ADVANCING SOCIAL RELATIONSHIPS IN INNOVATION NETWORKS AND THEIR COMMERCIALISATION SUCCESS IN MALAYSIAN PUBLIC UNIVERSITIES

A dissertation submitted by

Arbaiah Abdul Razak

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ABSTRACT

The start of the 21st century is marked by profound changes in applied knowledge in economy, technology and society - among others. Knowledge has become the modern day commodity, where innovation plays the main role in knowledge creation and implementation. Consequently, innovation is central for individual and organisational performance, for social and economic development of nations. Economists have conceptualised innovation as an agent of growth, while technologists have viewed innovation as an agent of change. Others have taken innovation from social perspectives where individuals are the agent for innovative actions that are connected and interacted within a network system. Thus, the ontological position of this research examines individual innovative behaviour during interactions with other innovation actors.

Generally, there is an issue for university research outputs to be effectively commercialised. In Malaysia, about 95% of university research outputs fail to commercialise (OECD 2013) although substantial resources (in terms of human, intellectual, financial and technological) for innovation are available. The problem is that many Malaysian universities work in isolation without networking, and poor links exist between university and industry. Malaysian university collaborations have not yet reached a satisfactory level because there is a lack of capability in strengthening relationships in innovation networks. Hence, this research develops and tests a conceptual framework related to *the ineffective management of social relationships within innovation networks and the lack of success of commercialisation attempts in Malaysian universities.*

Scholars have defined social relationships as a process of human interactions where social resources or capital is created and exchanged within a network that influences individual's specific behaviours and their next actions. However, social resources critical for innovation relationships are not fully understood. This research examines the importance of social resources related to openness, trust, motivation and leadership. Following extant research, these four themes are used as a basis to explore the relationship between innovation and commercialisation success in the Malaysian public university sector. In this research context, university researchers (or academics) are regarded as the innovation actors.

The philosophical paradigm for this research was of the pragmatism view. A sequential mixed-methods research design was implemented to investigate this practice-oriented research problem. Both qualitative and quantitative methodologies were mixed by using individuals as unit of analysis. A minor qualitative research that involved ten expert interviews and content analysis was initially conducted, prior to a major quantitative research that used field survey and statistical analysis. The qualitative stage helped to confirm the research problem, to validate the preliminary conceptual framework and to refine the survey instrument. In the quantitative stage, a larger data set was used to allow a power statistical analysis, to answer the research questions and to establish a model about innovation network relationships management in Malaysian public universities.

The main findings of this research are based on the final model generated by both theories and data that meet all statistical conditions. This research found that open innovation and strategic leadership significantly influence commercialisation success. In particular, strategic leadership emerged as a dominant factor where it has a highly significant direct relationship with commercialisation success, and more importantly, it mediates significantly an indirect relationship between open innovation and successful commercialisation. This indicated that open innovation practices and strategic leadership skills facilitate mutual sharing of resources and enculturation of innovative behaviours which are critical for commercialisation success strategies. Thus, these findings have significantly contributed to explaining the research problem for managing and advancing social relationships and innovation networks in Malaysian public universities.

The results of this research are expected to add to the knowledge of innovation and commercialisation in a public university sector within a developing country; it may also be possible to generalise the results internationally. Despite the research contributions, the findings should, however, be considered on theoretical, methodological and practical limitations that provide avenues for future research.

Keywords

Open innovation; strategic leadership; social relationships; commercialisation success; public university, Malaysia.

CERTIFICATION OF DISSERTATION

I certify that the ideas, results, analyses and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

Arbaiah Abdul Razak

_____ _____

Candidate Date

ENDORSEMENT

Professor Peter A. Murray

_____ _____

Principal Supervisor Date

Dr David Roberts

_____ _____

Associate Supervisor Date

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Last but not least, I dedicate this thesis to my late father, Razak and certainly, to Allah s.w.t. for answering all my prayers and making this challenging journey a success.

Oh my Lord! Open my chest. And ease my task for me.
Remove the impediment from my speech so that they may understand what I say.
- Surah Ta-Ha (20: 25-28)

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Abdul Razak, A, 2014, How university research is in accordance with open innovation concept? Paper accepted and presented at the 3rd International Seminar on Entrepreneurship and Business (ISEB 2014), 14 December 2014, Kelantan, Malaysia.

LIST OF ABBREVIATIONS

AAPOR	American Association for Public Opinion Research
AGFI	Adjusted Goodness of Fit Index
AGPS	Australian Government Publishing Service
AIM	*Agensi Inovasi Malaysia*
AMOS	Analysis of Moment Structures
ANOVA	Analysis of Variance
APH	Australian Parliament House
AVE	Average Variance Extracted
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CS	Commercialisation Success
C.R.	Critical Ratio
CR	Composite Reliability
CRA	Collaborative Research Advantage
EFA	Exploratory Factor Analysis
ERG	Existence, Relatedness and Growth
ERGS	Exploratory Research Grant Scheme
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GFI	Goodness of Fit Index
GII	Global Innovation Index
H_A	Hypothesis Alternative
H_O	Hypothesis Null
HEI	Higher Education Institutions
IA	Innovation Actor
IBM	International Business Machines Corporation
IGS	Industry Research & Development Grant Scheme
INSEAD	Institut Européen d'Administration des Affaires (France)
IP	Intellectual Property
IRPA	Intensification of Research in Priority Areas
ITAF	Industrial Technical Assistance Fund
KIBS	Knowledge Intensive Based Service
KMO	Kaiser-Meyer-Olkin

LRGS	Long-term Research Grant Scheme
MASTIC	Malaysian Science and Technology Information Centre
MATRADE	Malaysia External Trade Development
MAVCAP	Malaysia Venture Capital
MCAR	Missing Completely at Random
MI	Motivation to Innovate
MIGHT	Malaysia Industry Government Group for High Technology
MLE	Maximum Likelihood Estimation
MOHE	Ministry of Higher Education (Malaysia)
MOSTI	Ministry of Science, Technology and Innovation (Malaysia)
MSC	Multimedia Super Corridor
OECD	Organisation for Economic Co-operation and Development
OI	Open Innovation
PAE	Patent Assertion Entities
PRGS	Prototype Research Grant Scheme
QDA	Qualitative Data Analysis
R^2	Squared multiple correlations
R&D	Research and Development
RMR	Root Mean square Residual
RMSEA	Root Mean Square of Error Approximation
RU	Research-focused Universities
S.D.	Standard Deviation
SBMI	Strategic Business Management & Improvement (USQ)
SEM	Structural Equation Modeling
SL	Strategic Leadership
SME	Small and Medium Enterprises
SPSS	Statistical Package for the Social Science
SRMR	Standardised Root Mean square Residual
STI	Scientific, Technology and Innovation
SWOT	Strength, Weakness, Opportunity and Threat
TI	Trust in Innovation
TLI	Tucker Lewis Index
TPM	Technology Park Malaysia
USQ	University of Southern Queensland
WIPO	World Intellectual Property Organization

CHAPTER 1: INTRODUCTION

"If we knew what it was we were doing, it would not be called research, would it?"
- Albert Einstein, a physicist (1879 – 1955)

1.1. Overview

This research is about innovation management. The start of the 21st century is marked by profound changes in applied knowledge in economy, technology and society - among others. Knowledge has become the modern day commodity, where innovation plays the main role in knowledge creation and implementation. Consequently, innovation is central for individual and organisational performance, for social and economic development of nations (Gopalakrishnan & Damanpour 1997). This chapter introduces the research problem, highlights the gaps in the literature, and justifies the research and its methodology that lead to the conclusions of the research. This chapter consists of nine sections as shown in Figure 1.1. These research steps were determined to set the path for the investigation process.

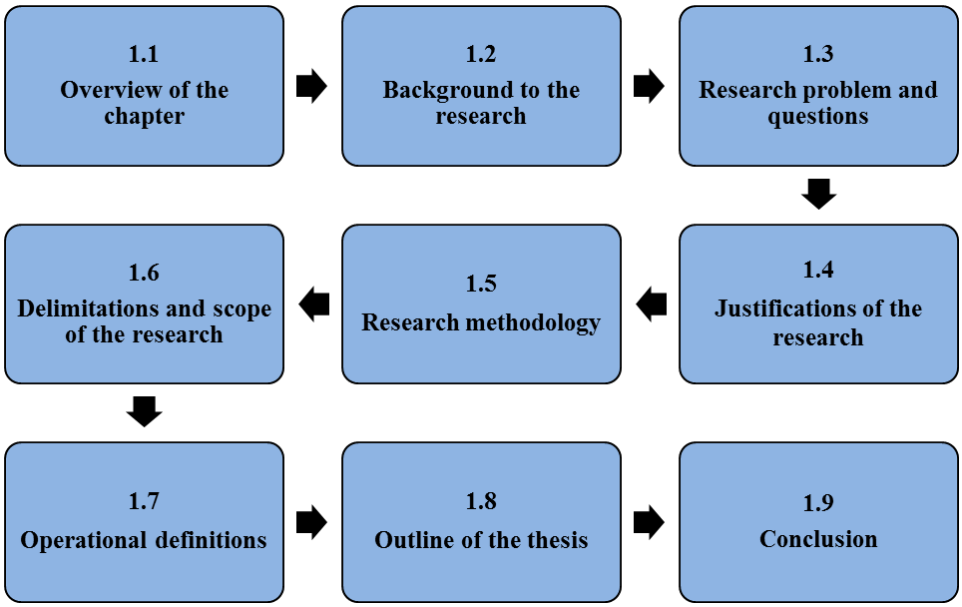


Figure 1.1: The outline of Chapter 1 on key elements of the research.

1.2. Background to the Research

The topic of innovation has been examined from various perspectives. For example, economists have conceptualised innovation as an agent of growth (Schumpeter 1934), or agent of change as viewed by technologists (Henderson & Clark 1990). Others have taken innovation from social perspectives where individuals are the agent for innovation that are connected and interacted within a network system (Teece 1992).

The idea of this research originated from the researcher's practical experiences encountered in managing innovation at one of Malaysia's public universities. One significant issue for the university was how to effectively commercialise research outputs. This was a problem for the Malaysian university sector as a whole as there had been little progress in the research commercialisation rate in Malaysia (Ab. Aziz et al. 2012; Govindaraju, Ghapar & Pandiyan 2009). For instance, about 95% of the Malaysian university research outputs were failing to be commercialised (OECD 2013). Although Malaysia has adopted the Western university research model, innovation efforts have yet to show similar commercialisation outcomes achieved by their Western university counterparts (Ramli et al. 2013). Furthermore, Malaysian university collaborations have not yet reached a satisfactory level because of the lack of capabilities in strengthening innovation relationships (Razak & Saad 2007).

The interest in innovation relationships has emerged in innovation management theory and practice (e.g. Hendry, Brown & Defillippi 2000; McAdam et al. 2010; Siegel et al. 2003; Yencken & Gillin 2006), with relevant literature focused on commercialisation of university research outputs (e.g. Harman & Harman 2004; Hayrinen-Alestalo & Peltola 2006; Shane 2002). In order to close the gap between research and commercialisation success – in the Malaysia context particularly, specific reports highlight the ineffectiveness of innovation relationships between universities and business (Day & Muhammad 2011; MASTIC 2012, 2013; OECD 2013; WIPO 2013).

As the commercialisation process involves various individuals as innovation actors (Kanter 1988; Plewa et al. 2013), the actors' social interactions within innovation networks is critical for bridging the science-to-market link and for complementing different resources. Thus, there is a possibility to improve the university research commercialisation rate by building strong social relationships

among innovation actors. For example, Neyer, Bullinger and Moeslein (2009) found that organisations can only fully optimise their innovation processes when more attention was given to the social interactions among internal and external innovators.

According to Homans (1958), a rewarding interaction between actors depends on the social relationships and exchange activity between tangible or intangible resources. In turn, the relationships create a form of capital or social resources that supports the actors to stay in a relationship (Bignoux 2006). The social capital that are created from the network of actors' interactions can take different forms. It is defined by the functioning and specific activities of a social system that facilitates actions (or behaviours) of actors inherent in the relationships (Coleman 1988). Thus, to explain innovation from a social perspective, multiple forms of social capital are plausible and embedded within innovation networks and the actors' relationships (Landry, Amara & Lamari 2002; Rutten & Boekema 2007).

In summary, it is important to connect innovation actors within the universities and external actors from industry, respectively. However, the embedded social capital within these innovation networks and relationships is not well understood. For instance, behaviours related to openness, trust, motivation and leadership are not transparent. Further, how these behaviours are related to successful or non-successful commercialisation attempts by Malaysian universities requires far greater clarification.

1.3. Research Problem and Questions

The research problem for this thesis is focused on asking questions about *the ineffective management of social relationships within innovation networks and the lack of success of Malaysian university commercialisation attempts*. Using the contextual setting of public universities, the researcher explores how social capital influences commercialisation success particularly when social capital is a function of innovation networks.

In order to determine data collection about the research problem, extant literature on open innovation, commercialisation, and social relationships was reviewed in Chapter 2. A preliminary conceptual framework was developed with three research objectives and associated research questions as listed in Table 1.1, for subsequent analysis in a field survey. This conceptual framework was confirmed by

ten expert interviews as described in Chapter 4. The framework illustrates the associations between *innovation actor's* characteristics, social constructs reflecting in *open innovation, trust in innovation, motivation to innovate* and *strategic leadership.* These four broad themes where used to explore the *commercialisation success* of Malaysian public universities.

Table 1.1: The research objectives and associated questions.

No.	Research Objectives	Research Questions	Remarks
1	To examine whether the difference in *Innovation Actors'* characteristics in Malaysian public universities differ from their perceptions towards *Commercialisation Success* strategies.	Does the difference in *Innovation Actors'* characteristics differ from their perceived strategies for *Commercialisation Success*?	The demographic characteristics of interest are age, gender, type of university, academic qualification, research expertise, academic position, industrial experience and industrial research.
2	To examine whether *Open Innovation, Collaborative Research Advantage* and *Strategic Leadership* influences *Commercialisation Success* strategies.	Does *Open Innovation, Collaborative Research Advantage* and *Strategic Leadership* influence *Commercialisation Success*?	*Collaborative Research Advantage* is a new construct emerging from exploratory factor analysis on items that were initially conceptualised to measure *Trust in Innovation* and *Motivation to Innovate*.
3	To examine whether the innovation relationships model differs across two groups of *Innovation Actors* (i.e. with and without industrial experience).	Is the innovation relationships model of *Open Innovation, Strategic Leadership* and *Commercialisation Success* equivalent across two groups of *Innovation Actors* based on industrial experience?	Given a baseline assumption that the model is identical across *Innovation Actors* with and without industrial experience.

Accordingly, the main null hypotheses for the research can now be presented:

H_{O1}: The mean scores of *Commercialisation Success* are equal between the *Innovation Actors* when they are classified according to their eight demographic characteristics, namely age, gender, type of university, academic qualification, research expertise, academic position, industrial experience and industrial research.

H_{O2}: *Open Innovation*, *Collaborative Research Advantage* and *Strategic Leadership* have no influence on *Commercialisation Success.*

H_{O3}: The innovation relationships model of *Open Innovation*, *Strategic Leadership* and *Commercialisation Success*, is equivalent between the *Innovation Actors* when they are grouped according to their industrial experience.

This research investigates the influence of several forms of social resources on strategies for commercialisation success and makes inferences about innovation and commercialisation management practices in Malaysian public universities. In particular, this research makes three types of contributions to the innovation management body of knowledge as explained in Section 6.6. This research is expected to:

(i) establish and test a newly generated relational model for facilitating university research commercialisation in public universities;
(ii) extend the existing knowledge on open innovation studies within a public university context that is categorised as knowledge-intensive based service; and
(iii) inform university researchers and managers about better support and governance of innovation network relationships.

1.4. Justifications of Research

This research is justified on the basis of three significant needs for university-led innovation and commercialisation strategies: (1) a need to focus on knowledge-based economic strategy; (2) gaps in university-led innovation and commercialisation research; and (3) expected benefits for university innovation and commercialisation management practices.

The first justification for this research was on the emphasis of knowledge-based strategy. In this post-industrial era, a nation's development is driven by knowledge-based economic strategies and innovation capabilities. A national innovation system that comprises of diverse innovation actors from firms, universities, government and others is integral to support this strategy (Hidalgo & Albors 2008). Focusing on universities, they have important roles in the national innovation system (van der Steen & Enders 2008) as a knowledge service provider and as a knowledge intensive based service (KIBS) organisation (Janeiro, Proença & Gonçalves 2013).

Malaysia, as the setting for this research, is a developing nation that aims to be a developed country by the year 2020. Central to this national vision, innovation is regarded as a driver for social and economic growth. Many policies and initiatives have been introduced to intensify national innovation capabilities (OECD 2013). The Global Innovation Index for 2013 (GII2013) reported Malaysia among the top ten best innovation performers among the middle-income countries mainly on the basis of a good national policy of innovation and healthy growth in gross expenditure in research and development (WIPO 2013). The report also indicated that tertiary education and research sectors were among the areas of concern for improving the Malaysia innovation input (WIPO 2013). There is also a need for research at universities to be intensified and linked with industries for maximising commercialisation opportunities (OECD 2013).

Specific to public universities in Malaysia, there are about 30,000 academic staff employed nationwide and being granted about 4,000 research projects yearly (MOHE 2012). These public universities are equipped with 50% of the national innovation infrastructures and have steady research funding (MASTIC 2013). Approximately 86% of research products have the potential for commercialisation owned by these public universities (MASTIC 2013). Despite these innovation

capabilities, there has been little progress in the Malaysia commercialisation rate (Ab. Aziz et al. 2012) with only 5% of the university research outputs successfully commercialised (Govindaraju, Ghapar & Pandiyan 2009; OECD 2013). This commercialisation rate is considered low compared to the average commercialisation rate at international level which is 10% (Ramli et al. 2013) and patent utilisation rate at between 10-30% (Chesbrough 2012). Noted gaps are mainly attributed to the way many universities work in isolation without networking (Govindaraju, Ghapar & Pandiyan 2009).

In addition, there has been increasing demands for public universities to act as profitable organisations, to generate new income streams and to contribute to economic development (Roper & Hewitt-Dundas 2012) by increasing commercial values of their research outputs (Gertler 2010; Tether 2002). In turn, the government and industries are increasingly seeking to use universities as a source of innovation and knowledge (Mowery & Sampat 2006). However, universities traditionally tend to focus on academic teaching (Arvanitis, Kubli & Woerter 2008) with minor involvement in commercialisation activity (D'Este & Patel 2007). Indeed, the need for better understanding the nature of relationships between universities and industries in terms of innovation has been highlighted by academics and practitioners (Bonaccorsi & Piccaluga 1994; Hendry, Brown & Defillippi 2000; Plewa et al. 2013). In brief, there is a close link between the Malaysian vision, the knowledge-based economic strategy and the effective relationships of universities with other innovation actors, to intensify innovation and commercialisation that justifies the focus of this research.

The second justification relates to gaps in academic research. In order to generate valuable economic impact from research outputs, universities need to review their relationships with society and with industries in particular (Padilla-Mele´ndez & Garrido-Moreno 2012). Innovation management scholars have also questioned the contributions of universities to an economy and the effectiveness of the relationships between universities and business (Audretsch, Leyden & Link 2013; Cohen, Nelson & Walsh 2002; Debackere & Veugelers 2005; Narayan 2011; van der Steen & Enders 2008). Responding to scholars' recommendations, theories related to innovation, commercialisation, social relationships and its resources have been reviewed (see Section 2.3, 2.4, 2.5 and 2.6). Four gaps can be identified in the literature.

(i) It is plausible that an open approach towards innovation is the basis for developing innovation networks that lead to successful commercialisation (Rahal & Rabelo 2006). While the field of innovation management is not new within industrial settings, research in open innovation practices is considered as only recent (Zhang, Ding & Chen 2014) and largely unexplored (Bianchi et al. 2011). In particular among university contexts, there is little reflection on the behaviours required for successful commercialisation outcomes (Salter, Criscuolo & Ter Wal 2014).

(ii) There was lack of research that comprehensively conceptualised several forms of social capital in examining the influence of innovation relationships between universities and other innovation actors (Rass et al. 2013). For example, trust becomes a critical success factor when innovation actors shift from closed to open innovation practices (Ciesielska & Iskoujina 2012). Motivation is also important to encourage the innovation actors going forward for better commercialisation outcomes (Collier 2007). Furthermore, universities increasingly require academics with leadership skills that can influence research cultures to be more commercially driven (Collier, Gray & Ahn 2011).

(iii) Most universities, including Asian universities, have reformed their education systems (Liefner & Schiller 2008) to accommodate the advancing global socio-economic needs. In terms of how these Asian universities respond to this globalisation of the knowledge economy is still unclear (Wong, Ho & Singh 2007). Thus, many aspects of innovation studies within the Asian public universities sector has not been systematically documented. As Asian business culture heavily relies on relationships and networks (Hitt, Lee & Yucel 2002), the need for better understanding social capital requirements is critical (Lim & Cu 2012).

(iv) Within the Malaysia public university context, there is a paucity of research related to studies that specify how social capital arrangements are embedded within innovation and commercialisation attempts. Research is needed to fill

this gap as social-relationships-oriented behaviours also exist in the Malaysian business context where developing trust for example is more important than the contractual obligation of getting the job done (Mat & Jantan 2009). Thus, how such relationships in university's innovation networks unfold will help to further our understanding of practical ideas and their implication for Malaysian academics (Ismail 2012).

The third justification of this research was the potential benefits of advancing innovation knowledge and informing academic researchers, managers and policy makers at universities. The latter relates to better development of social network relationships among various innovation actors in an open innovation system. It is envisaged that the intangible capital embedded within these innovation relationships create a set of social resources to support effective innovation. One significant outcome is commercialisation success. The contributions of this research are expected to add to our understanding of the critical management components required for effective innovation and commercialisation within a university context (Badawy 2011), and from a social perspective, that can act as a driving force for managerial and behavioural change (Flikkema, Jansen & Van Der Sluis 2007).

The importance of this research is critical for the Malaysian education sector. Unlike most advanced nations, the majority of research personnel in Malaysia (i.e. 62%) work in public universities or government research organisations rather than in the industrial sector (Day & Muhammad 2011). Indeed, this research topic is salient to Malaysian public universities and will dramatically help to enlighten the research participants working within innovation networks about the importance of social resources or capital requirements to support those networks.

1.5. Research Methodology

This research promotes a pragmatic view arising out of concern for real-world practice-oriented investigation (Creswell 2009) with detailed explanations on the research methods provided (Chapter 3 and 4). A pragmatic philosophy focuses on the research problem and uses all approaches available to understand the problem (Polit & Beck 2010). Pragmatism argues that the most important determinant of the

epistemology and ontology positions is the research question (Saunders et al. 2011, p. 190). Pragmatism offers an approach that can explain and improve today's innovation management issues that demands new behaviour (Emison 2010). The researcher's ontological position is that real people have both independent views and specific responsibilities. In turn, the epistemological stance of a phenomenon is based on both real experiences and expected actions.

Mixed methods research strategy is a common approach with pragmatism (Johnson & Onwuegbuzie 2004). Pragmatists have freedom of choice at the various research stages starting from initiation (e.g. conceptualisation stage), to implementation and interpretation stages (Andrew & Halcomb 2006; Hurmerinta-Peltomäki & Nummela 2006). Thus, this research employed a sequential mixed methods research design that is a valuable strategy to best answer the research questions (Gable 1994; Johnson & Onwuegbuzie 2004; Tashakkori & Creswell 2007). This allows the researcher to gain further insights about a quite recent phenomenon of university research commercialisation (Liefner & Schiller 2008) and previously under-researched subject (Huizingh 2011).

Both qualitative and quantitative methodologies were implemented in this research using individuals as a unit of analysis. This research seeks to predict the 'what' and 'how' of individuals intended actions or behaviours during innovation processes. A minor qualitative research that involved expert interview and content analysis was initially conducted prior to quantitative research as the dominant research strategy.

The first qualitative stage was used for three reasons. One, because of the low success rate of commercialisation among the Malaysian public universities, the source of relevant information is certainly limited. Exploratory research was needed to confirm the reality of the research problem about ineffective relationships between universities and other innovation actors in relation to commercialisation activity. A total of ten expert interviews were carried out on key informants (i.e. university researchers) who were involved in commercialisation research outputs at five public research-focused universities.

Two, a content analysis using NVivo 10 software led to the confirmation of the preliminary conceptual framework that indicated potential inter-relationships between the research constructs examined. Three, the information gained from these expert

interviews was also used to validate the items of the field survey instrument that was developed based on the literature review. From this initial research, the quality of social relationships among university researchers helped determine the success or failure of commercialisation projects; the latter has been a concern among innovation managers (Carmona-Lavado, Cuevas-Rodríguez & Cabello-Medina 2010).

Next, the quantitative stage used a field survey for three major reasons. One, large and quantifiable data enables the researcher to answer the research questions as outlined in Section 1.3 using appropriate statistical analysis for meaningful interpretations and more objective conclusions (Robson 2002; Sekaran 2006). The targeted research population was selected based on a predetermined criterion so as to meet the research objectives (Johnson & Christensen 2012), that is, academics in all twenty Malaysian public universities with registered intellectual property.

Two, a cross-sectional mail survey was administered to a total of 1,503 research participants at eleven public universities that agreed to participate in the research. A final sample size of 222 participants responded with reliable data for analysis. A series of statistical tests using SPSS 22 and AMOS 22 software explored the data for group analysis, correlation and regression based analyses.

Three, the data set was mainly used to establish and test the preliminary conceptual framework through model specification procedures that involved factorial and structural analyses. These analyses estimated the inter-relationships between constructs using multiple measurement items simultaneously (Hair et al. 2010). Several validity measures were evaluated on the hypothesised model (MacCallum & Austin 2000) to ensure accurate interpretations. In this research, the model analysis was driven by both theories and data with the objective to specify a model according to research standards. The model is substantively meaningful, well-fits the data, and is parsimonious (Kline 2011, p. 8).

1.6. Delimitations and Scope of Research

The first delimitation is that the research setting was confined to Malaysian public universities. Other higher education institutions such as polytechnics, private universities and research institutes were not investigated. These public universities have more innovation capabilities in terms of human capital, funding, and

infrastructure (MASTIC 2012, 2013). Also, several of these public universities have been classified as research-focused university, as a means to intensify research niche and activities as well as commercialisation in order to support the knowledge-based economy (Ramli et al. 2013).

The second delimitation is on the research scope that focused on the individual. The research is not focused at the group, organisational or national level. Because decisions to research, innovate and commercialise are based on individual researchers (Perkmann et al. 2013), the target of this research related to those individuals with registered intellectual property. The assumption was that academics with intellectual property are representative of university researchers, and have more advanced perceptions on innovation-related activities such as commercialisation. These groups of university researchers are more likely to consider or to advance their research outputs to commercialisation attempts (D'Este & Patel 2007).

1.7. Operational Definitions

Important key concepts and operational definitions of the constructs developed for this research are as follows:

Innovation. Based on the Oslo Manual, innovation is defined as the implementation of a new or significantly improved product (goods or services), or process, a new marketing method, or a new organisational method in business practices, workplace organisations or external relations (OECD 2005, p. 46). Further, innovation also related to activities that are scientific, technological, organisational, financial and in terms of commercial steps which lead to (or intended to lead to) implementation of the innovation (MASTIC 2012). This concept is explained in Section 2.3.

Innovation network. A series of social relations that formed linkages between innovation actors and organisations (e.g. industries and universities) for creating and integrating various knowledge and resources needed to be developed. These linkages enable ideas to be brought into the market (Calia, Guerrini & Moura 2007; Harrisson & Laberge 2002). This concept is defined and explained in Section 2.3.2 and 2.3.3.

Innovation actor. An agent who undertakes innovative activities and interacts with other actors from government, laboratories, universities, industries, policy departments, regulators, competitors, suppliers and customers (van der Steen & Enders 2008). In this research, the innovation actor is operationalised as university researchers from diverse backgrounds as further explained in Section 2.6.1.

Open innovation. The practice where innovation actors interact with others in a mutual environment of exchange for the purpose of inflow and outflow of knowledge. Also, the sharing of resources to accelerate internal innovation and expand the market for external use of innovation (Chesbrough 2012; Harman 2010). This definition is operationalised from the literature and further explained in Section 2.6.5.

Trust in innovation. Trust is the willingness to rely on people's actions that can be attributed to relationships and interactions between actors (Möllering 2001) for mutual collaboration (Gambetta 2000). Individuals characterised by high levels of trust are more likely to innovate (Landry, Amara & Lamari 2002). In this research, trust in innovation is operationalised as high levels of mutual agreement to share and innovate among innovation actors and further explained in Section 2.6.2.

Motivation to innovate. Motivation determines a persons need to act for specific behaviour and performance (Shamir 1991). The primary need for university innovation is professionally oriented that can be driven by non-pecuniary and pecuniary benefits (Audretsch, Leyden & Link 2013). Motivation to innovate is operationalised in this research as shared needs crucial for actors' engagement and going forward in innovation processes and further explained in Section 2.6.3.

Strategic leadership. Leadership is defined as the ability to influence and support others in the achievement of a purpose (Chemers 2000). In this research, strategic leadership defines the ability to make strategic decisions, communicate a vision, coordinate key competencies and to develop organisational culture (Boal & Hooijberg 2000, p. 516). The nature of strategic leadership is also about operationalising a set of skills to influence university research cultures to be more open and commercially-oriented as explained in Section 2.6.4.

Commercialisation success. The success of commercialisation refers to quantitative values such as number of patents filed, licensing agreements formed, spin-off companies created, royalties and cash received from equity investments, and number of products introduced to the market (Govindaraju, Ghapar & Pandiyan 2009). In the research, commercialisation success is operationalised as direct or indirect strategies to implement the innovation (including in the form of idea or knowledge) into the community (i.e. public or business community) and further explained in Section 2.6.6.

Collaborative research advantage. The benefit that is gained through collaboration with other innovation actors in research and innovation activities. This construct emerged from exploratory factor analysis as explained in Section 5.5.1. Indeed, the concept of collaborative research has been identified from the literature review as one of the main components for commercialisation as discussed in Section 2.4.1 and further justified in Section 6.3.2.

Social relationships. A process of human interactions where social 'capital' or 'resources' (two terms used interchangeably) are created and exchanged (Blau 1964) within a network that can influence individual's behaviours and their next actions. This concept is defined from the literature and further explained in Section 2.5.

1.8. Outline of Thesis

This thesis has six chapters as outlined in Figure 1.2. The structure of the thesis follows recommendations by Perry (1998, 2011), the referencing style manual of Harvard AGPS6 (Australian Government Publishing Service, 2002) and the guideline for Preparation of a Research Thesis (University of Southern Queensland, 2015).

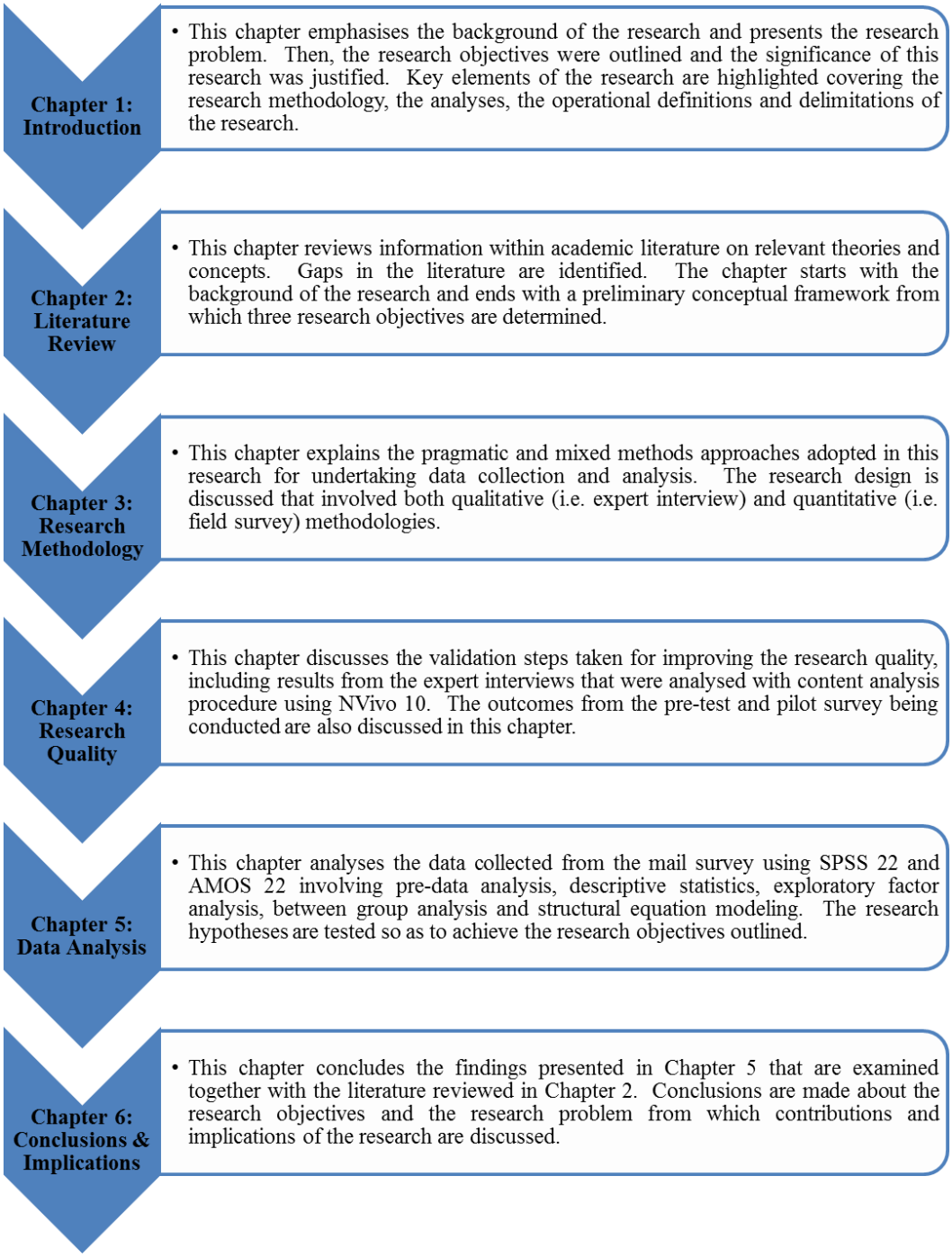


Figure 1.2: Outline of the thesis that summarised content of each chapter.

1.9. Conclusion

This chapter provided the outline of the research. The research main interest is on the actions or behaviours of an individual innovation actor (i.e. the Malaysian public university researcher) when interacting with other innovation actors during innovation processes for commercialisation success. The predicted concepts such as openness,

trust, motivation, and leadership are critical for building, advancing, and sustaining good social relationships among the actors within innovation networks that lead to successful commercialisation. In particular, such concepts are potentially relevant to negate issues related to outsourcing various resources, disclosing intellectual property to others, engaging in complex research processes, and influencing research culture to be more commercially-oriented.

One of the challenges in innovation management systems is to build relationships, which fundamentally depend on social capital (Lundvall 2007). Indeed, university researchers that are experts in their specific field(s) may still find themselves isolated if they are insufficiently interacting with other innovation actors suggesting a lack of embedded social resources. Thus, university researchers, managers and policy makers should pay more attention and 'invest' in managing good social relationships for innovation networks. In the next chapter (Chapter 2), relevant information about the key concepts are reviewed from extant literature and a preliminary conceptual framework is developed to indicate the positive associations between constructs that are operationalised and examined in the research.

CHAPTER 2: LITERATURE REVIEW

"Research is to see what everybody else has seen, and to think what nobody else has thought."
- Albert Szent-Gyorgyi, a biochemist (1893 – 1986)

2.1. Introduction

In Chapter 1, the key elements of the research were highlighted. This chapter aims to review information within the literature and to develop a conceptual framework that relates to the research problem. The idea of this research originated from the researcher's practical experiences and problems encountered in managing innovation at one of Malaysia's public universities. The research problem articulated in Chapter 1 was related to the difficulty of university research outputs to be effectively commercialised even while substantial innovation resources were available.

This chapter has seven sections as shown in Figure 2.1. Firstly, Section 2.1 outlines the main topics reviewed in the research. Next, the research context is elaborated in Section 2.2. Then, Sections 2.3, 2.4 and 2.5 discuss the concepts that underpin the research. A preliminary conceptual framework is presented in Section 2.6 that provides the predicted inter-relationships between the research constructs. Finally, Section 2.7 concludes the research thesis about innovation management in Malaysian public university.

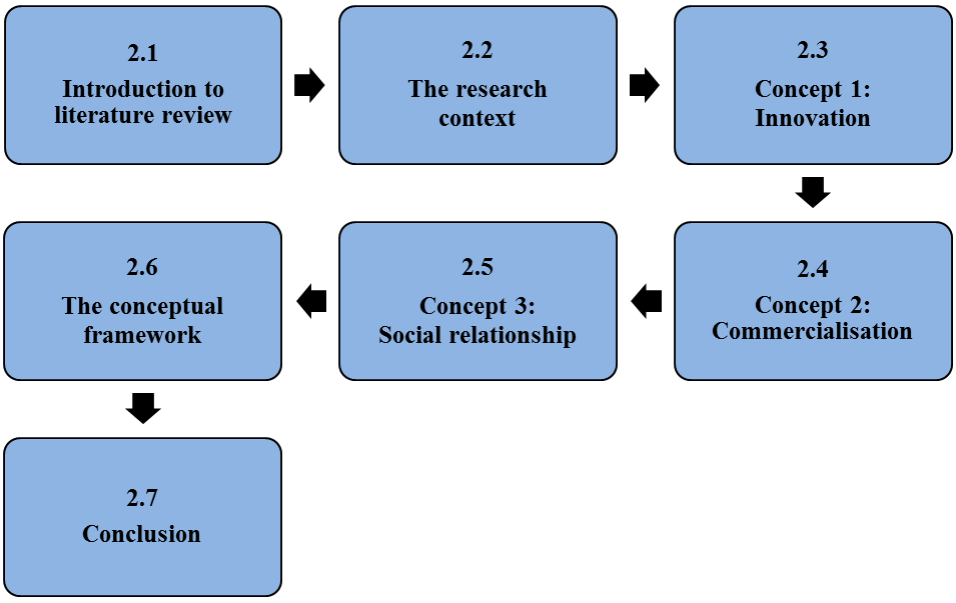


Figure 2.1: The outline of Chapter 2 on main topics of the research.

2.2. Context of the Research

The research context relates to public universities in Malaysia. As a developing country, Malaysia aims to be a developed nation by the year 2020. The key differences between developed and developing countries relate to economic (e.g. income per capita) and social (e.g. literacy rate) status. In this post-industrial era, a nation's socio-economic development is driven by knowledge-based strategies and innovation capabilities. Thus, universities have important roles to play in a national innovation system as sources for innovation and in educating knowledge workers (Lundvall 2007).

2.2.1. Malaysia's Innovation Profile

The importance of innovation in relation to economic and social growth is integral for most nations (Freeman 1995). An effective national innovation system comprises of diverse innovation actors from government, educational institutions, enterprises and other support agencies (Hidalgo & Albors 2008). The establishment of the Malaysian Science and Technology Centre (MASTIC) for example, has the task of gathering all strategic information on the nation's scientific, technology and innovation (STI) capabilities and to conduct the National Innovation Survey. The Malaysian Innovation Agency (AIM) was set up with the sole purpose of driving an integrated national effort towards a high-income and innovative economy. Other Malaysian agencies and initiatives aim to create a comprehensive national innovation system including (but not limited to) the Intensification of Research in Priority Areas (IRPA) fund, Industry Research & Development Grant Scheme (IGS), Multimedia Super Corridor (MSC), Malaysia Technology Park (TPM), Industrial Technical Assistance Fund (ITAF), Malaysia Industry Government Group for High Technology (MIGHT), Malaysia Venture Capital (MAVCAP) and Malaysia External Trade Development (MATRADE) (Wonglimpiyarat 2011).

The Global Innovation Index for 2013 (GII2013) reported Malaysia in the top ten best innovation performers among middle-income countries; the country has been regarded as an 'innovation learner' along with China and Vietnam. Overall, Malaysia ranked 32 out of 142 countries assessed (WIPO 2013). According to the GII2013

report, Malaysia's innovation capabilities were mainly attributed to a good national policy on innovation and healthy growth in gross expenditure on research and development (GERD). The report also indicated that tertiary education and research sectors were among the areas of concern for improving Malaysia's innovation input, while knowledge and technology application should be intensified so as to increase the innovation output.

In 2011, Malaysia's research intensity measured by the percentage of GERD over gross domestic product (GDP) was 1.1% (MASTIC 2013). The proportion of this research expenditure was attributed to private enterprises (57%), higher education institutions (29%) and public research institutes (14%). Although this achievement exceeded the national target of 1.0% by year 2015, it is still a small amount compared to other innovative countries such as Japan (3.3%), Switzerland (2.9%), Australia (2.4%), Singapore (2.1%) and China (1.8%). As of 2011, the number of active researchers (headcount) in Malaysia was 73,752 with an average of 58 researchers per 10,000 for the total labour force which exceeded the national target of 50 researchers per 10,000 of the total labour force by year 2010 (MASTIC 2013). A snapshot of the overall innovation capabilities available in Malaysia is summarised in Figure 2.2

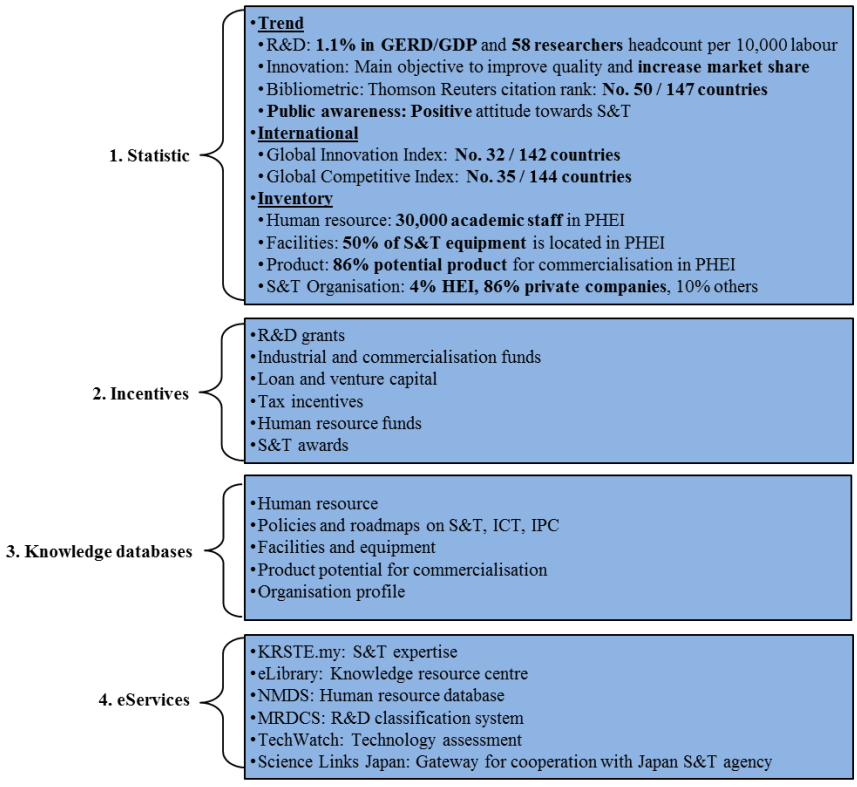


Figure 2.2: The Malaysia's innovation profile developed for the research.

Source: http://www.mastic.gov.my/en/web/guest/statistic accessed on 5 March 2014.

