	/
Licensing/assignment of IP	/		/	/
Sponsored research	/	/		x
Consulting	/	/	x	

/ = no statistically significant relationship
+ = statistically significant positive relationship (+p < 0.05; ++p < 0.01; +++p < 0.001)
- = statistically significant negative relationship (- p < 0.05; - -p < 0.01; - - - p < 0.001)
x = often coincide

6.3 IMPLICATIONS FOR RESEARCH

The study findings contribute to the debate on the role of the individual academic in the process of multiple helix interactions within the South African national system of innovation, shedding light on the question of which academics engage in entrepreneurial activities and the antecedents and consequences of these actions. The engagement of academics in consulting, sponsored research, licensing/assignment of IP and spin-off creation activities with industry, government and civil society proved to be a complex process of a heterogeneous nature, with resources influencing the four entrepreneurial activities described in this study in different ways. Resources refer to the knowledge and abilities of the individual and the organisational system, the routines and relationships of the institution that the academic is embedded in and the physical resources the academic may leverage.

This study aimed to contribute to the *humanisation* of research within the field of academic entrepreneurship by investigating the key actors in the knowledge and technology transfer process. It supported the concept that individual factors are more significant than institutional factors in determining entrepreneurial action (Dervojeda, 2012:283; Abreu & Grinevich, 2013:418). While some existing research emphasises the role of organisational capital (e.g. Ambos et al., 2008:1438; Bercovitz & Feldman, 2008:69), the results of this study suggest that the engagement of academics in entrepreneurial activities is determined primarily by their prior experiences. In particular, the study shows that academics with direct entrepreneurial experience are more likely to be involved in spin-off creation, licensing/assignment of IP and consulting activities than their counterparts with

little or no such experience. In addition, academics who have been exposed to entrepreneurship education are more likely to provide consulting services to industry, government or civil society than their counterparts who have not had such exposure. This finding regarding prior experience and its stimulus for creative action may be a promising avenue for future research into academic entrepreneurship. The finding is also in line with Joas's (1996:161) observation that the creativity of action has a strong, pre-reflexive component and that perceptions of the world appear to be structured by capacities for and experiences of action.

In addition, the results of this study emphasise the influence of the research orientation. Academics working on applications-driven research are more likely to engage in sponsored research and consulting activities than academics whose research is less applications-driven. Similarly, academics who rate their research as novel are more likely to engage in spin-off creation than their counterparts who do not rate their research as novel. This shows that both types of research orientation lead to interaction with external organisations and have the potential to achieve economic impact, despite the fact that they may be transferred via different channels. These effects and differences merit further examination, for instance how different subject fields and different universities play off in the outcomes.

This study broadened the focus of academic entrepreneurship research beyond academics who are prominent in university–industry interactions and also examined the interaction of academics with government organisations and civil society bodies and groups, including labour and community organisations, women's groups, environmental groups, as well as municipal and regional civic structures (Cooper, 2012:354). Thus, the study proved that these interactions do take place within the South African context.

In chapter 3 the study highlighted the broader context within which the researcher operated. The study aimed to adopt a broader social science perspective that is critical, reflexive and attentive to history. The findings suggest the existence of dynamic interactions on the part of academics at South African universities via sponsored research and consulting activities, not only with the private business sector but also with the public

sector and the third sector. Universities interconnected within the multiple helix may contribute significantly to the enhancement of the innovation system at both the regional level and the national level (Cooper, 2012:354). Further investigation of the contribution of these universities to the unlocking of knowledge for broader socio-economic-cultural development using an active and process-oriented approach may be a promising avenue of research for years to come.

Research in the field of academic entrepreneurship has focused primarily on academics already actively engaged in entrepreneurial activities (Bozeman et al., 2015:34). Thus, this study represents a progression in the existing research because it also included academics who were less actively engaged or else not involved at all in entrepreneurial activities. This approach allowed for a statistical comparison of the relative contribution of human, physical and organisational capital-related factors to the actual activity in question. Further investigation into the reasons why an individual with entrepreneurship-related knowledge and abilities, who is part of a supportive organisational system and who has access to physical resources that he/she may leverage, does not engage in entrepreneurial activities may also be of interest for scholars in this field. This line of thought relates to the suggestion by Venkataraman, Sarasvathy, Dew and Forster (2013:165) that there should be increased focus on both the intersubjective when studying entrepreneurship phenomena and on the difference that the sociocultural acceptance of the belief in individual agency makes to shaping reality.