2.2.2. Innovation in Malaysian Public Universities

There are a total of twenty public universities in Malaysia. These universities are relatively young institutions (e.g. Universiti Malaya was the first public university established in 1961). These universities are fully regulated by the government with the higher education system originally developed in reference to the British system with two traditional missions: academic teaching and research (Ramli et al. 2013; Wong, Ho & Singh 2007). The Malaysian higher education system has been reformed to support the national policy in knowledge-based economic strategy (Liefner & Schiller 2008). A third mission on community services is equally emphasised (Lee & Win 2004). In line with the knowledge-based economy, the role of public universities is to share knowledge not just for students and colleagues, but also for business and public community. Public universities are considered as knowledge manufacturers and innovation suppliers which have great resources to be explored and exploited (Kheng, June & Mahmood 2013). However, university commercialisation is considered as only a recent phenomenon in Malaysia (Aziz et al. 2013).

In relation to innovation capabilities within the Malaysian public university sector, there are approximately 30,000 academics (i.e. active researchers) employed nationwide conducting more than 4,000 research projects yearly (MOHE 2012). Based on Thomson Reuter's bibliometric study for the period of 2001-2011, Malaysia was ranked 45 out of 147 countries in terms of citation for academic publications. These public universities are equipped with 50% of the nation's scientific, technology and innovation facilities and owned around 86% of research products with the potential for commercialisation (MASTIC 2013). This information signals the innovation capabilities among Malaysian public universities in many forms of human, intellectual, financial and technological capital.

Other incentives are also available to support public university research in order to enhance innovation capability. For example, innovative research grants have been introduced, such as long-term research grants schemes (LRGS), exploratory research grant scheme (ERGS) and prototype research grant scheme (PRGS) with the aim to intensify applied research as well as commercialisation activities within public universities (Aziz, Harris & Norhashim 2011). Table 2.1 shows the list of Malaysian public universities with certain innovation capabilities.

Table 2.1: The list of Malaysian public universities with certain innovation capabilities.

No	Name of Public Higher Education Institutions	Year established[1]	No. of Academic Staff in Year 2012[2]	No. of Research Grant in Year 2012[2]	No. of IP Registered[3]
Research University					
1	Universiti Malaya	1961	2,136	889	391
2	Universiti Sains Malaysia	1969	1,853	248	200
3	Universiti Kebangsaan Malaysia	1970	2,258	820	276
4	Universiti Putra Malaysia	1971	1,647	274	640
5	Universiti Teknologi Malaysia	1975	2,098	395	943
Comprehensive University					
6	Universiti Islam Antarabangsa Malaysia	1983	1,886	270	26
7	Universiti Malaysia Sarawak	1992	761	34	32
8	Universiti Malaysia Sabah	1994	946	146	27
9	Universiti Teknologi MARA	1999	8,631	0	182
Focused University					
10	Universiti Utara Malaysia	1984	1,389	351	2
11	Universiti Pendidikan Sultan Idris	1997	838	93	5
12	Universiti Sains Islam Malaysia	1998	577	23	1
13	Universiti Malaysia Terengganu	1999	502	41	17
14	Universiti Tun Hussein Onn Malaysia	2000	1,017	145	81
15	Universiti Teknikal Malaysia Melaka	2000	807	132	53
16	Universiti Malaysia Pahang	2001	630	135	206
17	Universiti Malaysia Perlis	2001	768	303	77
18	Universiti Sultan Zainal Abidin	2005	437	3	0
19	Universiti Malaysia Kelantan	2006	290	12	4
20	Universiti Pertahanan Nasional Malaysia	2006	298	18	13
Total No.			**29,769**	**4,332**	**3,176**

Source:

1. http://www.mohe.gov.my/web_statistik/Perangkaan_SPT_2012.pdf.
2. http://www.mohe.gov.my/web_statistik/Perangkaan_SPT_2012.pdf.
3. https://iponline.myipo.gov.my/ipo/main/search.cfm as at 25 February 2014.

Malaysian public universities have been categorised into research, comprehensive and focused universities. The main objective for research universities is to enhance their research activities as well as commercialisation in order to support the knowledge-based economy (Ramli et al. 2013). Based on Table 2.1 the universities were founded between 9 – 54 years ago, employ approximately 30,000 academics,

conduct more than 4,000 research project yearly and have more than 3,000 research outputs in the form of intellectual properties.

2.2.3. The Contextual Issue

As noted earlier, the idea of this research originated from the researcher's practical experiences and problems encountered in managing innovation at one of Malaysia's public universities culminating in few research outputs effectively commercialised. Indeed, there has been little progress in the research commercialisation rate in Malaysia (Ab. Aziz et al. 2012; Govindaraju, Ghapar & Pandiyan 2009). About 95% of the Malaysian university research outputs fail to be commercialised (OECD 2013).

To better understand the issue, the researcher reviewed five specific reports related to Malaysia's innovation status published by local and international innovation-related agencies and authorities. The review noted many reports and secondary data related to the following:

i. Global Innovation Index 2013 – A report published in collaboration between Cornell University, European Institute of Business Administration (INSEAD) and the World Intellectual Property Organisation (WIPO). The index assessed 142 countries including Malaysia in terms of their enabling environment for innovation and innovation outputs (WIPO 2013);

ii. OECD Review of Innovation in Southeast Asia 2013: Malaysia's profile of innovation – A report published by Organisational for Economic Cooperation Development (OECD 2013). It assessed the country's innovation system and provided recommendations on how to improve innovation policies including research and development (R&D);

iii. National Survey on Innovation 2012 – A report published by Malaysian Science and Technology Centre (MASTIC), an official Malaysian agency under Ministry of Science, Technology and Innovation (MOSTI). It assessed the level of activity and status of innovation in the manufacturing and service sectors according to the Oslo Manual (MASTIC 2012);

iv. National Survey of R&D 2013 – A report published by the Malaysian Science and Technology Centre (MASTIC), an official Malaysian agency under Ministry of Science, Technology and Innovation (MOSTI). It assessed the developments of research activities undertaken by public and private research centres in Malaysia (MASTIC 2013); and

v. Malaysia: The Atlas of Islamic-World Science and Innovation 2011 – An independent report based on a case study approach conducted by Day and Muhammad (2011) in collaboration with international institutions and partners across the Islamic world particularly with Malaysian Ministry of Science, Technology and Innovation and University of Malaya.

Reviews of the reports mainly focused on the practical issues for innovation management. In brief, the reports highlighted Malaysia's substantial resources for innovation with a positive upward trend. However, there are indications that the country's innovation capabilities are weak and require intervention to accelerate innovative efforts (Govindaraju & Wong 2011). Despite many of the innovation capabilities explained (see Section 2.2.1 and 2.2.2), there has been little progress in the Malaysia commercialisation rate (Ab. Aziz et al. 2012) with only 5% of university research outputs being successfully commercialised (Govindaraju, Ghapar & Pandiyan 2009; OECD 2013). This commercialisation rate is considered low compared to the average commercialisation rate at international level – approximately 10% (Ramli et al. 2013) and patent utilisation rates are between 10-30% (Chesbrough 2012). Among the issues and problems identified are highlighted in Table 2.2.

Table 2.2: Innovation management issues related to public universities in Malaysia.

Report	Innovation Management Issues
i. The Global Innovation Index 2013	- Weakness identified in the generation of value from scientific production although the number of publication has increased. - Predominant culture of the researchers, who have considered research to be a public good and not an intangible asset with a market value. - Innovation hubs failed to close the gap between R&D and commercialisation which require sustained, public-private collaborations between governmental, academic and corporate firms.
ii. OECD Review of Innovation in Southeast Asia (Malaysia) 2013	- Stagnant university research and innovative capacity with little venture capital. - Need to intensify research activities from university and public research institutes specifically their links with private companies. - Need to intensify research outputs from universities and public research institutes and to maximise commercialisation opportunities.
iii. National Survey on Innovation 2012	- Around 80% of the companies developed their innovation internally or 'closed innovation', compared to 'open innovation' practices. - More collaborations in research are recommended between business sector and public research institutions including universities to synergise the innovative minds of business and greatly enhance the successful commercialisation.
iv. National Survey of R&D 2013	- Only around 15% of research expenditure was targeted on experimental research which promises potential innovative products. - More collaboration should be encouraged between private companies and public research institutions, so as to increase research funding and to promote innovative culture. - Insufficient number of innovative and creative R&D personnel.
v. The Atlas of Islamic-World Science and Innovation 2011	- Lack of human resources with the innovative flare required for scientific discovery and high quality research. - More localised plans should be developed in partnership mechanism as well as engaging other key players in academia and industry to develop a sense of shared ownership and commitment. - Ensuring an adequate skills supply as a mechanism to drive university and industry collaboration for more crossover and understanding.

Many commercialisation problems relate to the manner in which Malaysian universities often work in isolation of networking opportunities (Govindaraju, Ghapar & Pandiyan 2009). There has been poor links between university and industry (Wonglimpiyarat 2011) and there is a significant need to improve this performance by developing more effective collaborative relationships between universities and industry. Although Malaysia has adopted the Western university research model, innovation efforts for commercialisation have yet to show similar success outcomes achieved by their Western counterparts (Ramli et al. 2013). Furthermore, Malaysian university collaborations have not yet reached a satisfactory level because of the lack of capabilities in strengthening relationships (Razak & Saad 2007) within innovation networks.

2.2.4. Research Classification

The contextual problems and issues outlined previously in Chapter 1 and highlighted earlier in this chapter suggest that the research problem should be focused on the little progress of commercialisation success among public universities in Malaysia (OECD 2013). This was mainly attributed to the ineffectiveness of relationships between universities and businesses in order to close the gap between research and commercialisation (Day & Muhammad 2011; MASTIC 2012, 2013; OECD 2013; WIPO 2013). Organisations often fail to manage innovation and their innovative people (Patterson, Kerrin & Gatto-Roissard 2009). Hence, drawing from the Malaysian public university setting, the researcher contends that it is more likely that successful commercialisation attempts will derive from a network of relationships between innovation actors signalling the importance of social capital or resources.

Based on the need to dramatically lift the rate of commercialisation of Malaysian public universities plus the justification of the research outlined in Chapter 1, the concept of innovation was examined from a socio-psychological perspective to facilitate the rapid commercialisation of university research outputs. A classification model of the relationships to be studied is illustrated in Figure 2.3. Here, Figure 2.3 shows the parent and related body of literature to be reviewed for this research and the development of a number of emerging and related research questions and hypotheses.

The literature is discussed in detail next and the related research questions and hypotheses are discussed in the methodology chapter (Chapter 3).

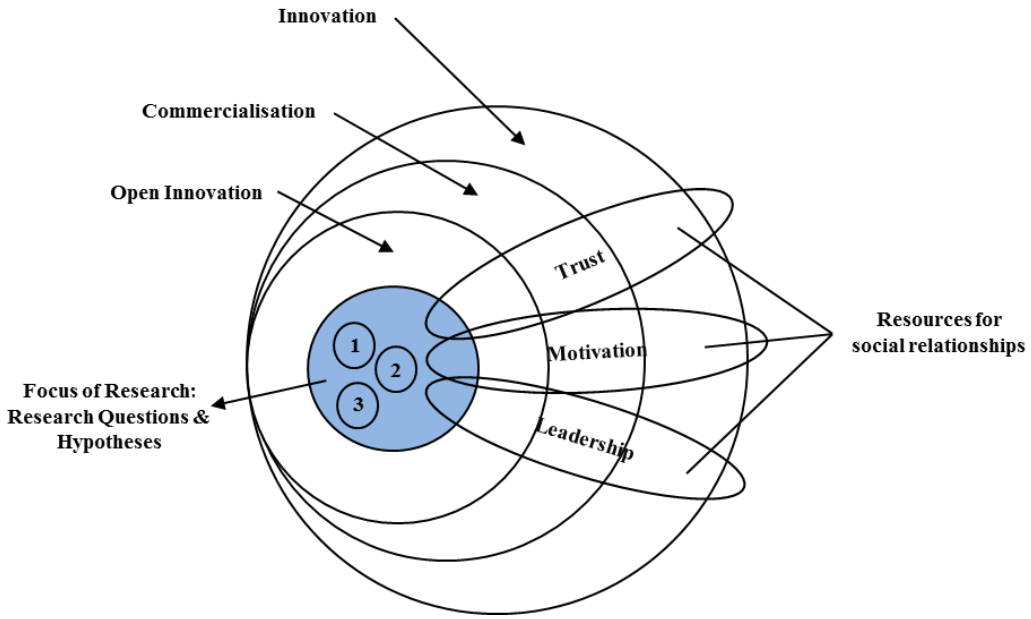


Figure 2.3: A classification model developed for the research.

Three research questions and related null hypotheses have been developed to examine the research problem stated above:

RQ1: Does the difference in *Innovation Actors'* characteristics differ from their perceived strategies for *Commercialisation Success*?

H_{O1}: The mean scores of *Commercialisation Success* are equal between the Innovation Actors when they are classified according to their eight demographic characteristics, namely age, gender, type of university, academic qualification, research expertise, academic position, industrial experience and industrial research.

RQ2: Does *Open Innovation*, *Trust in Innovation*, *Motivation to Innovate* and *Strategic Leadership* influence *Commercialisation Success*?

H_{O2}: *Open Innovation*, *Trust in Innovation*, *Motivation to Innovate* and *Strategic Leadership* have no influence on *Commercialisation Success*.

RQ3: Is the innovation relationships model of *Open Innovation*, *Strategic Leadership* and *Commercialisation Success* equivalent across two groups of Innovation Actors based on industrial experience?

H_{O3}: The innovation relationships model of *Open Innovation*, *Strategic Leadership* and *Commercialisation Success*, is equivalent between the *Innovation Actors* when they are grouped according to their industrial experience.

2.3. Innovation

The word 'innovation' relates to multifaceted ideas. Within the organisational behaviour literature, innovation is regarded as one of the main characteristics of organisational culture; a culture which encourages knowledge creation and sharing to increase organisational performance (Al-bahussin & El-garaihy 2013). Innovation also means continuous organisational adaptation with efficient application (Jewels et al. 2011) driven by individual responses to changes or events. These adaptations or innovations significantly improve organisational productivity. In today's rapidly changing environment, innovation strategies are crucial for achieving organisational competitive advantage and sustainability.

Scholars and managers of innovation have provided various definitions of innovation. The Oslo Manual (2005) has defined innovation as the implementation of a new or significantly improved product (goods or services), or process, a new marketing method, or a new organisational method in business practices, workplace organisations or external relations (OECD 2005, p. 46). Based on the Malaysian Ministry of Science, Technology and Innovation (MOSTI), innovation is also defined according to the Oslo Manual as the implementation of a new or significantly improved product or process, a new marketing or organisation method in business practices, workplace organisation or external relations (MASTIC 2012). Further to these definitions, activities associated with innovation include scientific, technological, organisational, financial and commercial ideas leading to (or intended to lead to) the implementation of innovation outputs. Some sub-activities are themselves innovative; others are not novel activities but are necessary for the implementation of innovation. Innovation activities also include a series of research and development activities that are directly or indirectly related to the development of

a specific innovation (MASTIC 2012). For example, Apple's iPhone not only depends on the innovative culture created but also a network of researchers external to the Apple company who have contributed to its mobile electronic platforms.

The principle of successful applied innovation is strong interactions between various innovation actors (Rasiah 2011) within innovation networks. The value of innovation actor's networks is the ability to source necessary resources for idea development and application for adoption and commercialisation (Kanter 1988). Since innovation actors come from diverse backgrounds, it is critical to manage the diversity of relationships that reflect different cultures, strategic objectives, modes of operation, levels of capabilities and resources (Couchman & Fulop 2009). These differences can be sources of potential advantages and also threats. The advantages are gained through seamless integration of innovation resources and complementing weaknesses. Threats, for instance, may be due to poor innovation management within a network such as inadequate interaction, ineffective communication and poor planning (Troshani, Rampersad & Plewa 2011). In the case of applied innovation, the process from idea generation to application takes a decade or longer (Fagerberg 2003; Thompson et al. 2011), and anticipates the development of a solid social network of relationships between the innovation actors.

2.3.1. Components of Innovation

In general, innovation has two major components namely the input and the output. The Global Innovation Index (GII) for example, a successful innovation benchmarking system, uses several input and output indicators to measure innovation performance across nations (WIPO 2013). The GII framework developed by the World Intellectual Property Organisation (WIPO), comprises five innovation input sub-indices (i.e. institutions, human capital and research, infrastructures, market sophistication and business sophistication) and two innovation output sub-indices (i.e. knowledge and technology, and creative output). The input sub-indices measure elements that enables innovation activities, while the output measure results from such innovation activities (WIPO 2013). The GII system assesses innovation performance at national level.

The assessment of innovation performance at organisational level also follows the input-and-output principle. The National Survey of Innovation (NSI) conducted

by the Malaysian government for example, assesses the innovation performance among private companies. The survey collects information on the organisational innovation inputs that includes expenditures on innovation activities such as research, acquisition of patent and licenses, purchase of related equipment and software and training of personnel in market analysis. The innovation outputs include the introduction of new products (goods and services), new processes, organisational changes and marketing innovations (MASTIC 2008). In addition to these measures, the NSI survey also assesses the organisational innovation modalities (or qualities) such as the sources of innovation, the obstacles, the cooperation and the effect of innovation.

The input-and-output principle is also applicable at an individual level of innovation performance assessment. In the university context for example, innovation is one of the core functions for academics apart from teaching activities and community services. Generally, innovation performance indicators at university are closely linked with the outputs of research related activities which includes the number of research students and amount of research grants as the innovation inputs, while the number of publications, creative exhibitions, intellectual properties, awards, services such as consultancies and training, as well as commercialised products and spin-offs represent the innovation outputs (Zhao 2004). This indicates the forms of innovation vary greatly, from ideas (tacit or codified knowledge) to tangible and intangible products and services.

The key word commonly associated with innovation is ‘new’ or ‘novel’. A product, process or even an idea might be new for some people, organisation or market, but old to others. Thus, the levels of newness differs depending on individual perceptions. Focusing on the individual level of innovation, innovation actors have to conduct multiple innovation-related activities during the process, which form the other critical component of innovation that is seldom being assessed (or rather complicated to assess) such as the process of innovation that involves the transformation of idea(s) into outputs. An interesting way to explain the innovation process is illustrated in Figure 2.4.

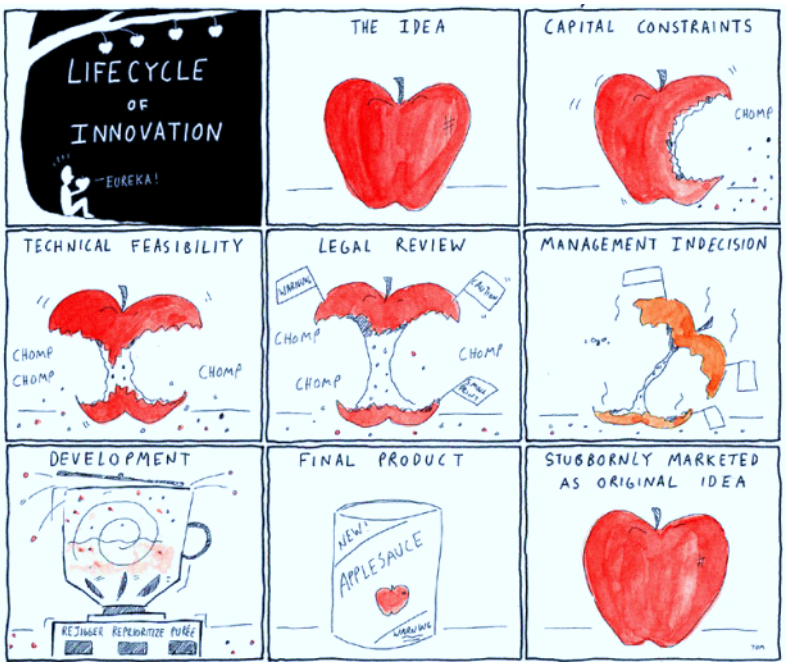


Figure 2.4: The process of an innovation.
Source: *www.tomfishburne.com*. Please do not use for commercial purposes.

From Figure 2.4, between the idea and the final product, there are multifaceted activities involved in the overall innovation process. According to Booz, Allen and Hamilton (1982), new product failures routinely outnumber successes caused by a variety of factors impeding the process, for example, failure in understanding client needs, lack of support, poor fit with organisational culture. Thus, the complex innovation process requires interactions between various innovation actors to support a successful innovation (Ritman et al. 2011). In recognising complexity of the innovation process, many organisations have shifted from closed to open innovation approaches as a way to integrate the internal and external resources in advancing innovative ideas. *Closed* innovation refers to conducting research in isolation whereas *open* innovation refers to including multiple actors and inputs into systematic ideas.

2.3.2. Innovation Management Theories

To familiarise with the innovation practice, it is important to review the theoretical aspect of innovation. There are many theories associating with innovation including Schumpeter's theory, the incremental versus radical innovation, the Henderson-Clark model, the S-Curve, the Teece model, the Abernathy-Utterback model and disruptive-innovation theory.

The Schumpeter's theory of innovation was developed around the 1930s to explain how economic development is driven by the continuous emergence of new combinations (i.e. innovations) (Drejer 2004). This theory defines innovation as the introduction of a novel artefact in the market: a new good, a new quality of a good, a new production method or a new way of handling a commodity commercially (Flikkema, Jansen & Van Der Sluis 2007). Schumpeter's research led to alternative explanations about the innovation phenomenon of incremental versus radical innovation theory. The radical innovation approaches emphasised technological innovation whereas incremental innovation emphasised minor changes to current technology. Thus, radical innovation involved major changes (Akenroye 2012).

Next, the Henderson-Clark innovation model developed the technological aspect of innovation from a knowledge-based view where two dimensions of knowledge are required for introducing innovation (Henderson & Clark 1990), namely knowledge of a component and knowledge of the linkage between components. Another similar innovation theory is the S-Curve innovation model that again emphasises the technological aspect of innovation, with additional time-based predictors of innovation performance along the introduction, growth and maturation phases of innovation processes (Christensen 1992).

The later innovation management theories have started to consider the 'who' or individual aspect that can potentially influence the innovation performance. The Teece (1986) model for example suggested that innovation assets are surrounded by innovation actors such as distributors, suppliers, marketers, strategic partners, customers and even imitators (or followers). Also, a dynamic innovation model should include technological impact, competitors, organisational structure and strategic decisions as variables for innovation that are interacting and linked together (Albernathy & Utterback 1975). In the late 1990's, the disruptive innovation theory emerged and highlighted that innovation performance is not only about technology creation or improvement, but also the value embedded within innovation networks. A network for innovation defines a series of social relations that form linkages between innovation actors and organisations (e.g. companies and universities) for creating and integrating various knowledge and resources needed to develop an idea and bring it into the market (Calia, Guerrini & Moura 2007; Harrisson & Laberge 2002). Thus, an innovation network value as described by Christensen (1997) includes firm

capabilities to identify and respond to customer's needs, solve problems, procure inputs, react to competitors and strive for profits. These evolutions of innovation theory have led to another emergent form of innovation known as 'open innovation'.

2.3.3. Open Innovation

The 'open innovation' concept has been introduced by (Chesbrough 2003b), where firms look to advance their technology through the use of external and internal ideas and internal and external paths to market. The principle of the open innovation concept is illustrated in Figure 2.5.

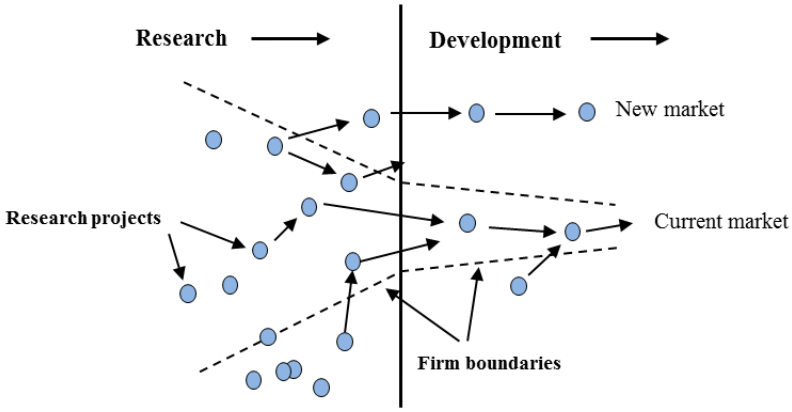


Figure 2.5: The open innovation model proposed by Chesbrough (2003b).

The open innovation concept was originally embedded within the industrial innovation strategies of large Western firms such as Xerox, IBM and AT&T (Chesbrough 2003a). The concept underpins strategies for commercialising new innovations into markets where various actors interact at different innovation stages (Bogers 2011; Østergaard 2009). The trend of standalone and 'closed' approaches to innovation are no longer sustainable for knowledge creation, product/process/service development and application. Gassmann, Enkel and Chesbrough (2010) and Chesbrough (2012) provide future directions for exploring the open innovation concept in terms of managerial, ontological, epistemological, behavioural and legal perspectives. A study by Neyer, Bullinger and Moeslein (2009) found that an organisation can only fully optimise its various knowledge resources when it is aware of the underlying social interactions between internal and external innovators.

In more recent literature, empirical evidence shows that open innovation is not a fad, but rather a phenomenon (Chesbrough & Brunswicker 2014); a modern and open way to conduct innovation compared to the traditional and closed approach. A survey conducted by Chesbrough and Brunswicker (2014) of 125 large manufacturing and service firms in Europe and the United States revealed that open innovation is widely practiced through customers co-creation, informal networking with universities - as leading inbound practices - while joint ventures and selling market-ready products as prominent outbound practices. The study found that firms considered the management of relationships with innovation partners as the most significant challenge (Chesbrough & Brunswicker 2014). Generally, the results confirmed that firms were not greatly satisfied with the established open innovation partnership with universities (or research institutes).

The extant innovation literature has given less attention on open strategy in innovation and commercialisation among public sectors compared to the industrial sector. Accordingly, this research adds to our understanding of the open innovation concept by discussing the phenomena within the public higher education sector. This sector is indeed categorised as a knowledge-intensive based service (KIBS) industry that includes universities (Janeiro, Proença & Gonçalves 2013). Along with the traditional role of universities in carrying out research and innovation, the current emphasis on community services including industrial linkages and commercialisation is more prevalent. More universities are strengthening their innovation capabilities by extending the research activity to commercialise the intellectual property created (Sharma, Kumar & Lalande 2006). This open strategy for innovation process leads to the formation of research networks that share similar approaches with research collaboration in universities, where the boundaries between a university and its society have become more permeable.

2.3.4. Innovation in Universities

Within the university context generally, innovation processes commence with idea generation by university researchers that potentially lead to business partners' involvement at a later implementation stage (Ismail 2012) or during the marketing stage (Siegel et al. 2003). Unlike researchers in industry, they frequently involve

suppliers or customers in the early product development stage (Rothwell 1994). As university researchers are often experts in certain subject areas, they tend to be too theoretical and experimental with limited experience in real business realities (Fontana, Geuna & Matt 2006). Thus, there is a sizeable gap between scientific theories and business practices. Accordingly, university researchers have to collaborate with others (from industries in particular) to allow them to gain strong business knowledge and practices related to contractual information, market assessment analysis, investment, equity and marketing information (Narayan 2011).

Relationships between universities and business are not a new phenomenon. Generally, such relationships have been described as university-industry linkages (Plewa et al. 2013), knowledge or technology transfer (Debackere & Veugelers 2005; Rast, Khabiri & Senin 2012), research collaboration or cooperation (Fiaz 2013), technology commercialisation (Govindaraju, Ghapar & Pandiyan 2009; Shane 2002), research partnerships (Berman 2008), business incubators (Liu & Jiang 2001), science parks (Malairaja & Zawdie 2008), government–university–industry partnerships (Carayannis, Alexander & Ioannidis 2000) and also as a 'triple helix' model (Razak & Saad 2007). Taken together, these relationships highlight the importance of developing collaborative research networks and transforming university knowledge into industry outputs through open innovation.

While the open innovation concept was originally conceived as a research strategy between private and manufacturing firms (Petroni, Venturini & Verbano 2012), the concept has become equally useful to a wider participant group including universities (Chesbrough 2012). The open innovation concept reinforces collaborative research where innovation actors' interactions is important (Lichtenthaler 2011; Petroni, Venturini & Verbano 2012) in order to execute multiple innovation sub-activities (Plewa et al. 2013). Thus, the 'openness' strategy is central to universities seeking to build research collaboration (Fontana, Geuna & Matt 2006).

Innovative universities are increasingly aware of the need to explore external resources for innovation (Grimaldi, Quinto & Rippa 2013). However, a major challenge within the open innovation space is how to connect internal and external innovation actors when many organisational differences exist. University researchers and managers are responsible for ensuring sustainable mutual relations (Siegel et al. 2003) as an innovation network evolves in order to avoid any opportunistic intention

(Feldman et al. 2002). Similarly, environmental characteristics and organisational change can affect innovation performance according to scholars (Chiaroni, Chiesa & Frattini 2011; Huizingh 2011) including influencing the sharing of knowledge, commitment and objectives alignment (Smeilus, Harris & Pollard 2011).

2.3.5. Summary

The role of public universities becomes critical mainly for building the nation's innovation capabilities that drive knowledge-based economic strategy. By acknowledging these increasing needs, public universities strive to enhance the economic relevance of research (Geuna & Martin 2003; Hicks 2012). Similarly, open innovation practices become critical to assist with the commercialisation of research outputs (Lee et al. 2010). The extent of open innovation practices mainly depend on university researchers establishing effective innovation networks (Rasmussen, Moen & Gulbrandsen 2006), underpinned by good social relationships between the innovation actors involved (Rahal & Rabelo 2006). Strong relationships within innovation networks thus bridge the knowledge and resources gap between academia and the business world.

In Malaysia, open innovation and commercialisation studies are still a new area of research. Even the more general aspect of innovation in terms of new product development is at the infancy stage (Mat & Jantan 2009) compared to developed countries. The pressure to externalise the innovation process is the result of a need to fill the resources gap and to expedite the innovation process (Costa & Peiró 2009; Petroni, Venturini & Verbano 2012). Collectively, the interactions between innovation actors become critical within an innovation network.

2.4. Commercialisation

Similar to innovation, the notion of 'commercialisation' means different things in different contexts. From an industrial perspective, commercialisation can be defined as a process of introducing an applicable idea (or innovation) into the market (Gassmann & Enkel 2004). Within universities, research commercialisation is viewed as a process in which ideas or research findings are transformed into greater wealth for individuals, businesses or society at large which includes intellectual property transfers and consultation works (Zhao 2004). Although commercialisation leads to interesting outcomes with financial benefits and wealth creation, the process has been characterised as very complex and highly risky. Also, it takes a long time to evolve, is costly and usually fails (Bozeman 2000).

Existing studies in commercialisation relate to the link between knowledge inputs, innovation processes and product outputs (Adams, Besant & Phelps 2006; Kotha, George & Srikanth 2013; Shane 2002). According to the Oslo Manual (2005), commercialisation is a market-oriented type of innovation that can be explained as an implementation of a new product involving changes in design or packaging, product placement, product promotion or pricing (OECD 2005, p. 152). Commercialisation also relates to better addressing customer needs, opening up new markets, or newly positioning a firm's product on the market with the objective of increasing the firm's sales (OECD 2005, p. 49). Clearly, commercialisation has more than just research and development implications; it is a subset of the innovation management process where it involves multiple activities in bringing a product to the market.

Embedded within integrated innovation sub-activities, commercialisation is the complex stage where an idea (or input) is transformed into successful application (as output) (Adams, Besant & Phelps 2006). During the process, necessary internal and external resources and paths are crossed to comprise the open innovation practice. Commercialisation activities among private firms is well understood, but is more problematic in multi-stages of activities in the public sector (APH 2006). In some public sector institutions such as education however, commercialisation has broader definitions. Several problems tend to occur when public universities have to perform dual roles as a societal and economic player where neither professional nor commercial objectives can be fulfilled properly (Hayrinen-Alestalo & Peltola 2006).

2.4.1. Components of Commercialisation

Generally, there are two key components of the commercialisation process: (1) generating a pool of ideas or explicit knowledge in the form of intellectual property (Gallego, Rubalcaba & Hipp 2013) and, (2) developing collaborative research processes in production and marketing in particular (Azmi & Alavi 2013). The whole process of commercialisation involves multiple sub processes (West & Bogers 2013) and various innovation actors (Perkmann et al. 2013). Because of the nature of commercialisation processes, they require an open approach towards innovation (Lee et al. 2010) for process efficiency.

The first component of commercialisation is an idea. The ideas or knowledge remain tacit until being documented and articulated. The tacit knowledge cannot be protected unless it is being declared as intellectual property and a creation of the mind. This intellectual property aspect closes the link with human capital (as the innovation actor that owned the idea) and the actor's innovative actions during commercialisation (Carmona-Lavado, Cuevas-Rodríguez & Cabello-Medina 2010). Common types of intellectual property include patents, trademarks, copyright and trade secrets.

Without protecting intellectual property, it would be less likely for an idea (or creation) to be commercialised (Colyvas et al. 2002). However, certain intellectual property strategies such as patent assertion entities (PAE) have the potential to impede commercialisation activities, among United States firms for instance (Hemphill 2014). According to Hemphill (2014), the PAE describes the strategy of purchasing and proclaiming patents against manufacturers already using intellectual property, rather than developing and transferring the property to licensees. This strategy may inhibit the knowledge-sharing of public universities and their commitment to open science as knowledge 'manufacturers' (Mowery & Sampat 2006).

Intellectual property created in the public university domain has important implications for knowledge-sharing and open research activities (Wong, Shulman & Wollin 2002). Research findings (from the public universities in particular) should be made available to peers and society at large through publications and seminars, instead of being prohibited for disclosure purposes. But for market-oriented and commercial research, intellectual property protection is crucial for maintaining competitive advantage and to ensure successful commercialisation. Indeed, this aspect of

intellectual property has led to changes in academic culture (Kumar 2010) in relation to publishing and protection. In most intellectual property (IP) registration systems, information that has been made available to the public in any form (including publication in journal or presentation in seminar) is considered as a prior art. This suggests that the innovation is already known and not relevant for IP's claim of originality and protection.

The second component is collaborative research. The role of research linkages or collaborations is crucial in accelerating the success of commercialisation (Govindaraju, Ghapar & Pandiyan 2009). The integrated involvement between industries, suppliers, customers and universities in an open innovation process leads to increases in technology collaboration and exchange of resources (Petroni, Venturini & Verbano 2012). When diverse innovation actors collaborate, substantial resources are available for more idea generation and implementation (Ahuja 2000). Hence, scholars in innovation management have emphasised the need for collaboration between various innovation actors in order to source innovation resources in terms of intellectual, technological and financial capital (Marion & Fixson 2014; Ylijoki, Lyytinen & Marttila 2011).

Collaborations for implementing research outputs and commercialisation between academic organisations (i.e. public universities) and non-academic organisations (i.e. private firms) have taken many forms (Perkmann et al. 2013). In the United Kingdom for example, while small and medium enterprises (SMEs) prefer to collaborate with other firms for technology purchasing, they prefer to engage with universities for strategic alliance purposes and research collaboration (Lee et al. 2010). In China by contrast, higher education institutions (HEIs) have been considered as a major source for new technology in industrial innovation (Liu & Jiang 2001). There is evidence that collaboration strategies relate to the success or failure of technological innovation resulting in either economic success or failure (Teece 1986). As one of the key components for successful commercialisation is collaboration, actors' innovation practices break down the boundaries of firms (Chesbrough 2012).

2.4.2. Commercialisation Models

Several models of commercialisation have been proposed by innovation scholars and business managers. Generally, commercialisation models can be categorised into two types. The first is a linear model which represents the commercialisation process as a step-by-step process. The second is a functional model which illustrates the overall relationships between each process and its components rather than a sequence of steps. The comprehensive linear-type was developed by Goldsmith (1995) as illustrated in Figure 2.6.

IDEA / KNOWLEDGE / INTELLECTUAL PROPERTY

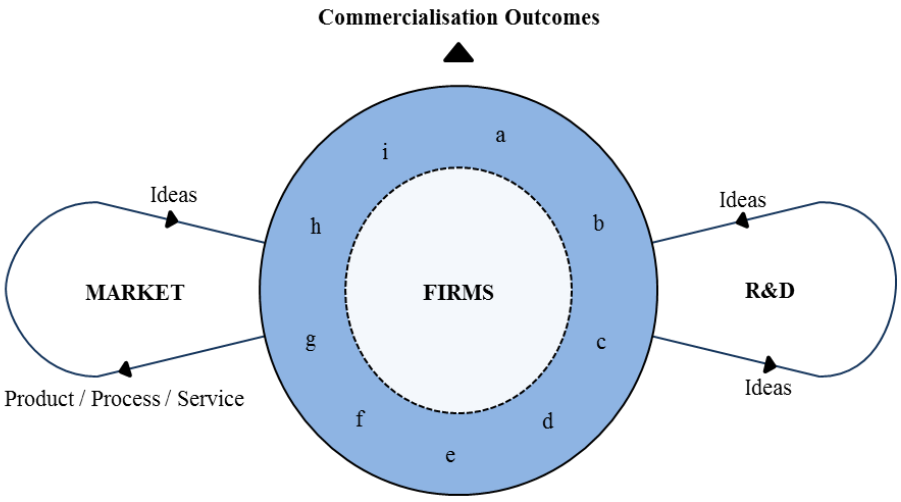
COMPONENTS	Technical	Market	Business
	CONCEPT PHASE		
STAGE 1 INVESTIGATION	TECHNICAL ANALYSIS • Define Concept • Confirm critical assumptions • Survey state of the art • ID critical barriers • Evaluate applicability • Determine technology	MARKET ASSESSMENT Conduct market overview • ID pricing structure • ID market barriers • ID risks • ID distribution channels • ID trends and competitors	VENTURE ASSESSMENT • Estimate profit potential • Conduct self, enterprise & commercialisation assessments • ID professional needs • ID capital needs
	DEVELOPMENT PHASE		
STAGE 2 FEASIBILITY	TECHNICAL FEASIBILITY • Develop working model • Test technical features • Assess preliminary manufacturability • Conduct manufacturing assessment • Assess safety & environmental features • Finalize designs	MARKET STUDY • Market size • Customers • Volume • Prices • Distribution • Competitors	ECONOMIC FEASIBILITY • Formulate financial assumptions • Develop *proforma* • ID seed capital • Form advisory team
STAGE 3 DEVELOPMENT	ENGINEERING PROTOTYPE • Develop Prototype • ID materials and processes • Conduct tests • Develop manufacturing methods	STRATEGIC MARKET PLAN • ID marketing team • Define target market • Select market channels • Field test	STRATEGIC BUSINESS PLAN • Decide venture or license • Finalize intellectual property • ID management team • Select organization structure • Write business plan
STAGE 4 INTRODUCTION	PRE-PRODUCTION PROTOTYPE • Develop production prototype • Determine production process • Select manufacturing process • Design field support system • Demo product features	MARKET VALIDATION • Establish market relationships • Conduct limited sales • Analyse sales • Survey customers • Refine marketing	BUSINESS START-UP • Establish business functions • Hire staff • Execute contracts • Secure first-stage financing
	COMMERCIAL PHASE		
STAGE 5 GROWTH	PRODUCTION • Prepare commercial design • Establish quality control • Construct facilities • Conduct full-scale production • Finalize internal distribution system	SALES & DISTRIBUTION • Expand distribution • Analyse competitor response • Assess customer satisfaction • Assess distribution satisfaction • Refine product features	BUSINESS GROWTH • Monitor enterprise position • Hire and train personnel • Execute contracts • Arrange 2nd & 3rd stage financing • Institute vision, mission, management policies
STAGE 6 MATURITY	PRODUCTION SUPPORT • Maximize production • After market support, repairs & spares • Warranty service • Implement training program	MARKET DIVERSIFICATION • Develop market retention • Establish market scan • ID new markets • ID new products	BUSINESS MATURITY • Establish SWOT • Invest profits • Monitor product life cycle • Monitor business trends • Monitor management technologies • Implement innovations

PRODUCT / PROCESS / SERVICE

Figure 2.6: The 'linear' commercialisation model adapted from Goldsmith (1995).

This model covers the whole commercialisation process starting from idea to product, covering pre- and post-development phases. There are six stages consisting of various research and non-research activities including technical, market and business aspects. The activities involve many innovation actors ranging from the inventors, other researchers, suppliers, distributors, competitors, experts, customers, marketers, capitalists, licensees, managers, supporting staff and others. All activities and innovation actors are interrelated or networked within the model which represents the critical component of a collaborative approach for commercialisation.

An example of the second functional-type of commercialisation model is illustrated in Figure 2.7. This type of model represents the sub-components of commercialisation processes in a diagram that describe a set of inter-relationships between components without distinct starting or end points. It is a cyclic process of core functional activities that is required for commercialisation with two main elements: technological and commercial functions.



Technology Functions
a. Research
b. Development
c. Proof of concept
d. Prototype
e. Planning

Commercial Functions
f. Operations
g. Marketing / Promotion
h. Distributions / Sales
i. Customer feedback

Figure 2.7: The 'functional' commercialisation model.
Source: Canada and Rotman (2006).

Both types of model emphasise the multiple activities involved within a commercialisation process. The success and failure of the overall process is very much dependent on the efficiency of collaborative efforts between the various innovation actors involved. Apart from the process, there are several commercialisation strategies or paths for transforming an innovation idea into an applicable product, process or service. The choice for the most appropriate strategy is critical because it affects the entire commercialisation process. Consequently, it is reasonable to suggest that commercialisation success depends on the strategy chosen which determines the scope of overall activities, resources and efforts to achieve it (Jorde & Teece 1989).

2.4.3. Successful Commercialisation

A successful commercialisation is defined as the whole process of acquiring ideas, developing and selling the products into the market (Radosevic & Yoruk 2012) for which collaborative networks seem critical (Aarikka-Stenroos & Sandberg 2012; Khademi & Ismail 2013). Successful innovators appear to be more efficient also in terms of how they perform tasks related to marketing, research, communication, and management (Ferguson 2012) as well as innovation actors' personal networks.

The success of commercialisation is generally dependent on the strategy implemented represented by tangible outcomes such (1) the number of patents filed, (2) licensing agreements formed, (3) spin-off companies created, (4) royalties and cash from equity investments paid to the academic institution, and (5) the number of products successfully introduced to the market (Govindaraju, Ghapar & Pandiyan 2009). There are various strategies to achieve successful commercialisation with pecuniary and non-pecuniary values (Chesbrough & Brunswicker 2014; Rass et al. 2013). Table 2.3 illustrates the relationships between different types of values linked to open innovation practices as well as commercialisation strategies.

Table 2.3: The types of commercialisation strategies, values and open innovation practices.

Types of Commercialisation Strategies		
	Inbound Innovation Practices	**Outbound Innovation Practices**
Pecuniary Values	Acquiring inventions through formal ties e.g. technology brokerage, partnership contract, contract research, IP in licensing, contracted R&D services, specialised open innovation intermediaries, idea and start-up competitions, supplier innovation awards and university research grants.	Selling ideas in the market place e.g. licensing, trading secret, visiting lectureships, business consulting, direct investments, spin offs, corporate business incubation, selling market ready products and IP out-licensing.
	Inbound Innovation Practices	**Outbound Innovation Practices**
Non-pecuniary Values	Sourcing ideas from external partners e.g. consultation, industrial training, coordination of technology, joint research, shared equipment, customer and consumer co-creation, crowdsourcing, publicly funded R&D consortia and informal networking.	Revealing internal resources to external environment e.g. training services, collaborative education, sharing codes, publication, joint venture activities, participation in standardisation and donations to commons or non-profits.

Source: Adapted from Chesbrough and Brunswicker (2014, p. 19); Rass et al. (2013).

Every commercialisation strategy has its own implications and two key issues are common to all strategies: (1) whether there are any payoffs at a societal, industrial, organisational or individual level, and (2) if there are any attempts to understand the behaviours exhibited by the collaborating organisation and its actors (Hambrick & Macmillan 1985). Each commercialisation strategy requires innovation actors to collaborate with others and form a network to proceed in the commercialisation process. Consequently, scholars have underlined several network competencies that are needed to succeed in commercialisation attempts and that innovation actors must display:

- Build trust and social relations in order to access resources;
- Motivate others to provide for resources trade-offs; and
- Organise resources and plan for goal coherence (Aarikka-Stenroos & Sandberg 2012, p. 200).

This indicates that a successful commercialisation process requires relational or social resources to support effective innovation networks, manifested by innovation actors' behaviours. Behavioural differences within the innovation network can be a source of threat and conflict which can potentially impede a successful commercialisation attempt. Thus, effective innovation networks are underpinned by good social relationships (embedded with sufficient social resources) that facilitate commercialisation success. It is common for innovation actors to adopt various commercialisation strategies and mixed open innovation practices as each strategy and commercialisation practice has it owns advantages and disadvantages (Dahlander & Gann 2010). Thus, commercialisation attempts that are timely, fulfil the needs of actors and achieve high quality product outcomes (Nobelius 2004) are more likely based on a network of actors' capacity to achieve satisfactory levels of social relationship engagement.

2.4.4. Commercialisation in University

University commercialisation may occur through direct and indirect strategies. These include (but are not limited to) contract research, consultation, centres of excellence, technology transfer offices, licensing agreement, joint ventures, start-up or spin-off companies, university holdings, university-industry partnerships, industry advisory panels, industry fellowship appointments and applied research grants, publication and public presentations (Bruneel, D'Este & Salter 2010; Cohen, Nelson & Walsh 2002; Fritsch & Lukas 2001; Heng, Rasli & Senin 2011; Kotha, George & Srikanth 2013; Rast, Khabiri & Senin 2012; van der Steen & Enders 2008). The indirect (non-commercial) strategies through scholarly publications or seminars are more prevalent (Yaacob et al. 2011), because broad dissemination of knowledge is the primary concern of universities (Rahal & Rabelo 2006).

Indeed, the emphasis on knowledge-based economic strategy has created new demands for universities to open up their research and collaborate with others so that the primary roles in knowledge generation and dissemination can be extended for knowledge implementation and application. The state of open innovation and commercialisation within a university context is illustrated as in Figure 2.8. The strategies adopted will depend on the objectives of the project (Ismail 2012) and how university researchers are connected during the process (Perkmann et al. 2013).

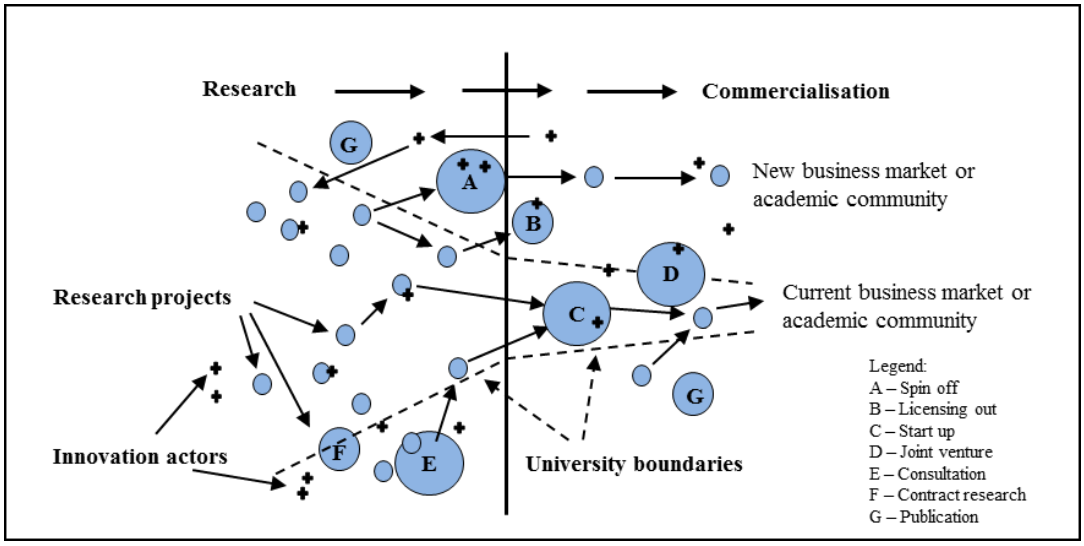


Figure 2.8: The university commercialisation strategies according to open innovation concept.
Source: Adapted from Chesbrough (2003b).

Figure 2.8 illustrates the openness of university commercialisation. Ideas or innovation from research outputs can exit the university either through direct or indirect commercialisation strategies (Fulop & Couchman 2006; Hewitt-Dundas 2012). Internal and external research projects and innovation actors are mobilising between the university's boundaries. It is worth noting that there are many research projects being conducted, but only a few of these emerge in new or current business markets or through the academic community. Figure 2.8 highlights the success rate for commercialisation and reinforces the challenges for university research. From a university researcher's perspective, the commercialisation model is simplified as Figure 2.9.

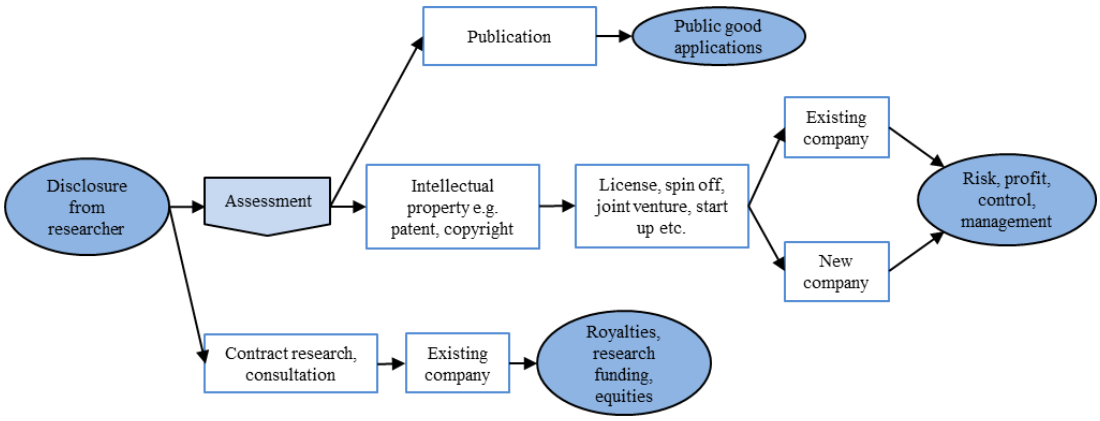


Figure 2.9: The simplified university commercialisation model.
Source: Adopted and modified from Hindle and Yencken (2004).

2.4.5. Summary

Current emphasis on knowledge-based economic strategies have led to an increasing focus on academic research that reflects changes in the role of universities (Etzkowitz et al. 2000). In addition to knowledge generation and dissemination, universities have new increasing demands to implement and apply the knowledge they acquire. Hence, universities need to adopt an open innovation approach that outlines the practices of innovating with partners for the purpose of commercialisation. Central to this is the development of innovation networks, with innovation actors who constantly interact (Plewa et al. 2013) and build key resources that enable commercialisation. Taken together, social resources that underpin effective innovation network relationships are critical for commercialisation success (Fulop & Couchman 2006). The next section discusses in more detail the social relationships and their link to commercialisation.

2.5. Social Relationships

University researchers are considered as the driver or source of innovation. They are well equipped with the scientific knowledge. However, it appears that universities may not be aware of the importance of developing strong social relationships within the commercialisation process itself. The open approach towards commercialisation requires social resources for relationship management, particularly in dealing with issues of sharing tangible (physical and financial) resources, intellectual disclosure, commitment to engage and making strategic decisions. A review conducted by Fagerberg (2003) of the innovation literature found that innovation is a result of social interactions between actors and closely linked with other socio-psychological concepts such as networks, leadership and openness. In turn, social resources or capital derived from network relationships (manifested in certain behavioural patterns) influence the level of individual innovativeness (Casanueva & Gallego 2010).

2.5.1. Definition and Perspectives

Social relationships take place between individuals (Harryson 2008) and how they act and react within a certain network influence the interactions. These networked behaviours are therefore socially embedded within a specific function. Among the

main theories concerning social networks is social exchange theory (Blau 1964; Homans 1958), social embeddedness theory (Granovetter 1985) and social capital theory (Coleman 1988). While Homans (1958) considers social behaviour as an exchange of goods, Blau (1964) considers the exchange of social resources as a fundamental form of human interaction. Other scholars such Granovetter (1985) and Coleman (1988) emphasise trust; the importance of social behaviour that is embedded and embodied in networks of interpersonal relations. However, within the commercialisation literature generally, there is a paucity of research related to motivation and leadership as other forms of social resources and inputs.

Referring to Homans (1958), social relationships are defined as a process of exchange activity of tangible or intangible resources for a more or less rewarding interaction between at least two persons. Homan's work illustrated that individual's behaviours during interactions is influenced by success, stimulus and satisfaction, which helps to determine the next social encounter. The basis of this theory views exchange as a social behaviour that may result in both economic and social rewards that drive the relationships through repetitive actions. Rewards in this context can be both tangible (e.g. monetary, physical resources) and intangible (e.g. social acceptance, support). The repeated exchanges allow a network relationship to evolve into a group of people with specific and mutual values.

In a network, social resources or capital are created when people (i.e. the actors) gain advantages, rewards or benefits from the network, that leads to actors' ongoing interactions (at individual level) that make up the relationship system. Most of the foundational views of social capital theory focused on the significance of relationships as resources for social action. Adequate social capital promotes social networks (i.e. personal relationships) development over time, embedded with valuable social resources such as trust (Fukuyama 2001) and openness, which positively contribute to free exchange of other economic resources (Weber & Weber 2007). Thus, the relationships create a form of capital or social resource that supports the actors to stay in a relationship (Bignoux 2006). Indeed, the social capital created by a network of actors' interactions can take different forms. Besides tangible capital (e.g. intellectual, financial and technological), intangible forms of social capital are equally critical for influencing the behaviours of innovation actor (Bammens 2015). This

intangible capital is defined by the specific functions of a social system that facilitate actions (or behaviours) of actors inherent in these relationships (Coleman 1988).

The innovation function, for example, comprises of innovation actors from universities that undertake innovation activities as well as commercialisation through collaborative research with industries. These innovation actors involved in a corporate venture where social capital in their relationships enables the actors to access each other's economic resources for the success of an innovation development (Weber & Weber 2007). A study relationships in emerging ventures suggested that some alliance partners would value the social capital benefits more than economic exchange within the new product development process (Marion et al. 2015). Indeed, there are differences between social and economic exchanges (Table 2.4).

Table 2.4: Comparison between social and economic exchanges.

Social exchange	Economic exchange
Focus on relationships and personal ties	Focus on transactions and prices
Examines social and also economic benefits	Examines economic benefits only
Exchange is voluntary	Exchange is mandatory
Exchange is not contracted explicitly	Exchange is contracted explicitly
Exchange takes place within a social system	Exchange takes place within market
For example: trust, recognition, support	For example: product, service, money

Source: Adapted from Bignoux (2006, p. 619).

Therefore, values related to social capital in university innovation networks lie within the relationships embodied by the academics or researchers during the commercialisation process to transform an idea into the market. Although social scientists have different perspectives on social capital, the core idea remains the same, i.e. a social network has 'values' that are inherent in social relationships (Fukuyama 2001). The actors can then exploit these social capital values to achieve certain objectives and use them to facilitate certain behaviours.

2.5.2. Trust

Trust is one of the socio-psychological constructs that can be attributed to relationships between people (i.e. the actors). It influences people actions and interactions with others. Studies on the concept of trust can be classified into two types: functional (e.g. Luhmann 2000) and structural (e.g. Giddens 1984). Functional consequences of trust

such as cooperation, relationships and social capital are distinct from structural processes of trust which emphasise the interactions between agents and structures within a social cycle (Möllering 2001).

From a social context perspective, trust is an important value specifically for mutual collaboration or cooperation. Trust is the standard solution for cooperation and perceived as the most realistic, economical and viable resource (Gambetta 2000). Once trust is established, people develop relationships and expectations that direct the future actions. Trust has contingent influence on interpersonal relationships. For collaboration, positive expectations and consequences leading to high trust relationships inspires trustworthiness behaviour among actors that make it easier for people to work together (Misztal 2013). Negative situations however, potentially expose a relationship to failure and loss of trust. Thus, there is a clear influence between trust, interpersonal relationships and expectations within a collaboration.

Trust from an economic perspective on the other hand is treated as a reliability in transactions (Zaheer & Venkatraman 1995). Actors have control over the relationships and underline specific expectations and performances. Trust has been regarded as an economic catalyst where formal collaborations (e.g. partnership agreements) are established, for example in expanding business activities. Because of this, trust even from an economic perspective is also attributed to social capital. Scholars have claimed that higher levels of trust are positively correlated with economic growth or success (Zak & Knack 2001). The rationale for this is that high trust exhibits more economic opportunities and good transactions while low trust leads to potential exploitations and failure in collaborations which reduce the rate of investment (Zak & Knack 2001).

At the individual level, trust creates the social value intrinsic to a network of people with specific objectives (Nahapiet & Ghoshal 1998). High levels of trust within networks encourages people to engage in continuous collaborative efforts for success. Particularly for work that relies on others' contributions such as creating a pool of ideas (or knowledge) for innovation and successful implementation at the commercialisation phase. Social relationships among innovation actors characterised by high trust is more likely to lead to an open exchange of knowledge (Goddard 2003) within an innovation network. Thus, the notion of trust is important in knowledge sharing (Bruneel, D'Este & Salter 2010).

High trust in innovation environments is critical especially between researchers in laboratory and users in markets (Lee 2011). Mutual agreements lead to greater commitment and motivation for researchers in conducting innovation. As innovation research involves various resources (intellectual, financial and technological), mutual agreement between innovation actors (i.e. trust in innovation) is perceived as a strategic (social) resource for successful research collaboration (Ciesielska & Iskoujina 2012). High trust promotes knowledge sharing (Al-Alawi, Al-Marzooqi & Mohammed 2007) and has a positive effect on increasing the understanding between individuals (Plewa et al. 2013). The interplay between creating an innovative environment with trust and mutual agreement relates to 'trust in innovation'.

2.5.3. Motivation

Other socio-psychological constructs can be used to explain the motivation behind people's behaviour, which accounts for people's actions. Motivation relates to a motive or need that determines a person to act for specific behaviour and performance (Shamir 1991). Motivation theories can be classified on the basis of incentive (e.g. intrinsic and extrinsic motivation), content (e.g. Maslow's hierarchy of need and Alderfer's ERG theory) and cognitive (e.g. goal-setting and Vroom's expectancy theories).

Intrinsic motivation is the self-desire to seek new challenges and gain knowledge that is driven by individual interest without external influence (Ryan & Deci 2000). Extrinsic motivation in contrast is influenced by factors outside of the individual in order to achieve desired outcomes. Both types of motivations are closely linked with rewards or incentives that can be tangible (e.g. money) or intangible (prestige) (Clark & Wilson 1961). Once reward is granted, a person will be motivated to perform or continue the action. Intrinsic motivation might be considered as the more important construct however, since it reflects the natural human desire or need for high quality learning which leads to creativity (Ryan & Deci 2000).

Implementation of motivational schemes within organisations is challenging as individual needs are different for every person. The content-based motivation theory such as Maslow's hierarchy of needs identified five levels of needs that can be satisfied (Maslow 1943). These needs ranged from basic to complex, namely, physiology (e.g.

hunger), security (e.g. salary), social (e.g. friendship), self-esteem (e.g. recognition) and self-actualisation (e.g. achievement of full potential). The Alderfer's motivation theory re-grouped the Maslow's motivational needs into three core needs such as existence, relatedness and growth (ERG) for maintaining personal relationships that involve interactions with others. A study conducted by Arnolds and Boshoff (2002) found that managers are mainly motivated by the growth needs where satisfactions can be fulfilled through creative mind processing.

Further, the cognitive theory defines motivation in terms of how an individual acts and reacts by examining the situation. Goal-setting theory sets a direction or end-state for a situation in motivating individual actions (Stanhope, Pond Iii & Surface 2013). Expectancy theory, by comparison, explains how individuals select certain actions based on situations that he/she experiences and which perceived actions will result in better performance (Erez & Isen 2002). These theoretical ideas link the process of learning as a motivator to work performance. A study by Locke et al. (1984) suggested that an additional construct of 'self-efficacy' is integrated between the learning-and-performance link. Self-efficacy defines people's judgement on how to best execute an action in order to deal with a specific situation through self-regulation of motivation (Bandura 2012).

Motivation that is generally driven by reward can be closely linked to performance. However, this is not necessarily the case in certain situations such as in public sector institutions (Shamir 1991). Considering the context of a university, freedom to innovate together with peer recognition can be a more powerful motivator than money or some other tangible reward. Creating and sharing knowledge can also be more satisfying than position. Fulfilment of higher levels of need (e.g. recognition) can lead to greater motivation for a more challenging goal such as commercialisation success. Studies have shown that the sharing of resources (knowledge, technology, financial) for successful innovation has often been tied to individual motives (Narayan 2011), both tangible (Govindaraju, Ghapar & Pandiyan 2009) and intangible (Fiaz 2013). The primary motives for innovation can be driven by non-pecuniary and pecuniary benefits (Audretsch, Leyden & Link 2013). While successful commercialisations guarantee pecuniary benefit, most university inventions are only at an early stage of the innovation process. Thus the motivation to innovate for industry purposes in this case may not be high (Rahal & Rabelo 2006) as there is no

guarantee of commercial potential. For universities as generators of innovation, the motivation to innovate often depends on both social and economic needs. As discussed more generally, these needs are not necessarily equal and both industry and university institutional needs may be fundamentally at odds.

2.5.4. Leadership

Leadership has been defined as the ability to influence and support others in the achievement of a purpose or common task (Chemers 2000). It is an important socio-psychological construct for organising a group of people. Early leadership theories recognised that the qualities of a leader were inherited (the traits theory) such as charisma, creativity and flexibility (Kirkpatrick & Locke 1991). According to Kirkpatrick and Locke (1991), later theories of leadership proposed that any individual can emerge as a leader that accounts for a sets of effective behaviour (the styles theory) including personal drive, motivation, integrity, self-confidence, cognitive ability and knowledge of the business.

Leadership is a concept with many definitions attributed as traits, characteristics, behaviours, roles, styles and skills (Barker 1997). The classic typology of leadership is based on styles: authoritarian, democratic and laissez-faire (Lewin, Lippitt & White 1939) styles. Authoritarian leaders can have absolute power (autocratic) and exhibit controlling behaviours in decision-making which may or may not be appropriate for periods of crisis. In contrast, democratic leaders take account of others' opinions during decision-making processes and are more suitable to consensus building. The laissez-faire style gives complete freedom to members to make decisions. These styles relate to managing a project with less consideration for goal achievement and performance.

According to some scholars, leaders can also change their behaviours depending on the situation (Hersey & Blanchard 1982) they encounter, as well as members' motivation for task completion. Thus, leadership has social influence in certain situations that result in the development of contingency leadership situations. The later theory suggests leaders tend to develop good relationships with others (relationship-oriented), and carry out task-related activities (Tabernero et al. 2009). Other scholars have developed leader-effectiveness attributes from the goal-setting theory of

motivation identifying four leader characteristics: achievement-oriented, directive, participative and supportive. These styles focus on managing group members as well as group performance (House 1971).

Other literature has suggested that leadership can be thought of in terms of transactional and transformational (Bass 1991) styles as well as functional (Hackman & Wageman 2005). Here, emphasis shifts from individual 'styles' to the group or organisation effectiveness and cohesiveness. Apart from managing situations, tasks and behaviours in previous theories, the roles of a leader in more recent leadership approaches shifts to organising subordinates' activities, motivating others, building trusted relationships and stimulating intellectual capacity. At the organisational level, supportive leadership and teamwork cohesion has been regarded as characteristics that significantly affect organisational learning and innovation, as well as contribute to organisational performance (Montes, Moreno & Morales 2005).

The notion of strategic leadership has also been identified as most effective in helping organisations achieve their objectives, while balancing the needs of individual members. According to Boal and Hooijberg (2000, p. 516) strategic leadership includes making strategic decisions, creating and communicating a vision for the future, coordinating key competencies and capabilities, developing organisational structures and supporting effective organisational culture. Since there is an increasing focus on the knowledge economy, there should be more attention on the leadership skills required for knowledge intensive based service (KIBS) sectors such as universities. Indeed, the principles of strategic leadership might be useful to investigate the strength of relationships between leadership priorities and innovation intent in public universities.

2.5.5. Social Relationships for University Innovation

Hardy, Phillips and Lawrence (2003) highlighted that networks and social capital in research collaboration can affect interpersonal relationships. According to Radjou (2005) a network innovation is based on the integrated collaborations of three underlying principles: (a) engage with customers, (b) source the best idea, and (3) respond proactively to partner's needs. The underpinning principle for open innovation practice is internal and external ideas; resources and strategies should be integrated to

expedite commercialisation success. As networked relationships are inherent within an open innovation approach, it is plausible that social resources is the basis for effective innovation networks and commercialisation success (Rahal & Rabelo 2006).

Commercialisation may be a secondary aim for university research and innovation. However, for university to best serve the business community and augment their innovation performance, academics have to adopt an industrial research strategy based on open innovation practices. The latter practices and processes are a priority for university innovations because traditionally innovation research has been hampered by risk of information disclosure, complicated project management and conflict of culture and interests (Zhang, Ding & Chen 2014). To negate these, university researchers need to have (or create) social competencies in order to manage the relationships within innovation networks.

According to Hofstede (1980, p. 43), culture is "…the collective programming of the people in an environment..." that manifest certain behaviours and values that create the identity of a group. Hence, the culture of a group of university researchers is distinct from a group of industrial researchers. For public university researchers, the behaviours and values are adjusted to the academic environment mainly for social benefits. As their function in research increasingly relates to innovation and economic benefits, they continually generate and apply the knowledge through interactions with others in innovation networks. While the field of innovation management is not new, research in open innovation in particular is considered as only recent (Zhang, Ding & Chen 2014). Many existing studies have not comprehensively investigated thus far the influence of social relationships for commercialisation success (Aarikka-Stenroos & Sandberg 2012) including open innovation practice (Rass et al. 2013). The relevant literature for the concepts examined are summarised in Table 2.5 to 2.9.

Table 2.5: A summary of several relevant innovation literature reviewed for the research concepts.

No.	Source	Dimension of studies	Findings	Limitations
1	Chesbrough and Brunswicker (2014) - UK & US	Examining the extent to which large firms are practicing open innovation by assessing the level of adoption, type of practices, barriers and benefits.	Most of the firms investigated are practicing open innovation through inbound practices namely co-creation, informal networking, and university grants, and outbound practices through joint ventures, selling market-ready products and standardisation services.	More systematic evidence of the extent to which firms took hold of open innovation practices is surprisingly scarce, with new phenomenon of open innovation practices at individual level is likely to evolve.
2	Salter, Criscuolo and Ter Wal (2014) - UK	Exploring the challenges confronting individuals (i.e. R&D professionals in industries) at various stages of external engagement during open innovation practices.	Four main challenges were identified: effective external engagement, safety of comfortable partners, paradox of disclosure and making external knowledge "digestible".	More understanding is needed of how individuals cope with open innovation, and which organisational practices can support them in this role.
3	Plewa et al. (2013) - Australia	The impact of relational success factors (communication, trust, understanding, individuals) on university linkages performance across commercialisation process.	Communication as a consistent predictor of success, with positive interrelationships between individuals advancing all relational success factors across commercialisation process.	Further investigation by integrating behavioural drivers focusing specifically on interrelationships between individuals.
4	Kotha, George and Srikanth (2013) - USA	Anticipated coordination costs influence whether an invention is licensed and that specific forms of team experience attenuate such coordination costs.	Prior licensing experience increases the hazard of licensing an invention and prior collaboration within a team influences team coordination costs and refinement of invention.	Study further on commercialisation of science invention of a single university from the aspects of prior licensing and collaboration experience.
5	Ismail (2012) - Malaysia	Result of the complexity of the process involved and also the commitment of the parties involved in the decision-making process.	Commercialisation process is influenced by motivation of the inventor, royalties, funding opportunity and the role played by the commercialisation centre in the whole process.	Adopt multiple cases from two or more universities and could also consider patents that have not been exploited.

Table 2.6: A summary of several relevant innovation literature reviewed for the research concepts (continued).

No.	Source	Dimension of studies	Findings	Limitations
6	Roper and Hewitt-Dundas (2012) - UK	Recent thinking on open innovation and the knowledge-based economy has stressed the importance of external knowledge sources in stimulating innovation.	University-based research centres establish more connections than company-based research and general bias towards links with larger firms with focusing on knowledge partnership activities.	The qualitative aspects of such linkages may be more important than the absolute number of linkages; however there is little empirical evidence on this specific point.
7	Narayan (2011) - New Zealand	Understanding of how governance structures enhance research commercialisation initiatives.	Corporate governance model of commercialisation comprised of professionals who had the capacity, willingness and ability to govern was most effective.	Study of how governance structures are tailored to enhance commercialisation initiatives is missing so far.
8	Lee (2011) - Japan	Analyses how the inter-organisational alliances are managed and investigates their impact on joint research projects, in comparison with the traditional interpersonal networks.	University-industry alliances, being equipped with contractual arrangements, organisational commitments and specialised coordination procedures, enable alliance partners to initiate more interdisciplinary research projects.	Future direction of research would be to enhance understanding on how and when inter-organisational alliances and the interpersonal networks may be complemented for an ideal balance.
9	Harman (2010) - Australia	Perceptions of technology transfer specialists, science and technology academics who hold industry research funding about both the success of university efforts and the effectiveness of government programs.	Academics tend to be strongly negative about the management of their own institutions and higher education and research policy especially in lack of financial support for research activities and support for commercialisation offices and 'proof of concept' funding.	One difficulty in making assessments of university performance in research commercialisation is the lack of an appropriate range of metrics and international benchmarking where the common metrics are quite narrow.
10	Bruneel, D'Este and Salter (2010) - UK	The effects of collaboration experience, breadth of interaction, and inter-organisational trust on lowering different types of barriers.	Prior experience of collaborative research lowers orientation related barriers and that greater levels of trust reduce both types of barriers studied.	Unclear whether changes in university patenting activity are a direct consequence of technological changes or of policy and do not know what effect these efforts at commercialisation.

Table 2.7: A summary of several relevant innovation literature reviewed for the research concepts (continued).

No.	Source	Dimension of studies	Findings	Limitations
11	Østergaard (2009) - Denmark	The extent of informal contacts between employees in firms and local university researchers in a wireless communications cluster.	Inter firm informal contacts are more numerous than university informal contacts. Participants who educated at the local university have a higher likelihood of acquiring knowledge from informal contacts with university researchers.	Future studies should investigate the effect of knowledge flows through social networks and their evolution and necessary to include university researchers in these studies.
12	Boardman (2009) - USA	Broad range of professional and personal predictors of scientists' interactions with the private sector, including tenure status, scientific values, and demographic attributes.	Positive relationship between behaviours expected of university scientists that conducting government funded research and interactions with the private sector.	There remains little understanding of which university scientists interact with industry and, when they do interact, what specific types of tasks and activities they perform.
13	Arvanitis, Kubli and Woerter (2008) - Switzerland	Factors determining the propensity of science institutions get involved in a wide spectrum of knowledge and technology transfer (KTT) activities with private corporations.	Scientific institutes with a stronger orientation to applied research are stronger inclined to get involved in overall transfer activities. Also valid for institutes which have already had experience with industry co-operations.	Primarily 'culture differences' between university and business due to the different goals pursued by the university and the corporation can build the starting point for a policy intervention.
14	Liefner and Schiller (2008) - Thailand	The role of universities in the technological upgrading of developing countries is based on the concept of academic capabilities.	Academic capabilities functions are still low in most cases. Direct involvement of universities and other local knowledge providers in economic development and technological upgrading has only just emerged.	It is likely that not all developing countries' higher education systems will develop in this way and future research could apply this framework to a cross-country analysis on university linkages.
15	D'Este and Patel (2007) - UK	The different channels through which academic researchers interact with industry and the factors that influence the researchers' engagement in a variety of interactions.	University researchers interact with industry using various channels such consultancy, contract research, training, patenting or spin-out. Researcher's characteristics has a stronger impact than departmental characteristics.	The influence of individual factors is mediated by the characteristics of university to which researchers are affiliated and such inter-dependencies are beyond the scope of this study.

Table 2.8: A summary of several relevant innovation literature reviewed for the research concepts (continued).

No.	Source	Dimension of studies	Findings	Limitations
16	Wong, Ho and Singh (2007) - Singapore	East Asian universities are responding to the globalization of the knowledge economy by shifting toward an "entrepreneurial university" model.	University's contribution to national economic development has changed, shifting from manpower provider and knowledge creator to knowledge commercialisation.	The specific initiatives / programs adopted may be unique to the Singapore context and may not be applicable to other contexts.
17	Decter, Bennett and Leseure (2007) - UK & USA	Examines at perceived barriers and motivations to university to business technology transfer.	Significant differences in the motivations of universities to transfer technology, the consistency of university technology transfer policies and the accessibility of university technologies to business.	The relationship in different countries between culture and levels of entrepreneurial activity has been discussed in wide field of study (economic, social, psychology).
18	Fontana, Geuna and Matt (2006) - UK	The determinants of firm collaboration with public research organisations in terms of both the propensity to undertake research projects with a university and the extent of this collaboration.	The propensity to forge an agreement with an academic partner depends on the 'absolute size' of the industrial partner and the openness of firms to the external environment as measured by their willingness to search, screen and signal efforts.	The survey was limited to five sectors of product and process innovation with the focused on SMEs with current policies are mainly directed to creating incentives for public research organisations.
19	Rahal and Rabelo (2006) - USA	Identify the determinants that influence the licensing and commercialisation of university technologies, their relative importance, most current and up-to-date selection criteria used.	A framework to properly predict and identify which of the university's intellectual properties, inventions, or technology discoveries have an above-average licensing and commercialisation potential.	None focused on the assessment and prediction of the likelihood of intellectual property being licensed and / or commercialized from the perspective of licensing professionals.
20	Debackere and Veugelers (2005) - Belgium	The transfer of scientific and technological know-how into valuable economic activity has become a high priority on many policy agendas.	Appropriate balance between incentive structures, decision and monitoring processes within academia are critical elements in fostering an "effective" commercialisation of the academic science base.	Little attention has been devoted to the organisational structure of technology transfer activities within science institutions as a condition factor.

Table 2.9: A summary of several relevant innovation literature reviewed for the research concepts (continued).

No.	Source	Dimension of studies	Findings	Limitations
21	McAdam et al. (2005) - UK	Investigate how potential business and management inputs can be used to define improvements for technology transfer processes, namely the technology licensing process and the business building process.	The complex behaviour associated with technology transfer business processes combined with the technological risk involved in the participating small firm requires management interventions.	Need for much more systematic provision in relation to business and managements infrastructure, and physical services are not the complete answer.
22	Lee and Win (2004) - Singapore	Different modes and performances of technology transfer at university research centres base on general background and research activities.	The higher the commitment in motivating industry to participate in technology transfer projects, the more successful the joint research project will become.	However, the type of transfer and other artefacts accompanying the process differ with economic, social and political climates of different countries.
23	Siegel et al. (2004) - USA	A new organisational entity has emerged at research universities: the technology transfer office to facilitate commercial knowledge transfers from universities to practitioners.	There are numerous impediments to effectiveness in university technology transfer: cultural barriers among stakeholders, technology transfer officers and inadequate rewards for faculty involvement.	To conduct a comprehensive survey among scientists and firms using variables which includes rewards, resources, culture, skills, experience, flexibility and relationships.
24	Jantan, Nasurdin and Fadzil (2003) - Malaysia	Determine the influence of organisational structure and culture on innovation.	Cultural variables, specifically the participation in decision-making, support and collaboration had significant positive effects on innovation process.	Findings were limited by the more low-level managers than middle and top-level managers participated in the study to represent the organisational data.
25	Siegel et al. (2003) - USA	Analyse the university–industry technology transfer process and its outcomes through licensing agreements, research joint ventures, and start-ups.	Stakeholders have different perspectives on the desired outputs of technology transfer. Managerial behaviours and skills are critical factors in facilitating transfer to foster commercialisation.	Further understanding by studying on not top-tier universities with qualitative method involving top administrator of technology transfer offices.

2.5.6. Summary

Based on Table 2.5 to 2.9 and the extant literature reviewed thus far, four principal gaps can be identified. First, little attention has been given by academics and managers to individual behaviours within knowledge-intensive service organisations. Even less attention has been focused on the commercialisation processes within universities (Castro-Martínez 2013; Zhang & Li 2010). In particular, studies of open innovation practices within the university context are largely unexplored (Bianchi et al. 2011) with little examination of the behaviours of the individuals involved (Salter, Criscuolo & Ter Wal 2014).

Second, few studies have explored conceptually the different forms of social capital - such as trust, motivation, leadership - that influence relationships between universities and others for successful innovation (Rass et al. 2013). As noted earlier, social capital is critical resources for improving the limited number of efficient university-industry partnerships (Belso-Martínez 2013).

Third, studies of innovation within Malaysian universities have not been systematically documented. As Asian business culture is heavily reliant on relationships and networks (Hitt, Lee & Yucel 2002), the need for better understanding of social capital requirements is critical (Lim & Cu 2012). Thus how to build social capital is a key priority between universities and participating industries.

Fourth, there is a paucity of comprehensive studies on the relationships between social capital, open innovation and commercialisation within the Malaysia public university context. Research is needed to explore this gap as social-relationships-oriented behaviours has traditionally existed in the Malaysian business context (Mat & Jantan 2009).

2.6. Conceptual Framework

Innovation is not only influenced by technology and economic determinants, but also by a number of social determinants that are created through networks of actors' interactions. Thus, multiple forms of social capital could be attributed to the innovation phenomenon (Landry, Amara & Lamari 2002; Rutten & Boekema 2007).

In particular, social resources that are embedded within innovation networks and innovation actors' relationships.

As commercialisation involves multiple sub-activities, research and innovation networks are established among various innovation actors where social values are embedded within network relationships. These social values (or social capital) then form a kind of resource for a particular society or system (de Dominicis, Florax & de Groot 2013) which can be used to explain the behaviours of the people involved. Therefore, social capital relates to the values within networks that facilitate collective action and the relationships between actors (Ling & Dale 2013). The research for this thesis argues that effective social relationships between innovation actors – university researchers and others – and open innovation practices facilitates the successful commercialisation of university research outputs.

Indeed, the antecedent for successful commercialisation goes beyond tangible (financial and technological) capital because intangible social capital is equally critical. The social capital created by various innovation actors in collaborative innovation networks who interact proactively is a plausible approach towards innovation and commercialisation in Malaysian universities. Values such as building a trusted relationship, encouraging collective participations, distinctive leadership, and being open towards cultural differences are among the emerging themes for university and industry interactions (Johnston, Robinson & Lockett 2010).

From a systematic theoretical approach, innovation can be viewed as an input-output model linked by a procedural 'black box'. At the vanguard of research for this thesis are social relationships and innovation actors as input determinants, and open innovation practices as the basis for the interactive process (Etzkowitz & Leydesdorff 2000; Manley 2003). Taken together, these practices and processes are required for commercialisation success as an output in a public university context. Figure 2.10 illustrates the systematic flow of the concepts explained.

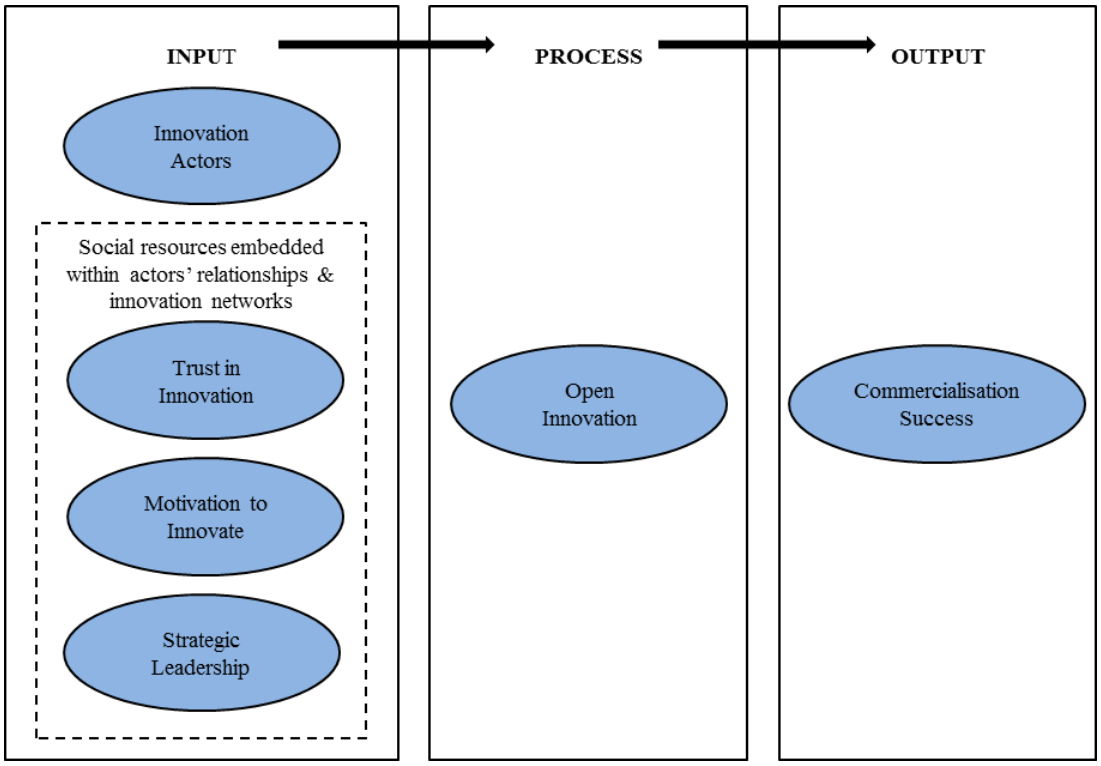


Figure 2.10: The systematic flow of the concepts adopted for the research.

The concepts were operationalised in order to develop a preliminary conceptual framework for the research. The framework comprises *Innovation Actors*, *Trust in Innovation*, *Motivation to Innovate*, *Strategic Leadership*, *Open Innovation* and *Commercialisation Success*. Accordingly, each of the research constructs were defined and explained including their inter-relationships. Figure 2.10 also establishes the framework for the research design articulated and explained in Chapter 3.

2.6.1. Innovation Actors

The innovative potential of an organisation resides in the behaviours of its people (Patterson, Kerrin & Gatto-Roissard 2009). Within universities, academic researchers are the most important agent of innovation (van der Steen & Enders 2008). As innovation actors, their interactions with others is the key source of social capital. They are the champions of tacit knowledge that develop the intellectual property in certain knowledge areas. They are also responsible for further application of the knowledge. They have an important role to play in society by providing services through learning processes and knowledge sharing (Sol, Beers & Wals 2013).

Simultaneously, they are able to develop innovation networks for knowledge application and contribute to the economy.

Academic researchers have been regarded as individuals with expertise. External parties such as government and industry constantly seek academic expertise. In small and medium enterprises for example, university experts are a source of innovation (Janeiro, Proença & Gonçalves 2013; Purcarea, Espinosa & Apetrei 2013) and are important economic actors. Scholars have highlighted the importance of individual innovation as the foundation for organisational high-performance, competitive advantage and sustainable success (Pratoom & Savatsomboon 2012; Zheng 2013). Therefore, the personal attributes of an innovation actor relate strongly to the innovation process.

Previous studies have indicated that demographic differences such as age and education level are significantly related to innovative behaviour (Arad, Hanson & Schneider 1997; Pratoom & Savatsomboon 2012). Other studies have shown that industrial experience has contributed significantly to innovation actor's attributes in innovation development processes (Schäfer & Richards 2007; Sharma, Kumar & Lalande 2006). And the innovation actor's employment characteristics such as the type of university they are associated with, the field of research expertise and academic position are also found to be related to inter-organisational network relationships (Perkmann & Walsh 2007) which determined the sources of innovation. For instance, a study by Yaacob et al. (2011) among Malaysian universities revealed significant differences in perceptions of commercialisation initiatives between academic positions.

2.6.2. Trust in Innovation

A collaborative research for applied innovation and commercialisation are not risk-free activities. Various innovation actors with different levels of resources (i.e. intellectual, financial, technological) work together towards a common objective. During the process, they explore the resources and try to exploit them optimally. As trust dynamics in a research network is developed over time (Fulop & Couchman 2006), a network relationship may cause potential risks that include the possibility of one partner opportunistically exploiting other partners for their own advantage or not

fully committing to the venture, and leaking strategic resources and core competencies. Therefore, trust is the critical value of social capital for a networked innovation.

Trust is also considered as a prerequisite for mutual sharing of resources and it has been conceptualised in many different ways (Lee et al. 2008). In this research, the concept of trust is operationalised as high levels of mutual agreement to share and innovate among innovation actors, or simply termed as trust in innovation. Trust becomes the critical success factor when innovation actors shift from closed to open innovation practices (Ciesielska & Iskoujina 2012). It is also a reasonable expectation for innovation actors to give and receive trust behaviour from each other when collaborating in a shared research project that determines a seamless integration of innovation capabilities.

Scholars have found that relational success factor such as trust show a positive effect on university and industry collaboration across innovation processes (Bruneel, D'Este & Salter 2010; Plewa et al. 2013). Case studies by Lee (2011) on several Japan universities collaboration mechanisms have strongly suggested that the evolution from interpersonal network to inter-organisational alliances for innovation is highly dependent on trust. High trust in innovation processes is critical because it predicts for success in mutual knowledge sharing (Al-Alawi, Al-Marzooqi & Mohammed 2007). Although universities tend to establish clusters of knowledge or focused-group of research, increased commercialisation success however depends on knowledge diversity (Cohen & Levinthal 1990) and establishment of trust could be an antecedent for mutual knowledge sharing (Amayah 2013).

2.6.3. Motivation to Innovate

While strong knowledge sharing attitudes are important for successful commercialisation, the sharing of optimum resources have been tied to individual motives (Narayan 2011). In addition, the motivation to innovate is also important to encourage the innovation actors going forward for better commercialisation outcomes (Collier 2007) in the competitive market environment (Campbell 2005). Universities have multiple reasons to innovate. For university researchers, the reasons to innovate can be professionally or commercially oriented. An individual can have several innovation motivations that are based on goal-oriented and also self-expressive values

(Shamir 1991). For instance, as largely academic responsibilities are prioritised into professional development needs (i.e. teaching, publication, and community service), commercialisation is perceived as not relevant to academic work, too time-consuming and expensive (Ab. Aziz et al. 2012).

Therefore, in this research, the motivation to innovate is defined as shared needs for optimum engagement that is crucial for every actors going forward in complex innovation processes. Unlike universities, most industrial innovation is motivated by commercial advantages (Andreeva & Kianto 2011) such as reducing the research cost, better access to a pool of ideas and technology, and improved product quality and marketability (Zhang, Ding & Chen 2014). Generally, the primary motives for university innovation are professionally oriented that can be mixed with non-pecuniary and pecuniary benefits (Audretsch, Leyden & Link 2013). The motivation to innovate is more focused on building academic reputation for university researchers in terms of articles for publication, participation in seminars, subscription to professional bodies, providing educational services, and to improve technical or practical skills (Mortara et al. 2010).

Several additional studies indicate that commercialisation in the university is influenced however by tangible motivation (Ismail 2012; Padilla-Mele´ndez & Garrido-Moreno 2012). A study by Fiaz (2013) showed that university collaboration is encouraged by factors such as gaining technological updates and sharing research costs. Other reasons for commercialisation in American research universities (e.g. Stanford University) is to source industry research project funding as well as a mean to better serve the community (Harman 2010). Scholars have found that pecuniary rewards are not the best way to motivate innovation actors (Antikainen, Mäkipää & Ahonen 2010; Frey, Lüthje & Haag 2011). Instead, much discussion suggests that non-pecuniary benefits including the sharing communities of practice, learning new ideas, having entertainment and receiving good support from among collaborators are equally relevant.