6.4 IMPLICATIONS FOR PRACTICE

South Africa's history of colonialism and apartheid has left a legacy not only of complexity and diversity but also of a unique evolution in academic freedom, institutional autonomy and public accountability in higher education in the country. Together with the private sector, government and civil society, higher education serves as an innovation actor within the South African national system of innovation. Currently, South Africa is ranked 53 out of 143 nations in the Global Innovation Index 2014 (Global Innovation Index, 2014:256). An examination of the innovation profile of South Africa reveals that the major challenges to innovation are a shortfall in human capital development, low business expenditure on

research and development, low triadic patents per million population, as well as low-level ICT penetration (Global Innovation Index, 2014:256). South Africa's National Development Plan 2030 (South Africa. National Planning Commission, 2012:326) calls for greater investment in research and development and increased innovation efficiency. It further stresses the importance of enhanced cooperation between the actors in the national innovation system.

This research study has shown that the academics affiliated to South African universities are highly engaged in consulting and sponsored research activities with industry, government and civil society. In fact, their sponsored research and consulting activities often coincide. On the other hand, in comparison with the dynamic knowledge transfer activities within the multiple helix of South Africa's national system of innovation, relatively few academics participate in the commercialisation of their IP through the use of spin-off creation, assignment or licensing. However, boosting the entrepreneurial activities of academics is a long-term process. A recent milestone was the passing of South Africa's Intellectual Property Rights from Publicly Financed Research and Development Act 51 (IPR-PFRD Act) in 2008 which was to come into operation on 2 August 2010. In addition, the National Roadmap on Innovation Infrastructure is currently being developed (OECD, 2012:382). Thus, this study offers a sound baseline for future comparisons. Nevertheless, within this context and in the light of recent developments, it is important to note that the study did not find any significant relationship between the organisational capital resources the academic may leverage and her/his engagement in entrepreneurial activities. In addition, neither the university's IP managerial support nor the university's entrepreneurial culture showed any effects. In addition, the university's innovation infrastructure was not significantly related to spin-off creation, licensing/assignment of IP or consulting. In fact, the study showed that academics who are affiliated to universities with less prominent innovation infrastructure are more likely to engage in sponsored research activities than their counterparts at universities with a wide innovation network and more extensive infrastructure.

The results of this study suggest that policy makers and university administrators should build on the notion of prior experience and aim at creating experiential learning

opportunities, for example for less senior academics to become involved in venture creation projects. Previous experience in the sense of having gained entrepreneurship-related knowledge while running a new venture, being involved in the creation of a new venture or while owning a new venture was proved to be associated with the consulting, licensing/assignment of IP and spin-off creation activities of academics. However, it is worth mentioning that, in contrast to this finding, no significant difference was found in relation to academics with work experience outside of academia as compared to academics with no work experience outside of academia as regards the likelihood of their engaging in entrepreneurial activities. In addition, exposure to entrepreneurship education was significantly related to the consulting activities of academics only and did not appear to have an influence on the other three entrepreneurial activities. This is in line with the findings of Abreu and Grinevich (2013:417) and indicates that entrepreneurship training increases the involvement of academics in knowledge transfer activities but has no effect on commercialising activities. The finding that seniority is significantly related to the sponsored research activities of academics also proves that reputation and tenure status facilitate the interactions of academics with external organisations.

In addition, the results of this study emphasise the cross-fertilisation effects between sponsored research and publication output, as well as licensing/assignment of IP and publication output. These findings may be of particular interest to the university management and administration. However, it is also worth noting that teaching commitment, as measured by the percentage of weekly time allocated to teaching activities, was shown to be negatively related to all four of the entrepreneurial activities of academics. In view of the fact that academic seniority was shown to have a significant negative relationship with teaching commitment, but was significantly positively related to both publication output and sponsored research activities, one may assume an important moderating effect of the academic's seniority in this context. At the same time, it must be acknowledged that excessive emphasis on entrepreneurial activities or overinvestment may detract from the traditional functions of the university. Further research is needed to define and analyse the consequences of the entrepreneurial activities of academics and it is hoped that the findings of this study may serve as stimulus for further engagement in such efforts.

6.5 LIMITATIONS OF THE STUDY

The study investigated just four of most prevalent activities out of the numerous mechanisms through which academics engage with society. In addition, the study did not explore whether these activities take place formally or informally. Although the study used a simple categorisation of universities for data analysis purposes, it was apparent in chapter 3 that different universities have different heritages and different strong points and that this is in turn reflected in the knowledge exchange spectrum in which their affiliated academics participate. Furthermore, the empirical study did not consider external environmental factors that may influence the university's decision-making and policy implementation. For example, the new South African IPR-PFRD Act, which came into operation in 2010, gives universities no choice but to engage in the transfer of inventions to the market, as the Act effectively transfers ownership of IP arising from public-funded research to the universities. The spatial dimension of the interactions of academics was also beyond the scope of this study. However, it must be borne in mind that the entrepreneurial activities of academics may be with local, regional, national or international partners.