2.6.4. Strategic Leadership

The extant literature has frequently associated leadership with other concepts such as motivation, strategic planning including entrepreneurial behaviour (Stumpf & Mullen

1991; van Wart 2003). Indeed, there are key skills which determine whether an individual is being strategic in his/her leadership efforts. Strategic leaders in private firms for instance should have skills related to knowing the business, managing conflicts, controlling threats, staying on strategy, accommodating adversity and being an entrepreneurial force (Stumpf & Mullen 1991).

Managing research and innovation in a not-for-profit organisation such as public universities is challenging because of the duality between meeting academic and industry needs. In terms of commercialisation activity, it is perceived as going against the traditional roles of a university in providing higher educational learning, research and community services aimed at creating a knowledge society (Nonaka 1994). There is however, an increasing need for public universities to look for new funding arrangements to generate their own income (Blackman & Kennedy 2007) and to conduct university research for economic rational purposes as noted earlier (Nonaka 1994). To accommodate these needs, the strategic objective of gaining commercial advantages is another strong priority noted by universities (Ab. Aziz et al. 2012). Therefore, universities increasingly require academic researchers with strategic leadership skills that can influence research cultures to be more commercially driven (Collier, Gray & Ahn 2011).

Many elements of leadership are relevant to innovation (Arad, Hanson & Schneider 1997) including strategies, shared values, styles, skills and structures (Johne & Snelson 1990). For example, a leader should have the ability to make strategic decisions, communicate a vision, coordinate key competencies and develop organisational culture (Boal & Hooijberg 2000, p. 516). In this research, the operational definition of strategic leadership relates to leaders possessing the necessary strategic skills to influence research cultures to be more commercial-oriented, open and networked. Studies in leadership have demonstrated a positive link between being open in collaborative research and successful individual innovation (Jewels et al. 2011; Wippich 2011).

A study by Asmawi, Zakaria and Wei (2013) found that leadership is an important factor that influences research cultures through open communication, social networks and knowledge sharing which are fundamental for effective innovation processes. Similarly, a comprehensive review of commercialisation processes in a public agency by Mir and Rahaman (2006) found that leadership is an important

determinant of cultural change that helps the agency prioritise and manage their innovation strategically. In studies of cases on innovative firms such Canon, Inc. and Apple Computer, Inc., Nonaka and Kenney (1991) found that the leader's role in such organisations acted as a catalyst and facilitator. Indeed, the capability to successfully commercialise innovation is based on strategic orientation (Slater & Mohr 2006) and strategic leader capacity overall.

2.6.5. Open Innovation

Open innovation refers to a process of innovating with partners where firms should use internal and external ideas, resources and paths for commercialisation (Chesbrough 2003b). In this research, open innovation is a practice in which innovation actors interact with each other in a mutual environment for the purpose of knowledge inflows and outflows. The sharing of resources in this process appears to accelerate implementation or application of knowledge or innovation (Chesbrough 2012; Harman 2010). Three key underlying ideas for this concept are: (1) its practicality to any organisations seeking a commercial advantage (Lazzarotti, Manzini & Pellegrini 2011), (2) the fact that organisations cannot rely entirely on their own research (Gassmann & Enkel 2004), and (3) the economic advantages associated with decreased research costs, and increased product quality and marketability (Lee et al. 2010).

The open innovation process is often described in terms of innovation actors interacting at different stages of innovation (Østergaard 2009). Others suggest that open innovation is the act of conducting collaborative research for commercialisation (Bogers 2011). It involves the use of inflows and outflows of knowledge that accelerate the rate of internal innovation that potentially create opportunities in the market for its commercialisation (Chesbrough 2007). Within the context of this research, open innovation is also viewed as a process by which networked relationships and social resources are created between innovation actors that lead to superior innovative actions and commercialisation success.

Previous studies of open innovation showed that publicly funded universities establish relationships with external collaborators as knowledge partnership activities involving knowledge sharing, co-creation, supply and dissemination (Roper & Hewitt-

Dundas 2012). These activities are considered as indirect commercialisation paths as distinct from more direct commercialisation strategies such as patenting, licensing and start-ups (West 2012). For example, a case study research has shown that patents have no significant effect on technology commercialisation while publications have effects on stimulating technology transfer between universities and industries (Wen-Ling & Yun 2014). Other studies have found that open innovation often fails when individual researchers are unable to overcome challenges on their own, and therefore need to build relationships with other innovation actors (Salter, Criscuolo & Ter Wal 2014).

2.6.6. Commercialisation Success

Successful commercialisation can be viewed as a process where ideas, knowledge and innovations are converted into tangible assets that can satisfy the society and economy at large (Khademi & Ismail 2013). Within a university setting, a wide range of indicators are used to assess the range of innovation capabilities such as the number of publications, amount of research grants, number of postgraduate students, the number of intellectual properties and income from services. More advanced indicators include income generated from commercialisation activities such as invention disclosures, licenses executed, number of spin-off companies created (Khademi & Ismail 2013) as well as the level of research network intensity. In this research, commercialisation success is viewed from a university context that utilises broad types of strategies (direct or indirect paths) for taking the innovation (in the form of ideas or knowledge) into the community (i.e. public or business community).

A networked and collaborative research for commercialisation is suggested as a potential solution for bridging the knowledge gap (Kotha, George & Srikanth 2013) between the science created and the market needs. However, an open approach to innovation is often exposed to various other issues (Maier 2012). Many of these are related to the risk of information disclosure, lack of motivation to engage, and conflict of interest. Therefore, good relationships among the innovation actors should be developed to facilitate a conducive innovation ecosystem socially.

Many scholars suggest that commercialisation success is influenced by several factors such as trust (Bruneel, D'Este & Salter 2010), openness (Fontana, Geuna & Matt 2006), motivation (Ismail 2012), and leadership (Krabel & Schacht 2014).

Studies have shown that successful commercialisation relies on more than just organisational resources (Payumo et al. 2012). The actors involved in the innovation system is equally important to ensure its success. This suggests that more attention should be placed on the innovation actor's roles (Grimaldi, Quinto & Rippa 2013; Lichtenthaler 2011) and their relational competencies within innovation networks (Aarikka-Stenroos & Sandberg 2012). Thus, good social values such as openness, trust, motivation and leadership are manifested in individual's innovative behaviours that can support or inhibit innovation (Martins & Terblanche 2003; Plewa et al. 2013). These values might also help to predict commercialisation success.

2.6.7. Constructs Inter-relationships

Taken together, the underpinning concepts discussed thus far indicate the association between constructs. With the goal of increasing successful commercialisation within the Malaysian public university context, a preliminary conceptual framework has been developed to illustrate the predicted relationships (Figure 2.11). Figure 2.11 illustrates how the research for this thesis explores the relationship between open innovation (OI) and commercialisation success (CS). Further, social relationships are embodied by trust in innovation (TI), motivation to innovate (MI) and strategic leadership (SL) among innovation actors (IA). The model indicates their relationships to commercialisation success (CS).

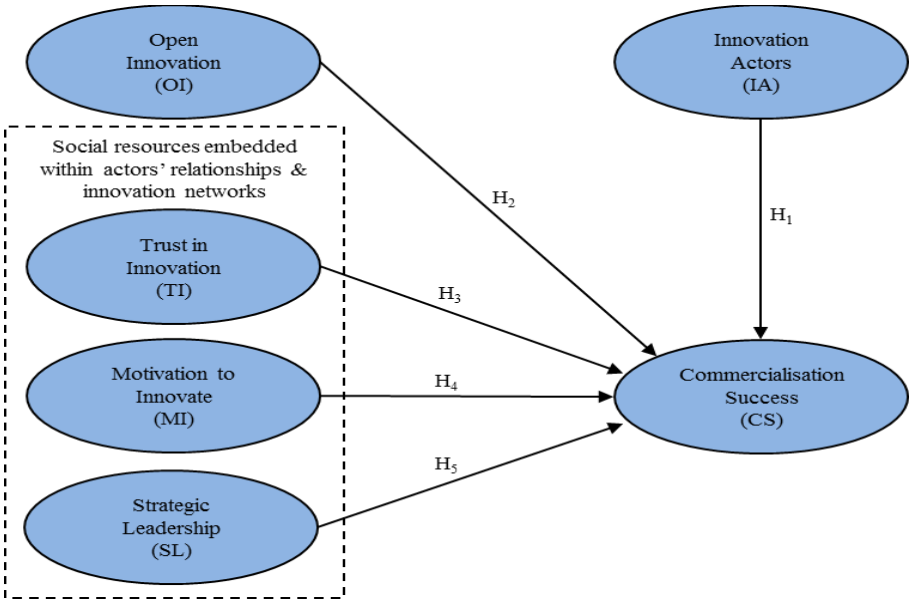


Figure 2.11: The preliminary conceptual framework developed for the research.

The university researcher's demographic characteristics represented by *Innovation Actors* are the extraneous variables (also known as control or confounding variables) that can specify the consequences of individual behaviour or action (Weingarten & Mechner 1966). The demographic characteristics of interest were age, gender, type of university, academic qualification, research expertise, academic position, industrial experience and industrial research. Thus, one of the research objectives was to examine whether the difference in *Innovation Actors* characteristics in Malaysian public universities differ from their perceptions towards *Commercialisation Success* strategies.

There are four independent variables (or exogenous constructs): *Open Innovation, Trust in Innovation, Motivation to Innovate,* and *Strategic Leadership,* and one dependent variable (or endogenous construct) namely *Commercialisation Success.* Relevant terminologies of the adopted concepts were adapted and operationalised in order to develop measurement instruments for the research. Based on a review of the literature, it is predicted that all four independent variables have a significant and positive influence on the dependent variable. Based on Figure 2.11, the preliminary null hypotheses (H_O) were developed as follows:

H_{O1}: The mean scores of *Commercialisation Success* are equal between the *Innovation Actors* when they are classified according to their age, gender, types of university, academic qualifications, research expertise, academic positions, industrial experience and industrial research.

H_{O2}: *Open Innovation* has no influence on *Commercialisation Success.*

H_{O3}: *Trust in Innovation* has no influence on *Commercialisation Success.*

H_{O4}: *Motivation to Innovate* has no influence on *Commercialisation Success.*

H_{O5}: *Strategic Leadership* has no influence on *Commercialisation Success.*

In summary, the concept of transactions is a useful way to compare the Western style of conducting business to the Asian style (Hitt, Lee & Yucel 2002). The discussion indicates that the latter are based more on relationships and social interaction than transactions and prices per se. Social relationship-oriented behaviour appears to be a key factor for open innovation and commercialisation attempts within Malaysian universities. For example, developing trust (a form of social capital) is more important than the contractual obligation of getting the job done (Mat & Jantan

2009). Therefore, open innovation practices integrated with sufficient social resources enhance the innovation process (Collier 2007). Next, the research methodology outlines how these inter-relationships will be explored. The mechanisms that facilitate commercialisation success that stress the importance of social interactions (Chatenier et al. 2010; Neyer, Bullinger & Moeslein 2009; Rass et al. 2013) represent the key components to be explored.

2.7. Conclusion

This chapter reviewed relevant theories and concepts in order to establish a conceptual framework for the research. The research problem for this thesis is focused on examining issues about *the ineffective management of social relationships within innovation networks and the lack of success of university commercialisation attempts*. The context for the research problem related to Malaysian public universities. The shift from a labour-intensive to a knowledge-intensive economy has challenged the existing Malaysian university research model which has been principally funded by the Malaysian government. This comes on the back of new opportunities for social and economic development. As noted by Auranen and Nieminen (2010), the progression of global knowledge on science and society including existing economic strategies is more complex than policy-makers seems to believe.

From a social perspective, individuals are agents for innovation that are connected and interacted within a network system (Teece 1992). Thus, the philosophical stance of this research takes the same position as this view and examines individual innovative behaviours during interactions with other innovation actors. The review examined the current state of Malaysian public university commercialisation processes within a wider world context of commercialisation that facilitates more progressive performance. The discussion has outlined how open innovation practices coupled with good social relationships among researchers can lead to successful commercialisation. Here, social relationships are embodied by social resources or capital in the form of trust in innovation, motivation to innovate and strategic leadership. Trust is explained within the context of relationship building and sharing of resources with innovation networks. Accordingly, motivation from the context of university research and innovation collaboration can be tangible (economic) or

intangible (academic). And leadership is defined within the context of individual capacity to nurture an innovative culture and setting strategic mission and vision for commercialisation.

For public universities to accommodate the more advancing socio-economic needs, research cultures have evolved from 'simple, closed and individual' approaches to a more 'complex, open and networked' approach. In so doing, university research activities are not being compromised, but rather intensified as either professionally or commercially oriented. Therefore, public universities have to formulate strategies that can improve collaborative research networks; this means conducting effective social innovation practices combined with economic rationality rather than just producing scholarly knowledge and graduates (Debackere & Veugelers 2005).

In this chapter, a preliminary conceptual model was developed as a means to explore the research problem and questions into temporary answers (i.e. hypotheses) that can be tested using different methodological techniques. Also, the operational definitions for each of the constructs were developed for the purposes of: (a) enabling a consensus understanding throughout the research, (b) facilitating empirical instrument development, and (c) designing a research plan for data collection and analysis. Explanations of the research design are discussed next in Chapter 3: Research Methodology.

CHAPTER 3: RESEARCH METHODOLOGY

"Research is formalised curiosity. It is poking and prying with a purpose."
- Zora Neale Hurston, an anthropologist (1891-1960)

3.1. Introduction

The previous chapter reviewed relevant literature and developed a preliminary conceptual framework for the research. In this chapter, the research plan outlines the methodology used to collect and analyse data for testing the conceptual framework.

This chapter has nine sections as shown in Figure 3.1. In Sections 3.2 and 3.3, general explanations are made about the research paradigm and multiple research methods. Section 3.4 then elaborates the specific research design implemented in this research. Next, Sections 3.5, 3.6 and 3.7 discuss the research's population, sampling, data collection and analysis procedures. The research ethics is explained in section 3.8. Finally, conclusions on main elements of the research design are made in Section 3.9.

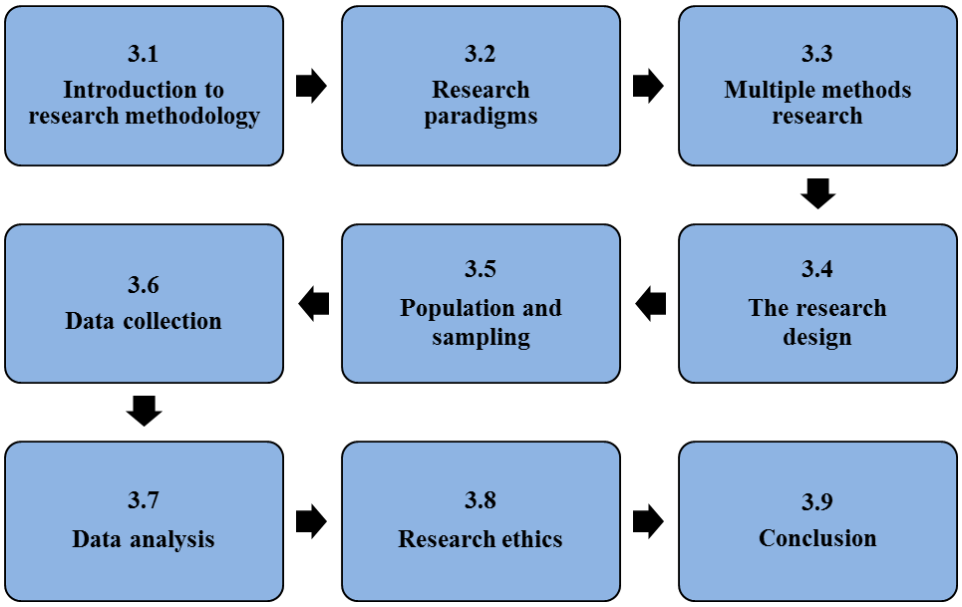


Figure 3.1: The outline of Chapter 3 on the research methodology.

3.2. Research Paradigms

The ontological and epistemological stance of this research came from a social perspective where individuals are the agents for innovation that are interacted within a network system. Based on the literature, the researcher argued that social capital embedded within relationships among innovation actors and their networks could significantly influence commercialisation success which was addressed by prior research, e.g. Lundvall (2007).

The justifications for the research were stated in Section 1.4. There were gaps in the extant innovation literature on a comprehensive examination of several forms of social capital in relation to innovation relationships between innovation actors (Rass et al. 2013). In particular, there was a paucity of research related to the open innovation concept and innovation networks in Malaysian universities. Moreover, commercialisation attempts appeared limited and was considered only as a recent phenomenon in Malaysia (Aziz et al. 2013).

A review of long-established innovation concepts required a more flexible approach to innovation research consistent with contemporary modern practices (Creswell 2009). Thus, the philosophical tradition for this research was based on the pragmatist view. Pragmatism offers a more adaptable research approach related to the demands for new behaviour in innovation management practices (Emison 2010). The research paradigm for this thesis is highlighted in Table 3.1 together with other approaches.

Table 3.1: The main research paradigms.

Post positivism	**Constructivism**
• Determination • Reductionism • Empirical observation and measurement • Theory verification	• Understanding • Multiple participant meanings • Social and historical construction • Theory generation
Advocacy / Participatory	***Pragmatism***
• Political • Empowerment issue-oriented • Collaborative • Change-oriented	• **Consequences of actions** • **Problem-centred** • **Pluralistic** • **Real-world practice oriented**

Source: Adopted from Creswell (2009, p. 6).

Based on Table 3.1, the pragmatist tradition focuses on situational problems and consequences of actions. The inquiry processes involve multiple research methods (pluralistic) in order to explain an event that arises out of real-world practical problems (Creswell 2009). In this research, the choice was of situational-based pragmatism aligned to its philosophical stance that focuses on a research problem and uses all approaches available to understand the problem (Polit & Beck 2010).

According to Andrew and Halcomb (2006), pragmatists believe that the research questions are of the greatest importance to a study reflecting freedom of choice in designing a research process spanning various aspects of research methodology. The pragmatist approach helps to orientate the researcher's view about the current phenomenon and guides the planning for an ideal research design in order to explain the research problem and to answer the research questions.

3.2.1. Research Questions

The research problem for this thesis is focused on examining *the ineffective management of social relationships within innovation networks and the lack of success of university commercialisation attempts*. Accordingly, a number of related and emerging research questions were developed to explain the phenomenon within the Malaysian public universities context. The overarching research question was: How do the characteristics and behaviours of the innovation actor (university researcher) relate to the success of university commercialisation attempts in innovation networks? In turn, three research questions were posited.

RQ1: Does the difference in *Innovation Actors'* characteristics differ from their perceived strategies for *Commercialisation Success*?

RQ2: Does *Open Innovation*, *Trust in Innovation*, *Motivation to Innovate* and *Strategic Leadership* influence *Commercialisation Success*?

RQ3: Is the innovation relationships model of *Open Innovation*, *Strategic Leadership* and *Commercialisation Success* equivalent across two groups of *Innovation Actors* based on industrial experience?

As innovation processes are a dynamic human activity-based, the phenomenon cannot be simply conceptualised from a deductive or inductive approach (Nonaka & Kenney 1991). Indeed, the pragmatist view was deemed suitable for this research that accepts traditional research dualisms (e.g. subjectivism and objectivism). The researcher's ontological position is that real people have both independent views and specific responsibilities. Thus, an epistemological stance of the phenomenon mentioned above would be best investigated both from real experiences and expected actions. Other characteristics of the pragmatism view as listed below also justify this particular research approach (Johnson & Onwuegbuzie 2004).

- Recognises the existence and importance of the natural world as well as the emergent social and psychological world;
- Places high regard for the reality of and influence of the inner world of human experience in actions;
- Replaces the epistemic distinction between subject and object with the naturalistic, process-oriented and network transaction;
- Human inquiry (i.e., what we do in our day-to-day lives as we interact with environments) is viewed as being analogous to scientific inquiry;
- Theories are viewed instrumentally (they become true and they are true to different degrees based on how well they applicable);
- Endorses pluralism (e.g. different, or even conflicting theories or perspectives can be useful to gain understanding of people);
- Views current truth, meaning and knowledge as tentative and changing over time. The current findings are considered as provisional truths;
- Takes an explicitly value-oriented approach to research that is derived from cultural shared-values such democracy, equality and progress; and
- Endorses practical theory (theory that informs effective practice) and people are constantly adapting to new situations (Johnson & Onwuegbuzie 2004, p. 18).

Generally, pragmatism is the philosophical partner for mixed methods research design (Johnson & Onwuegbuzie 2004) with the flexibility in mixing the research

strategies, techniques and procedures. Levels or layers of research design structure is illustrated in Figure 3.2.

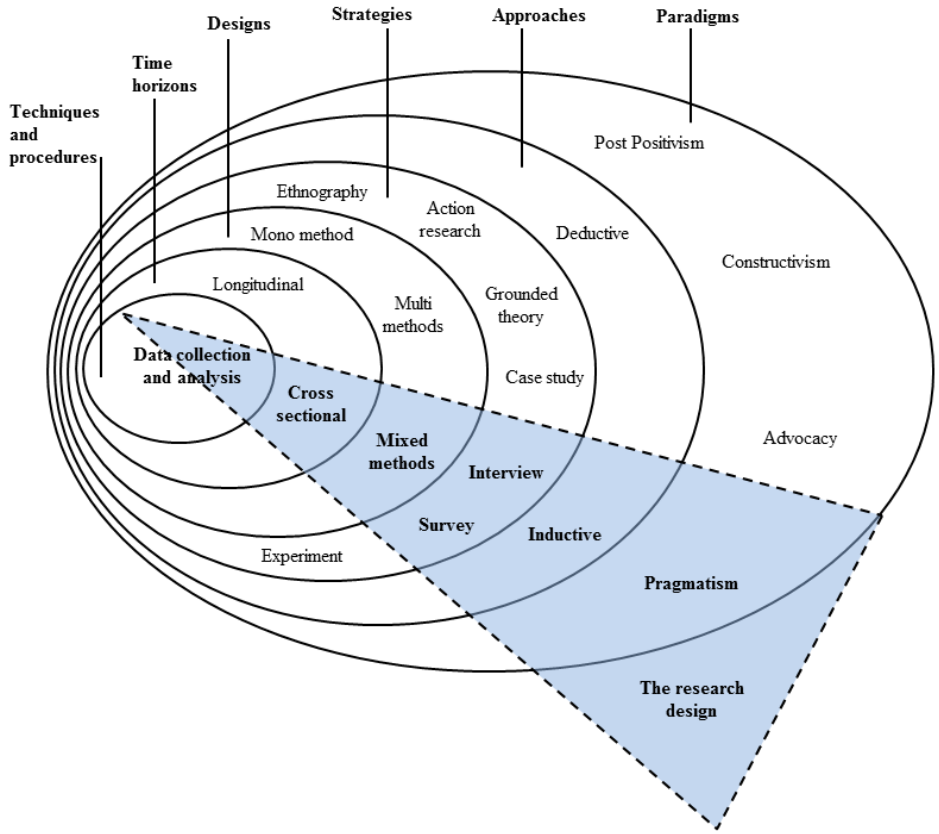


Figure 3.2: The research 'onion' layers.
Source: Adapted from Saunders et al. (2011, p. 138).

Based on Figure 3.2, a mixed methods research design was adopted in the research (indicated by the coloured triangle). The research design comprised of interview and survey strategies using both probability and non-probability sampling techniques. The data was collected in numeric and text data format and analysed using both qualitative and quantitative procedures. The researcher used a field survey as the primary strategy for inquiry and expert interviews as a secondary strategy. The primary strategy was used to answer the research questions and to explain the research problem. The secondary strategy was implemented to confirm the contextual issue, to validate the preliminary conceptual framework and to refine the measurement instrument for the survey. This approach is consistent with the recommendation by Olsen (2004) that mixed methods research should have a dominant or major strategy (primary) and a minor strategy (secondary).

3.3. Multiple Methods Research

There are several designs for multiple methods research. To facilitate the discussions, a research design category is illustrated in Figure 3.3. A mono method is a self-explanatory strategy, compared to multiple methods which are less straightforward with ambiguous interpretations among scholars. Therefore, it is important to briefly discuss the multiple methods research design.

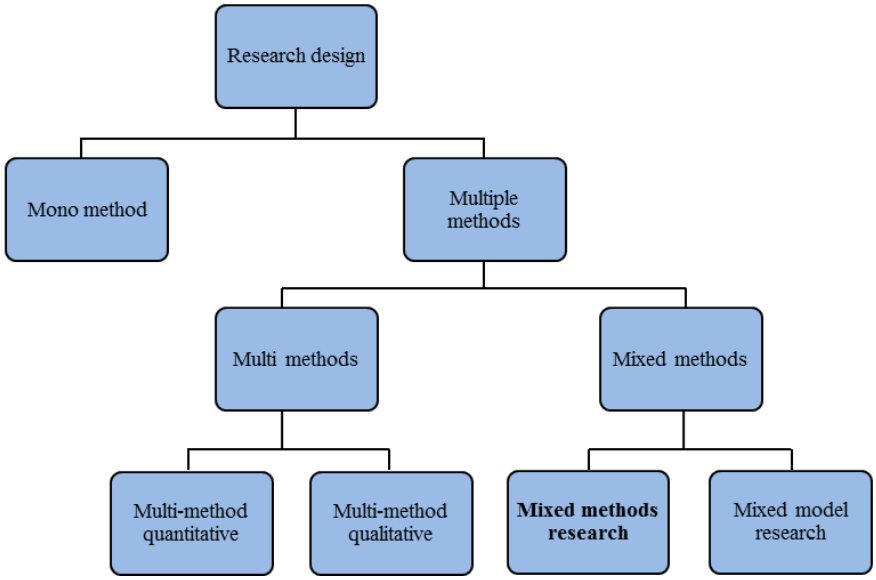


Figure 3.3: Research design categories.
Source: Adapted from Saunders et al. (2011, p. 152).

According to Saunders et al. (2011), the type of research design is basically differentiated based on data collection techniques and data analysis procedures employed in a study. A mono method uses single technique and procedure for data collection and analysis, and multiple methods uses more than one technique or procedures in combination. Within the multiple methods category, there are four possible designs: (1) multi-method quantitative studies; (2) multi-method qualitative studies; (3) mixed methods research; and (4) mixed model research. Today's trend in management research is increasingly using multiple methods for designing better investigation strategies (Moradi et al. 2012).

The multi methods design refers to the use of more than one data collection technique for a single data analysis procedure. For example, data collection is done using both survey and experimental techniques only for a statistical (i.e. quantitative)

data analysis. This research design was described as a multi method quantitative study and alternate strategy for a multi method qualitative study.

In this research, a mixed methods research design was implemented that refers to the use of both quantitative and qualitative type of data collection techniques and data analysis procedures in a single research. Specifically, field survey and expert interview strategies were used to collect data and the data was analysed using statistical and content analysis procedures. In contrast to a mixed model research design, the strategies are interchanged during the research process. For example, interview transcripts that were originally in text (i.e. in the form of qualitative data) are transformed and quantified based on the present or absent (binary coding) based on certain themes that have been identified a priori for statistical analysis. A further explanations on mixed methods research design is discussed next.

3.3.1. Types of Mixed Methods Research

The typology for mixed methods research design is dynamic in nature and the field of research methodology has kept evolving with various arrangements (Teddlie & Tashakkori 2006). Although definitions for every research method (various data collection techniques and data analysis procedures) and research methodologies (quantitative and qualitative approaches to research) are clearly distinct, there is however, a certain degree of overlap in the mixed methods research design (Johnson & Christensen 2012) as illustrated in Figure 3.4. The middle point shows the pure form of mixed methods where both types of approaches are given equal status. To the left, is the approach that is labelled as qualitative dominant, where qualitative methods are the priority, while to the right is quantitative dominant with more priority on quantitative methods.

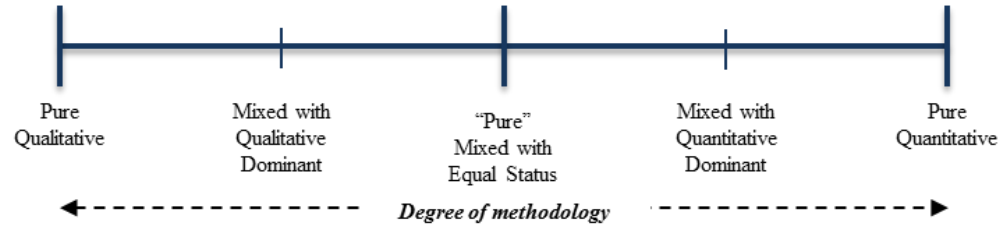


Figure 3.4: The research methods continuum.
Source: Adapted from Johnson, Onwuegbuzie and Turner (2007, p. 124).

In practice, it depends on the emphasis of the methodologies given; nine types of mixed methods research design are possible as illustrated in Figure 3.5.

		Time Order	
		Concurrent	Sequential
Method Emphasis	Equal Status	QUAL + QUAN	QUAL → QUAN QUAN → QUAL
	Dominant Status	QUAL + quan	QUAL → quan **qual → QUAN**
		QUAN + qual	QUAN → qual Quan → QUAL

Figure 3.5: The mixed methods research design matrix.

Source: Adapted from Johnson and Onwuegbuzie (2004, p. 22).

Criteria used to create the matrix as shown in Figure 3.5 are based on the method being emphasised at the time of implementation (Johnson & Onwuegbuzie 2004; Teddlie & Tashakkori 2006). The notation "qual" stands for qualitative, "quan" stands for quantitative, "+" stands for concurrent, "→" stands for sequential, uppercase letters denote high priority and lowercase letters denote lower priority. The type of mixed methods research design employed in the study is of "qual → Quan" as indicated in bold letters.

Concurrent designs benefit researchers in terms of shorter time for undertaking the research, but it also means more human resources are needed to manage several processes simultaneously. While in sequential design, the multiple methods will be conducted one after the other. This design imposes more time for conducting the research, but it is suitable for a research project with less number of researchers or single researcher as in postgraduate research projects (Onwuegbuzie & Leech 2005). Regardless of the time order, final interpretations and conclusions of the findings can be derived from either one of the method or both, depending on the researcher's reason for choosing a particular design.

3.3.2. Rationale of Mixed Methods Research

There are many advantages of pure qualitative or quantitative research methods. Researchers can fully focus in single paradigm, strategy, technique or procedure.

However, Onwuegbuzie and Leech (2005) advocated graduate students to learn to utilise both qualitative and quantitative approaches to their research. This is especially useful when either a qualitative or quantitative approach by itself is inadequate to best explain a research problem (Creswell 2009). Indeed, I personally appreciated a more pragmatic way to do the research as I was exposed and was able to learn about various data collection techniques and data analysis procedures. Other advantages and disadvantages of mixed methods design are listed in Table 3.2.

Table 3.2: The advantages and disadvantages of mixed methods.

Advantages	Disadvantages
i) Non-numerical data can be used to add meaning to numeric data, and vice versa. ii) Use strengths of a method to overcome weaknesses in another method. iii) Provide stronger evidence for a conclusion through corroboration of findings. iv) Add further insights that might be missed when only a single method is used. v) Offers more versatility in answering research question and achieving research objective. vi) Can be used to increase the accuracy and generalisability of the results.	i) Could be difficult for a researcher to carry out both qualitative and quantitative research. ii) Researcher has to learn about various methods and understand how to mix them appropriately. iii) More expensive and time consuming. iv) Field of mixed research methodology is still developing with more ways of implementation.

Source: Developed from Creswell (2009).

The mixed methods research design offers versatility to researchers in ways to conduct research that aims to determine the best explanation for the research problem and research questions. Greene, Caracelli and Graham (1989) developed a concept on the rationales for conducting mixed methods research that serve as a general reason in determining the appropriate research design. There are five rationales for mixed methods research design: triangulation, complementarity, development, initiation and expansion. The rationale for this particular research is for development, where the use of a preceding study (i.e. a minor qualitative research) is mainly to inform the subsequent study (i.e. a major quantitative research).

3.4. The Research Design

A research design is the plan that delineates actions taken throughout the data collection and analysis phase. Central to this plan, a research problem – the core statement of a study – is the issue that needs to be addressed. There are various sources for the research problem; such as personal observation, working environment and academic literature. A valid research problem, ideally should originate from a combination of experience and knowledge that relates to issues in a society (Baker 1994). Once the research problem has been identified, a systematic process of inquiry starts as illustrated in Figure 3.6.

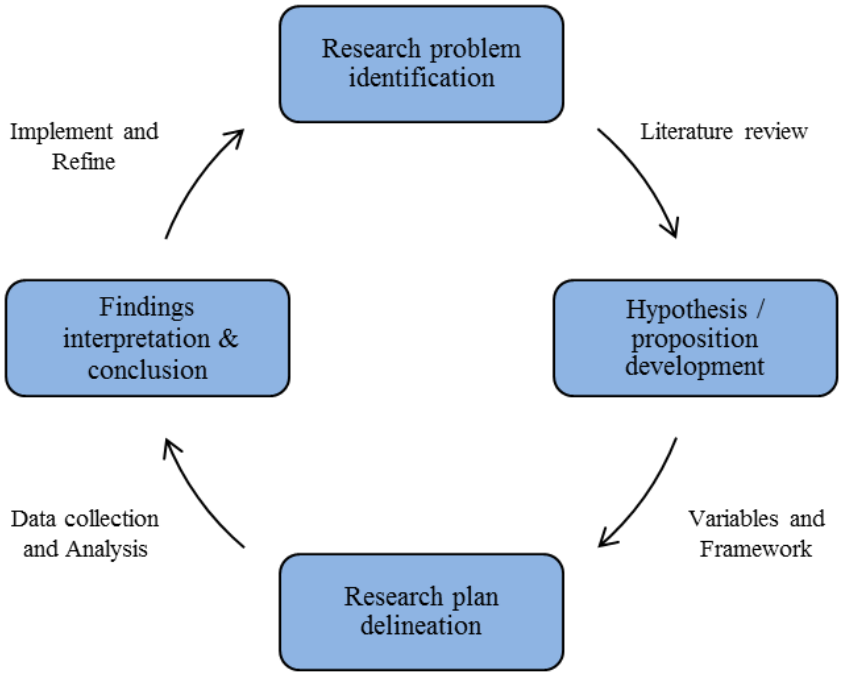


Figure 3.6: The research processes.
Source: Adapted from Sekaran (2006, p. 28).

Figure 3.6 illustrates an overall process of a scientific research consisting of several phases and components (Hurmerinta-Peltomäki & Nummela 2006; Teddlie & Tashakkori 2006). In designing this particular research, two data collection techniques and two data analysis procedures were mixed based on three considerations as below:

a. *Research problem* that motivates the research. As explained in Sections 1.2 and 1.3, the background of the research was based on the problem of ineffective management of social relationships within innovation networks and the lack of success in university commercialisation. As there are twenty public universities in Malaysia, research that involves a field survey of a large population is suitable to explain the issue in general;

b. *Research framework* that guides the research. As explained in Section 2.5.6, there are gaps in the academic research pertaining to the constructs examined. Studies in open innovation practices is only recent and largely unexplored among a public university context, with little examination of behaviours of the individuals who were involved in successful outcomes. Because of these, expert interview was also considered to confirm the issue, to validate the constructs and to inform a following major research; and

c. *Research plan* that is feasible for the research. With the specific time and resources allocated, careful considerations were given on the choice of study population, sampling procedures, data collection techniques and data analysis procedures.

The main challenge of mixed methods research design is around how to balance between the rigours desired and the resources available. This particular research for instance, was conducted by a postgraduate student with less skills and resources. Thus, the compromised decisions made by the researcher in the research were explicitly stated in the thesis where applicable. The overall plan for conducting this research is illustrated in Figure 3.7. Several research methods were mixed at the level of initiation, integration, implementation and interpretation phases (Hurmerinta-Peltomäki & Nummela 2006).

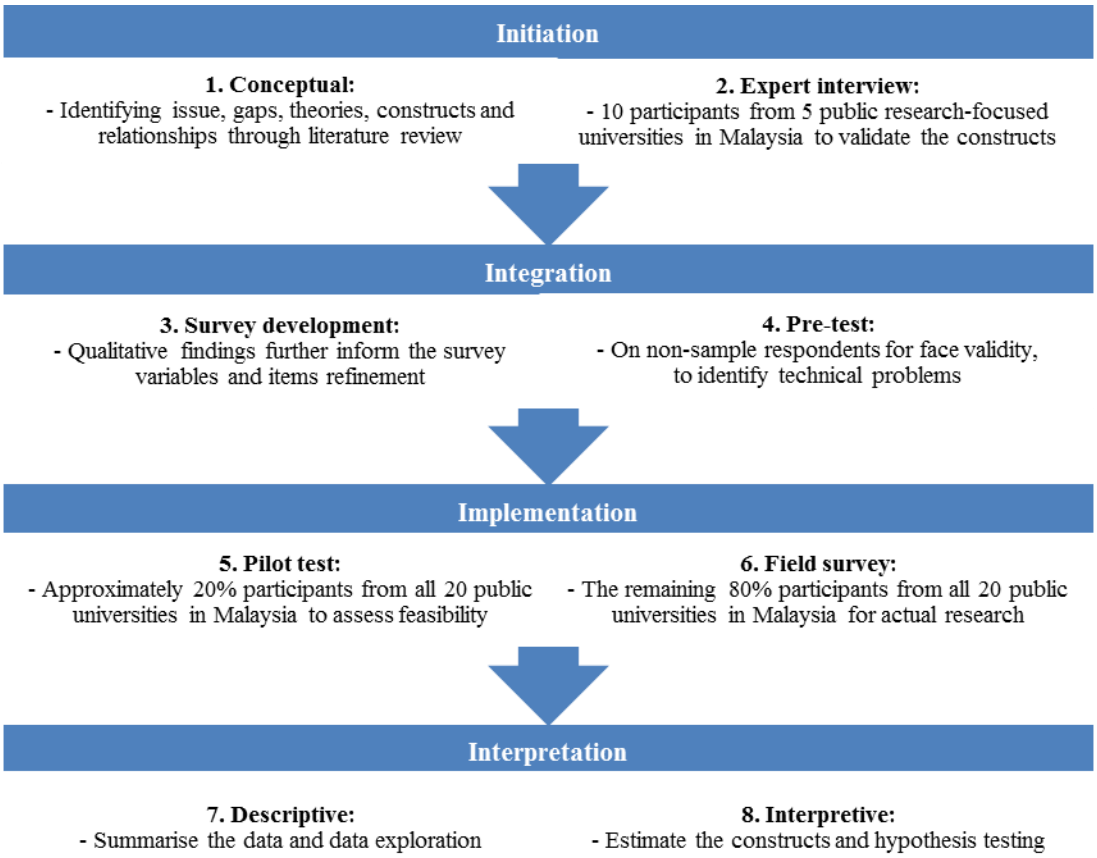


Figure 3.7: The research design.

Source: Developed for the research.

At the initiation phase, a qualitative approach was adopted by conducting a literature review and expert interviews. The literature that was reviewed covered various relevant topics in order to develop a preliminary conceptual framework and survey instrument. To validate this preliminary information, interviews were conducted among experts in the area and each interview was treated as a single case for examination. A total of ten university researchers at five research-focused universities in Malaysia were interviewed. These participants have participated in university commercialisation activities. Selection of the five research-focused universities was based on the Malaysian public university categorisation system and these universities use more intensive efforts and resources for research, innovation, as well as commercialisation. Cases from these research-focused universities are valuable for salient investigation of the research problem within its real-life context which provide convergent evidence on the issue (Yin 2014). A more detailed explanation of this qualitative study was discussed in Section 4.7.

During the integration phase, findings from the interviews were cross-checked and integrated with the preliminary survey instrument for refinement purposes. The updated survey instrument was sent for proofreading at the University of Southern Queensland (USQ), Learning Centre. Then, an online survey instrument was developed using the USQ Custom Survey System platform that was administered by a Course Evaluation and Survey Officer at the Sustainable Business & Management Improvement (SBMI) Unit. The online survey was pre-tested for face validity on non-sample respondents (i.e. among USQ lecturers and postgraduate students). Issues on spelling, word choice, design, measurement scale, time to completion and technical problem were identified during the pre-testing. Corrections were made on the online survey in terms of content (words and phrases related) and design (colour, text appearance and arrangement). The decision to use the USQ Custom Survey System platform was due to the current USQ Higher Degree Research Office recommendation on the use of the USQ proprietary online survey system.

In the implementation phase, the survey was administered in the actual research setting in Malaysia. Considering the items used in the survey were adapted from several related studies with new sets of statements developed specific for the research constructs, a pilot testing was conducted. A more detailed explanations of this pilot study was discussed in next Section 4.8. Finally, at the interpretation phase, data from the survey was analysed and interpreted using appropriate statistical procedures as further discussed in Chapter 5. A summary of actions implemented in this sequential mixed methods research design is shown in Figure 3.8.

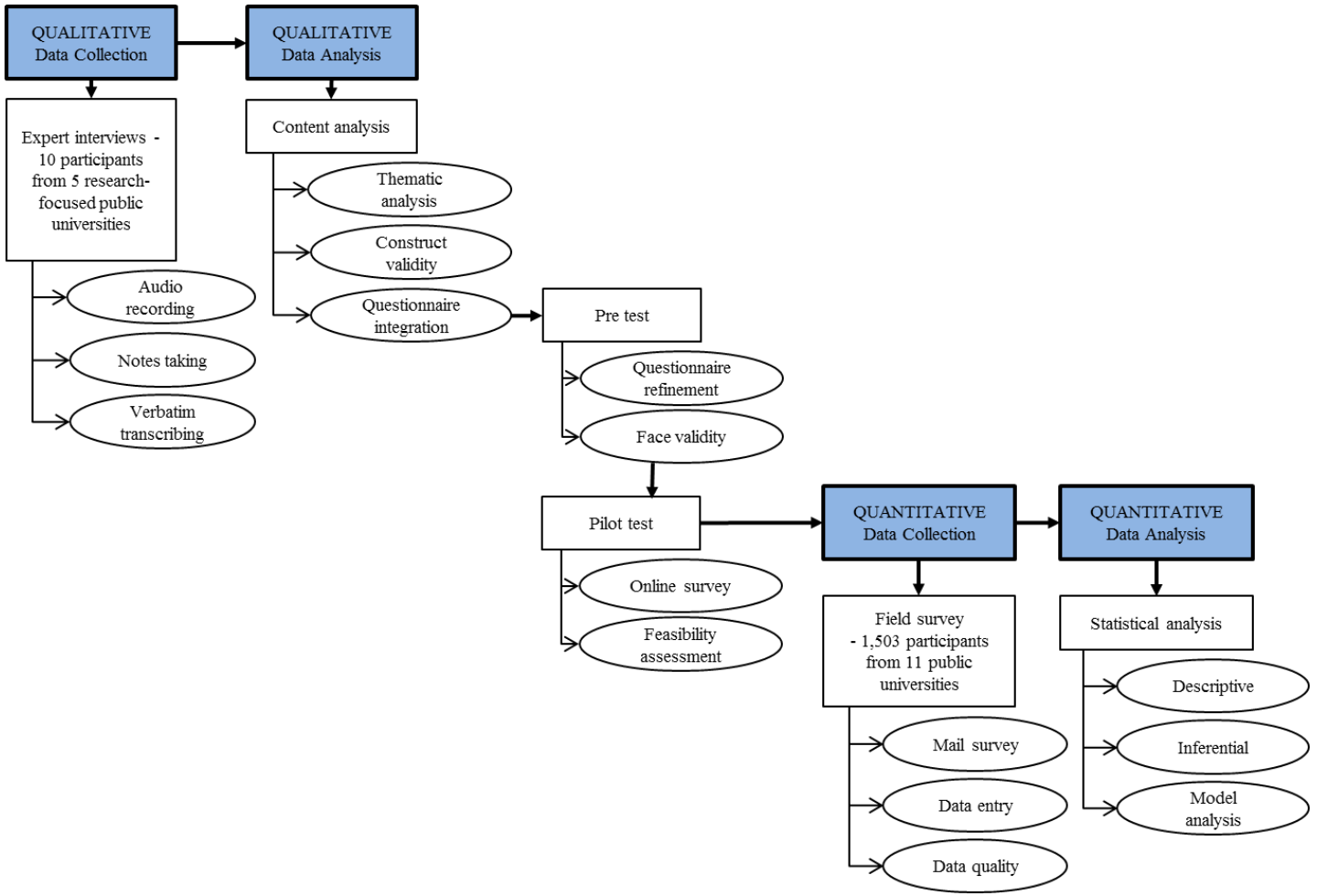


Figure 3.8: The sequence of actions in the research plan.

Source: Developed for the research.

3.5. Population & Sampling

The unit of analysis of this research was individual public university researchers since they are the main person (or actor) that makes decisions related to their research, innovation and commercialisation (Heng, Rasli & Senin 2011). This research aimed to explain the influence of actor's characteristics and innovative behaviours among the research participants in relation to commercialisation success. The innovative behaviours embodied by open innovation included trust in innovation, motivation to innovate and strategic leadership. A purposive strategy was used to establish a targeted population where particular individuals of interest are found that met predetermined criteria to inform the research objectives (Guest, Bunce & Johnson 2006), and they can provide reliable information to answer the research questions. This research purposely selected Malaysian public university researchers with intellectual property as the targeted population. The key themes of the research questions related to innovative behaviours during innovation and commercialisation.

The expert interviews were carried out on key informants (i.e. university researchers) from the five public research-focused universities (RU) in Malaysia. These five universities were chosen because it was feasible (in terms of location, time and cost) for the researcher to conduct the initial study within close proximity. Guest, Bunce and Johnson (2006) suggested six interviews would be sufficient for a high level, overarching themes development of key data provided with meaningful interpretations. This research therefore used non-probability sampling with a size of ten interviews. The resources used to conduct the qualitative study were:

(i) Logistics – own transport was used to travel to the five universities located in four states covering approximately 2,000km;
(ii) Time – one month was allocated to conduct the ten interviews; and
(iii) Cost – about AUD$700 was spent on fuel, tolls and accommodation using personal funding.

For the quantitative study, a field survey was targeted at all twenty public universities in Malaysia. The list of public universities is shown in Appendix A. A sampling frame was established with the help of the respective university's research

management offices by compiling a list of university researcher's names with intellectual property. The initial sampling frame consisted of 2,453 names of targeted participants. According to Israel (1992), a sample size around 333 is suggested for populations around 2,000 with margin of error of 5%. This study therefore decided on random probability sampling of 600 participants (around 24%) for the pilot study, and the remaining 1,853 participants (76%) were used for the actual study. The pilot study was conducted using an online survey method, while the actual study used a mail survey methods. Justifications for these two different strategies used in the field survey are elaborated in the next section (Section 4.8: The Pilot Study). The resources used to conduct this quantitative study were:

(i) Logistics – the researcher's own transport was used to manage the mail survey (i.e. preparing the survey kit, posting and collecting responded surveys);
(ii) Time – about four months were allocated to conduct both the pilot and actual surveys; and
(iii) Cost – about AUD$1,600 was spent on private mail box rentals, stamps, envelopes and documents printing using personal funding.

The targeted participants were chosen based on those characteristics of university researchers that most relevance to the research topic. The credibility of the participants was highly validated in relation to meeting the research objectives. Since the researcher does not have any prior relationship with all participants, issues of bias on the information obtained is expected to be negligible.

3.6. Data Collection

Data for this research was collected in two phases sequentially. First, qualitative data was collected using an interview technique and then followed by quantitative data collection using a survey technique. In the qualitative phase, expert interviews were conducted in order to obtain rich information drawn from relevant individuals' real experiences and perceptions about the issue investigated. The qualitative data gathered

from the interviews were in the form of verbal language that was voice-recorded and transcribed verbatim into textual data for content analysis (Polkinghorne 2005).

In the second phase, quantitative data was collected using a mail survey. Items of the survey instrument were first developed and adapted from relevant literature reviews. Then, the survey instrument was validated and refined by integrating information gathered from the expert interviews. The instrument was proofread, reviewed and pre-tested by reliable persons (i.e. university lecturers and researchers at USQ) that were not involved in the actual study as a form of external source of validation (Constas 1992). The quantitative data gathered from the survey was in the form of numbers representing behaviours concerning the constructs examined. The survey was administered twice, in the pilot and the actual study to the same targeted population but independent groups of participants.

3.7. Data Analysis

This research used both qualitative and quantitative data analysis procedures. Results from the preceding qualitative study i.e. expert interview; were used to inform the subsequent quantitative study, i.e. field survey. Interpretations and conclusions of the research findings were mainly drawn from the major quantitative study.

The verbal data collected from the interviews was transcribed verbatim using 'f4' version 2012, a transcribing software. Then, the transcripts consisting textual data were analysed using 'NVivo' version 10, a qualitative data analysis software. A content analysis method was employed by using themes identification procedure where themes or constructs discovered in the interviews were categorised systematically. The qualitative analysis procedures and findings are further elaborated in the next section (Section 4.7: The Qualitative Study).

The numerical data collected from the survey was analysed using 'SPSS' version 22, a generic statistical software and 'AMOS' version 22, a specific structural modeling software. Descriptive, factorial, inferential and model analysis procedures were carried out on the quantitative data. There was one open-ended question in the survey asking the participants about any opinion pertaining to the research. The answers were in textual form and analysed manually using a simple content analysis procedure where direct interpretations were made on the expressions. Details of

quantitative analysis procedures and findings are explained in Chapter 5: Data Analysis.

3.8. Research Ethics

The primary objective of research ethics is to guide researchers in conducting a trustworthy scientific research. The ethical protocol employed ensures the rights, anonymity and welfare of the subjects (people, animal or environment) are protected and promoted (Joungtrakul & Allen 2012). There are three different ethical philosophies when considering ethical appropriateness of a research. First, the *deontological* approach where a universal code or rule is assumed for standard ethical issues assessment. Second, the *ethical scepticism* where an individual's conscience decides what is right or wrong, and third, the *utilitarianism* where ethical decisions are weighed to compare between a research's benefits and consequences for the participants or of a majority (Johnson & Christensen 2012).

Because this research aims to contribute to better innovation management practices among individuals in a university context, the researcher adopted a utilitarianism approach in the research ethics consideration. Specifically, this research followed the USQ ethical guideline for human research that is in accordance to the Australian Code for the Responsible Conduct of Research and the National Statement on Ethical Conduct in Human Research 2007. This research was only commenced after the ethical approval was granted by the USQ Human Research Ethics Committee with the approval number H14REA145 for the period of three years (from 4 September 2014 until 4 September 2017).

There are three primary areas of ethical concern for a research; the relationship between science and society, professional issues and treatment of the research participants (Johnson & Christensen 2012). This research is concerned with the behaviours of Malaysian public university researchers and their society with regards to innovation and commercialisation activities. The research has no intention of any physical or psychological harm to the participants. Three main ethical aspects were considered in order to comply with the human research ethics requirements. These were based on the potential risks and benefits to the participants, the informed consent

protocol and the assurances for data confidentiality. The codes of ethics were reflected on what has been done to a participant at each stage of the research.

3.8.1. Risks and Benefits

In research, a risk refers to the likelihood and the severity that a harm, discomfort or inconvenience will occur to the subject, while benefit is the result of a research that may include contribution to knowledge, improvement of socio-economic status and enhancement of skills to participants or researchers. A research is ethically acceptable only when its potential benefits justify any risks identified in the research (NHMRC 2007). In this research, social risks and time imposition were identified with a generally low level of risk assessment.

As this research involved interview methods, there was the possibility of social risks whenever a participant expressed his/her opinions during the interview session. These risks might be related to participant's feeling of: (1) anxiety prior to, during or after the research, (2) perception around being judged by the researcher, (3) discomfort when discussing personal experiences, and (4) concerns regarding disclosing sensitive information and how the information would be used. In order to negate these social risks, this research implemented strategies such as: (1) provided a well written participant information sheet, (2) briefed the participants about the research procedure, (3) provided opportunities for participants to answer questions freely, (4) treated the participant's opinions and experiences with respect, (5) kept all information confidential, (6) reported all the findings as anonymous, (7) used an interview guide to ensure discussions were within the research topic, and (8) convinced regarding the freedom to refuse or withdraw from the study with no adverse effect on them.

Strategies to mitigate time and time scheduling risks were: (1) used an interview guide to ensure discussions were within the research topic, (2) designed the survey instrument at the simplest format, and (3) pre-tested the survey to ensure data collection time about ten minutes.

Overall, the anticipated benefits of the study outweighed the risks identified in terms of advancement of knowledge and enlightening the participants (i.e. Malaysian public university researchers) about the importance of better social network relationships among various innovation actors in innovation processes.

3.8.2. Informed Consent Process

Two consent methods were obtained in the research; an active and a tacit consent. The active consent was applied in the expert interviews. Before each of the face-to-face interview session commenced, the researcher explained the research procedures based on the information sheet. Once the participants understood and agreed with the research, they signed a consent form that indicated an informed consent from participants.

For the anonymous survey, a tacit consent was obtained whereby a statement of consent was included within the participant information sheet that was distributed via email or letter during the invitation process. A participant who then completed the survey (either via online or mail) was assumed to imply consent.

Both the interview and survey participants were also advised of the voluntary nature of the research. Any participant's decision not to be involved in the research was fully respected. This research did not involve any deceptions and participants had the opportunity to ask questions and provide feedback about the research personally to the researcher via email or phone as the researcher's contact details had been provided on the participant information sheet. In writing the research reports, the researcher maintained privacy, anonymity and confidentiality of the participants' identity.

3.8.3. Data Storage

The data are stored in identifiable and non-identifiable form. The interview data are in identifiable form where specific individual data can reasonably be ascertained as the researcher collected information from a participant in a face-to-face interview. The non-identifiable form refers to the survey data that were not labelled with individual identifiers during the anonymous data collection process. In turn, participants who were involved in the interview were still able to remove data if they chose to withdraw from the research at any time. For the survey participants however, because the survey was anonymous, it was impossible to identify specific data pertaining to each participant for data withdrawal.

The primary voice-recorded data collected from the interview was stored digitally, and then each interview session was de-identified during the transcribing process. Data collected from the online and mail surveys were also de-identified by giving a unique respondent identification number. The soft copy data were copied and were stored in the researcher's password protected computers, personal hard drives and USQ network drive. The hard copy data was kept in a locked cabinet at the School of Management & Enterprise, USQ. All the data are retained for five years.

3.9. Conclusion

This chapter explains the methodological aspect of the research that employed a sequential-mixed-method-quantitative-dominant research design. The main reason for mixing the research methods was for development, in ways of validating the research constructs, refining the measurement instrument and informing the subsequent major research. It has been recommended for application of mixed methods research design in management studies, as, the more sources of evidence, the more accurate the conclusions can be drawn (Scandura & Williams 2000).

This research examined generally new concepts of open innovation and commercialisation among the Malaysian public university context (Aziz et al. 2013) from a socio-psychological perspective which is well-known for its tacit explanations. Thus, a strategy to best study these concepts is from a pragmatic approach, where multiple research methods were applied for enriching interpretations of the findings (Sekaran 1983) for a more accurate and reliable explanations on the research problem. In designing the research plan, several key elements were considered and decisions were made based on guidelines from Onwuegbuzie and Leech (2006, pp. 474-5) as shown in Table 3.3. Apart from a good research design, specific quality actions in research is equally important to increase research rigour. Thus, explanations on the research quality assessment are discussed next in Chapter 4: Research Quality that covers major validity aspects, the qualitative study findings and the pilot study outcomes.

Table 3.3: The key elements considered in designing the research plan.

Elements for consideration	Decision made for the research
1. Main goal of the research	To explain the influence of open innovation practices and social relationships embodied by trust in innovation, motivation to innovate and strategic leadership in relations to university commercialisation success.
2. Formula of research questions	Based on the research problem of the ineffective management of social relationships within innovation networks that leads to lack of success in university commercialisation; three research questions were developed that guided the data collection and analysis stages.
3. Rationale for mixing research methods	Examination of new concepts of open innovation and commercialisation among the Malaysian public university context from social relationships perspective required information on both real experiences and expected actions.
4. Research paradigm	Pragmatism
5. Research approach	Inductive approach
6. Rationale of research design	A mixed methods research design was employed for the purpose of development. This design provided confirmation of the researcher's preliminary observation on the issue, verification on the inter-relationships between constructs examined and refinement of the survey instrument.
7. Research strategy used	Expert interview and field survey
8. Flow of research strategies	In sequential with the preceding minor qualitative study informing the subsequent major quantitative study.
9. Sampling design	A purposive non-probability sampling technique for the interview and random probability sampling for the survey.
10. Time of data collection	Cross-sectional
11. The type of data	Qualitative (texts) and quantitative (numbers)
12. Source of construct's definition	From extant literature review and validation through expert interviews.
13. Validating the data	Positive and negative case analysis for qualitative data. Factor analysis with unidimensionality, validity, reliability and fitness measures for quantitative data.
14. Data analysis tools	a) f4_2012: transcribing software b) NVivo 10: content data analysis c) SPSS 22: descriptive and between group data analysis d) AMOS 22: structural equation modeling analysis

CHAPTER 4: RESEARCH QUALITY

"The only relevant test of the validity of a hypothesis is comparison of prediction with experience."
- Milton Friedman, an economist and statistician (1912-2006)

4.1. Introduction

The previous chapter explains the research design that guided the overall research process. In this chapter, discussions are made on validation aspects that were considered and performed at multiple research stages before actual data collection (i.e. the field survey) was conducted. The validation aspects encompassing internal validity, external validity, construct validity, face validity and reliability. The main aim for assessing the research quality was to increase the accurateness of findings.

This chapter has nine sections as shown in Figure 4.1. In Sections 4.2, 4.3, 4.4, 4.5 and 4.6, explanations are made on the validity and reliability aspects of the research. Section 4.7 then discusses findings from the expert interviews being conducted (i.e. a minor research) for the rationale to inform the subsequent major research. Next, Section 4.8 discusses outcomes from the pilot study. Finally, conclusions on the research quality are made in Section 4.9.

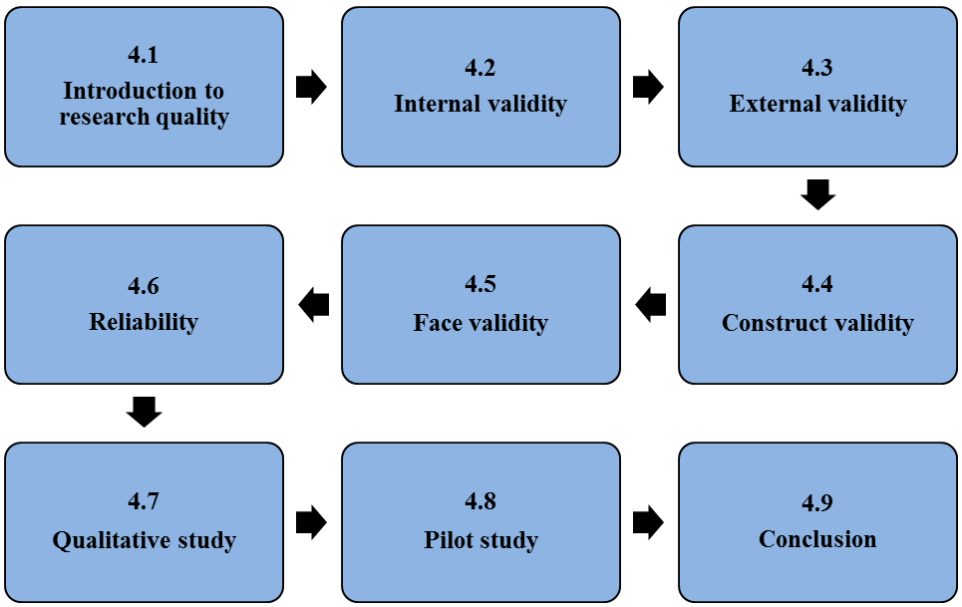


Figure 4.1: The outline of Chapter 4 on the research quality.

4.2. Internal Validity

The ability to determine accurate findings for conducting research depends on internal validity. This type of validity can be affected by (1) the type of research design adopted, and (2) the potential threats faced. Compared to experimental study, a relationship-based study (as in this research) has less certainty on the cause-and-effect explanations of a phenomenon. In relationship-based study, researchers normally can only posit accurate associations or predictions between two or more variables. There is a wide range of potential threats to internal validity (Campbell 1986; Chen 2006, 2010). Some of the main threats that the researcher faced in this particular research were caused by research instrumentation bias and selection bias.

The research instrumentation bias was suspected to pose potential threats in the research because of the survey instrument being changed over time (i.e. three versions of the questionnaire were used for pre-testing, pilot testing and actual field survey). To overcome this issue, the researcher maintained the main contents (i.e. themes of the items) in the survey instrument based on definitions of the constructs that were operationalised for the research. By adhering to the operational definitions, it helped the researcher to identify misalignment of the instrument's items and also assisted the researcher to familiarise with the research constructs.

In turn, the selection bias is generally due to the individual differences. As unit of analysis of the research is individuals, thus the research participants might differ along a wide range of factors, such as age, gender, experience and so forth. The researcher was unable to eliminate such individual characteristics and had to take into account these factors as extraneous variables, or also known as control, confounding or contingency variables. One of the fundamental steps implemented to overcome this selection bias was random sampling of the targeted population. Demographic information (i.e. age, gender, ethnic, academic qualification, field of expertise, academic position, type of university, industrial research and experience) was considered and collected in the research. This was due to existing empirical evidences indicating that there was association between certain university researcher's characteristics and their innovative behaviour (e.g. Perkmann & Walsh 2007; Sharma, Kumar & Lalande 2006).

4.3. External Validity

The concept of external validity is important because it enables a researcher to generalise findings to the population where the sample was drawn (Chen 2010). Unlike the internal validity that can be affected differently by each type of research design, external validity is affected considerably the same irrespective of the type of research design. This is because explanations are made internally based on the sampled data and the findings. However, the question is whether these explanations can be inferred to the targeted population? In the research, the targeted population was public university researchers in Malaysia who had registered intellectual property. Thus, interpretations of the findings were limited to this population and were not externally valid for other higher education institutions such as private universities, polytechnics and community colleges in Malaysia. The main threats to external validity of this research were related to contextual bias and also selection bias.

The source of contextual bias was due to diverse organisational settings among the Malaysian public universities. At the time the research was conducted, the universities were categorised into three groups namely 'research', 'comprehensive', and 'focused'. These categories were mainly based on the size of the university (i.e. in terms of number of students), government funding allocation and specified academic and research objectives. Because of this, the research participants drawn from each university might have had different perceptions on the research topic. To negate this issue, the researcher clearly stated the research aim and constructs being examined in the participant's information sheet.

Similarly, the selection bias can be a threat to external validity because of the nature of individual differences. To overcome this issue, the researcher randomly selected a homogenous sample and took account of the demographic differences among the individuals as extraneous variables for further analysis. In addition to this, another source of selection bias was voluntary participation. Literature has shown that volunteers did not have the same individual characteristics as the general population (Rosenthal 1965; Sundeen 1992). The group of individuals who volunteered took part in a research for specific purposes (e.g. personal benefits), which can influence how they respond during the research process. To overcome this issue, the researcher strictly adhered to the procedure of the USQ's Human Research Ethics procedures

where among the components being considered were the relevance and suitability of selected participants with the research topics, aims, procedures, risks and benefits.

4.4. Construct Validity

Assessing construct validity is the most essential part for evaluating the research quality. The importance of this validation step is that it incorporates other forms of validity such as content, convergent and discriminant validity (Messick 1980). The aim of construct validity assessment is to achieve the most ideal measurement procedure that will significantly increase the accuracy of findings. In this research, construct validity was achieved based on several good-of-fitness indexes, while convergent and discriminant validity measures were calculated using the data set from the actual survey that are further explained in the data analysis in Chapter 5 (discussed next). However, to achieve a strong construct validity in a single study is quite impossible as there are many factors interacted in a social event (e.g. in a social relationships phenomenon). These factors can be potential sources of threat to construct validity. In order for an overall construct validity to exist, there should be a clear distinction between the operational definitions of each constructs (Cronbach & Meehl 1955).

In a research, definition for a construct can be inadequate or inexact, which may then affect research quality (Nunnally & Bernstein 1994). The inadequacy may be due to (1) lacking of exact operationalisation of the general concept examined, (2) failing to consider important component of a concept, and (3) insufficient arguments (usually supported by relevant studies) to explain the interrelationships between concepts, constructs and contexts. To meet these requirements, the researcher developed a preliminary conceptual framework model and operational definitions for each of the constructs that were based on the literature review.

There is a lot of uncertainty in research, particularly in social science study. Not only about how a construct is defined and operationalised, but also how constructs relate to each other and more importantly, how people (i.e. the research participants) perceive or define a construct. These issues might give rise to constructs overlapping and the results obtained from such overlapped measurement of constructs can become confounded (Cronbach & Meehl 1955). This was the main threat to this research that

became one of the justifications for adopting a mixed methods research design as a way to achieve good construct validity.

An initial minor qualitative research was conducted followed by major quantitative research. The qualitative research involved expert interviews mainly to assess the constructs and contents validity. Indeed, the purposes of these interviews were (1) to investigate the research issue in a real setting, (2) to explore perceptions of the targeted participants about the research topic, (3) to identify meanings of the general concepts in a specific context, (4) to confirm inter-relationships between the operationalised research constructs, and (5) to assist in content refinement of the survey instrument. In so doing, key contents of the survey instrument were ensured to be relevant and representative of the constructs examined.

4.5. Face Validity

In the research, face validity or surface validity was also assessed as a supplemental form of validation step in order to increase the research quality. It is a subjective and superficial assessment of the measurement instrument (Drost 2011). For this purpose, both the interview guide and the survey instrument were pre-tested using non-participant individuals consisting of university researchers and postgraduate research students at USQ. As the aim of the research was to examine how a university researcher connects with others during the innovation process, it was believed that these groups of people had to some extent connected with others during their research activities and were able to assess this particular research procedure.

One interview session was conducted to pre-test the interview guide. The researcher followed the same interview procedure as outlined for the qualitative research. This pre-testing step demonstrated that the interview questions and its structure were well understood and sufficient to meet the research objective. For the survey, the first version of the questionnaire was administered online to pre-test the instrument among ten non-research participants. Pre-testing the survey helped the researcher (1) to estimate the survey completion time that was approximately ten minutes, and (2) to improve the appearance of the survey in terms of word spelling, grammatical error, scale rearrangement, font type and design, and structure of the sentences.

4.6. Reliability

Reliability (or internal consistency) is the other way to assess quality of a measurement instrument. The central concept of reliability is that the set of items being measured is stable. The assumption is that an instrument with a relatively small error will produce reliable data (Osborne & Waters 2002). However, no measurement instrument is perfect and has a tendency to produce some degree of error. Among the main source of errors is participants' behaviour (Drost 2011), which the researcher has less control over. Therefore, if possible, a relatively stable instrument with high reliability results needs to be achieved to ensure good research quality. The Cronbach's alpha test and composite reliability are the common methods for assessing measurement instrument reliability. In the research, both type of reliability measures were calculated using data set from the major research (i.e. the field survey), and further explained in the data analysis in Chapter 5. This research followed Nunnally and Bernstein (1994) and Gefen, Straub and Boudreau (2000) suggestions for a reliability value above 0.7 as satisfactory.

4.7. The Qualitative Study

Expert interviews were utilised in the qualitative research. The primary aims for conducting expert interviews were to validate the research constructs and to refine the survey instrument. Secondary to that, the researcher also used the interview information to confirm the research problem and the constructs' inter-relationships in its real setting. Interviews among the key informants were an explorative type of qualitative inquiry in order to obtain insights into the nature of social network relationships in innovation processes within the Malaysian public universities context. The overarching question of this qualitative research was: Within innovation networks, which university researcher (as innovation actor) characteristics and behaviours are best associated to the success of university commercialisation attempts? This question was posited for the purpose of exploring the characteristics and behaviours for effective management of social relationships in innovation networks. Each of the interviews contributed as a case for the research with the belief that in-depth, critical

and valuable tacit information on social capital embedded within innovation networks would be discovered (Rass et al. 2013).

4.7.1. Expert Interviews

Guest, Bunce and Johnson (2006) suggested six interviews would be sufficient to provide meaningful interpretations for a high level, overarching themes exploration of key data. This research, however, conducted ten interviews among public university researchers from all five research-focused universities (RU) in Malaysia. The establishment of the RU status came with a critical agenda to intensify innovation activities, as well as commercialisation (Ramli et al. 2013). Therefore, relevant and rich information was expected from these group of university researchers and they were considered to have appropriate expertise and experiences in the research topic. These cases were valuable for investigation of a contemporary phenomenon within its real-life context (Yin 2014), with regards to public university research, innovation and commercialisation. In particular, to explore the dynamic influence of social capital in relation to human interactions and relationships (Eisenhardt & Graebner 2007).

The main objective of these interviews was to explore the attributes and perceptions of public university researchers in relation to effective management of social relationships in innovation networks for facilitating successful commercialisation. Relevant information gathered was useful for integration and refinement of the survey instrument that accounts to the specific research context. A preliminary conceptual framework which had been developed from the literature review, related to concepts of innovation, commercialisation, social relationships and its resources within universities context worldwide. The guiding concepts were then adapted into an interview guide for the qualitative research. All the interviews were conducted by the researcher in November 2014 by following the standard protocol for face-to-face individual interview techniques.

The interview guide was first pre-tested with a non-participant that has similar criteria as the targeted research participants. The pre-testing showed that the interview questions and its structure were well understood. Analysis on the pre-test data also indicated that the information was sufficient to meet the research objectives. Then a list of targeted participants was obtained with the assistance from each of the

universities' research and innovation management offices. By using a purposive sampling method, the researcher initially recruited about thirty targeted participants by personal approach through phone calls. The purposive sampling was used to ensure that the participants fitted the following criteria:

- Participant who had experience in collaborative research;
- Participant who had registered intellectual property (IP); and
- Participant who had been involved in commercialisation activities.

Once these targeted participants considered the research, a personal invitation was emailed together with a participant information sheet, consent form and the interview questions. A complete interview guide is shown in Appendix B. Out of thirty participants recruited, eleven participants agreed to take part and be contacted again to set the date, time and place that was convenient to them for an interview. However, one participant postponed the interview session to a much later date that was not feasible for the researcher to consider. Table 4.1 provides a profile of the final ten university researchers interviewed.

Table 4.1: The interviewee's profile.

Participant Characteristics	**Profile**
Average years working as an academic researcher	16 years
Average number of innovations (or IP) per researcher	9 products
Marketed product	
• Yes (considered as positive case)	5
• No (considered as negative case)	5
Gender	
• Male	5
• Female	5
Field of research	
• Medical Science	2
• Agricultural Science	1
• Engineering	5
• Social Science	2
Industry experience	
• Yes	6
• No	4

All the participants met the criteria mentioned above. They have and had been involved with innovative research and commercialisation attempts. Hence, the credibility of the participants was highly validated and trusted. It was believed that these participants were the key informants and reliable source for the research.

The interview (average duration of 56 minutes) was in semi-structured format, consisted of general questions related to demographic information and ten specific questions related to experiences in conducting collaborative research within innovation networks for innovation and commercialisation. The specific questions provided an opportunity to explore a number of circumstances pertaining to innovation management in public universities such as managing relationships with industry partners and collaborators within innovation networks. The interviews were conducted in mixed English and Malay languages, depending on what was most comfortable to the participants. All the interviews were digitally voice-recorded with the participants consent. To ensure trustworthiness of the data, the researcher summarised what the participants said at the end of each interview and sought further comments from the participants. All the interviews were transcribed literally following a simple transcription convention (amounting to 112 pages of transcription and 20 pages of notes) using a transcribing software, 'f4' version 2012. Then the data were analysed using a qualitative data analysis software, the NVivo version 10 using content analysis technique.

The content analysis technique allows the researcher to make subjective interpretations of the information (Elo & Kyngäs 2008) and classify the text data within the transcripts into nodes (i.e. systematic coding categories) based on the research conceptual framework. Translation into English was done on the coded data that was in Malay language for analysis and reporting purposes. Repeated readings of the transcripts and the coded data led to categorisation of the text data into relevant constructs. In this way, the constructs were validated inductively through expressions and identifications of the operational meanings. As the research aimed to contribute for facilitating successful public universities' commercialisation through building good social relationships, thus cases with successful commercial outcomes (i.e. indicated by marketed product and monetary income) were categorised as positive cases. Cases without the tangible outcomes were categorised as negative. Negative

case analysis was utilised to establish credibility of the coding categories and to increase validity of the findings (Hsieh & Shannon 2005).

4.7.2. Findings

The objective of these interviews was to explore the meanings of good social relationships within innovation networks as perceived by a group of Malaysian public university researchers. Good relationships which created social capital are embodied by 'trust in innovation', 'motivation to innovate' and 'strategic leadership'. While these values of social capital are embedded within such network relationships, other themes such as 'open innovation' and 'commercialisation success' were also explored to relate the research problem with its real context of Malaysian public university innovation and commercialisation phenomena. Example of excerpts from the interviews are presented as a mean to support the validation processes.

4.7.2.1 Open Innovation

The basis of the open innovation concept introduced by Chesbrough (2003b) is the practice of using external and internal ideas and resources to expedite the innovation process for successful commercialisation. The interview questions being asked specifically to explore this construct were: Do you work in a team or conduct your innovation alone? Can you tell about when you worked with others; what did you do?

All the interviewees conducted their innovation in teams, which comprised of innovation actors from different field of experts, manufacturers, end users or clients, industry partners and graduate students. The reasons for collaborating with other innovation actors was mainly to get complementary and applicable ideas. There was evidence of an openness approach among the participants when conducting innovative research. During this open innovation process, these research participants performed various actions such as established research team members, explored end users requirements, shared and contributed ideas to others for further development, promoted capability and resources, outsourced to others for implementation, purchased sub-components from partners, consulted or sought ideas from others for

adoption. A notable expression was indicated by the excerpt, "…we have to be open, explain our capability and try to meet their requirement".

4.7.2.2 Commercialisation Success

According to Radosevic and Yoruk (2012), successful commercialisation is defined as the whole process of acquiring ideas, developing and selling the products into the market. In this research context however, the term for commercialisation success was found to have a broader meaning which was closely linked with the primary objective of the innovative project. As one participant said "…suppose if I go towards commercialisation, I don't think I can change the policy". This expression indicated that the success of public university innovation was not always represented by commercial benefits. Generally, for university researchers interviewed in this research each interpreted the success of innovation as achieving the objective of their project.

To reduce the prevalence of public issues in various sectors, such as health, farming, education and environment, was among the objectives for innovative research discovered in these interviews. These research projects mainly aimed to solve societal issues by creating success with non-pecuniary benefits such as publication and intellectual property. Other pecuniary benefits with economic benefits were also evidenced in several cases, such as to generate income for a spin-off company and to create new products for industry. These findings supported the constructs for commercialisation success that was operationalised in terms of direct or indirect strategies to implement the innovation into the community (i.e. public or business community).

The specific interview questions for exploring the strategies or paths for applying the innovation (either professionally or commercially) were: What did you do with the innovation? How do you implement or move the innovative idea into reality? The participants used several strategies for commercialisation such as developing the idea through commercialisation intermediaries (i.e. university innovation office), selling a ready-made product to client, collaborating with industry for consultation and development, extending the usability of an idea in the form of training service, participating in innovation exhibition, using licensing agreements, establishing a joint venture and forming a company within the university (i.e. spin-

off). None of the participants created their own private company (i.e. separate from university management) for commercialising their innovation products.

4.7.2.3 Trust in Innovation

In the research, the operational definition for trust in innovation was defined as high levels of mutual agreement to share and innovate among innovation actors. To explore this construct, a question was developed: When you collaborated with other people, how do you establish effective working relationships? Although half of the participants (five out of ten) mentioned 'trust' in the interviews, all participants talked about 'share', 'shared' or 'sharing of knowledge' during research and innovation processes. As academics, knowledge sharing is the principal philosophy for every educational activity, such as academic teaching, community service, as well as research and innovation. An expression indicated by the excerpt, "…the Korean came for a work visit to our laboratory, and they wanted to learn about this [the innovation]. So, we tell, we share".

Previous studies highlighted the importance of continuous knowledge sharing in university-industry interaction for collaborative innovation, where building trust and being open were among the emerging themes identified (Johnston, Robinson & Lockett 2010). Similar findings were evident in the research as all participants agreed that it was common for university researchers to share knowledge. Apart from mutual knowledge sharing, the research participants built trust with other innovation actors and believed that successful innovation lay in collaborative effort with others. They built trust by organising social activity, conducting informal meetings, connecting with team members through social media and meeting regularly to update progress of the research projects. All these actions were for the reasons of creating good social relationships with all people involved or related to such projects.

In addition, one of the participants conducted contract research for private companies that indicated formal relationships also being established during the innovation process. Other participants even performed strength-weakness-opportunity-threat (SWOT) analysis on individual team members. In summary, trust was important for innovation, as one participant said: "…I use values that are common

to all, such as trust, open and positive thinking in order to create good working relationships".

4.7.2.4 Motivation to Innovate

While strong knowledge sharing attitudes are important for building trusted relationship for innovation, the sharing of optimum resources has been tied to individual motivation (Narayan 2011). The interview question developed for exploring this construct was: Innovation or applied research can be so complicated. How did you gain commitment? Only three participants specifically mentioned 'motivation'. However when the researcher performed the text search query for the word 'motivation' including stemmed words and synonyms, the result showed also references to the word 'need'. All the participants talked about 'need' that matched with the description of motivation that was operationalised for the research. Motivation to innovate refers to the shared needs for optimum engagement, crucial for every actors going forward in innovation processes.

The specific needs for collaborating with others during innovation identified in the interviews were to gain advice and training, to expand the knowledge and its usability, to build academic career (in publications), to produce research papers, to advance research expertise into something innovative, to connect with more people or network and to get financial profit. Two participants mentioned that working with others, particularly people from industries, enabled them to use other resources such as laboratory facilities and to outsource some of the tasks which helped sharing the workload. One participant highlighted that there was a need for university researchers to promote their capability or expertise, so that people could get in contact with them. These needs appeared to motivate establishing networking in research and innovation.

Overall, the motivation covered both tangible and intangible benefits. More prominent however, were intangible benefits related to knowledge advancement and transfer of technology. All the innovation projects examined were categorised as applied research that involved multidisciplinary fields of expertise. This type of research itself became the motivation for some of the participants: "…I like to integrate others into my research project so that I can expand my knowledge and connect with people through my innovation".

4.7.2.5 Strategic Leadership

Findings from this research have shown that innovation processes involve many innovation actors working together in a research team. Establishing alliances, partnerships or networks is a way to win innovation by creating multiple strategies, competencies and structures (Tushman 1997). However, many people with different mind-sets and ways of doing things can be a source of conflict. The specific interview question for strategic leadership in innovation was: When you were part of a work group that did not share the same mind-set, how did you handle this situation? This question was deliberately asked in order to explore the styles of leadership for managing innovative research in university and how leaders engage with others.

The majority of participants (eight out of ten) talked about 'leader' and/or 'leadership'; as one participants said: "…when you talk about team, there should be a leadership component". The exact responsibilities for leaders identified in the interviews were to gather skills and resources, set the team vision, find a matching point among the team members, plan innovation processes into phases according to the expertise, support innovative efforts and encourage collaboration. The participants interviewed were all project leaders that were also responsible for engaging with the end users, partners and stakeholders. During the engagement with others (i.e. external people from outside the university), these leaders had to educate the external partners and to explain the objectives of the project from the larger perspective of the knowledge rather than just for profit and monetary perspectives.

It was worth noting that these participants had to play dual roles when conducting innovative research for commercialisation so as to combine science with business for optimum results. They had to change the mind-set of the scientist to be business savvy, while exposing the businessman to scientific knowledge. All these participants acknowledged the various mind-sets in their team, but more importantly the participants emphasised getting a consensus agreement for creating good partnerships in collaborative research. Participants appeared to be in agreement with the definition for strategic leadership in the research that was operationalised as a set of skills to influence university research cultures to be more open and commercially-oriented.

4.7.3. Discussions

The cases presented narratives of a group of academics at five Malaysian research-focused public universities regarding their experiences conducting innovation. In order to validate the findings, the researcher checked the coding system repeatedly to avoid drifting from operational definition of the constructs and triangulated information from the literature review, text data and field notes. A summary of the notes taken during the interviews is presented in Appendix C.

In the public university context, applying the innovation is regarded as a community service; as a social responsibility to share the knowledge with a wide range of communities. It is more a professionally-oriented mission rather than commercial-oriented. Because outputs from a university research are measured from both tangible and intangible aspects, the success or failure of innovative ideas is determined by assessing the link between the research objective and its achievement. A university has broader innovation missions and tends to progress from a 'simple, closed and individual' to 'complex, open and network' approach. The fact that it is impossible to conduct innovation and commercialisation alone (Dahlander & Gann 2010), it is critical to establish good relationships within open innovation networks.

By using the NVivo 10, cluster analysis was conducted on the coded data to visualize patterns in the research findings by grouping constructs (or codes) that shared similar words as shown in Figure 4.2.

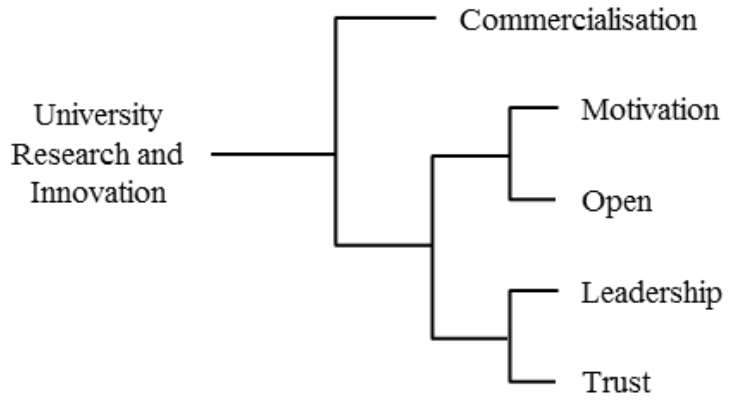


Figure 4.2: The constructs (or codes) clustered by word similarity analysis.

In Figure 4.2, a horizontal dendogram displays the output of the cluster analysis that was generated by Nvivo 10. The principle of the cluster analysis in Nvivo 10 is based on word similarity, where codes that have a higher degree of similarity based on the occurrence and frequency of words are shown clustered together. And codes with a lower degree of word similarity are displayed further apart.

The figure illustrates *commercialisation* is clustered together on the same branch with the constructs *motivation*, *open*, *leadership* and *trust*. This result indicates that commercialisation in university research and innovation context has associations or is closely linked with social elements such trust, motivation, leadership and open innovation that are embedded in the social relationships. This result was supported by an expression: "…to establish effective working relationship with others [during innovation and commercialisation], I use values that are common to all such as trust, and being open". Thus, to further confirm and explain inter-relationships between the constructs, quantitative study that involved a larger number of participants was conducted using an anonymous survey technique.

The main contents (or themes) identified from these expert interviews were used to refine items of the survey instrument. A summary of the items refinement are presented in Table 4.2 to 4.4. Out of this, a second version of the survey instrument was created with finalised items for constructs measurement.

Table 4.2: Summary of information integration for the survey items refinement.

No.	**Initial survey items** (Obtained from literature)	**Themes identified in interviews**	**Updated sets of survey items**
Construct: Open Innovation			
1	Form collaboration with others	✓	Establish formal research collaboration
2	Explore ideas from others	✓	Explore ideas/resources from others
3	Conduct research for others	**X**	*Not included*
4	Sell ideas (IP) to others	**X**	*Not included*
5	Buy ideas (IP) from others	✓	Purchase ideas from others
6	Adopt ideas from others	✓	Adopt ideas from others
7	Reveal ideas to others	✓	Share ideas to others
8	Promote ideas to others	✓	Promote ideas to others
9	Outsource parts of research	✓	Outsource section of research project
10	Contribute ideas to others	✓	Contribute ideas to others
11	Get input from others	✓	Get input from others
12	Consult others using expertise	**X**	*Not included*

Source: Developed for the research.

Table 4.3: Summary of information integration for the survey items refinement (continued).

No.	Initial survey items (Obtained from literature)	Themes identified in interviews	Updated sets of survey items
Construct: Trust in Innovation			
1	Enjoy sharing ideas with others	✓	Simply enjoy sharing ideas
2	Trusting others in research project	✓	Consider trusting others
3	Believe in collaborative research	✓	Believe in research collaboration
4	Have a balance control	**X**	*Not included*
5	Prefer informal relationship	✓	Prefer informal relationship
6	Conduct research without contract	**X**	*Not included*
7	Expect something in return	**X**	*Not included*
8	Need contractual agreement	✓	Need agreement in place
9	Transparent motives and needs	✓	Clear objectives and expectations
10	Formal mechanisms for exchange	**X**	*Not included*
11	Consider only well-known partners	**X**	*Not included*
12	Share a communication system	✓	Share communication group
Construct: Motivation to Innovate			
1	Access new knowledge	**X**	*Not included*
2	Facilitates knowledge transfer	✓	Facilitates knowledge transfer
3	Linkage with industry	**X**	*Not included*
4	Establish research niche	✓	Establish research niche and network
5	Build academic reputation	✓	Build reputation and expertise
6	Share knowledge to community	**X**	*Not included*
7	Get financial support	✓	Get financial support for research
8	Use other resources e.g. laboratory	✓	Able to use other resources
9	Reduce cost	✓	Reduce research cost and workload
10	Improve quality of innovation	✓	Improve the innovation quality
11	Increase speed of completion	**X**	*Not included*
12	Gain exposure on other practices	✓	Gain other related knowledge
Construct: Strategic Leadership			
1	Promote research partnership	✓	Promote research networking
2	Connect team members	**X**	*Not included*
3	Manage conflict that arises	✓	Manage conflicts arising
4	Balance the risks and benefits	**X**	*Not included*
5	Willing to learn from others	**X**	*Not included*
6	Engage with stakeholders regularly	✓	Engage with all stakeholders
7	Set clear missions	✓	Set out clear mission for research
8	Explore potential resources	✓	Maximise potential resources
9	Venture beyond comfort zone	**X**	*Not included*
10	Employ new approach	✓	Employ new approach
11	Challenge status quo	**X**	*Not included*
12	Support idea creation activities	✓	Support innovative culture

Source: Developed for the research.

Table 4.4: Summary of information integration for the survey items refinement (continued).

No.	Initial survey items (Obtained from literature)	Themes identified in interviews	Updated sets of survey items
Construct: Commercialisation Success			
1	Use licensing agreements	✓	Use licensing agreement
2	Use commercialisation agents	✓	Through commercialisation agents
3	Create own private company	**X**	*Not included*
4	Form spin-off company	✓	Form spin-off
5	Joint venture with industry	✓	Establish joint venture
6	Sell ready-made products	✓	Supply or sell ready-made product
7	Involve industry for development	✓	Involve industry for development
8	Collaborate with end users	✓	Expand ideas with end users
9	Use ideas for other services	✓	Use ideas for training
10	Involve in innovative exhibition	✓	Participate in innovation exhibition
11	Produce technical document	**X**	*Not included*
12	Donate the idea/technology	**X**	*Not included*

Source: Developed for the research.

4.8. The Pilot Study

Before the updated survey was administered in actual field research, a pilot study was conducted for evaluating the feasibility (in terms of time, cost and other adverse events) in an attempt to improve the quality of the data collection method on a large scale (Polit & Beck 2010). In addition, the pilot study helped to (1) estimate sample size based on response rate, (2) try out the research instrument, and (3) check the reliability and validity of the trial results (van Teijlingen & Hundley 2002).

The pilot study was conducted following the general procedure for anonymous survey research using an online survey technique for the advantages of shorter time and lower cost of survey delivery and data entry (Fan & Yan 2010). The online survey was in English and developed on the University of Southern Queensland (USQ) Custom Survey System platform that was administered by the Strategic Business Management & Improvement (SBMI) unit. Although Malaysia is a country with a non-English speaking background, the targeted research participants were considered well-educated people and predicted to have suitable English language competency needed to participate in the research.