As explained in chapter 2, knowledge and technology transfer processes are iterative processes by nature. However, this study did not enquire into either feedback loops or the complexity of interactions between academics and external organisations.

In addition, the study may have been constrained by the following methodological issues:

- For the purposes of empirical study, a census was conducted. Despite the response rate of 17.5% – a response rate which is consistent with other studies in this field of research – such a response rate does not allow for an unrestricted generalisation of the study results.

- The study was cross-sectional. Thus, in order to conduct a further, in-depth investigation of the antecedents and consequences of the entrepreneurial activities of academics, a process-oriented approach should be applied and a longitudinal study conducted.

- As mentioned above, external influencing factors were excluded from the study.

- The categorical response data did not allow for the analysis of mediating and moderating effects.

- The variability between the four response variables was too small to enable the data to be tested using a non-parametric correlation coefficient and, consequently, hypotheses 13 to 18 could not be tested using inferential statistics. Descriptive findings were used to answer research question three.

- Teaching commitment was measured in terms of the percentage of weekly time allocated to teaching activities. However, extended measures of the variable described should be used.

- A small number of respondents only rated the response variables of spin-off creation and licensing/assignment of IP as true. Ideally, there should be more data to represent these variables.

- The study measured participation in entrepreneurial activities retrospectively. The respondents were asked to recall their engagement during the preceding two years (calendar years 2011 and 2012). This created a certain bias at a specific moment of time.

Finally, the entrepreneurial activities of consulting, sponsored research, licensing or assignment of IP and spin-off creation also differ in terms of both their intensity and their impact. For example, spin-off creation is likely to be considerably more time-consuming, challenging and disruptive with regard to other academic work compared to consulting activities. In addition, the empirical study focused on the consequences of entrepreneurial activities for the traditional activities, research and teaching, only and did not analyse either how the entrepreneurial activities may influence society or measure their impact.

While further analysis of interdependencies were beyond the scope of this research study, it is hoped that the findings will inspire other scholars to investigate the entrepreneurial activities of academics further and to explore the antecedents and consequences of these complex processes within the context of multiple helix innovation systems.

6.6 CONCLUSION

This chapter linked the research findings back to the research problem. It summarised the key findings pertaining to each research question and derived the overall conclusions. The chapter then elaborated on the implications of the study for both research and practice and put forward suggestions for future research. Finally, the chapter discussed the limitations of the study.

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APPENDIX A

Questionnaire

Academic Entrepreneurial Activity Survey of South African NRF-rated University Researchers 2013:

Demographic Information		
Which university are you currently affiliated with?	1 Cape Peninsula University of Technology 2 Central University of Technology 3 Durban University of Technology 4 Mangosuthu University of Technology 5 Nelson Mandela Metropolitan University 6 North-West University 7 Rhodes University 8 Stellenbosch University 9 Tshwane University of Technology 10 University of Cape Town 11 University of Fort Hare 12 University of the Free State 13 University of KwaZulu-Natal 14 University of Johannesburg 15 University of Limpopo 16 University of Pretoria 17 University of South Africa 18 University of the Western Cape 19 University of the Witwatersrand 20 University of Venda 21 University of Zululand 22 Vaal University of Technology 23 Walter Sisulu University	UNI V1
Which faculty do you belong to?	1 Engineering 2 Information Technology 3 Medical/Health Science 4 Natural Science 5 Humanities 6 Education 7 Law 8 Economics and Management Sciences 9 Agricultural/Veterinarian Sciences 10 Research Office 11 Military Sciences Other. Please specify:	FOR V2
What is your current academic position?	1 Lecturer/Researcher 2 Senior Lecturer/Senior Researcher 3 Associate Professor 4 Full Professor 5 Emeritus Professor 6 Head of Department 7 Dean Other. Please specify:	SEN V3

APPENDIX A
Questionnaire

What is your gender?	1 Female 2 Male	GEN V4
In which year were you born?	#	YOB V5

1. Please rate each of the following statements according to your own personal judgement.

	Strongly Disagree	Disagree	Agree	Strongly Agree	ATE
Academic research topics should be determined by the private sector's needs.	1	2	3	4	V6
Academia-industry collaborations are important.	1	2	3	4	V7
I actively seek interactions with entities outside academia.	1	2	3	4	V8
Increased attention to the commercialisation of intellectual property will improve the quality of research.	1	2	3	4	V9
Starting up a new venture is a career option for me.	1	2	3	4	V10

2. Think about your last two years as a researcher [calendar year 2011 and 2012].

How many times have you been involved in a JOINT RESEARCH PROJECT with…	times (if never, enter 0)	SPR
- Industry? (e.g. private sector company)	#	V11
- Government? (e.g. parastatal, government department)	#	V12
- any other entity outside academia, industry and government? (e.g. civil society, non-governmental organisation (NGO), not-for-profit organisation (NPO), community group)	#	V13

How many times have you been involved in a CONTRACT RESEARCH PROJECT for…	times (if never, enter 0)	SPR
- Industry?	#	V14
- Government?	#	V15
- any other entity outside academia, industry and government?	#	V16

How many times did you, or the university on your behalf,...	times (if never, enter 0)	LAI
- sell intellectual property created during a university research project?	#	V17
- licensed intellectual property created during a university research project?	#	V18
- create a university spin-off? (a new firm created to commercially exploit some knowledge, technology or research results developed within a university)	#	SPC V19

To how many clients did you provide CONSULTING services?	number of clients (if none, enter 0)	CON
- in industry.	#	V20
- in government.	#	V21
- outside academia, industry and government.	#	V22

3. How do each of the following statements describe your research projects?

	Strongly disagree	Disagree	Agree	Strongly Agree	ADR
My research projects are focused mainly on end-user needs. (End-user is a person who will actually work with the good or service or consume it.)	1	2	3	4	V23
Existing problems in the market place form the major focus of my research projects.	1	2	3	4	V24
Most of my research addresses issues that affect society.	1	2	3	4	V25
My research projects involve the active participation of end-users.	1	2	3	4	V26

4. For your research results to be used in the development of new or improved products, processes or services, to what extent is the following required?

	Almost never	Sometimes	Often	Almost always	NOR
Use of new materials.	1	2	3	4	V27
Use of radical new technology.	1	2	3	4	V28
Use of new production techniques.	1	2	3	4	V29
Significant financial investments.	1	2	3	4	V30

Note: Question 5 and 6 do not form part of the research study.

5. Please indicate your opinion on the statements below. No answer is right or wrong.

My strength lies in:	Strongly Disagree	Disagree	Agree	Strongly Agree	
- identifying products people want.	1	2	3	4	V31
- my ability to seize high quality business opportunities.	1	2	3	4	V32
- having ideas that may materialise into profitable businesses.	1	2	3	4	V33
- achieving results by organising people.	1	2	3	4	V34
- coordinating tasks.	1	2	3	4	V35
- using limited resources to achieve maximum results.	1	2	3	4	V36
- my expertise in a technical area.	1	2	3	4	V37
- my expertise in my field of research.	1	2	3	4	V38
- my ability to develop products.	1	2	3	4	V39

6. How does each of the following statements describe you?

	Strongly Disagree	Disagree	Agree	Strongly Agree	
I feel comfortable working with people from diverse backgrounds.	1	2	3	4	V40
I am actively involved in my local community.	1	2	3	4	V41
I have strong connections to various different business networks.	1	2	3	4	V42
I like to discuss new ideas with people from diverse fields of expertise.	1	2	3	4	V43
If I need information to make a critical life-oriented decision, I know where to find it	1	2	3	4	V44

7. Thinking about your University's entrepreneurial culture, please indicate your opinion on each of the following statements.

	Strongly Disagree	Disagree	Agree	Strongly Agree	I don't know	UEC
The structure of the university's incentive system encourages entrepreneurial activities.	1	2	3	4	5	V45
The university recognises entrepreneurial activities for promotion.	1	2	3	4	5	V46
There are role models who are entrepreneurially active within the university.	1	2	3	4	5	V47
The university provides structured quality time for entrepreneurial activities.	1	2	3	4	5	V48
The university provides training opportunities for researchers to obtain competence in entrepreneurial activities.	1	2	3	4	5	V49

8. Moving on to your university's intellectual property (IP) managerial capabilities, please rate each of the following statements.

	Strongly Disagree	Disagree	Agree	Strongly Agree	I don't know	UIM
The university's technology transfer office has expertise in facilitating entrepreneurial activities.	1	2	3	4	5	V50
The university's technology transfer office has the capacity to facilitate entrepreneurial activities.	1	2	3	4	5	V51
The university has a clear process for conducting due diligence on intellectual property rights.	1	2	3	4	5	V52
I have been informed about the new IPR-PFRD Act 51 of 2008 by the university.	1	2	3	4	5	V53
The university has established procedures for collaboration with industry.	1	2	3	4	5	V54

APPENDIX A
Questionnaire

9. Regarding the innovation infrastructure of the university you are currently affiliated with, what is your opinion on each of the statements below?