4.8.1. Method

The pilot study was conducted on individuals among the targeted populations that were then excluded from subsequent actual research so as to avoid contamination or interference of results (Baker 1994; van Teijlingen & Hundley 2002). To determine the sampling frame, the researcher contacted (via telephone) every research management offices at all twenty public universities in Malaysia to express the intention to conduct such research. Then, a formal letter of intent was emailed to each of the universities, together with information on the research, ethic approval and sample of the survey. The universities' assistance was sought to provide a name list of the targeted participants with their email addresses. These documents were also posted to the universities as they required a hardcopy of the documents for their record.

Out of the twenty universities contacted, (1) one university declined to participate in the research, (2) eight universities did not provide further feedback after six weeks, (3) eight universities agreed to participate and provided the name list, and (4) three universities allowed the research to be conducted at their organisations but advised the researcher to obtain the targeted participant's names from public domain which were published in the universities' official websites.

Finally, a total of eleven public universities were involved in the research. The universities were: Universiti Malaya, Universiti Sains Malaysia, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia, Universiti Teknologi Malaysia, Universiti Teknologi MARA, Universiti Malaysia Sabah, Universiti Malaysia Terengganu, Universiti Tun Hussein Onn Malaysia, Universiti Malaysia Pahang, and Universiti Sultan Zainal Abidin. A master name list of the targeted participants was created to establish the sampling frame. The sampling frame comprised of 2,453 targeted participants.

There was little guideline on how to determine an appropriate sample size for a pilot study (Johanson & Brooks 2009). According to Baker (1994), a sample size of 10%-20% of the population of the actual study group is a reasonable number of participants to consider enrolling in a pilot. Thus, using random sampling, the researcher selected 600 participants (approximately 24%) from the sampling frame for the pilot study. For random selection, the researcher used random number generator, a free software available online accessed on 17 December 2014 (random.org 2014).

This software generated a set of 600 random non-repeating integers that was used to guide the selection of pilot participants. The pilot participants were then contacted individually by email requesting their participation in the research and provided them with the research information, consent statement and a web address that linked to the online survey. The pilot study was conducted for a duration of four weeks starting on 18 December 2014 to 15 January 2015.

4.8.2. The Outcomes

Surprisingly, the pilot study that used the online survey showed a very low response rate which resulted in small size of reliable data. This outcome gave an early warning on potential weaknesses of the proposed research method in relation to the survey strategy. The problems faced by the researcher in this pilot study were: (1) a total of 143 email addresses out of 600 (i.e. approximately 24%) were no longer valid, resulting in the email being bounced back to the researcher, and (2) after four weeks of the survey invitation, only 15 participants responded in the pilot study that yielded a response rate of 3.3%.

The initial research plan was to use the online survey method for the quantitative study. Based on the pilot study outcomes however, it was decided that online mode was not a feasible method for the survey administration. Although the online survey method offers superior advantages (in terms of lower cost, shorter time and easier administration) compared to other method such as mail survey, the adverse event of lower response rate is evidenced in online surveys (Fan & Yan 2010; Kaplowitz, Hadlock & Levine 2004; Manfreda et al. 2008). Indeed, the pilot study achieved the aim for feasibility assessment but not on instrument validation. It was crucial for the researcher to address these weaknesses before proceeding with the actual research.

4.8.3. Discussions

The low response rate observed in the pilot study indicated a critical weakness of using online survey method for the subsequent actual research. To negate this problem, the researcher decided on the following actions:

(a) The data collection method was changed for the actual research from online survey to mail survey in order to anticipate the low response rate issue that might result in small sample size. Since the research intended to test the hypotheses using structural equation modeling (SEM), sample size had always been a major concern, because a small sample size was more likely to yield unreliable results (Bentler 1980). The recommended sample size required to use SEM is at least 200 data points (Barrett 2007; Lei & Wu 2007);

(b) Ensured better administration of the survey in the actual research by (1) renting a private mail box to ensure safety of returned responses of the mailed survey, (2) cross-checked valid postal addresses of the remaining targeted participants from the established sampling frame through a public source of information, i.e. the directory of experts available at the universities' official websites, (3) removing names which were redundant or no longer active which resulted a total of final 1,503 names for the actual research, (4) preparing a survey kit which consisted of a letter of invitation, the survey that was in printed form and a self-addressed stamped envelope, and (5) mailing the survey to all targeted participants on the same day; and

(c) Noting the information in hand, feedback from the fifteen respondents of the pilot study was considered. In particular, how to improve the survey instrument design. Thus, a third version of the survey was created and printed for the actual research. The modifications involved (1) re-numbering sequence of the items, and (2) changing a five-point to a ten-point rating scale for measuring the constructs.

The reason for changing the scale was that the use of a five-point scale (or odd scale) was less favourable since the respondent would be most likely to choose the 'neutral' point (Presser & Schuman 1980). The unfavourable fact about odd scale was also highlighted by a statistic expert at a public university in Malaysia who has

extensive experience in teaching statistic, supervising postgraduate research, providing service for statistical analysis and consulting researchers on the use of structural equation modeling (SEM) analysis. According to Linacre (2002), a neutral category in bi-polar scale which usually is denoted by the mid-point value as commonly observed in odd scale should be avoided and it was suggested to present respondents with an even number of scale. Based on this suggestion, the researcher decided to use an even ten-point scale. In addition, Dawes (2008) emphasised that the use of more scale points provided more options for the participant and therefore improved data metric, enriched data analyses, provided higher degree of precision and facilitated accurate calculation in multivariate data analysis such as structural equation modeling.

4.9. Conclusion

This chapter gives further explanations about the research methodology from a research quality perspective. Apart from good research design, the quality of research methods being implemented is more important as it determines the accuracy of the actual findings. The major concern in achieving high quality research is to negate potential factors that can threaten the validity and reliability of results. The threats faced by the researcher and steps to control these threats before actual data collection for the major field survey being conducted were explained in this chapter.

In summary, the first version of the survey instrument was developed from extant literature review consisting of 60 items for measuring the five constructs. Pre-testing was done on the first version survey to assess face validity. Then, through a minor qualitative study (i.e. the expert interviews), the constructs were validated in terms of its meanings and inter-relationships within the real research context. Content analysis on the interviews helped the researcher to identify themes that were used to reduce and refine the initial survey instrument. This stage yielded a second version of the survey and consisted of 40 items. A pilot study was done on the second version survey to assess the actual field research feasibility. The proposed online survey technique was changed to mail survey because of the very low response rate observed in the pilot study. The survey was modified into a third version (i.e. in hardcopy form) for the mail survey. All of these changes were made for the purposes of increasing the

quality of the major research. A workflow and timeline of the research processes conducted is shown in Figure 4.3. Explanations on the major field research, the actual data collected and, in particular, the results of the data analyses are discussed in Chapter 5.

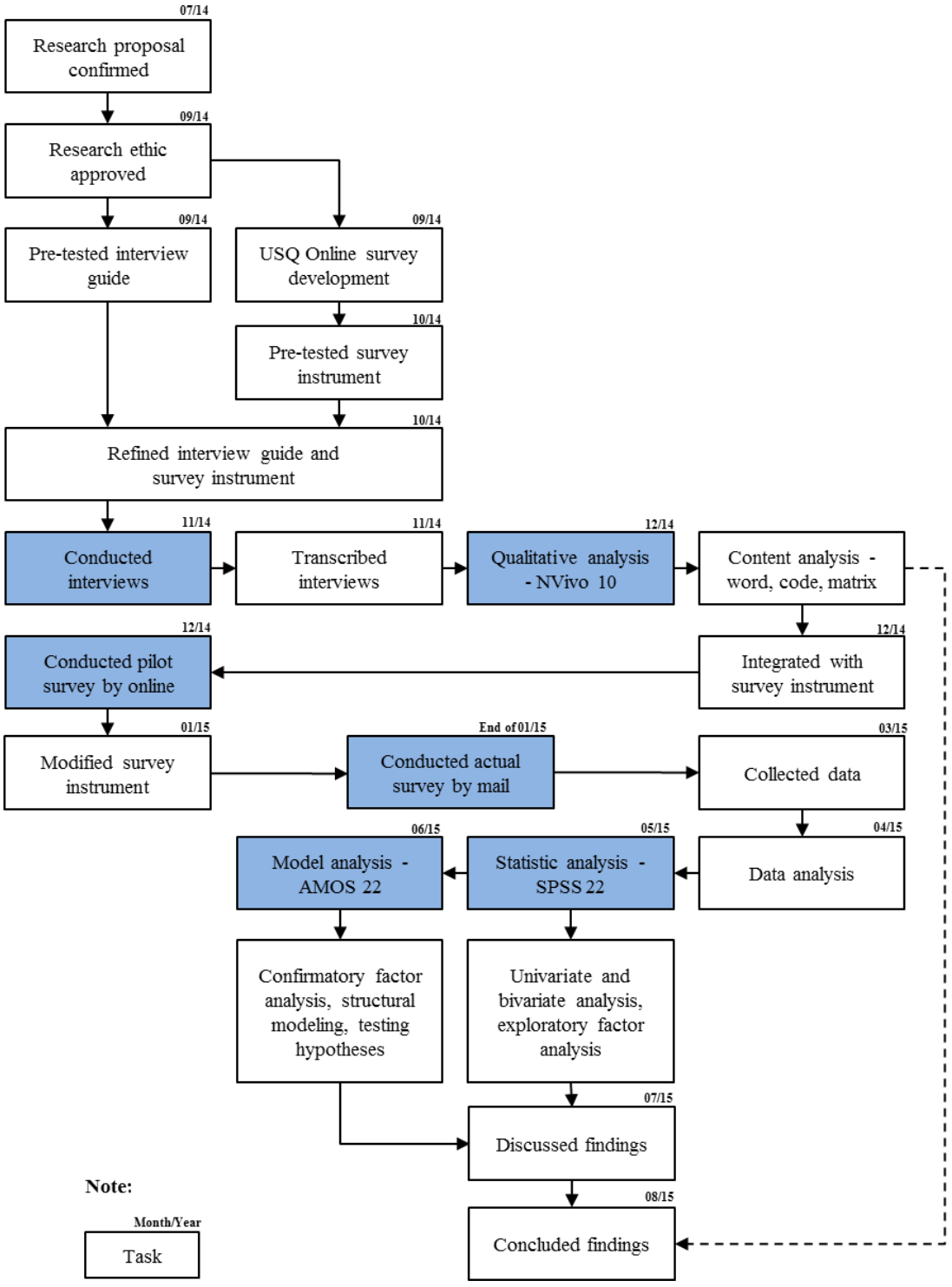


Figure 4.3: The workflow and timeline of the research processes.

CHAPTER 5: DATA ANALYSIS

"An approximate answer to a right problem is worth a good deal more than an exact answer to an approximate problem."
- John Wilder Tukey, a mathematician (1915 – 2000)

5.1. Introduction

Minor research using expert interviews and an online survey were explained in Chapter 4 with the aim of validating the survey instrument and to assess the feasibility of the research for this thesis. In this chapter, the aim is to analyse the numerical data collected from a questionnaire and to analyse the data using a series of statistical procedures. This chapter explains the data analyses ranging from data quality assessment, descriptive, factorial, inferential and content analysis procedures.

This chapter consists of eight sections as shown in Figure 5.1. In Sections 5.2 and 5.3 explanations are given of the major field survey conducted and quality of the data collected. Next, Sections 5.4, 5.5 and 5.6 present summaries of the data, factorial analysis for validating the preliminary conceptual model, results on the hypotheses and modeling tests. Section 5.7 then describes content analysis of an open ended question of the survey. Finally, the conclusion of the data analysis is outlined in Section 5.8.

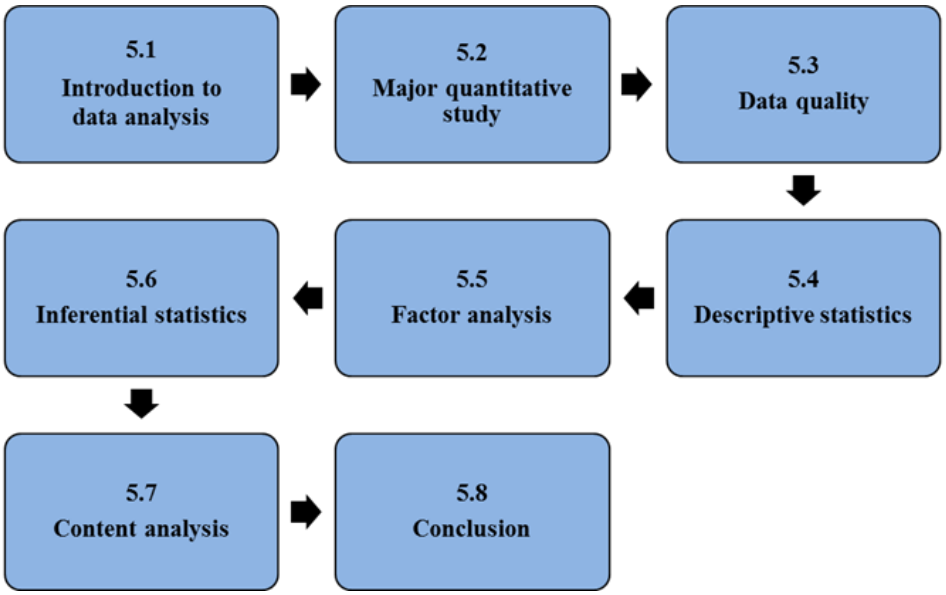


Figure 5.1: The outline of Chapter 5 on the data analysis.

5.2. The Major Study

This research used a cross-sectional anonymous mail survey technique for primary data collection. The aims of the analysis are to: (1) describe basic statistical features of the data and the constructs identified, (2) validate the items that were used to measure the constructs, and (3) achieve the research objectives by assessing the structure of the research model and testing hypotheses that has been postulated.

5.2.1. Measurement Instrument

The initial survey instrument was developed through an extensive literature review. The review emphasised the importance of trust, motivation and leadership to explain how social network relationships between innovation actors develop. The context for the research related to Malaysian public university researchers who had intellectual property and who were engaged in innovation related activities with internal and external actors. To further support the research, other concepts of open innovation and commercialisation were also reviewed.

A preliminary conceptual model was then developed to show the hypothesised relationships between constructs of the study (as explained in Chapter 2). Relevant terminologies of the concepts were adapted to develop measurement instruments for the survey. Table 5.1 shows the research constructs and how key literature informed the development of the research instrument.

Table 5.1: The key literature referred for survey instrument development.

Research Constructs	Key Literature
1. Commercialisation success	Abulrub and Lee (2012); Heng, Rasli and Senin (2011); Petroni, Venturini and Verbano (2012); Rass et al. (2013).
2. Open innovation	Bianchi et al. (2011); Chesbrough and Brunswicker (2014); Dahlander and Gann (2010).
3. Trust in innovation	Ciesielska and Iskoujina (2012); Johnston, Robinson and Lockett (2010); Kheng, June and Mahmood (2013).
4. Motivation to innovate	Collier (2007); Lee and Win (2004); Lucia et al. (2012); Zomer, Jongbloed and Enders (2010).
5. Strategic leadership	Asmawi, Zakaria and Wei (2013); de Jong and Den Hartog (2007); Petroni, Venturini and Verbano (2012); Stumpf and Mullen (1991); Wippich (2011).

Given that the initial survey instrument was developed from relevant literature, the instrument was validated by a group of experts, pre-tested and pilot tested. A final version of the survey instrument (i.e. the third version) was used for collecting data in this major research. The instrument collected three types of data: (1) interval – 40 questions measured by ten-point scale, (2) nominal – nine questions measured by sets of categories, and (3) textual – one open-ended question. The survey instrument consisting of four sections is shown in Appendix D.

There was one endogenous construct (or dependent variable), *Commercialisation Success (CS)* measured by nine items on a ten-point scale with answers ranging from 'Never consider' to 'Definitely consider'. There were four exogenous constructs (or independent variables): *Open Innovation (OI), Trust in Innovation (TI), Motivation to Innovate (MI)* and *Strategic Leadership (SL)*. Each construct was measured by nine, seven, eight and seven items respectively on a ten-point scale with two types of scale responses.

Information on the participants' age, ethnicity, gender, type of university, academic qualification, research expertise, academic position, industrial experience and research were also collected. These were control variables (also known as extraneous or confounding variables) measured using sets of categories that represented *Innovation Actors (IA)* characteristics. The one open-ended question asked the participant's general or specific opinion about the research. Figure 5.2 illustrates the preliminary conceptual model or research framework.

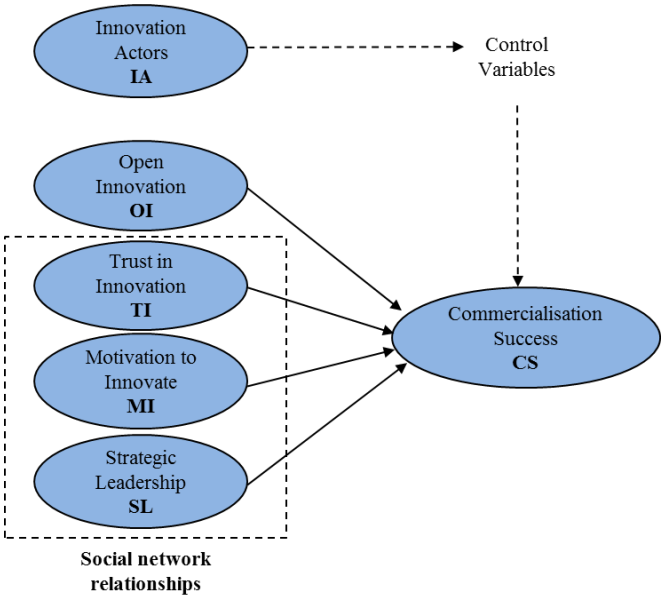


Figure 5.2: The preliminary conceptual model developed for the research.

5.2.2. Data Collection

The data was collected using a questionnaire distributed by mail to the research participants. Although a mail survey method involves higher cost, longer time and more difficult data management compared to an online survey, the pilot study that used an online survey showed a low response rate of only 3%. Therefore, the major research adopted the mail survey method in order to achieve a better response rate and thus a larger sample size to enable a reliable data analysis.

The targeted population of the research was the public university researchers in Malaysia, who had filed their intellectual property as a patent, utility innovation, trademark, copyright, industrial design, new plant varieties or otherwise. Out of all twenty Malaysian public universities contacted, eleven universities agreed to participate in the research. A sampling frame was established by compiling a name list of the targeted participants from the participated universities. Employing a random sampling technique, a total of 1,503 individuals were identified for the research. The participants were contacted by sending an individually named mail package consisting of: (1) a letter requesting their participation in the research together with the research information and implied consent statement, (2) the questionnaire, and (3) a self-addressed stamped envelope. The research was conducted for a duration of five weeks commencing on 24 January 2015 until 28 February 2015.

5.3. Data Quality

Before data analyses was performed, several steps were conducted to ensure the data was suitable for the analysis and to achieve a certain level of quality for reasonable statistical decisions that are driven based on the data (Karr, Sanil & Banks 2006).

5.3.1. Pre-Data Analysis

Three steps were completed on the raw data; screening, coding and recording. First, data screening means checking for errors that might occur during the data collection process. The screening was done by the researcher after the returned self-administered questionnaires were received from respondents. The purpose of data screening was to

increase accuracy of the data by identifying rare responses in the questionnaire and legibility of handwriting for the open-ended question. In the research, the response status of the returned questionnaires were categorised following one of the standard definitions for final dispositions of case codes for surveys; a guideline by The American Association for Public Opinion Research (AAPOR 2011, p. 26). The categories are:

(a) Less than 50% of all questions answered equals break-off;
(b) 50%-80% equals partial; and
(c) More than 80% equals complete (AAPOR 2011, p. 26).

Overall, the response status of the returned questionnaires was complete (more than 80% questions answered). Only one respondent with the lowest number of questions answered (41 out of 50) or 82%. The researcher assigned a dot (.) to indicate the unanswered questions as missing value during data entry into statistical software, the SPSS version 22.

Second, these raw data were coded systematically in order to facilitate the data recording. Data coding refers to the process of identifying and classifying each responses with a code (usually a number) to each question. In so doing, the researcher specified codes, names and numerical values for possible responses of each questions. Other attributes such as types of data (e.g. scale, ordinal or category) were also specified to guide the data recording process. For the one open-ended question, the responses were coded as free text (or string type in SPSS 22).

Third, the recording process involved data entry into the SPSS 22. One critical task of this data entry process was to ensure that the data being entered were correct and error free. With statistical software like SPSS 22, it has automated process for validating the data by identifying unusual or invalid values in the active data set. This was done by running checks against pre-defined validation rules. The rules were: (a) a maximum of 5% of missing value for all variables was defined, (b) a value range of 1 to 10 was defined for the five constructs measured to check for out-of-range values, and (c) different value ranges were defined for demographic data depending on the questions asked. The SPSS 22 output for this data validation step was "all cases, variables or data values passed the requested checks".

5.3.2. Response Rate

The use of a questionnaire instrument for collecting data from individuals is widely used in social science studies. A high response rate is desired in order for the data gathered to be comprehensive and representative of the targeted population. However, it is not clear how high the response rate needs to be (Baruch 1999). There is still no agreed norm for acceptable response rates, as well as, there are many definitions of response rates (Shih & Fan 2008) that lead to different interpretations and calculations. This research calculated the response rate following Lineback and Thompson (2010), which is defined as:

$$\text{Response Rate} = [R / (E + U)] \times 100$$

where R is the number of reported units that is classified as responses, E is the number of reporting units selected for the sample that were eligible and U is the number of reporting units selected for the sample for which eligibility could not be determined such as the postal address invalid or the person not present at the address.

A total of 1,503 questionnaires were mailed out to the targeted participants on 24 January 2015. After about five weeks, 262 questionnaires were returned and considered as eligible responses. A total of 1,241 questionnaires were not returned. Therefore, the research response rate was 17.4% which is considered a low rate compared to the average response rate for surveys conducted at an individual level i.e. 52.7% with a standard deviation of 20.4 (Baruch & Holtom 2008). The response rate observed in the research is comparable with other innovation studies however, of approximately 10% to 30% (Carmona-Lavado, Cuevas-Rodríguez & Cabello-Medina 2010; Syamil, Doll & Apigian 2004; von der Heidt & Scott 2009). In a response rate trends analysis conducted by Baruch and Holtom (2008), the authors identified a decreasing trend in the level of response rate over time.

5.3.3. Nonresponse Bias

Due to the low response rate, a follow up nonresponse bias test was conducted. This was done to determine that the non-respondents were not of any systematic pattern.

There are many reasons for a low response rate. It may simply be an unwillingness of participants to participate (Sax, Gilmartin & Bryant 2003) or the participant may be too busy to participate (Menachemi 2011). Nonetheless, a low response rate does not necessarily suggest bias if the participants' that responded have similar characteristics and are representative of the population (Sax, Gilmartin & Bryant 2003). According to Baruch and Holtom (2008), regardless of how low or high a response rate is, a researcher is advised to conduct a nonresponse bias assessment to indicate the sampling quality.

There are several methods to assess nonresponse bias such as (1) comparing respondents' characteristics to the population, (2) comparing respondents to non-respondents, (3) follow-up to the non-respondents, and (4) comparing early to late respondents (Lindner, Murphy & Briers 2001). The researcher chose to compare early to late respondents as previous research had shown that late respondents had similar characteristics to those non-respondents and could be used as a proxy for nonresponse bias assessment (Lindner, Murphy & Briers 2001). The researcher collected a total of 262 completed questionnaires from a private mail box in four batches with the following number of respondents:

(i) Batch–1 - 36 respondents collected on 7 February 2015 (early);
(ii) Batch–2 - 118 respondents collected on 14 February 2015;
(iii) Batch–3 - 73 respondents collected on 21 February 2015; and
(iv) Batch–4 - 35 respondents collected on 28 February 2015 (late).

Thus, the Batch 1 respondents considered as 'early' was compared to the Batch 4 that considered as 'late' respondents. The data of Batch 1 and Batch 4 respondents were recoded into two new categories representing 'early' and 'late' respondents. The early and late comparison was done using mean scores of the five constructs measured that were derived from values of the survey items. The independent t-test was used to compare the mean scores between the two groups of respondents – Batch 1 and Batch 4 – for each of the constructs: *Open Innovation, Trust in Innovation, Motivation to Innovate, Strategic Leadership* and *Commercialisation Success.* Results of the nonresponse bias assessment are shown in Table 5.2.

Table 5.2: Comparison of early and late respondents on five constructs.

Research Constructs	Group	N	Mean	S.D.	t-test	d.f.	Mean Difference	*p*-value
Open Innovation	Early	36	6.66	1.27	0.555	69	0.17	0.580
	Late	35	6.49	1.38				
Commercialisation success	Early	36	5.17	2.51	-0.706	69	0.40	0.482
	Late	35	5.57	2.19				
Trust in Innovation	Early	36	8.04	1.21	-0.860	69	0.20	0.393
	Late	35	8.24	0.75				
Motivation to Innovate	Early	36	8.06	1.28	0.429	69	0.13	0.669
	Late	35	7.93	1.11				
Strategic Leadership	Early	36	8.11	1.37	0.789	69	0.26	0.433
	Late	35	7.85	1.34				

Based on Table 5.2, the t-test results for mean score differences between Batch 1 (Early) and Batch 4 (Late) were not statistically significant with all probability values larger than significance level (i.e. $p > 0.05$). There were no differences between early and late respondents and thus no problem of nonresponse bias in the research.

5.3.4. Sample Representativeness

A representative sample is a subset of population that accurately reflects or has similar characteristics to the targeted population. This allows researchers to generalise the small group findings (sample) to the larger group (population). Although all of the twenty public universities in Malaysia were contacted to request their participation in the research, only eleven universities agreed to participate.

In order to determine how well the sample in the research is representative of the entire Malaysian public universities researchers' population specifically who have registered intellectual properties, a chi-square test was conducted. In the university researcher's population, there is unequal proportion in terms of gender. In the sample, there were 143 males and 115 female respondents. The chi-square test results indicated that the gender distribution of the sample was not significantly different from the population ($x^2(1) = 3.039$, $p = 0.081$).

In the university researcher's population, there is also an unequal proportion of intellectual property registrations where research-focused universities (RU) have more intellectual property compared to non-research-focused university (non-RU). There

were 217 respondents from the RU and 42 respondents from the non-RU. A further chi-square test confirmed that the distribution of intellectual property registrations between the two university types in the sample was not significantly different from the population ($x^2(1) = 2.318$, $p = 0.128$). Thus, the sample was representative in that aspect.

5.3.5. Statistical Power

A power analysis is important for statistical tests because it defines the probability that a test will correctly reject the null hypothesis (H_O) when the alternative hypothesis (H_A) is true. Tests with lack of statistical power are unreliable because they cannot discriminate the true effect of H_O and H_A which can lead to Type 1 Error (rejecting true H_O) and Type 2 Error (accepting false H_O).

The power analysis can also be used to calculate minimum sample size requirements needed to detect the effect of a given size, or vice versa. For the research, a statistical power of 0.80 at 0.05 significance level was used as this is recommended for social management studies (Cohen 1988). As the main hypotheses testing in the research involved regression based analysis of statistical tests with four exogenous constructs (or predictors), a medium effect size of 0.15 (according to Cohen's effect size, *f-test* criteria) was considered. The minimum sample size requirement was calculated using G*Power 3.1 software (Faul et al. 2009). By selecting a priori type of power analysis, the G*Power 3.1 computed the minimum sample size of 85 was needed. Thus, the research sample size of 262 was more than adequate to achieve the main objective and should allow for using other statistical tests such as between groups and correlation based analysis in order to achieve additional objectives of the research.

5.3.6. Missing Values

A data set with missing values will likely decrease a power analysis because typical statistical procedures exclude missing values from the analysis using pairwise or listwise method, or simply replaced with the mean. According to Cohen and Cohen (1983), a data set with missing values up to 10% was not large and unlikely to be problematic for interpretation of the findings. In turn, a total of less than 5% missing

values is considered to be missing at random, which means a value is missing independent of other values (Schafer & Graham 2002).

A missing value analysis was conducted on the research data set based on Little's MCAR (Missing Completely at Random) test (Little 1988). The SPSS 22 output for missing value analysis showed the range of missing value for a variable was 0.4% - 4.2%. The result for Little's MCAR test was $x^2(1229) = 1255.834$, $p = 0.291$. Since the statistic was not significant ($p > 0.05$), the missing values were assumed to be missing at random or unsystematic.

However, the researcher decided to remove 39 data points with missing values in order to improve power analysis. One data point with a lack of variation in the responses (i.e. the responses were 9, 9, 9, 9, 9, 8, 9, 9, and so on) was also removed from the data set. The reason was because this type of response may cause information bias where the digit preference issue has been found to be associated in research that used self-reporting techniques such as a survey (Chen 2010). Thus, a total of 40 data points were removed and a final data set with sample size (N) of 222 was used for the following data analyses.

5.3.7. Data Normality

It is necessary to screen for outliers and assess for normal distribution of a data set in order to justify the use of parametric statistical tests. There are many different methods to analyse for outliers and normal distribution. In this research, graphical methods using boxplot and normal Q-Q plot were used. Numerical methods using skewness and kurtosis measures were also analysed to confirm a normal distribution of the data.

A common assumption in all parametric tests is that the dependent variable is approximately normally distributed on each of the independent variables. For general assessment, normality of the research data set was assessed using SPSS 22 on the mean scores of *Commercialisation Success* (i.e. the dependent variable) against gender as the categorical independent variable that consisted two categories: male and female. Inspection on the boxplot indicates that there are no outliers in the data set for values greater than 1.5 box-lengths from the edge of the box. Based on normal Q-Q plot, all data points are positioned approximately along the diagonal line for both categories of gender which indicate the data are normally distributed. The boxplot and Q-Q plot are

shown in Appendix E. Normality assessment based on skewness and kurtosis measures for the dependent and independent variable are shown in Table 5.3.

Table 5.3: Skewness and kurtosis measures for normality assessment.

Dependent Variable	Independent Variable	Skewness			Kurtosis		
		Statistic	Std. Error	z-score	Statistic	Std. Error	z-score
Commercialisation Success	Male	0.000	0.216	0.000	-0.922	0.428	-2.154
	Female	-0.254	0.245	-1.037	-1.024	0.485	-2.111

The skewness value between -1.0 to 1.0, and the kurtosis value between -7.0 to 7.0 are considered normally distributed with 0.0 indicating data is perfectly in normal distribution. From Table 5.3, the skewness and kurtosis values for the dependent and independent variable were within the acceptable range which indicates the data set was normally distributed.

Then, a z-score was calculated by dividing the skewness and kurtosis values by their respective standard error. A statistical significance level of 0.01 that equates to a z-score of ±2.58 is an acceptable indicator for normal distribution. The calculated z-scores for the dependent variable (i.e. *Commercialisation Success*) for both groups of the independent variable (i.e. gender) were within ±2.58 that indicate the data set was normally distributed. In addition to that, inspection on the histograms of *Commercialisation Success* for male and female showed approximately normal distribution curve exhibited by the classic 'bell shape' curve. The histograms are shown in Appendix E. Thus, the requirements for employing parametric statistical tests for further data analysis were met.

5.4. Descriptive Statistics

The purpose of descriptive statistical analysis is to summarise the information in a sample. It helped the researcher to assess the basic features and distributions of the data across all variables. This analysis was used: (1) to summarise demographic characteristics of the respondents, and (2) to describe scores of a single variable or item (also termed as univariate analysis). The descriptive statistics were reported using frequency distribution (for categorical or nominal data) and central tendency (for scale or interval data).

5.4.1. Demographic Characteristics

In the research, demographic data on the respondents were collected using nine categorical variables as shown in Table 5.4. These data represented the innovation actor's characteristics that were hypothesised to have difference responses on the perceptions toward university's commercialisation strategies.

Table 5.4: Demographic characteristics of the respondents (N = 222).

Characteristics	Frequency	Valid Percent (%)
Age range		
• ≤ 29 years	3	1.4
• 30-39 years	71	32.0
• 40-49 years	81	36.5
• 50-59 years	59	26.5
• ≥ 60 years	8	3.6
Ethnic		
• Malay	150	67.6
• Chinese	39	17.5
• Indian	11	5.0
• Others	22	9.9
Gender		
• Male	125	56.3
• Female	97	43.7
Type of university		
• Research	185	83.3
• Comprehensive	16	7.2
• Focused	21	9.5
Academic qualification		
• Doctorate	198	89.2
• Master	20	9.0
• Bachelor	1	0.4
• Others	3	1.4
Research expertise		
• Sciences/Applied Sciences	89	40.1
• Technology/Engineering	97	43.7
• Social Sciences/Applied Arts	32	14.4
• Others	4	1.8
Academic position		
• Professor	50	22.5
• Associate Professor	63	28.4
• Senior Lecturer/Lecturer	104	46.8
• Others	5	2.3
Industrial experience		
• Yes	125	56.3
• No	97	43.7
Industrial research		
• Yes	143	64.4
• No	79	35.6

The majority of respondents in the research (i.e. 95%) were between 30 to 59 years old. These respondents consisted of all major groups of ethnics in Malaysia (i.e. Malay, Chinese and Indian), with 56.3% male and 43.7% female university researchers. The respondents were from all types of universities with various academic qualifications, where 83.3% of the respondents were from a 'Research University' category and 89.2% held 'Doctorate' qualifications. The respondents' research expertise ranged from sciences, technology to social sciences, and their academic position ranged from professor to lecturer. The proportion of the respondents who had industrial experience was 56.3% compared to those who had no working experience in industry. Many of them (i.e. 64.4%) had conducted research for industries. Hence, interpretations of the research findings represent the perceptions expressed by those in this sample.

5.4.2. Univariate Analysis

There were five constructs examined in the research namely *Open Innovation*, *Trust in Innovation*, *Motivation to Innovate*, *Strategic Leadership*, and *Commercialisation Success*. These constructs were latent variables that were measured using a ten-point scale on five sets of items. Descriptive analyses were carried out on individual items for each of the latent constructs by reporting the central tendency measures.

5.4.2.1 Open Innovation

The *Open Innovation* construct measured different practices among the public university researchers in interacting with others during innovation research. For this construct, the respondents indicated their frequency of action on the *Open Innovation* practices using a ten-point scale, where 1 denoted "Never do" and 10 denoted "Almost every time". Descriptive statistics for *Open Innovation* are shown in Table 5.5.

Table 5.5: Descriptive statistics for *Open Innovation* (N = 222).

Item	Min	Max	Mean	S.D.
1. I establish formal research collaboration with others for acquiring resources.	1	10	7.15	1.95
2. I explore ideas/resources from others outside of the university e.g. industries.	1	10	7.09	1.92
3. I share my research ideas/resources with others outside of my university.	1	10	7.32	1.89
4. I promote my ideas/resources to people outside of the university e.g. industries.	1	10	7.06	2.00
5. I outsource section of my research project to people who have the appropriate resources.	1	10	6.34	2.29
6. I contribute my ideas and resources to others for their use or further development.	1	10	7.16	1.85
7. I purchase ideas (in the form of intellectual property) or concepts from other people.	1	10	2.81	2.32
8. I adopt ideas from other people for further research and development.	1	10	6.35	1.95
9. I get input from other people for improvement of my research ideas.	1	10	7.36	1.75

There were nine items used to measure the *Open Innovation* construct. From Table 5.5, the practices of 'sharing ideas to others' and 'getting input from others' were the most frequent actions performed by the respondents with a mean of 7.32 ± 1.89 and 7.36 ± 1.75, respectively. On the other hand, 'purchasing ideas from others' was the least practiced among the public university researchers with the lowest mean of 2.81 ± 2.32.

5.4.2.2 Trust in Innovation

The *Trust in Innovation* construct measured the respondents' perceptions on the levels of mutual agreement with other innovation actors in an innovation research. For this

construct, the respondents indicated their level of agreement on the *Trust in Innovation* statements using a ten-point scale, where 1 denoted "Strongly disagree" and 10 denoted "Strongly agree". Descriptive statistics for *Trust in Innovation* are shown in Table 5.6.

Table 5.6: Descriptive statistics for *Trust in Innovation* (N = 222).

Item	Min	Max	Mean	S.D.
1. I simply enjoy sharing ideas with other researchers in a research project.	1	10	8.12	1.59
2. I consider trusting other people when cooperating in a research project.	1	10	7.65	1.76
3. I believe that greater chance for success depend on collaboration with others.	3	10	8.29	1.46
4. I prefer an informal relationship when collaborating with other researchers.	1	10	7.14	2.07
5. I need agreement in place for long term research collaboration.	1	10	7.69	1.97
6. I set out clear objectives and expectations for other researchers.	2	10	7.73	1.63
7. My research team and I share a communication system e.g. email group.	1	10	8.07	1.87

There were seven items used to measure the *Trust in Innovation* construct. From Table 5.6, the respondents' level of agreement on the 'believe in collaboration' for greater chance of successful innovation was the highest with a mean of 8.29 ± 1.46. They were however, less agreed in the 'forming informal relationships' with others during innovation research with a mean of 7.14 ± 2.07.

5.4.2.3 Motivation to Innovate

The *Motivation to Innovate* construct measured the respondents' perceptions on the needs or benefits (including both tangible and intangible) of engaging in innovation research. For this construct, the respondents indicated their level of agreement on the *Motivation to Innovate* statements using a ten-point scale, where 1 denoted "Strongly

disagree" and 10 denoted "Strongly agree". Descriptive statistics for *Motivation to Innovate* are shown in Table 5.7.

Table 5.7: Descriptive statistics for *Motivation to Innovate* (N = 222).

Item	Min	Max	Mean	S.D.
1. Collaborating with others facilitates knowledge and technology transfer.	1	10	8.23	1.49
2. Collaborating with others helps me to establish research niche and network.	3	10	8.29	1.40
3. I build academic reputation and expertise the more I network.	1	10	8.36	1.49
4. I can reduce research (tangible and intangible) costs by sharing the tasks.	2	10	7.98	1.55
5. I can improve the quality of my innovation when I include others.	3	10	8.21	1.44
6. I gain other related knowledge such as best practices, legislation and policies.	2	10	8.05	1.56
7. I get financial support for research mainly through contract research.	1	10	6.43	2.36
8. I able to use other resources e.g. laboratory facilities, organisational database.	1	10	7.50	1.95

There were eight items used to measure the *Motivation to Innovate* construct. From Table 5.7, the respondents were most interested in 'building academic reputation' as the motivation to conduct innovation research with a mean of 8.36 ± 1.49. They were however, less motivated in 'getting financial support' with a mean of 6.43 ± 2.36.

5.4.2.4 Strategic Leadership

The *Strategic Leadership* construct measured the respondents' perceptions of the leadership skills that facilitate effective innovation research within the public university context. For this construct, the respondents indicated their level of agreement on *Strategic Leadership* statements using a ten-point scale, where 1 denoted

"Strongly disagree" and 10 denoted "Strongly agree". Descriptive statistics for *Strategic Leadership* are shown in Table 5.8.

Table 5.8: Descriptive statistics for *Strategic Leadership* (N = 222).

Item	Min	Max	Mean	S.D.
1. I promote research networking and partnerships in research.	2	10	7.91	1.60
2. I set out a clear mission and strategic directions for a research project.	3	10	8.09	1.47
3. I maximise potential resources and core competencies.	4	10	7.99	1.48
4. I support idea creation activities and promote an innovative culture.	3	10	8.31	1.43
5. I manage conflicts arising from the research team members.	2	10	7.63	1.58
6. I engage with all stakeholders regularly for their ideas and feedbacks.	1	10	7.11	1.95
7. I employ new approaches to stimulate creativity of doing things.	1	10	7.61	1.78

There were seven items used to measure the *Strategic Leadership* construct. From Table 5.8, the respondents strongly agreed that a leader should 'support innovative culture' for facilitating effective innovation research in the universities with a mean of 8.31 ± 1.43. They were however, less agreed on 'engaging with stakeholders regularly' for innovation research ideas with a mean of 7.11 ± 1.95.

5.4.2.5 Commercialisation Success

The *Commercialisation Success* construct measured different strategies for commercialising university research outputs (including in the form of idea or knowledge, innovation products or intellectual properties). For this construct, the respondents indicated the extent of their consideration to apply the *Commercialisation Success* strategies using a ten-point scale, where 1 denoted "Never consider" and 10

denoted "Definitely consider". Descriptive statistics for *Commercialisation Success* are shown in Table 5.9.

Table 5.9: Descriptive statistics for *Commercialisation Success* (N = 222).

Item	Min	Max	Mean	S.D.
1. I involve industry for idea/technology consultation and development.	1	10	6.40	2.38
2. I expand idea/technology creation in collaboration with customers or end users.	1	10	6.58	2.31
3. I extend the usability of idea/technology for other services e.g. industrial testing or certification.	1	10	6.14	2.44
4. I participate in innovative exhibitions or start-up competitions for potential direct investments.	1	10	6.34	2.53
5. I use licensing agreements with suitable firms or commercial entities.	1	10	4.83	2.82
6. I further develop the idea/technology through commercialisation intermediaries/agents.	1	10	5.40	2.73
7. I form a company within the university structure for spin-offs.	1	10	4.18	3.01
8. I establish joint ventures or business partnerships for idea/product development and marketing.	1	10	4.85	2.97
9. I supply or sell ready-made products to retailers or in the market.	1	10	4.16	3.03

There were nine items used to measure the *Commercialisation Success* construct. From Table 5.9, the respondents considered the most in 'collaborating with customers' as a preferred strategy for commercialising the university research outputs with a mean of 6.58 ± 2.31. On the other hand, the least considered strategies for commercialisation among the respondents were 'selling ready-made products' and 'forming spin-offs' with a mean of 4.16 ± 3.03 and 4.18 ± 3.01, respectively.

5.5. Factor Analysis

In the preliminary conceptual model, five latent constructs were operationalised for investigating the influence of *Open Innovation*, *Trust in Innovation*, *Motivation to Innovate* and *Strategic Leadership* towards *Commercialisation Success*. These five constructs were measured using a ten-point scale on a set of 40 measurement items. An exploration type of factor analysis was conducted on these 40 items to reduce a larger set of items or variables into a smaller set of 'principal' components. This approach allowed the researcher to refine the preliminary model by means of validating the constructs and developing a more parsimonious explanation on the structures or relationships between constructs (Henson & Roberts 2006).

Principle component with eigenvalues greater than one (≥ 1) was the extraction method used for this exploratory factor analysis in SPSS 22. Through this analysis, unrelated or redundant items and multicollinearity were removed. In order for this exploratory factor analysis to produce a reliable result, an appropriate sample size is required. Many different rules-of-thumb have been proposed regarding sample size in factor analysis. Generally, with communalities of around 0.50 (the extent of inter-correlations between items), a minimum sample size of 100 to 200 is recommended (MacCallum et al. 1999).

Exploratory factor analysis is heuristic (Williams, Brown & Onsman 2010). During the exploration, the researcher had to choose how many principal components to extract, how to make the items load properly, and how to determine a 'simple' model or structure (Helyer & Lee 2012). It was an iterative process involving multiple options and subjective reasoning whether simple or complex structure had been attained. In order to limit the subjectiveness, researchers are advised to be systematic and apply sound judgment during exploratory factor analysis (Henson & Roberts 2006). Therefore, the researcher conducted the factor analysis by following standard guideline as recommended by Williams, Brown and Onsman (2010).

5.5.1. The Principal Components

The first exploratory factor analysis started with 40 items. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for the overall data set was 0.900 where KMO

≥ 0.50 is considered as a minimum limit for sampling adequacy (Nunnally & Bernstein 1994). The Bartlett's test of sphericity was statistically significant ($p < 0.000$) and indicated significant correlations between the items suitable for principal component procedures (van Teijlingen & Hundley 2002). The eigenvalue ≥ 1 was used for establishing how many components to retain (Henson & Roberts 2006) and reflected where a point in a scree plot is clearly levelling off (Linacre 2002). Based on the scree plot as shown in Figure 5.3, the first exploratory factor analysis suggested that the number of principal components is eight with eigenvalues ≥ 1 accounting for 68.0% of the variance.