The university provides:	Strongly Disagree	Disagree	Agree	Strongly Agree	I don't know	UII
- links to a network of alumni.	1	2	3	4	5	V55
- innovation infrastructure. (e.g. links to science and technology parks, business incubators, technology networks)	1	2	3	4	5	V56
- seed funding for entrepreneurial activities.	1	2	3	4	5	V57
- connections to funding institutions. (e.g. angel investors, venture capitalists, government agencies)	1	2	3	4	5	V58
- access to buffer institutions. (e.g. applied laboratories, technology stations, Institutes for Advanced Tooling)	1	2	3	4	5	V59
- access to legal advisers. (e.g. IP lawyers, experts within the Faculty of Law)	1	2	3	4	5	V60
- access to business developers. (e.g. external consultants, experts within the Faculty of Economics and Management)	1	2	3	4	5	V61
- links to industrial partners.	1	2	3	4	5	V62

10. Please rate each of the following statements according to your own personal judgement.

I gained entrepreneurship-related knowledge…	Strongly disagree	Disagree	Agree	Strongly Agree	DEE (V64, V65, V66) EEE (V63, V67, V68)
- in our family business.	1	2	3	4	V63
- while running a new venture.	1	2	3	4	V64
- while being involved in the creation of a new venture.	1	2	3	4	V65
- while owning a new venture.	1	2	3	4	V66
- during a course where I learned how to transform opportunities into profitable businesses.	1	2	3	4	V67
- during a course where I learned how to run and manage businesses.	1	2	3	4	V68

11. The following questions pertain to your work experience outside of academia, e.g. in industry, government or in other organizations. Please submit your answer in the space provided.

	number (if none, enter 0)				WEO
How many years of professional work experience outside academia do you have?	#				V69
How many organisations outside academia have you worked for in a full time employment capacity?	#				V70
What was your highest job function in an organisation outside of academia?	None 1	Operational 2	Managerial 3	Strategic 4	V71

12. Within the last two years [calendar years 2011 and 2012] as a researcher, how many...

	number (if none, enter 0)	
- invention disclosures did you make to your university's technology transfer office?	#	V72
		PUP
- articles did you publish in accredited international journals?	#	V73
- academic books did you publish [not including single chapters]?	#	V74

13. Within the last two years [calendar years 2011 and 2012] as a researcher, how many...

	Number (if none, enter 0)	IPP
- international patent applications, based on IP emanating from R&D did you file?	#	V75
- local patent applications, based on IP emanating from R&D did you file?	#	V76
- trademark applications, based on IP emanating from R&D did you file?	#	V77
- registered design applications, based on IP emanating from R&D did you file?	#	V78
- plant breeder right applications, based on IP emanating from R&D did you file?	#	V79
- times did you protect your IP emanating from R&D by means of the common law? (e.g. trade secret or copyright, excluding publications)	#	V80

14. Please estimate the approximate % share of your average weekly time allocation among your different tasks for the current academic year (note that the column must add up to 100%, where no time allocated to a listed section = 0).

		TEC
Teaching and teaching-related activities.	#	V81
Conducting research that does not involve partners outside academia.	#	V82
Administrative and management tasks.	#	V83
Clinical practices.	#	V84
Consulting for people outside of academia/community service	#	V85
Working on research activities with people outside academia	#	V86
Creative work	#	V87
Other. Please specify:		

APPENDIX B

Letter of Introduction and Informed Consent

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty Of Economic And Management Sciences

Letter of Introduction and Informed Consent for participation in academic research

Dept. of Business Management

ASSESSING ANTECEDENTS AND CONSEQUENCES OF ENTREPRENEURIAL ACTIVITIES OF ACADEMICS AT SOUTH AFRICAN UNIVERSITIES

Research conducted by:

Ms. M. Meusburger (10496808)

Dear Respondent

You are invited to participate in an academic research study titled “Assessing antecedents and consequences of entrepreneurial activities of academics at South African universities” conducted by Magdalena Meusburger, doctoral student from the Department of Business Management at the University of Pretoria.

The purpose of the study is to gain a general understanding of the level of engagement in entrepreneurial activities (consulting, sponsored research, licensing/assignment of IP and spin-off creation) amongst NRF-rated researchers at South African Universities. The study seeks to determine which resource bundles determine these activities and how they substitute or complement each other.

Please follow this link to the Survey: Take the Survey

Or copy and paste the URL below into your internet browser:
https://tuks.qualtrics.com/WRQualtricsSurveyEngine/?SID=SV_6J34I9FI9995glT&Preview=Survey&_=1

Please note the following:

- This study involves an anonymous survey. Your name will not appear on the questionnaire and the answers you give will be treated as strictly confidential. You cannot be identified in person based on the answers you give. [Kindly note that consent cannot be withdrawn once the questionnaire is submitted as there is no way to trace the particular questionnaire that has been filled in.]

- Your participation in this study is very important to us. You may, however, choose not to participate and you may also stop participating at any time without any negative consequences.

- Please answer the questions in the questionnaire as completely and honestly as possible. This should not take more than 15 minutes of your time.

- The results of the study will be used for academic purposes only and may be published in an academic journal. We will provide you with a summary of our findings on request.

- Statistical processes will be done by the Department of Statistics at the University of Pretoria.

- Please feel free to contact the study leader, Dr. Alex Antonites, (Email: alex.antonites1@up.ac.za; Tel.: +27 12 420 3119) or the doctoral student Magdalena Meusburger (Email: u10496808@tuks.co.za; Tel.: 0719299448) if you have any questions or comments regarding the study.

Many Thanks and Best Regards,

Dr. Alex Antonites and Magdalena Meusburger

APPENDIX C

Odds ratios and incident rate ratios

Table C.1: Calculation of odds ratios for spin-off creation

Odds Ratios		2.50%	97.50%
(Intercept)	7.10E-05	4.70E-07	6.30E-03
BlockHlt	2.50E-01	5.00E-02	1.20E+00
BlockNtr	3.30E-01	9.50E-02	1.20E+00
BlockHmt	5.80E-01	1.10E-01	2.90E+00
BlockMng	1.20E-01	1.20E-02	8.00E-01
WEOTRUE	1.00E+00	4.00E-01	2.70E+00
DEETRUE	5.40E+00	2.00E+00	1.60E+01
EEETRUE	1.60E+00	6.00E-01	4.10E+00
SENProfessor	2.50E+00	8.10E-01	9.00E+00
ADR	9.70E-01	4.50E-01	2.10E+00
NOR	2.50E+00	1.30E+00	5.20E+00
IPPTRUE	3.60E+00	1.30E+00	1.00E+01
UII	1.00E+00	2.90E-01	3.80E+00
UIM	1.60E+00	5.80E-01	4.60E+00
UEC	1.60E+00	5.90E-01	4.50E+00
Genderm	1.40E+00	4.40E-01	4.80E+00
Age	1.00E+00	9.70E-01	1.10E+00
UniUT	3.60E-07	2.90E-152	2.50E+13
UniCU	4.20E+00	1.10E+00	1.50E+01

Table C.2: Calculation of odds ratios for licensing/assignment of IP

Odds Ratios		2.50%	97.50%
(Intercept)	7.60E-03	2.00E-04	2.30E-01
BlockHlt	8.10E-01	2.10E-01	3.30E+00
BlockNtr	8.70E-01	2.70E-01	3.00E+00
BlockHmt	9.00E-01	1.90E-01	4.20E+00
BlockMng	1.70E+00	4.10E-01	7.50E+00
WEOTRUE	6.80E-01	3.10E-01	1.50E+00
DEETRUE	3.10E+00	1.40E+00	6.70E+00
EEETRUE	5.10E-01	2.10E-01	1.20E+00
SENProfessor	5.30E-01	2.20E-01	1.30E+00
ADR	1.60E+00	8.60E-01	2.80E+00
NOR	9.70E-01	5.60E-01	1.70E+00
IPPTRUE	1.50E+01	6.20E+00	4.10E+01
UII	7.50E-01	2.80E-01	2.00E+00
UIM	1.60E+00	7.20E-01	3.50E+00
UEC	1.20E+00	5.40E-01	2.70E+00
Genderm	1.00E+00	4.50E-01	2.40E+00
Age	1.00E+00	9.70E-01	1.10E+00
UniUT	4.80E-08	NA	2.80E+24

UniCU	1.30E+00	3.60E-01	3.90E+00

Table C.3: Calculation of odds ratios for sponsored research

Odds Ratios		2.50%	97.50%
(Intercept)	0.201	0.011	4.072
BlockHlt	0.364	0.046	1.871
BlockNtr	0.253	0.035	1.062
BlockHmt	0.166	0.022	0.75
BlockMng	0.172	0.022	0.82
WEOTRUE	1.222	0.664	2.248
DEETRUE	1.607	0.791	3.375
EEETRUE	1.516	0.733	3.29
SENProfessor	2.077	1.029	4.228
ADR	2.518	1.598	4.072
NOR	1.322	0.839	2.116
IPPTRUE	2.594	0.651	17.515
UII	0.366	0.171	0.755
UIM	1.772	0.928	3.503
UEC	1.849	0.969	3.589
Genderm	0.903	0.472	1.706
Age	1.017	0.982	1.055
UniUT	0.24	0.049	1.453
UniCU	0.514	0.227	1.184