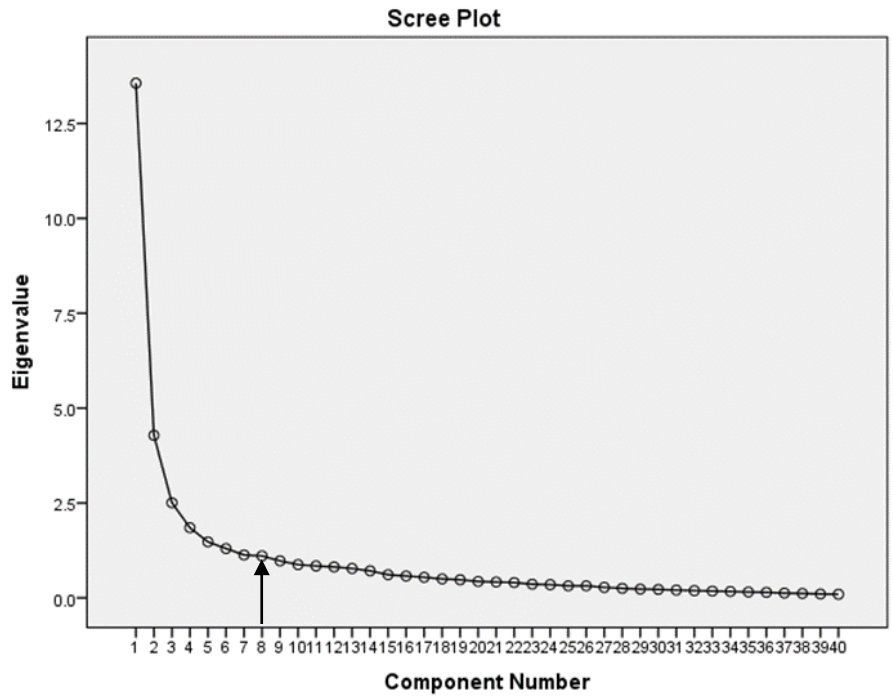


Figure 5.3: Scree plot of the first exploratory factor analysis.

A rotated component matrix output as shown in Table 5.10 illustrates how the initial eight principal components load on each item. Based on Cronbach and Meehl (1955), correlation coefficient values of 0.30 is minimal, 0.40 is important, and 0.50 is practically significant. In the first exploratory factor analysis, the items with correlation coefficient, $r \geq 0.30$ are worth retaining. This initial solution was considered as 'complex structure' where few components loaded with several same individual items (i.e. cross loading). The exploratory factor analysis was repeated in order to achieve a final 'simple structure' solution.

Table 5.10: The initial principal components extracted with varimax rotation method.

Items	Component							
	1	2	3	4	5	6	7	8
M27. Establish research niche	**.785**							
M30. Improve the quality	**.784**							
M26. Facilitates knowledge transfer	**.782**							
T21. Believe in collaboration	**.765**							
M29. Reduce research cost	**.727**							
M28. Build academic reputation	**.681**							
M31. Gain other expertise	**.620**							
T19. Enjoy sharing ideas	**.574**			**.423**				
T20. Consider trusting others	**.566**							
T25. Share communication systems	**.527**				**.339**			
C17. Establish joint ventures		**.899**						
C14. Use licensing agreements		**.854**						
C15. Via commercialisation agents		**.851**						
C16. Form spin-offs		**.818**						
C18. Sell ready-made products		**.788**						
C12. Provide other services		**.697**		**.372**				
C13. Participate in exhibitions		**.696**						
C10. Develop with industries		**.692**		**.358**				
C11. Collaborate with customers		**.653**		**.479**				
L38. Manage conflicts that arises			**.751**					
L36. Maximise potential resources			**.731**		**.351**			
L37. Support innovative culture	**.349**		**.720**					
L40. Employ new approaches			**.699**					
L35. Set out clear mission	**.399**		**.643**		**.309**			
L34. Promote research networking	**.412**		**.530**					
L39. Engage with stakeholders		**.354**	**.527**					
O3. Share ideas with others				**.787**				
O4. Promote ideas to others				**.771**				
O6. Contribute ideas to others				**.703**				
O2. Explore ideas from others				**.619**				
O1. Formal collaboration with others				**.604**				
T23. Need agreement in place					**.742**			
T24. Set out clear objectives	**.304**		**.329**		**.670**			
O8. Adopt ideas from others						**.771**		
O9. Get input from others	**.324**			**.309**		**.725**		
T22. Form informal relationships	**.427**						**.623**	
O7. Purchase ideas from others							**.622**	
O5. Outsource research project				**.372**			**.438**	
M33. Use other facilities								**.717**
M32. Get financial support							**.307**	**.655**

Note: Small coefficients (i.e. r < 0.30) were suppressed in display format.

Based on Table 5.10, an example of 'complex structure' is seen for the item O9 where it loads strongly on components 1, 4 and 6. It is difficult to interpret this structure or relationship between variables. Thus, an item that was weakly correlated with other items (i.e. based on correlation coefficient matrix) or cross-loaded with multiple components (i.e. based on varimax rotation matrix) was removed one at a time. The exploratory factor analysis procedure was repeated until a 'simple structure' was achieved. Finally, a total of ten items were removed from the initial set of 40 items as listed in Table 5.11. The series of varimax rotation matrix or 'solution' results that were computed by SPSS 22 are shown in Appendix F.

Table 5.11: The items removed in step-by-step exploratory factor analysis procedure.

No.	Items	Removal Criteria
1	O7	Out of 39 correlations with other items, all were weak correlations
2	O8	Out of 38 correlations with other items, 37 were weak correlations
3	M32	Out of 37 correlations with other items, 31 were weak correlations
4	T22	Out of 36 correlations with other items, 30 were weak correlations
5	M33	Out of 35 correlations with other items, 25 were weak correlations
6	O9	Out of 34 correlations with other items, 25 were weak correlations
7	O5	Out of 33 correlations with other items, 24 were weak correlations
8	T23	Out of 32 correlations with other items, 20 were weak correlations
9	L39	Cross loading on component 2, 3, and 4
10	C11	Cross loading on component 2, 4, and 5

Note: A weak correlation is where $r \leq 0.30$.

The remaining 30 items revealed a 'simple structure' solution with four components that accounted for 64.5% of the variance as shown by the final scree plot in Figure 5.4.

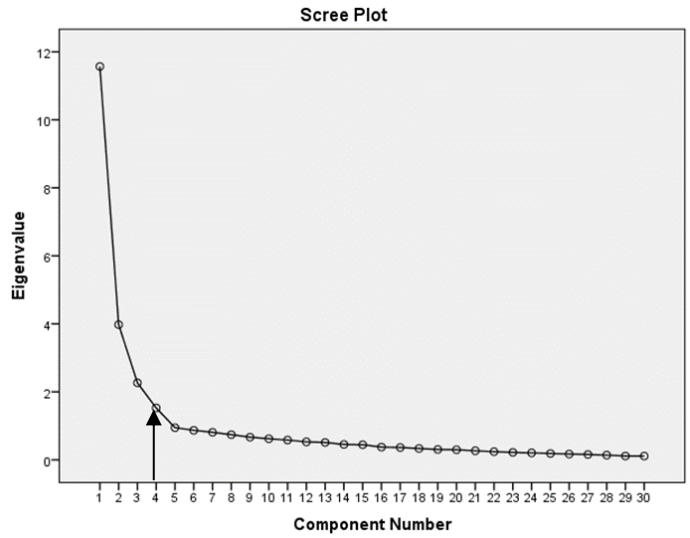


Figure 5.4: Scree plot of the final exploratory factor analysis.

When small coefficients (i.e. < 0.50) were suppressed in display format, the remaining items loadings are shown as in Table 5.12.

Table 5.12: The final principal components extracted with varimax rotation method.

Items	Component			
	1	2	3	4
M27. Establish research niche	**.817**			
M26. Facilitates knowledge transfer	**.800**			
M30. Improve the quality	**.795**			
M29. Reduce research cost	**.751**			
T21. Believe in collaboration	**.726**			
M28. Build academic reputation	**.699**			
M31. Gain other expertise	**.646**			
T19. Enjoy sharing ideas	**.590**			
T20. Consider trusting others	**.543**			
T25. Share communication systems	**.531**			
C17. Establish joint ventures		**.915**		
C14. Use licensing agreements		**.859**		
C15. Via commercialisation agents		**.854**		
C16. Form spin-offs		**.837**		
C18. Sell ready-made products		**.820**		
C13. Participate in exhibitions		**.703**		
C12. Provide other services		**.668**		
C10. Develop with industries		**.660**		
L36. Maximise potential resources			**.837**	
L37. Support innovative culture			**.760**	
L35. Set out clear mission			**.754**	
L38. Manage conflicts that arises			**.695**	
L40. Employ new approaches			**.618**	
L34. Promote research networking			**.585**	
T24. Set out clear objectives			**.578**	
O3. Share ideas with others				**.819**
O4. Promote ideas to others				**.769**
O6. Contribute ideas to others				**.739**
O2. Explore ideas from others				**.664**
O1. Formal collaboration with others				**.617**

Based on Table 5.12, several items that were initially developed to measure the constructs for *Trust in Innovation* and *Motivation to Innovate* have loaded on the same components. Thus, at this stage, some meanings should be assigned to the newly extracted components or factors. According to Hair et al. (1995), the items with the highest loadings were more strongly associated with a factor and should be examined for the meaning of the factor. The Cronbach's alpha, α was also computed for each

sets of the components to check for the items reliability. The research followed Nunnally and Bernstein (1994) suggestion for the Cronbach's alpha; α value above 0.70 is generally accepted as satisfactory.

The first component accounted for 38.6% of the variance and contained ten items that were associated with advantages that were gained through collaboration in research and innovation as shown in Table 5.13.

Table 5.13: Component 1 – Collaborative research advantages.

Collaborative research advantage (CRA)	**Cronbach's α**
M27. Collaborating with others helps me to establish research niche and network. M26. Collaborating with others facilitates knowledge and technology transfer. M30. I can improve the quality of my innovation when I include others. M29. I can reduce research (tangible and intangible) costs by sharing the tasks. T21. I believe that greater chance for success depend on collaboration with others. M28. I build academic reputation and expertise the more I network. M31. I gain other related knowledge such as best practices, legislation and policies. T19. I simply enjoy sharing ideas with other researchers in a research project. T20. I consider trusting other people when cooperating in a research project. T25. My research team and I share a communication system e.g. email group.	0.908

The second component accounted for 13.3% of the variance and contained eight items that were associated with commercialisation success strategies for taking the university research outputs into the market as shown in Table 5.14.

Table 5.14: Component 2 – Commercialisation success strategies.

Commercialisation success (CS) strategies	**Cronbach's α**
C17. I establish joint ventures for idea/product development and marketing. C14. I use licensing agreements with suitable firms or commercial entities. C15. I further develop the idea through commercialisation intermediaries/agents. C16. I form a company within the university structure for spin-offs. C18. I supply or sell ready-made products to retailers or in the market. C13. I participate in innovative exhibitions/competitions for investment opportunity. C12. I extend the usability of idea for other services e.g. industrial training. C10. I involve industry for idea/technology consultation and development.	0.933

The third component accounted for 7.6% of the variance and contained seven items that were associated with the type of strategic leadership skills required for ensuring an open and networked innovation as shown in Table 5.15.

Table 5.15: Component 3 – Strategic leadership skills.

Strategic leadership (SL) skills	Cronbach's α
L36. I maximise potential resources and core competencies. L37. I support idea creation activities and promote an innovative culture. L35. I set out a clear mission and strategic directions for a research project. L38. I manage conflicts arising from the research team members. L40. I employ new approaches to stimulate creativity of doing things. L34. I promote research networking and partnerships in research. T24. I set out clear objectives and expectations for other researchers.	0.907

The fourth component accounted for 5.1% of the variance and contained five items that were associated with the type of open innovation practices adopted by the public university researchers as shown in Table 5.16.

Table 5.16: Component 4 – Open innovation practices.

Open innovation (OI) practices	Cronbach's α
O3. I share my research ideas/resources with others outside of my university. O4. I promote my ideas/resources to people outside of the university e.g. industries. O6. I contribute my ideas/resources to others for their use or further development. O2. I explore ideas/resources from others outside of the university e.g. industries. O1. I establish formal research collaboration with others for acquiring resources.	0.846

Then, items of the newly extracted components were re-numbered for further analysis.

5.5.2. Common Method Bias

As the exploratory factor analysis was driven based on the measured items, it was important to assess common method bias. This bias refers to variance in a data set that is attributable to the measurement method (Podsakoff et al. 2003). The common method bias is one of the main sources of measurement error. The Harman's single-factor test was used to test for a common method bias by fixing the number of factors to be extracted in the exploratory factor analysis to one (rather than extracting via eigenvalues). The unrotated factor solution was examined to check if the majority of the variance (i.e. more than 50%) can be explained by a single factor (Carmona-Lavado, Cuevas-Rodríguez & Cabello-Medina 2010). A research that has significant common method bias is one in which a majority of the variance can be explained by a

single factor (Podsakoff et al. 2003). Results of the single-factor test did not account for a majority of the variance (i.e. 38.6%) and indicated common method bias was not a problem in the data set.

5.5.3. Revised Conceptual Model

The results from exploratory factor analysis revealed four reliable components or constructs instead of five as proposed in the preliminary conceptual model. The initial sets of items used to measure the constructs of 'trust in innovation' and 'motivation to innovate' were highly correlated and had been extracted into a component that seems to be concerned with the advantages of doing research and innovation in a collaborative way. Hence these items were combined to form a new exogenous variable namely 'collaborative research advantage'. A revised conceptual model is illustrated in Figure 5.5.

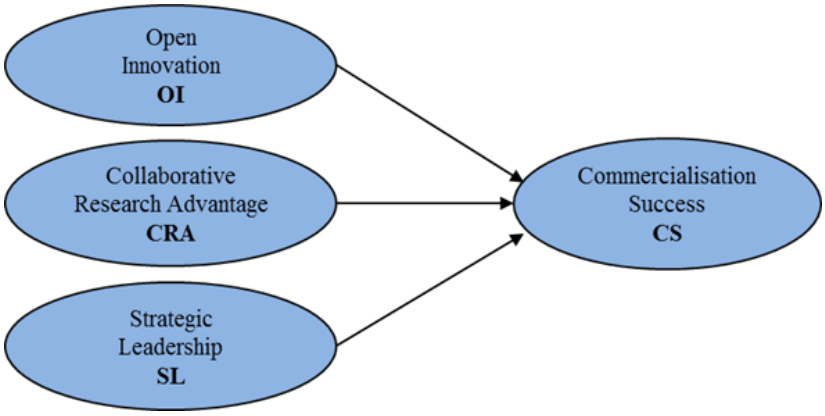


Figure 5.5: The revised conceptual model developed for the research.

Through this exploratory factor analysis, therefore, it helped to further refine the constructs and provided construct validity of the measurement items. The revised sets of items were given new coding numbers according to each components extracted for better identification. The initial hypotheses for the second research question were also revised accordingly.

For next data analysis, values of the retained items for measuring *Commercialisation Success* (i.e. the dependent variable) were used to compute mean scores using SPSS 22. The computed mean scores were analysed for testing the research hypotheses about mean differences of *Commercialisation Success* between

groups of respondents based on their demographic characteristics that were represented by the control variable of *Innovation Actors*.

5.6. Inferential Statistics

The procedure for inferential statistical analysis is closely tied to the logic of hypothesis testing. The research hypotheses were postulated using the constructs developed from the literature review, expert interviews and exploratory factor analysis. An alternative hypothesis, H_A is suggested with the goal to reject a null hypothesis, H_O with confidence. The H_O is a statement of the null condition (or no difference or no relationship) in the population. In order to achieve the research objectives, the researcher presented the inferential analyses based the research questions and tested the corresponding hypotheses.

5.6.1. Bivariate Analysis

Bivariate analysis was used to compare the mean scores between the respondents' demographic characteristics (i.e. *Innovation Actors*) on the dependent construct (i.e. *Commercialisation Success*). The independent-samples t-test and one-way analysis of variance (ANOVA) were used to analyse whether the differences in the means of two or more independent groups are statistically significant. To provide valid results, the data were first examined for the tests assumptions based on: (a) no outliers assessed by inspection of boxplot, (b) normally distributed assessed by inspection of Q-Q plot, and (c) equal variances assessed by Levene's test.

The first objective of the research is stated below.

Objective 1: To examine whether the difference in *Innovation Actors'* characteristics differ from their perceptions towards *Commercialisation Success* strategies in the university. The variables of interest are age, gender, type of university, academic qualification, research expertise, academic position, industrial experience and industrial research.

The related research question is: Does the difference in *Innovation Actors'* characteristics (i.e. age, gender, type of university, academic qualification, research expertise, academic position, industrial experience, and industrial research) significantly differ from their perceived *Commercialisation Success* strategies in the university? With these question, eight corresponding hypotheses were tested.

5.6.1.1 Age

The one-way analysis of variance (ANOVA) was used to determine whether the mean scores of *Commercialisation Success* differ between the *Innovation Actors* age groups. The data of age groups were recoded into three new categories representing 'young', 'junior', and 'senior' university researcher. The data met the test assumptions and the mean scores of *Commercialisation Success* between age groups are shown in Table 5.17.

Table 5.17: Descriptive statistics for *Commercialisation Success* between age groups.

Commercialisation Success (CS) strategies	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Young (< 40 years old)	74	5.515	2.281	0.265	4.987	6.044
Junior (40-49 years old)	81	5.407	2.214	0.246	4.918	5.897
Senior (> 49 years old)	67	4.896	2.298	0.281	4.335	5.456

Note: Levene's test for equality of variances (p = 0.997).

Based on Table 5.17, the mean score for *Commercialisation Success* strategies decreased from Young Researcher (5.515 ± 2.281), to Junior Researcher (5.407 ± 2.214) and to Senior Researcher (4.896 ± 2.298) group. Based on the equal variances assumed, the ANOVA results showed no statistically significant difference in the mean scores of *Commercialisation Success* between the age groups, $F(2,219) = 1.495$, $p = 0.227$. Since the $p > 0.05$, the research accepts the null hypothesis.

H_{O1a}: The mean scores of *Commercialisation Success* are equal between the *Innovation Actors* when they are classified according to their age.

5.6.1.2 Gender

The independent-samples t-test was used to determine whether the mean scores of *Commercialisation Success* differ between the *Innovation Actors* gender. The data met the test assumptions and the mean scores of *Commercialisation Success* between gender are shown in Table 5.18.

Table 5.18: Descriptive statistics for *Commercialisation Success* between gender.

Commercialisation Success (CS) strategies	Gender	N	Mean	Std. Deviation	Std. Error Mean
	Male	125	5.145	2.155	0.193
	Female	97	5.474	2.403	0.244

Note: Levene's test for equality of variances (p = 0.157).

Based on Table 5.18, the mean score for *Commercialisation Success* strategies was higher for female university researchers (5.474 ± 2.403) compared to male university researchers (5.145 ± 2.155). Based on the equal variances assumed, the t-test results showed no statistically significant difference in the mean scores of *Commercialisation Success* between the gender, $t(220) = -1.074$, $p = 0.284$. Since the $p > 0.05$, the research accepts the null hypothesis.

H_{01b}: The mean scores of *Commercialisation Success* are equal between the *Innovation Actors* when they are classified according to their gender.

5.6.1.3 Type of University

The independent-samples t-test was used to determine whether the mean scores of *Commercialisation Success* differ between the *Innovation Actors* types of university. The data of types of university were recoded into two new categories representing 'research-focused' and 'non-research-focused' university. The data met the test assumptions and the mean scores of *Commercialisation Success* between types of university are shown in Table 5.19.

Table 5.19: Descriptive statistics for Commercialisation Success between types of university.

Commercialisation Success (CS) strategies	Type of university	N	Mean	Std. Deviation	Std. Error Mean
	Research-Focused	185	5.235	2.263	0.166
	Non-Research Focused	37	5.557	2.302	0.378

Note: Levene's test for equality of variances (p = 0.877).

Based on Table 5.19, the mean score for *Commercialisation Success* strategies was higher for non-research-focused university (5.557 ± 2.302) compared to research-focused university (5.235 ± 2.263). Based on the equal variances assumed, the t-test result showed no statistically significant difference in the mean scores of *Commercialisation Success* between the types of university, $t(220) = -0.789$, $p = 0.431$. Since the $p > 0.05$, the research accepts the null hypothesis.

H_{O1c}: The mean scores of *Commercialisation Success* are equal between the *Innovation Actors* when they are classified according to their types of university.

5.6.1.4 Academic Qualification

The independent-samples t-test was used to determine whether the mean scores of *Commercialisation Success* differ between the *Innovation Actors* academic qualifications. The data of academic qualifications were recoded into two new categories representing 'doctorate' and 'non-doctorate' qualification. The data met the test assumptions and the mean scores of *Commercialisation Success* between academic qualifications are shown in Table 5.20.

Table 5.20: Descriptive statistics for *Commercialisation Success* between academic qualifications.

Commercialisation Success (CS) strategies	Academic Qualifications	N	Mean	Std. Deviation	Std. Error Mean
	Doctorate	198	5.294	2.227	0.158
	Non-Doctorate	24	5.250	2.630	0.537

Note: Levene's test for equality of variances (p = 0.058).

Based on Table 5.20, the mean score for *Commercialisation Success* strategies was higher for doctorate university researchers (5.294 ± 2.227) compared to non-doctorate university researchers (5.250 ± 2.630). Based on the equal variances

assumed, the t-test result showed no statistically significant difference in mean scores of *Commercialisation Success* between the academic qualifications, $t(220) = 0.089$, $p = 0.929$. Since the $p > 0.05$, the research accepts the null hypothesis.

H_{O1d}: The mean scores of *Commercialisation Success* are equal between the *Innovation Actors* when they are classified according to their academic qualifications.

5.6.1.5 Research Expertise

The one-way analysis of variance (ANOVA) was used to determine whether the mean scores of *Commercialisation Success* differ between the *Innovation Actors* fields of research expertise. Due to unbalanced sample sizes between the categories, data points with the research expertise categorised as 'Others' (N = 4) were excluded from this analysis. The data had no outliers and was normally distributed. The mean scores of *Commercialisation Success* between research expertise are shown in Table 5.21.

Table 5.21: Descriptive statistics for *Commercialisation Success* between research expertise.

Commercialisation Success (CS) strategies	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Sciences/Applied Sciences	89	5.287	2.492	0.264	4.762	5.811
Technology/Engineering	97	5.513	1.962	0.199	5.117	5.908
Social Sciences/Applied Arts	32	4.883	2.376	0.420	4.026	5.739

Note: Levene's test for equality of variances ($p = 0.034$).

Based on Table 5.21, the mean score for *Commercialisation Success* strategies decreased from Technology/Engineering (5.513 ± 1.962), to Sciences/Applied Sciences (5.287 ± 2.492) and to Social Sciences/Applied Arts (4.883 ± 2.376) research expertise. Because the assumption of homogeneity of variances was violated, the Welch ANOVA was used to interpret the mean differences. There was no statistically significant difference in the mean scores of *Commercialisation Success* between the fields of research expertise, $F(3, 14.075) = 1.646$, $p = 0.224$. Since the $p > 0.05$, the research accepts the null hypothesis.

H_{O1e}: The mean scores of *Commercialisation Success* are equal between the *Innovation Actors* when they are classified according to their research expertise.

5.6.1.6 Academic Position

The one-way analysis of variance (ANOVA) was used to determine whether the mean scores of *Commercialisation Success* differ between the *Innovation Actor's* ranks of academic position. Due to 'unbalanced' sample sizes between the categories, data points with the academic position categorised as 'Others' (N = 5) were excluded from this analysis. The data met the test assumptions and the mean values of Commercialisation Success between academic positions are shown in Table 5.22.

Table 5.22: Descriptive statistics for *Commercialisation Success* between academic positions.

Commercialisation Success (CS) strategies	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Professor	50	4.740	2.448	0.346	4.044	5.436
Associate Professor	63	5.306	2.125	0.268	4.771	5.841
Senior Lecturer/Lecturer	104	5.565	2.214	0.217	5.134	5.996

Note: Levene's test for equality of variances (p = 0.491).

Based on Table 5.22, the mean score for *Commercialisation Success* strategies decreased from Senior Lecturer/Lecturer (5.565 ± 2.214), to Associate Professor (5.306 ± 2.125) and to Professor (4.740 ± 2.448) academic position. Based on the equal variances assumed, the ANOVA result showed no statistically significant difference in the mean scores of *Commercialisation Success* between the levels of academic position, $F(3, 218) = 1.574$, $p = 0.197$. Since the $p > 0.05$, the research accepts the null hypothesis.

H_{O1f}: The mean scores of *Commercialisation Success* are equal between the *Innovation Actors* when they are classified according to their academic positions.

5.6.1.7 Industrial Experience

The independent-samples t-test was used to determine whether the mean scores of *Commercialisation Success* differ between the *Innovation Actors* with or without industrial experience. The data met the test assumptions and the mean scores of *Commercialisation Success* between industrial experience are shown in Table 5.23.

Table 5.23: Descriptive statistics for *Commercialisation Success* between industrial experience.

Commercialisation Success (CS) strategies	Industry Experience	N	Mean	Std. Deviation	Std. Error Mean
	No	97	4.874	2.358	0.239
	Yes	125	5.611	2.149	0.192

Note: Levene's test for equality of variances (p = 0.142).

Based on Table 5.23, the mean score for *Commercialisation Success* strategies was higher for university researchers with industrial experience (5.611 ± 2.149) compared to university researchers without industrial experience (4.874 ± 2.358). Based on the equal variances assumed, the t-test result showed a statistically significant difference in the mean scores of *Commercialisation Success* between university researchers with and without industrial experience, 0.737± 0.303, $t(220) = -2.430$, $p = 0.016$. **Since the $p < 0.05$, the research rejects the null hypothesis and accepts the alternative hypothesis.**

H_{A1g}: The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their industrial experience.

The effect size of the mean scores difference of *Commercialisation Success* between university researchers with and without industrial experience was calculated using the formula as shown below:

$$d = \frac{|M_1 - M_2|}{s_{pooled}}, \text{ with } \quad s_{pooled} = \sqrt{\frac{s_1^2(n_1 - 1) + s_2^2(n_2 - 1)}{n_1 + n_2 - 2}}$$

where | M | the absolute mean values (negative value becomes a positive value), s is standard deviation and n is sample size.

Therefore, d = | 4.874 – 5.611 | / 2.243
= 0.737 / 2.243
= 0.329

The industrial experience had a medium effect ($0.20 > d < 0.80$) on *Commercialisation Success* strategies based on Cohen's *d* effect size indices (Cohen 1988).

5.6.1.8 Industrial Research

The independent-samples t-test was used to determine whether the mean scores of *Commercialisation Success* differ between the *Innovation Actors* with or without involvement in industrial research. The data met the test assumptions and the mean scores of *Commercialisation Success* between industrial research are shown in Table 5.24.

Table 5.24: Descriptive statistics for *Commercialisation Success* between industrial research.

Commercialisation Success (CS) strategies	Industry Research	N	Mean	Std. Deviation	Std. Error Mean
	No	79	4.744	2.311	0.260
	Yes	143	5.590	2.193	0.183

Note: Levene's test for equality of variances ($p = 0.529$).

Based on Table 5.24, the mean score for *Commercialisation Success* strategies was higher for university researchers with industrial research (5.590 ± 2.193) compared to university researchers without industrial research (4.744 ± 2.311). Based on the equal variances assumed, the t-test result showed a statistically significant difference in the mean scores of *Commercialisation Success* between university researchers with and without industrial research, 0.846 ± 0.313, $t(220) = -2.701$, $p = 0.007$. **Since the $p < 0.05$, the research rejects the null hypothesis and accepts the alternative hypothesis.**

H_{A1h}: The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their industrial research.

The effect size of the mean scores difference of *Commercialisation Success* between university researchers with and without industrial research was calculated using the formula as shown below:

$$d = \frac{|M_1 - M_2|}{s_{pooled}} \quad \text{, with} \quad s_{pooled} = \sqrt{\frac{s_1^2(n_1 - 1) + s_2^2(n_2 - 1)}{n_1 + n_2 - 2}}$$

where | M | the absolute mean values (negative value becomes a positive value), *s* is standard deviation and *n* is sample size.

Therefore, d = | 4.744 – 5.590 | / 2.236
= 0.846 / 2.236
= 0.378

The industrial research had a medium effect ($0.20 > d < 0.80$) on *Commercialisation Success* strategies based on Cohen's *d* effect size indices (Cohen 1988).

5.6.2. Multivariate Analysis

Multivariate analysis refers to statistical technique used to analyse multiple variables (i.e. more than two) simultaneously. It is a useful technique particularly to test a conceptual framework consisting of multiple relationships between constructs that is represented by a schematic diagram or model. The researcher had developed and revised the research conceptual model based on the relevant theories and the data exploration in order to hypothesise inter-relationships between the constructs. In the research, a structural equation modeling technique was used to analyse the inter-relationships between latent constructs that were measured by multiple items.

5.6.2.1 Structural Equation Modeling

A structural equation modeling (SEM) technique enhances accurateness of the multivariate analysis, by means of the inter-relationships between latent constructs were analysed simultaneously with their observed (or measured) items. A covariance-based SEM technique was employed by using Analysis of Moment Structure (AMOS)

software version 22. The revised conceptual model in Figure 5.6 showing the updated hypotheses and relationships between constructs.

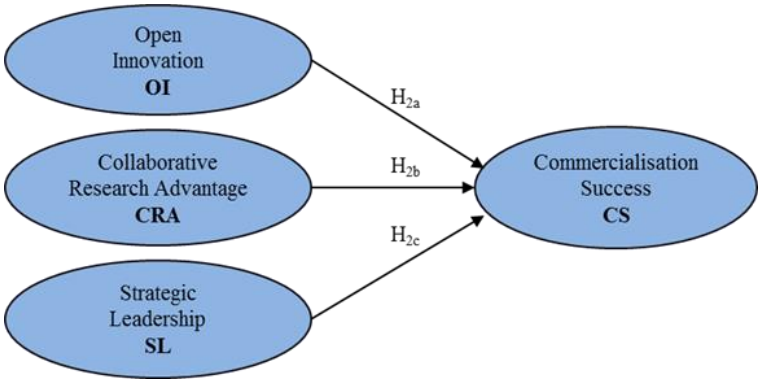


Figure 5.6: The revised conceptual model showing the hypothesised relationships.

Based on the revised model (Figure 5.6), the research aimed to examine the influence of *Open Innovation*, *Collaborative Research Advantage* and *Strategic Leadership* on *Commercialisation Success* within the Malaysian public university context. The second objective arising from the research, specific for this structural equation modeling analysis, is as follows:

Objective 2: To examine whether there are significant influences of *Open Innovation*, *Collaborative Research Advantage* and *Strategic Leadership* on *Commercialisation Success* strategies in the university.

The related research question for the stated objective is: Does *Open Innovation*, *Collaborative Research Advantage* and *Strategic Leadership* significantly influence *Commercialisation Success*? The alternative hypotheses tested using structural equation modeling (SEM) analysis are as follows:

H_{A2a}: *Open Innovation* has a significant and positive influence on *Commercialisation Success.*

H_{A2b}: *Collaborative Research Advantage* has a significant and positive influence on *Commercialisation Success.*

H_{A2c}: *Strategic Leadership* has a significant and positive influence on *Commercialisation Success*.

The analysis for these hypothetical relationships involved four latent constructs and 30 measurement items. With AMOS 22, the revised conceptual model was converted into a structural equation modeling (SEM) schematic model as shown in Figure 5.7. Full list of the measurement items is shown in Appendix G.

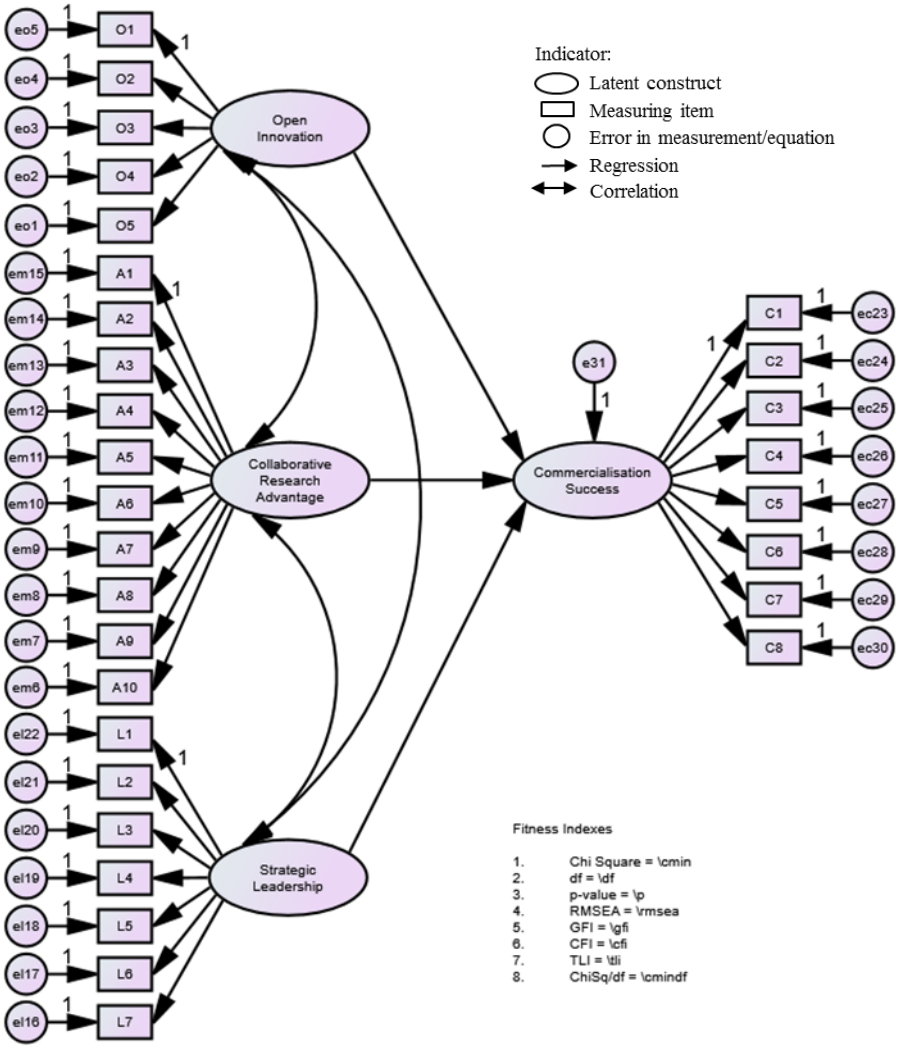


Figure 5.7: The schematic conceptual model developed using AMOS 22.

The rationale for using SEM analysis lies with its multiple advantages that meet the following requirements (Awang 2012):

a. Running the confirmatory factor analysis;
b. Analysing multiple regression models simultaneously;
c. Analysing regression with multicollinearity problems;
d. Analysing the path (structural) analysis with multiple dependents;
e. Estimating the correlation and covariance in a model;

f. Modeling the inter-relationships among multiple variables;
g. Assessing the fitness of measurement model for latent constructs;
h. Analysing mediating or moderating variables in a model; and
i. Handling the correlated errors among measured items.

5.6.2.2 Quality of Model

There are two models involved in structural equation modeling (SEM) analysis, namely the measurement model and the structural model. The measurement model needs to be analysed first prior the structural model analysis. In analysing the measurement model; unidimensionality, validity and reliability need to be assessed in order to achieve a good model fitness that reflects a robust model for testing. In the research, the assessment was done as follows:

a. Unidimensionality

Each measuring item needs to have an acceptable factor loading on a latent construct. In order to achieve unidimensionality, the item with low factor loading was removed from the analysis. The researcher followed a recommendation by Hair et al. (2014) that is, items with standardised loadings between 0.40 and 0.70 should be considered for removal from analysis only when deleting the item leads to an increase in the composite reliability. This was an iterative process, where one item being removed at a time and followed by model re-assessment before removing the next item.

b. Validity

A valid instrument consists of measuring items that are able to measure the latent constructs accurately. Three types of validity were assessed as listed below:

- Convergent validity: This was verified by Average Variance Extracted (AVE) calculated manually with the formula

$$AVE = \frac{\sum \lambda^2}{[\sum \lambda^2 + \sum(1 - \lambda^2)]}$$, where λ = loadings of items of a latent construct. The Average Variance Extracted (AVE) value of 0.50 or higher suggests adequate convergent validity (Bagozzi & Yi 1988).

- Discriminant validity: This was verified according to Fornell and Larcker (1981) criterion, where a latent construct should explain better the variance of its own indicators than the variance of other latent constructs. Therefore, the Average Variance Extracted (AVE) value of a latent construct should be higher than the squared correlations between a latent construct and all other constructs (Fornell & Larcker 1981).

- Construct validity: This was verified by several fitness indexes which can be divided into four categories with certain levels of acceptance as shown in Table 5.25.

Table 5.25: The fitness index categories and the levels of acceptance.

Fitness Category	Name of Fitness Index	Level of Acceptance	Reference
1. Absolute fit	Root Mean Square of Error Approximation	RMSEA ≤ 0.08	Browne and Cudeck (1993)
	Goodness of Fit Index	GFI ≥ 0.90	Chau and Hu (2001)
2. Residuals fit	Standardised Root Mean Square Residual	SRMR ≤ 0.08	Hu and Bentler (1999)
	Root Mean Square Residual	RMR ≤ 0.08	Browne and Cudeck (1993)
3. Incremental fit	Comparative Fit Index	CFI ≥ 0.90	Bagozzi and Yi (1988)
	Tucker Lewis Index	TLI ≥ 0.90	Bentler and Bonett (1980)
4. Parsimonious fit	Chi Square / Degree of Freedom	Chisq/df ≤ 5.00	Marsh and Hocevar (1985)
	Adjusted Goodness of Fit Index	AGFI ≥ 0.90	Chau and Hu (2001)

c. Reliability

The items should establish consistency for measuring the latent constructs. This was verified using: (i) the Cronbach's alpha test for internal reliability calculated using SPSS 22 with acceptable value of 0.70 or higher (Nunnally 1978), and (ii) the Composite Reliability (CR) manually calculated with the formula

$$CR = \frac{(\sum \lambda)^2}{[(\sum \lambda)^2 + \sum(1 - \lambda^2)]}$$, where λ = loadings of items of a latent variable. The Composite Reliability (CR) value of 0.70 or higher indicates adequate internal consistency (or convergence) (Gefen, Straub & Boudreau 2000).

5.6.2.3 Measurement Model Analysis

By using AMOS 22, the measurement model was evaluated through a pooled Confirmatory Factor Analysis (CFA) procedure. A standardised estimate was calculated to obtain factor loadings for every items in the measurement model. Correlations between latent constructs was also calculated through this procedure. The data set being used consisted of 30 items that measured four latent constructs with the sample size of 222.

The measurement model was analysed using a maximum likelihood estimation (MLE) approach to yield comparatively good estimates (Boomsma 2000). In the research, strategy for the measurement model analysis was based on a model-generating approach where the researcher tested the hypothesised model on the basis of its poor fit to the sample data and proceeds to modify or re-specify the model (Byrne 2013). The primary focus was to locate the source of misfit in the model and generate a model that was both substantively meaningful and statistically well fitting (Byrne 2013). Two criteria were mainly used to assess the measurement model and helpfulness in detecting model misfit – the items loadings and the modification indices. Decisions made based on these two criteria resulted in re-specification of the model either by removing items or setting parameters to be freely estimated.

The initial measurement model is presented in Figure 5.8. This is a full measurement model analysis where all latent constructs were estimated simultaneously using all measuring items. The quality of the model was evaluated

based on the criteria as outlined in Section 5.6.2.2: Quality of Model. This was an iterative process where the model was reassessed after each re-specification done.

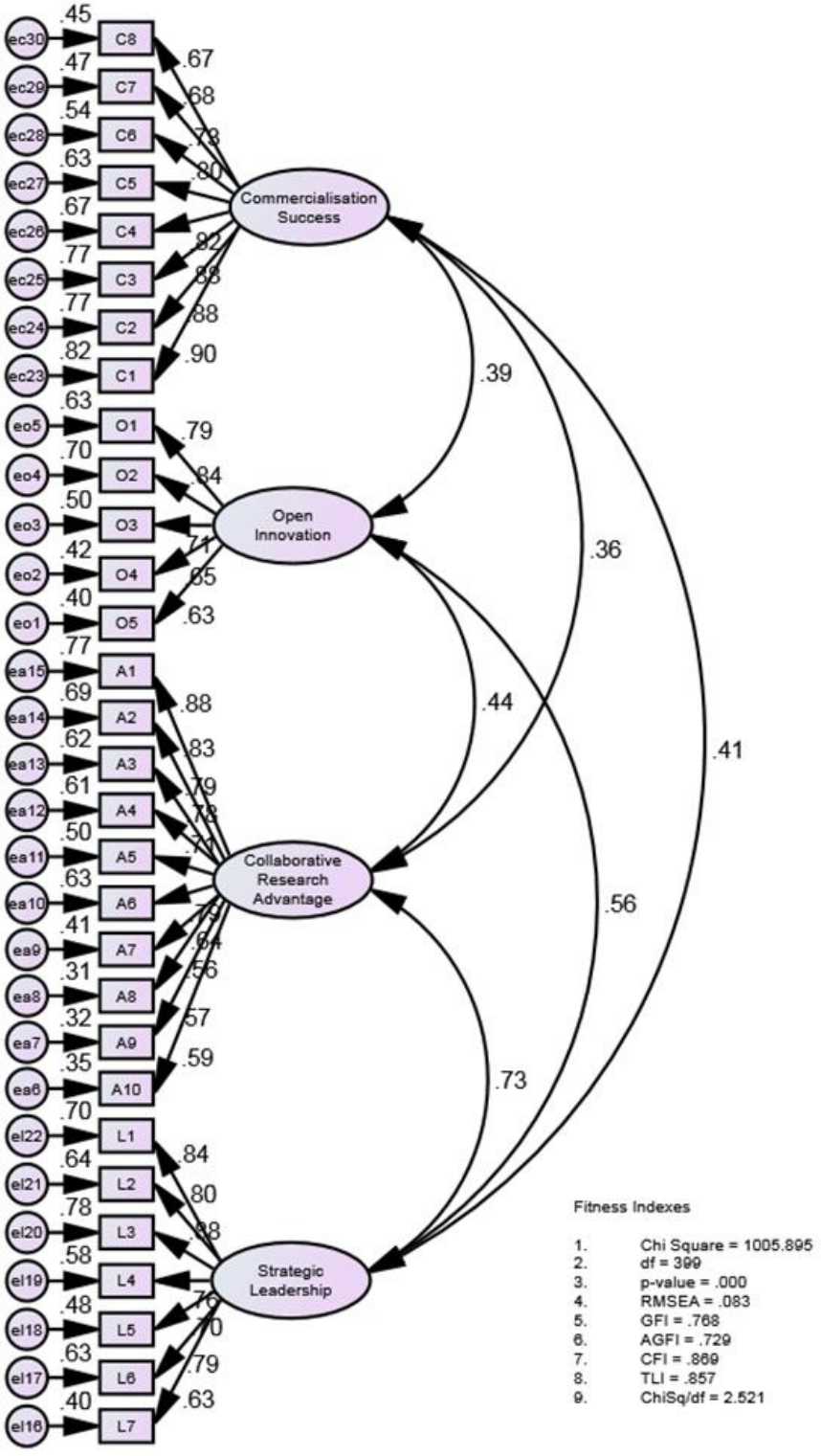


Figure 5.8: The initial measurement model with all four latent constructs and 30 items.