Table C.4: Calculation of odds ratios for consulting

Odds Ratios		2.50%	97.50%
(Intercept)	0.527	0.056	5.066
BlockHlt	0.486	0.15	1.428
BlockNtr	0.474	0.162	1.214
BlockHmt	0.386	0.122	1.098
BlockMng	0.632	0.187	1.98
WEOTRUE	1.054	0.641	1.726
DEETRUE	2.159	1.233	3.851
EEETRUE	1.821	1.011	3.363
SENProfessor	1.072	0.602	1.895
ADR	1.861	1.291	2.718
NOR	0.847	0.581	1.225
IPPTRUE	2.367	0.952	6.592
UII	0.684	0.366	1.258
UIM	1.328	0.768	2.323
UEC	0.738	0.431	1.255
Genderm	1.668	0.987	2.831
Age	1.019	0.99	1.049
UniUT	0.614	0.146	3.257
UniCU	0.709	0.346	1.464

APPENDIX C
Odds and Incident Rate Ratios

Table C.5: Calculation of odds for entrepreneurial activities

Item	M	Spin-off creation		Licensing and assignment of IP		Sponsored research		Consulting	
		fit	odds	fit	odds	fit	odds	fit	odds
Block	Eng	0.05	3.02	0.06	0.95	0.96	1.14	0.83	1.18
Block	Hlt	0.01	0.51	0.05	0.74	0.9	1.05	0.7	0.96
Block	Ntr	0.02	0.7	0.05	0.8	0.86	0.99	0.69	0.95
Block	Hmt	0.03	1.37	0.05	0.84	0.8	0.91	0.65	0.87
Block	Mng	0.01	0.22	0.09	1.8	0.81	0.92	0.75	1.05
WEO	FALSE	0.02	0.98	0.07	1.45	0.85	0.97	0.7	0.98
WEO	TRUE	0.02	1.02	0.05	0.69	0.87	1.03	0.71	1.02
DEE	FALSE	0.01	0.19	0.04	0.35	0.84	0.94	0.65	0.81
DEE	TRUE	0.05	5.15	0.1	2.86	0.9	1.06	0.8	1.23
EEE	FALSE	0.02	0.64	0.06	1.9	0.85	0.95	0.68	0.85
EEE	TRUE	0.03	1.56	0.03	0.53	0.9	1.05	0.79	1.17
SEN	notProf.	0.01	0.4	0.08	1.83	0.81	0.9	0.7	0.98
SEN	Prof.	0.03	2.5	0.04	0.55	0.9	1.11	0.72	1.02
ADR		0.02	1.05	0.03	0.45	0.61	0.71	0.49	0.67
ADR		0.02	1.03	0.04	0.57	0.72	0.84	0.57	0.79
ADR		0.02	1.01	0.04	0.72	0.8	0.96	0.64	0.91
ADR		0.02	1	0.05	0.91	0.86	1.05	0.71	1.03
ADR		0.02	0.98	0.07	1.16	0.91	1.12	0.77	1.13
ADR		0.02	0.97	0.08	1.49	0.94	1.16	0.82	1.22
ADR		0.02	0.96	0.1	1.93	0.96	1.19	0.86	1.29
NOR		0.01	0.16	0.06	1.05	0.83	0.94	0.74	1.09
NOR		0.01	0.25	0.05	1.03	0.85	0.96	0.72	1.06
NOR		0.02	0.41	0.05	1.01	0.87	0.98	0.7	1.03
NOR		0.03	0.67	0.05	1	0.88	1	0.69	1
NOR		0.05	1.12	0.05	0.98	0.9	1.02	0.67	0.97
NOR		0.08	1.93	0.05	0.97	0.91	1.04	0.65	0.94
NOR		0.12	3.53	0.05	0.96	0.92	1.05	0.63	0.91
IPP	FALSE	0.02	0.29	0.04	0.1	0.85	0.91	0.69	0.82
IPP	TRUE	0.05	3.43	0.39	9.79	0.94	1.1	0.84	1.22
UII		0.02	0.92	0.08	1.56	0.97	1.19	0.82	1.18
UII		0.02	0.95	0.07	1.33	0.95	1.16	0.79	1.13
UII		0.02	0.97	0.06	1.13	0.92	1.12	0.75	1.07
UII		0.02	1	0.06	0.96	0.88	1.05	0.72	1.01
UII		0.02	1.03	0.05	0.82	0.81	0.96	0.68	0.94
UII		0.02	1.05	0.04	0.7	0.72	0.84	0.63	0.88
UII		0.02	1.08	0.04	0.6	0.61	0.7	0.59	0.81
UIM		0.01	0.4	0.03	0.43	0.72	0.83	0.61	0.85
UIM		0.01	0.52	0.03	0.55	0.77	0.9	0.64	0.9
UIM		0.01	0.67	0.04	0.71	0.82	0.97	0.67	0.95
UIM		0.02	0.88	0.05	0.9	0.86	1.02	0.7	1.01
UIM		0.02	1.16	0.06	1.17	0.89	1.06	0.73	1.05
UIM		0.03	1.55	0.08	1.51	0.91	1.1	0.76	1.1
UIM		0.04	2.11	0.1	1.98	0.93	1.13	0.78	1.14
UEC		0.01	0.41	0.04	0.72	0.74	0.84	0.79	1.15
UEC		0.01	0.52	0.05	0.8	0.79	0.91	0.76	1.11
UEC		0.02	0.68	0.05	0.89	0.84	0.97	0.73	1.06
UEC		0.02	0.89	0.06	0.98	0.88	1.02	0.7	1.01

UEC		0.03	1.16	0.06	1.09	0.91	1.06	0.67	0.95
UEC		0.03	1.55	0.07	1.21	0.93	1.09	0.63	0.9
UEC		0.04	2.09	0.07	1.35	0.95	1.12	0.6	0.84
Gender	f	0.01	0.74	0.05	0.98	0.87	1.01	0.63	0.85
Gender	m	0.02	1.36	0.05	1.02	0.86	0.99	0.74	1.17
Age		0.01	0.6	0.04	0.78	0.81	0.94	0.61	0.86
Age		0.01	0.75	0.05	0.88	0.84	0.97	0.66	0.93
Age		0.02	0.95	0.05	0.99	0.86	1	0.7	1.01
Age		0.02	1.22	0.06	1.12	0.88	1.03	0.74	1.08
Age		0.03	1.59	0.06	1.27	0.89	1.06	0.77	1.14
Uni	U	0.02	0.51	0.08	1.59	0.88	1.24	0.72	1.14
Uni	UT	0	0	0	0	0.63	0.76	0.61	0.9
Uni	CU	0.09	7.82	0.1	2.51	0.79	1.04	0.65	0.97

Table C.6: Calculation of incident-ratios for publication output and teaching commitment

Incident Ratios	Publication Output			Teaching commitment		
		2.50%	97.50%		2.50%	97.50%
(Intercept)	6.37	5.22	7.76	54.96	48.94	61.69
BlockHlt	2.09	1.84	2.38	0.67	0.62	0.72
BlockNtr	1.82	1.63	2.06	0.92	0.87	0.98
BlockHmt	1.55	1.36	1.77	0.87	0.81	0.93
BlockMng	1.62	1.42	1.86	0.79	0.73	0.85
Genderm	1.18	1.1	1.25	1.04	1	1.08
SENProfessor	1.38	1.29	1.47	0.81	0.77	0.84
SPCTRUE	0.93	0.84	1.03	0.89	0.82	0.96
LAITRUE	1.09	1	1.18	0.78	0.73	0.83
SPRTRUE	1.26	1.16	1.37	0.9	0.86	0.94
CONTRUE	1.02	0.95	1.09	0.88	0.84	0.92
Age	0.99	0.99	1	1	1	1
UniUT	1.78	1.55	2.04	1.04	0.94	1.15
UniCU	0.91	0.83	0.99	1.01	0.95	1.07

Table C.7: Calculation of incidents for publication output and teaching commitment

Item	M	Publication output		Teaching commitment	
		fit	incidents	fit	incidents
Block	Eng	7.8	0.56	35	1.23
Block	Hlt	16.2	1.4	23	0.74
Block	Ntr	14.2	1.17	32	1.11
Block	Hmt	12	0.95	30	1.03
Block	Mng	12.6	1	28	0.91
Gender	f	11.7	0.85	29	0.96
Gender	m	13.7	1.18	30	1.04
SEN	not Professor	10.8	0.73	34	1.24
SEN	Professor	14.9	1.38	27	0.81
SPC	FALSE	13.1	1.08	30	1.12
SPC	TRUE	12.2	0.93	27	0.89
LAI	FALSE	12.9	0.92	31	1.28
LAI	TRUE	14	1.09	24	0.78

SPR	FALSE	10.8	0.79	33	1.11
SPR	TRUE	13.6	1.26	29	0.9
CON	FALSE	12.9	0.98	33	1.14
CON	TRUE	13.1	1.02	29	0.88
Age		14.8	1.15	32	1.07
Age		14	1.07	31	1.03
Age		13.2	1	30	1
Age		12.5	0.93	29	0.97
Age		11.8	0.86	29	0.94
Uni	U	13	0.74	30	0.98
Uni	UT	23.1	1.87	31	1.04
Uni	CU	11.8	0.65	30	0.99