Based on Figure 5.8, the fitness indexes yielded a ChiSq/df = 2.521, a RMSEA = 0.083, and a CFI = 0.869. In assessing these fitness indexes, the initial measurement model was a relatively poor fit. A review of the items loadings and the modification indices revealed some evidence of misfit in the model. Thus, items with low loadings or large modification indices were removed or reset free one at a time. The measurement model was reassessed until a considerably well-fitting model was achieved. Finally, a total of eight items were removed and a pair of parameters was set to be freely estimated as summarised in Table 5.26. The series of measurement model estimation results that were calculated by AMOS 22 are shown in Appendix G.

Table 5.26: The step-by-step measurement model re-specification process.

No.	Items	Re-specification Decision
1	A8	Removed based on factor loading of 0.560
2	A9	Removed based on factor loading of 0.556
3	A10	Removed based on factor loading of 0.587
4	L7	Removed based on factor loading of 0.628
5	O5	Removed based on factor loading of 0.632
6	O4	Removed based on factor loading of 0.615
7	A7	Removed based on factor loading of 0.635
8	C8	Removed based on factor loading of 0.671
9	ea23-ea26	Reset free based on modification indices of 18.854

In assessing the measurement model, items with the loadings between 0.40 and 0.70 were considered for removal conditionally. The modification indices were also evaluated particularly for values 15.0 or higher which indicate correlated measurement error between items. Each re-specifications done was followed by model reassessment, and a final model consisted of 22 items is presented in Figure 5.9.

Normality of the data set was also assessed using the skewness and kurtosis measures. Based on Nevitt and Hancock (2001), the assessment of normality indicated the data set was a moderate departure from a normal distribution with the highest skewness value was 1.532 (i.e. should be < 2.0) and the highest kurtosis value was 3.581 (i.e. should be < 7.0). Indeed, the multivariate kurtosis value was 208.581 which indicated the data was not normally distributed. According to Awang (2012), in the case the data normality assumption is not met, one of the option for structural equation modeling analysis is using maximum likelihood estimator (MLE). The MLE method is fairly robust to skewed and kurtotic data as long as the sample size is large enough

(normally more than 200) and cross-validate the estimated results with bootstrapping method.

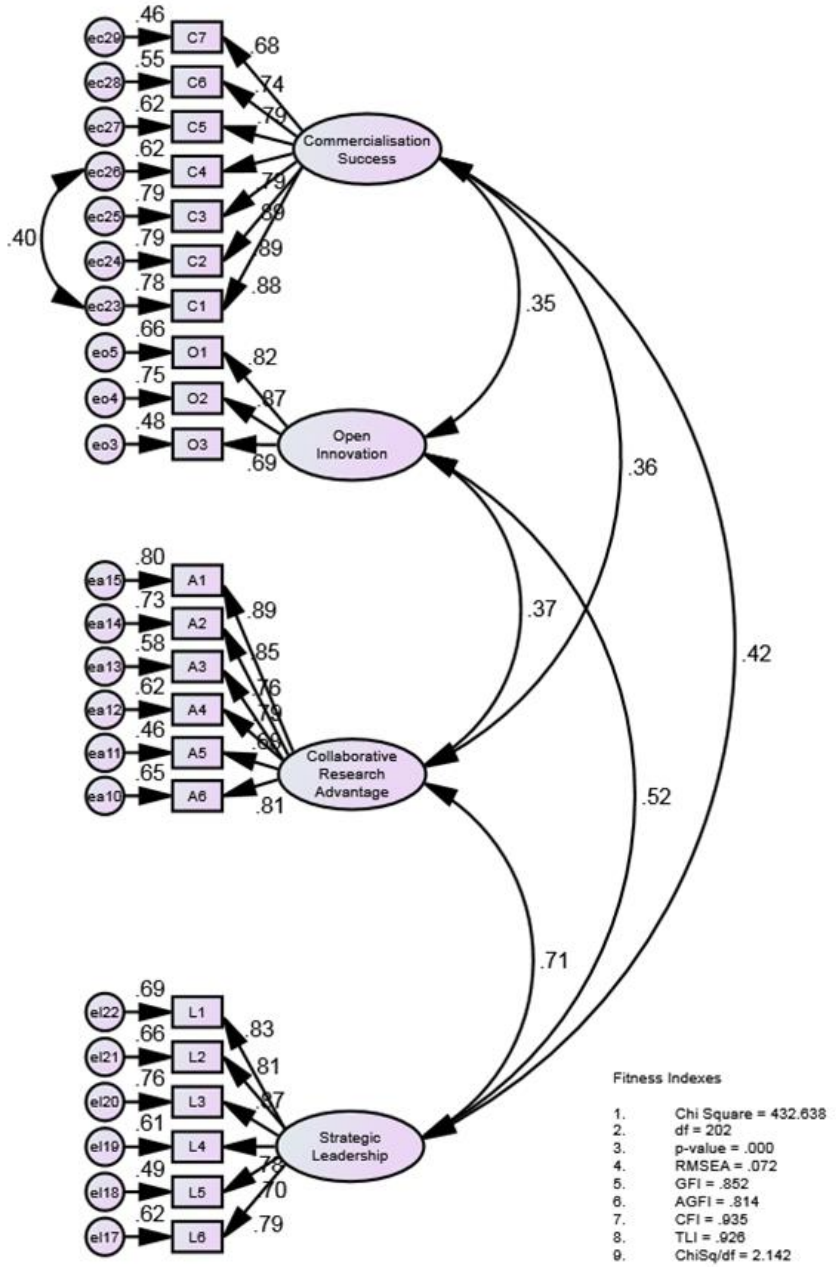


Figure 5.9: The final measurement model with all four latent constructs and 22 items.

There is no agreement among scholars which fitness indexes should be reported (Awang 2012). There is no single 'magic' value for the fitness index that separate good from poor models. Multiple fitness indexes are recommended to be used when assessing a model fitness. Among the fitness indexes commonly reported in innovation management literature were the RMSEA, CFI, SRMR, ChiSq/df, GFI, TLI (e.g. Hajikarimi et al. 2013; Unsworth et al. 2009; von der Heidt & Scott 2009;

Xerri 2012). This research followed Hair et al. (1995) recommendation to use at least one index from each category of model fitness. The final model as shown in previous Figure 5.9 represented a good fit with the indexes as listed in Table 5.27.

Table 5.27: The fitness indexes for final measurement model.

Fitness Index	Fitness Category	Index Value
1. RMSEA ≤ 0.08	Absolute fit	0.072
2. SRMR ≤ 0.08	Residual fit	0.060
3. CFI ≥ 0.90	Incremental fit	0.935
4. ChiSq/df ≤ 5.00	Parsimonious fit	2.142

The fitness indexes in Table 5.27 indicated construct validity of the model had been achieved. Then, the Average Variance Extracted (AVE) and Composite Reliability (CR) were manually calculated to assess the convergent validity and the Cronbach's alpha for reliability was calculated using SPSS 22 with results as shown in Table 5.28.

Table 5.28: Convergent validity and reliability of the measurement model.

Construct	Items	Loadings ≥ 0.60	AVE ≥ 0.50	CR ≥ 0.70	Cronbach's α ≥ 0.70
Commercialisation Success	C1	0.881	0.659	0.931	0.931
	C2	0.887			
	C3	0.891			
	C4	0.789			
	C5	0.789			
	C6	0.743			
	C7	0.677			
Open Innovation	O1	0.815	0.633	0.837	0.834
	O2	0.868			
	O3	0.693			
Collaborative Research Advantage	A1	0.895	0.639	0.913	0.912
	A2	0.853			
	A3	0.763			
	A4	0.786			
	A5	0.676			
	A6	0.806			
Strategic Leadership	L1	0.833	0.639	0.914	0.909
	L2	0.810			
	L3	0.872			
	L4	0.781			
	L5	0.700			
	L6	0.789			

Based on Table 5.28, all the Average Variance Extracted (AVE), Composite Reliability (CR) and Cronbach's alpha values exceed the acceptance levels which indicated convergent validity and reliability had been achieved. The square root of the Average Variance Extracted (AVE) measures as shown in Table 5.29 are used to assess the discriminant validity.

Table 5.29: Discriminant validity of the measurement model.

Construct	(1)	(2)	(3)	(4)
1. Strategic Leadership	**0.799**			
2. Collaborative Research Advantage	0.707	**0.799**		
3. Open Innovation	0.523	0.370	**0.796**	
4. Commercialisation Success	0.419	0.355	0.355	**0.812**

Note: Values on the diagonal (bolded) represent the square root of the AVE while values off-diagonal represent correlations.

Based on Table 5.29, the square root of the Average Variance Extracted (AVE) values exceed the inter-correlations between constructs that indicated discriminant validity had been achieved (Fornell & Larcker 1981). The correlations between each constructs were between 0.355 and 0.707. According to Taylor (1990), correlations between ± 0.30 to 0.70 are considered modest and acceptable, because too low correlations indicate weak inter-item dependency and too high correlations indicate multicollinearity. It was recommended that the inter-correlations between variables not exceed 0.80 and statistical problems frequently occur for correlations at 0.90 or above (Tabachnick & Fidell 2007).

5.6.2.4 Structural Model Analysis

Once unidimensionality, validity and reliability for the measurement model had been achieved, the structural model was analysed using the maximum likelihood estimator (MLE) method. Analysing the structural model using AMOS 22 would give two sets of output namely the standardised and the unstandardised estimates. The standardised estimation gives values of correlations between exogenous constructs, factor loadings for each items, standardised beta for regressions and squared multiple correlations (R^2). While the unstandardised estimate gives values of the actual beta for regressions which indicates the influence (or prediction) of the exogenous construct on the

endogenous construct and the calculated probability (*p* value). The standardised estimates for the hypothesised relationships are presented in Figure 5.10.

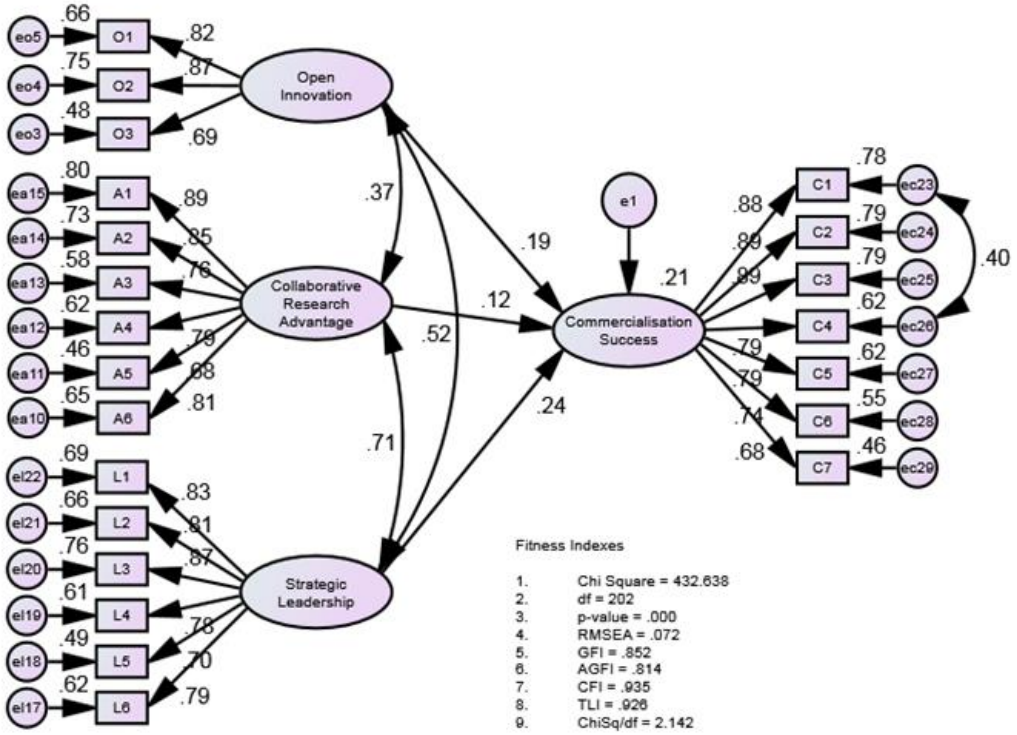


Figure 5.10: The standardised regression weights (beta estimate).

The AMOS 22 text outputs of the standardised regression weights between constructs are presented in Table 5.30.

Table 5.30: The standardised regression weights (beta estimate) results.

Construct	Path	Construct	Standardised Beta Estimate
Commercialisation Success	<---	Open Innovation	0.187
Commercialisation Success	<---	Collaborative Research Advantage	0.119
Commercialisation Success	<---	Strategic Leadership	0.237

The explanations for results in Table 5.30, for example, when *Open Innovation* goes up by 1 standard deviation, the *Commercialisation Success* is estimated to increase by 0.187 standard deviations. And when *Collaborative Research Advantage* goes up by 1 standard deviation, the *Commercialisation Success* is also estimated to increase by up 0.119 standard deviations. Based on Figure 5.10, the squared multiple correlations (R^2) for *Commercialisation Success* is 0.21. It was estimated that the

predictors of *Commercialisation Success* explained 21% of its variance. Something other than the constructs examined explain 79% of the variance in *Commercialisation Success*. Next, the result for unstandardised estimate is presented in Figure 5.11.

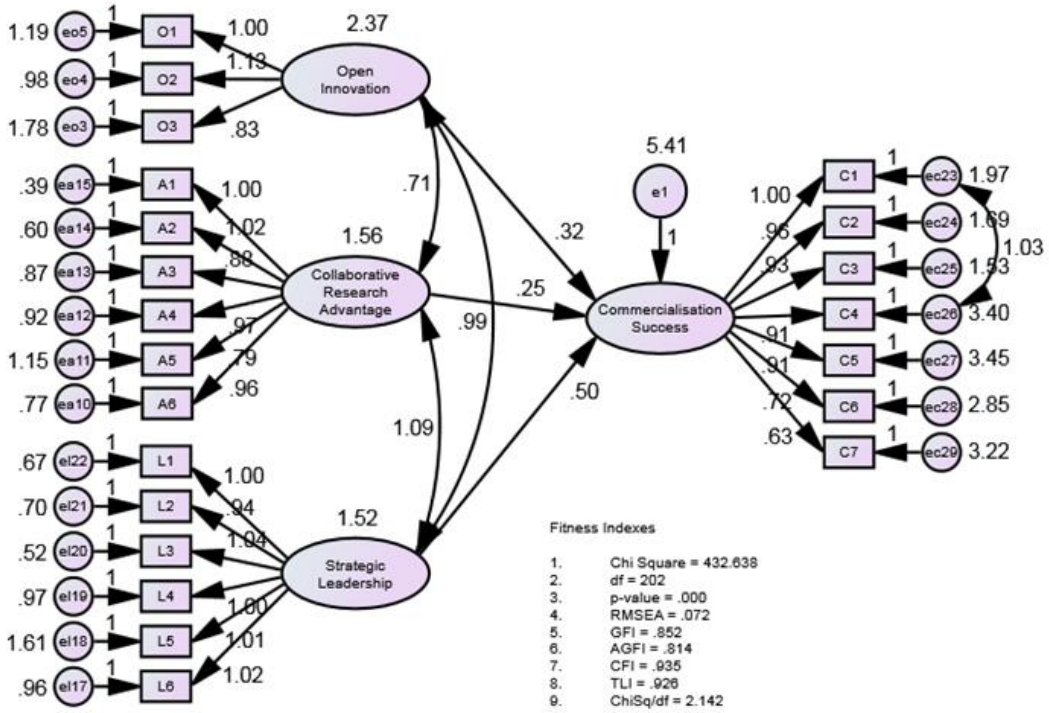


Figure 5.11: The unstandardised regression weights (actual beta estimate).

The AMOS 22 text outputs of the unstandardised regression weights between constructs are presented in Table 5.31.

Table 5.31: The unstandardised regression weights (actual beta estimate) results.

Construct	Path	Construct	Actual Beta Estimate	S.E.	C.R.	*p*-value
Commercialisation Success	<---	Open Innovation	0.317	0.142	2.233	**0.026**
Commercialisation Success	<---	Collaborative Research Advantage	0.248	0.208	1.194	0.232
Commercialisation Success	<---	Strategic Leadership	0.503	0.237	2.126	**0.034**

The explanations for results in Table 5.31, for example, when *Open Innovation* goes up by 1 unit, the *Commercialisation Success* is estimated to increase by 0.317 unit with a standard error of 0.142. The probability of getting a critical ratio as large

as 2.233 in absolute value is 0.026. In other words, the regression weights for *Open Innovation* in the prediction of *Commercialisation Success* was significantly different (p = 0.026) from zero at the 0.05 level (two-tailed). On the other hand, when *Collaborative Research Advantage* goes up by 1 unit, the *Commercialisation Success* is estimated to increase by 0.248 unit with a standard error of 0.208. The probability of getting a critical ratio as large as 1.194 in absolute value is 0.232. In other words, the regression weights for *Collaborative Research Advantage* in the prediction of *Commercialisation Success* was not significantly different (p = 0.232) from zero at the 0.05 level (two-tailed).

Based on Figure 5.11, the covariance results between exogenous constructs were estimated to be 0.71 (between *Open Innovation* and *Collaborative Research Advantage*), 1.09 (between *Collaborative Research Advantage* and *Strategic Leadership*) and 0.99 (between *Open Innovation* and *Strategic Leadership*).

5.6.2.5 Hypothesis Testing

The advantage of conducting structural equation modeling (SEM) analysis is its effectiveness in estimating correlational and causal relationships between the constructs simultaneously. The comprehensive SEM estimation was adequate for the researcher to test the research hypotheses regarding the inter-relationships between constructs. The aim of this analysis was to examine whether *Open Innovation (OI)*, *Collaborative Research Advantage (CRA)* and *Strategic Leadership (SL)* significantly influence *Commercialisation Success (CS)*. Based on the unstandardised regression weights (i.e. the actual beta estimates), the calculated probability (p value) was used for testing the research hypotheses with results as presented in Table 5.32.

Table 5.32: The results for the research hypotheses testing.

Hypothesis	**The Path**	**Actual Beta Estimate**	**Standard Error**	***p*-value**	**Bootstrapping Bias-corrected at 90% Confidence Interval**		**Result on H_A**
					Lower	**Upper**	
H_{A2a}	CS <--- OI	0.317	0.142	**0.026**	0.029	0.670	**Accepted**
H_{A2b}	CS <--- CRA	0.248	0.208	0.232	-0.115	0.681	Rejected
H_{A2c}	CS <--- SL	0.503	0.237	**0.034**	0.017	0.959	**Accepted**

Note: Based on 1,000 bootstrap samples.

The explanations for results in Table 5.32, for example, when *Open Innovation* increases by 1 unit, the *Commercialisation Success* is predicted to increase 0.317 unit with a standard error of 0.142. The influence of *Open Innovation* on *Commercialisation Success* was significant ($p = 0.026$) at the 0.05 level. The bootstrap procedure was conducted to cross-validate the stability of the estimation results, especially for a non-normal data set that allows a greater degree of accuracy in results reporting (Byrne 2013). The bootstrap estimates for *Open Innovation* were calculated with lower and upper limits of 0.029 and 0.670, where zero was not included in the 90% confidence interval. **Since the $p < 0.05$, the research rejects the null hypothesis and accepts the alternative hypothesis, H_{A2a}.** This indicated that *Open Innovation* has a significant and positive influence on *Commercialisation Success*. This explanation is also applicable for interpretations of hypothesis, **H_{A2c}.**

On the other hand, when *Collaborative Research Advantage* increases by 1 unit, the *Commercialisation Success* is predicted to increase 0.248 unit with a standard error of 0.208. The influence of *Collaborative Research Advantage* on *Commercialisation Success*, however, was not significant ($p = 0.232$) at the 0.05 level. The bootstrap estimates for *Collaborative Research Advantage* were calculated to cross-validate the actual beta estimate with lower and upper limit of -0.115 and 0.681, where zero was included in the 90% confidence interval. Since the $p > 0.05$, the research accepts the null hypothesis, H_{O2b}. This indicated that *Collaborative Research Advantage* has no significant influence on *Commercialisation Success*.

5.6.2.6 Post Hoc Analysis

A post hoc analysis or *specification searches* in structural equation modeling (SEM) is a process of further modifying a model so as to improve its parsimony (MacCallum 1986). A study by MacCallum (1986) indicated that the likelihood of success in a specification search is optimal when a researcher's preliminary model corresponds closely to the true model. Based on the structural analysis results on the hypothesised model (Table 5.32), the research proceeded with a post hoc analysis in order to arrive at a more parsimonious model. Accordingly, the insignificant latent construct of *Collaborative Research Advantage* and its measuring items were removed revealing a simple model with standardised estimates as shown in Figure 5.12.

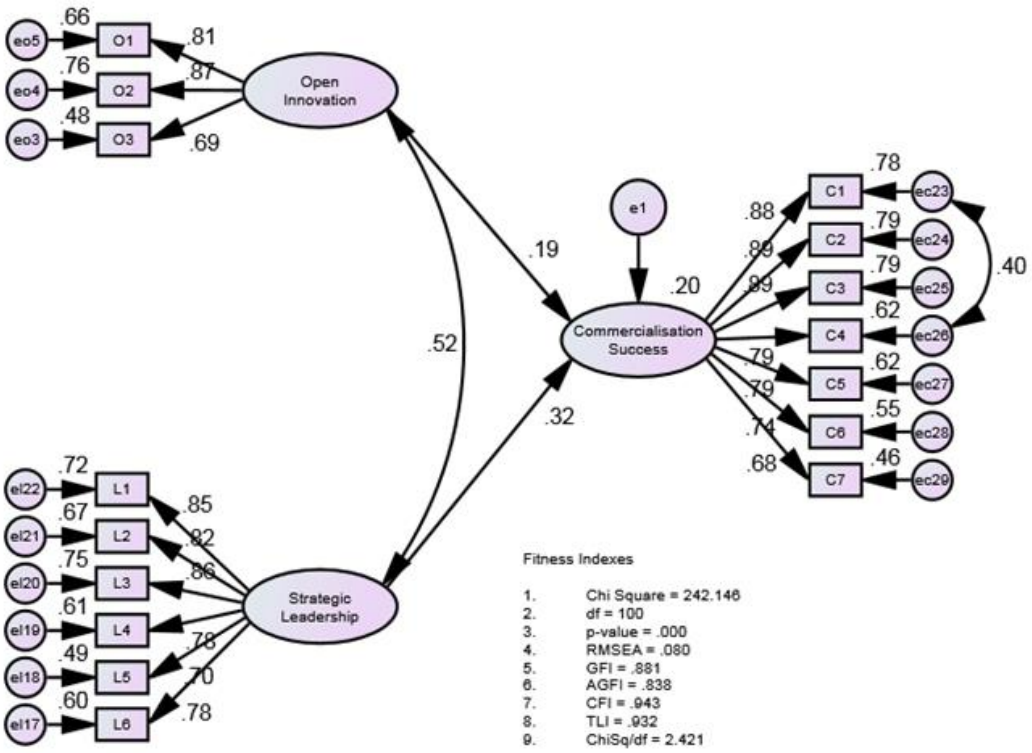


Figure 5.12: The standardised regression weights (beta estimate) for the simple model.

Based on Figure 5.12, the fitness indexes yielded a good model with a ChiSq/df = 2.421, a RMSEA = 0.080 and a CFI = 0.943. The AMOS 22 text outputs of the unstandardised regression weights (actual beta estimate) are presented in Table 5.33.

Table 5.33: The unstandardised regression weights (actual beta estimate) results for the simple model.

The Path	Actual Beta Estimate	S.E.	C.R.	*p*-value	Bootstrapping Bias-corrected at 90% Confidence Interval	
					Lower	Upper
CS <--- OI	0.320	0.143	2.243	**0.025**	0.032	0.675
CS <--- SL	0.670	0.172	3.898	***	0.314	0.982

Note: Based on 1,000 bootstrap samples; ***$p < 0.001$.

Based on Table 5.33, the regression weights for *Open Innovation* and *Strategic Leadership* in the prediction of *Commercialisation Success* were significant and highly significant at the 0.05 and 0.001 level (two-tailed). The squared multiple correlations (R^2) for *Commercialisation Success* was 0.20. Both predictors in the simple model explained 20% variance of *Commercialisation Success* compared to 21% variance contributed by three predictors as in the hypothesised model.

Further post hoc analysis also revealed an alternative mediating model with the standardised estimates as presented in Figure 5.13.

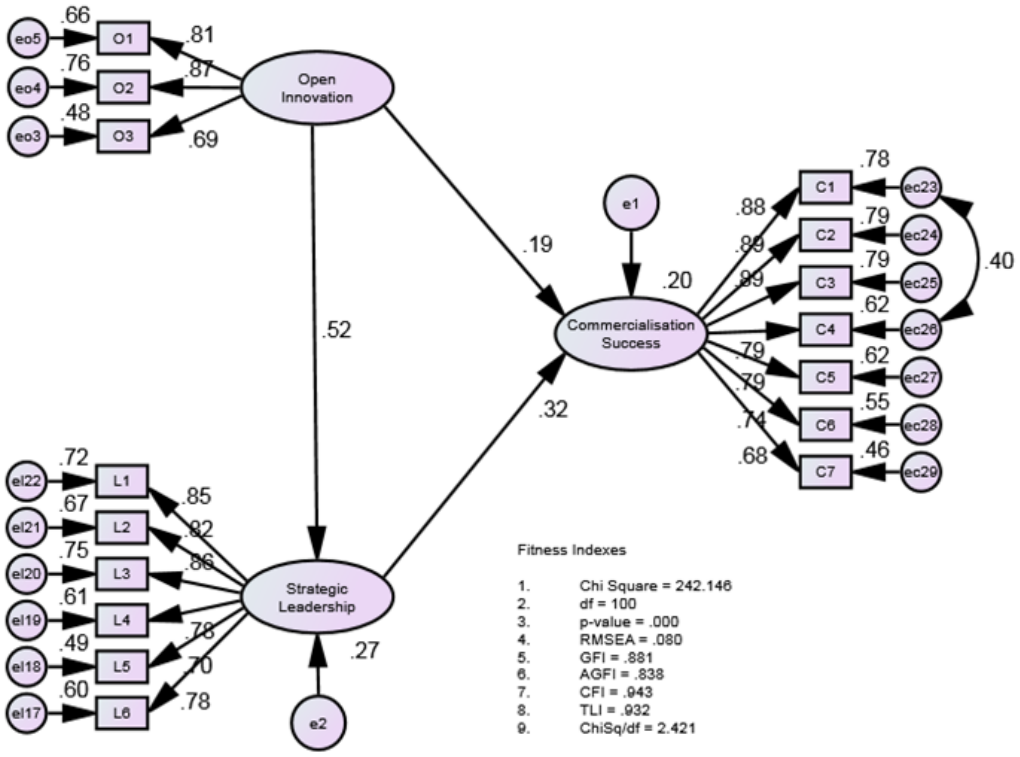


Figure 5.13: The standardised regression weights (beta estimate) for the alternative mediating model.

Based on Figure 5.13, the fitness indexes yielded a good model with a ChiSq/df = 2.421, a RMSEA = 0.080, and a CFI = 0.943. The AMOS 22 text outputs of the unstandardised regression weights (actual beta estimate) are presented in Table 5.34.

Table 5.34: The unstandardised regression weights (actual beta estimate) results for the alternative mediating model.

The Path	Actual Beta Estimate	S.E.	C.R.	P-value	Bootstrapping Bias-corrected at 90% Confidence Interval	
					Lower	Upper
CS <--- OI	0.320	0.143	2.243	**0.025**	0.032	0.675
CS <--- SL	0.670	0.172	3.898	***	0.314	0.982
SL <--- OI	0.425	0.061	6.939	***	0.297	0.578

Note: Based on 1,000 bootstrap samples; ***$p < 0.001$.

Based on Table 5.34, the regression weights for indirect relationships between *Open Innovation* and *Strategic Leadership* in the prediction of *Commercialisation Success* was highly significant at the 0.001 level (two-tailed). The squared multiple

correlations (R^2) for *Strategic Leadership* as predicted by *Open Innovation* was 0.27 (or 27% of its variance).

5.6.2.7 Multigroup Analysis

Multigroup analysis was used to examine whether or not the structural model is equivalent (i.e. invariance) across particular groups of interest (Byrne 2013). Based on the bivariate analysis results in Section 5.6.1.7 and 5.6.1.8, the mean scores of *Commercialisation Success* were significantly not equal between the *Innovation Actors* when they were classified according to their 'industrial experience' and 'industrial research'.

A minimum sample size of 85 was required for the research to achieve statistical power analysis and precision in parameters estimation (Dawson 2014). Thus, the multigroup analysis was conducted to confirm whether the simple structural model was equivalent between two groups of *Innovation Actors* with industrial experience (N = 125) and without industrial experience (N = 97). The multigroup analysis was not done for 'industrial research' categories due to insufficient sample size for each group. The third objective of the research, specific for this multigroup analysis is as follows:

Objective 3: To examine whether the innovation relationships model differs across two groups of *Innovation Actors* (i.e. with and without industrial experience).

The related research question for the stated objective is: Is the innovation relationships model of *Open Innovation*, *Strategic Leadership* and *Commercialisation Success* equivalent across two groups of *Innovation Actors* based on industrial experience? The alternative hypotheses tested using the multigroup analysis are as follows:

H_{A3a}: The innovation relationships model of *Open Innovation* and *Commercialisation Success*, is not equivalent between the *Innovation Actors* when they are grouped according to their industrial experience.

H_{A3b}: The innovation relationships model of *Strategic Leadership* and *Commercialisation Success*, is not equivalent between the *Innovation Actors* when they are grouped according to their industrial experience.

The multigroup analysis used a critical ratio (C.R.) difference test that consists of z-score for a simpler way to test the significance of structural equivalent (Afthanorhan, Ahmad & Safee 2014). Using AMOS 22, the text outputs for the critical ratio (C.R.) difference test are shown in Table 5.35.

Table 5.35: The unstandardised regression weights (actual beta estimates) and the critical ratio (C.R.) difference test results.

The Path	With Industrial Experience		Without Industrial Experience		Critical Ratio (C.R.) Difference Test	Result
	Actual Beta Estimate	*p*-value	Actual Beta Estimate	*p*-value		
CS <--- OI	0.208	0.299	0.294	0.128	0.311	Rejected
CS <--- SL	0.815	***	0.633	0.011	-0.522	Rejected

Note: ***$p < 0.001$.

Based on Table 5.35, the critical ratio (C.R.) difference test values for the paths or relationships between *Open Innovation* and *Strategic Leadership* on *Commercialisation Success* were 0.311 and -0.522 that equated to probability (*p*) values of 0.378 and 0.301. Since both the C.R. values were between ±1.96 (i.e. $p > 0.05$), the research accepts the null hypotheses. Therefore, the innovation relationships model consisted of *Open Innovation, Strategic Leadership* and *Commercialisation Success* was equivalent between the *Innovation Actors* when they were grouped according to their industrial experience.

5.7. Content Analysis

There was one open-ended question in the questionnaire asking the respondent's general or specific opinions about the research. The data were examined manually using a direct content analysis technique that further informed the research and provided avenues for improving the research in the future. This technique allowed the

researcher to make subjective interpretations of the content (Elo & Kyngäs 2008) and classified the text data into systematic categories as presented in Table 5.36.

Table 5.36: Summary of the content analysis on open-ended question.

Category	Responses
1. Theoretical	A respondent perceived the concepts of 'share' and 'promote' as similar meanings and recommended for a clearer definition. Other respondents responded that an integration between academic and industry was an excellent effort, but such collaboration could be different in other countries. In a country like Malaysia, for example, it is much easier to gain intellectual property rather than to commercialise a product from academic research work. In Malaysia particularly, research needs to have 'personal' contact rather than 'online' contact.
2. Methodological	Several respondents commented that the instrument format such as the rating scale (1-10) was too broad, the fonts were small, too many questions and too long, the form outdated, preferred a digital format and unnecessary ethnical profiling. On the other hand, there were a few responses that appraised the instrument as a nice survey form. Other respondents mentioned the importance of assessing the individual's research expertise as it may affect their perceptions towards commercialisation. For example, some of the questions might not be applicable to a clinical doctor who was employed in a teaching hospital or the service section. Or, some questions might be irrelevant to researchers who preferred to solve social issues rather than for industrial oriented. Thus, it was advisable to also seek input from different groups of researchers, such as from the industry.
3. Practical	Some respondents had minimal or no experience in university commercialisation and industry collaboration particularly those who were from pure sciences or social science areas. There was also lack of collaboration among researchers especially among the interdisciplinary knowledge production area. Some respondents had been involved in research work with the industry in terms of sharing facilities, student exchange, prototype testing and they knew how to commercialise products. Other respondents suggested that research culture should always be groomed in the society that is supported by top management in order to create good network linkages between academia and industries. The academic researchers must enhance their social capital and focused on certain research groups. The university research should also stay independent of industrial complexity or else the outcomes could be compromised or corrupted. One specific comment regarding the foreign academic employment scheme was regarding its short term basis of one-year contract (extendable). This situation impeded them from conducting research as their focus was mainly on studies (academic teaching).

5.8. Conclusion

This chapter presented the analysis procedures and findings based on the data collected using an anonymous mail survey technique. Relying on survey data from 222 public university researchers in Malaysia, 13 alternative hypotheses were tested in order to achieve the research objectives and to answer the research questions outlined. A summary of the main findings as indicated by the alternative hypothesis statements is presented in Table 5.37. Discussions of the findings and conclusions of the research are presented in Chapter 6.

Table 5.37: A summary of the alternative hypotheses (H_A) results.

Research Objective & Hypothesis Statement		Findings	Results
Objective 1: To examine whether the difference in *Innovation Actors'* characteristics differ from their perceptions towards *Commercialisation Success* strategies in the university. The variables of interest are age, gender, type of university, academic qualification, research expertise, academic position, industrial experience and industrial research.			
H_{A1a}	The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their age.	Table 5.17	Rejected
H_{A1b}	The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their gender.	Table 5.18	Rejected
H_{A1c}	The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their types of university.	Table 5.19	Rejected
H_{A1d}	The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their academic qualifications.	Table 5.20	Rejected
H_{A1e}	The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their research expertise.	Table 5.21	Rejected
H_{A1f}	The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their academic positions.	Table 5.22	Rejected
H_{A1g}	The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their industrial experience.	Table 5.23	Accepted
H_{A1h}	The mean scores of *Commercialisation Success* are not equal between the *Innovation Actors* when they are classified according to their industrial research.	Table 5.24	Accepted

Table 5.37: A summary of the alternative hypotheses (H_A) results (continued).

Research Objective & Hypothesis Statement		Findings	Results
Objective 2: To examine whether there are significant influences of *Open Innovation*, *Collaborative Research Advantage* and *Strategic Leadership* on *Commercialisation Success* strategies in the university.			
H_{A2a}	*Open Innovation* has significant and positive influence on *Commercialisation Success.*	Table 5.32	Accepted
H_{A2b}	*Collaborative Research Advantage* has significant and positive influence on *Commercialisation Success*.	Table 5.32	Rejected
H_{A2c}	*Strategic Leadership* has significant and positive influence on *Commercialisation Success*.	Table 5.32	Accepted
Objective 3: To examine whether the innovation relationships model differs across two groups of *Innovation Actors* (i.e. with and without industrial experience), given a baseline model that is identical across groups.			
H_{A3a}	The innovation relationships model of *Open Innovation* and *Commercialisation Success* is not equivalent between the *Innovation Actors* when they are grouped according to their industrial experience.	Table 5.35	Rejected
H_{A3b}	The innovation relationships model of *Strategic Leadership* and *Commercialisation Success* is not equivalent between the *Innovation Actors* when they are grouped according to their industrial experience.	Table 5.35	Rejected

CHAPTER 6: CONCLUSIONS AND IMPLICATIONS

"Everything should be made as simple as possible, but not simpler."
- Albert Einstein, a physicist (1879 – 1955)

6.1. Introduction

The research for this thesis examined the lack of effective social relationships in innovation networks that underpin successful commercialisation. The context for the research was Malaysian public universities involved in innovation and commercialisation. This chapter concludes the findings derived from the investigation.

Chapter 1 emphasised the background of the research and presented the research problem. Then, the research objectives were outlined, as shown in Table 6.1, and the significance of this research was justified. Key elements of the research were highlighted covering the research methodology, the analyses, the delimitations of the research and the operational definitions.

Table 6.1: List of the research objectives.

No.	Research Objective
1	To examine whether the difference in *Innovation Actors'* characteristics in Malaysian public universities differ from their perceptions towards *Commercialisation Success* strategies.
2	To examine whether *Open Innovation, Collaborative Research Advantage* and *Strategic Leadership* influence *Commercialisation Success* strategies in the university. Note: *Collaborative Research Advantage* is a new construct emerging from exploratory factor analysis on items that were initially conceptualised to measure *Trust in Innovation* and *Motivation to Innovate*.
3	To examine whether the innovation relationships model differs across two groups of *Innovation Actors* (i.e. with and without industrial experience).

In Chapter 2, the extant literature relating to the research issues were reviewed and gaps in the knowledge were identified. The discussions started with the context of innovation management in Malaysian public universities. Then, the concepts of innovation and commercialisation were explored. As discussed, there is a paucity of research within the Malaysian public university context of the individual innovative behaviour(s) required to as a basis of good social relationships within innovation networks. Social constructs such as open, trust, motivation and leadership were explored in order to outline the issues. Based on this literature, the preliminary conceptual framework and hypotheses were developed.

Next, Chapter 3 explained the pragmatic and mixed methods approaches adopted for undertaking the research. The expert interviews were conducted in the first stage to confirm the preliminary conceptual framework and refine the measurement instrument. In the second stage, the major research involved a mail survey technique to validate the constructs and test the research hypotheses.

Chapter 4 presented the validation steps taken for improving the research quality, including results from the expert interviews that were analysed with NVivo 10 using content analysis procedures. The outcomes from the pre-test and pilot surveys were also discussed in this chapter.

Chapter 5 then analysed the data collected from the mail survey using SPSS 22 and AMOS 22 involving pre-data analysis, descriptive statistics, exploratory factor analysis, between-group analysis, structural equation modeling and multigroup analysis. The research hypotheses were tested so that the research objectives could be achieved together with answering the research problem and questions outlined in Chapter 1.

Finally, in this Chapter 6, the conclusions are drawn from the findings presented in Chapter 5, and with the gaps explored in the literature reviewed in Chapter 2. There are nine sections in this Chapter as shown in Figure 6.1. Firstly, the introduction of the chapter is presented in Section 6.1. Next, conclusions are made about the research objectives in Sections 6.2, 6.3 and 6.4 by comparing the findings with the literature. Section 6.5 then concludes the main findings in relation to the research problem. A summary of the conclusions and contributions of the research is presented in Section 6.6. Implications of the findings for theory, method, practice and

policy are provided in Section 6.7. Finally, Sections 6.8 and 6.9 discuss limitations of this research and recommendations for future research.

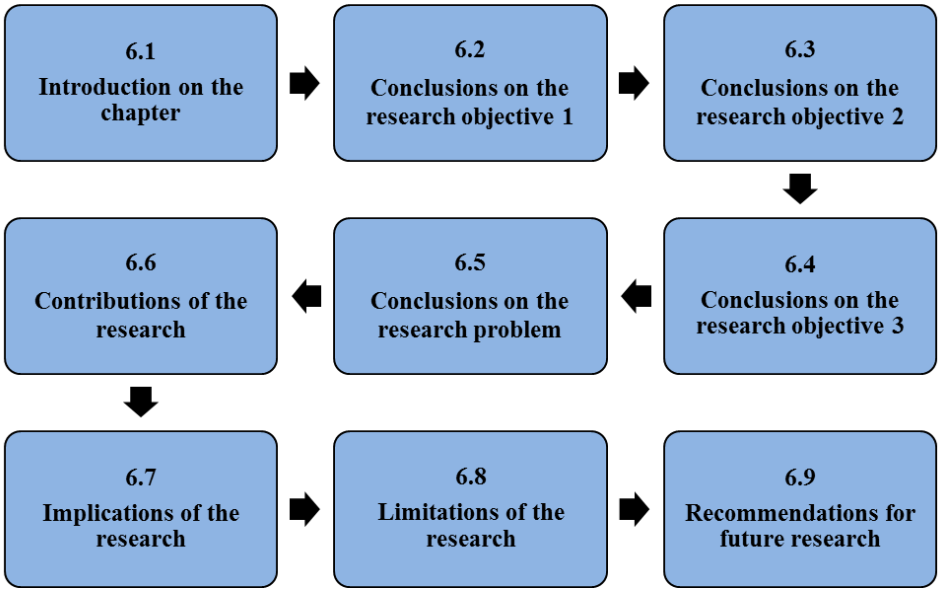


Figure 6.1: The outline of Chapter 6 on the research conclusions and implications.

6.2. Conclusions Related to Research Objective 1

The first objective of this research is now restated: To examine whether the difference in *Innovation Actors'* characteristics in Malaysian public Universities differ from their perceptions towards *Commercialisation Success* strategies. There were eight demographic characteristics of interest: age, gender, type of university, academic qualification, research expertise, academic position, industrial experience and industrial research. Two main conclusions can be made for Research Objective 1.

The first conclusion relates to the insignificant individual characteristics in determining the type of commercialisation strategy adopted in public universities. The *Commercialisation Success* strategies considered by university researchers were the same irrespective of their age, gender, type of university, academic qualification, research expertise and academic position.

The literature suggested that individual innovation is the foundation for high-performance and success (Pratoom & Savatsomboon 2012; Zheng 2013). Thus, various individual characteristics represented by demographic differences such as age and education level significantly relate to innovative behaviour (Arad, Hanson & Schneider 1997; Pratoom & Savatsomboon 2012). In addition, the innovation actor's

employment characteristics, such as the type of university they were associated with, field of research expertise and academic position, were found to relate to inter-organisational network relationships for external sources of innovation (Perkmann & Walsh 2007) and perceptions of commercialisation strategies (Yaacob et al. 2011).

In this research however, the findings suggest that certain demographic characteristics do not relate to university researchers' perceptions towards commercialisation strategies. This was because there were no differences in the responses (based on mean scores) of the commercialisation strategies when the university researchers were classified according to their age (i.e. young, junior or senior researcher), gender (i.e. male or female), type of university (i.e. research or non-research focused university), academic qualification (i.e. doctorate or non-doctorate level), research expertise (i.e. science, technology or social science) and academic position (i.e. professor, associate professor or lecturer). Types of commercialisation strategies examined in the research related to establishing joint ventures, using licensing agreements or commercialisation agents, forming spin-offs, selling ready-made products, participating in exhibitions, providing other services such training and development with industries. Thus, these findings were at odds with the literature noted earlier yet offer interesting insights about demographic factors related to commercialisation within the university.

The second conclusion relates to the significant individual characteristics in determining the type of commercialisation strategies adopted within the public university domain. The *Commercialisation Success* strategies adopted by university researchers were different based on two characteristics: working experience with industry and conducting research for industry.

The literature has shown that industrial experience has contributed significantly to innovation actor's attributes in innovation development processes (Schäfer & Richards 2007; Sharma, Kumar & Lalande 2006). As university researchers have been criticised for being too theoretical with limited experience in real business realities (Fontana, Geuna & Matt 2006), experience with industry bridges a mutual knowledge gap for commercialisation of university science by reducing the anticipated coordination costs (Kotha, George & Srikanth 2013). Furthermore, research institutes with stronger orientation to applied research and industry

engagement are more inclined to become involved in knowledge and technology transfer activities as well as commercialisation (Arvanitis, Kubli & Woerter 2008).

In turn, and consistent with prior research, the findings of this research suggest that the level of consideration for adopting commercialisation strategies is higher among university researchers with industrial working experience. The difference in the responses of the commercialisation strategies between university researchers with and without industrial working experience is 0.74 ± 0.30 (i.e. mean difference and standard error). The industrial experience has a medium effect (i.e. 0.33) on *Commercialisation Success* strategies based on Cohen's *d* effect size indices (Cohen 1988).

In addition, this research shows that the level of consideration for adopting commercialisation strategies is higher among university researchers who have conducted research in industry. The difference in the responses of the commercialisation strategies between university researchers who have and have not conducted research for industries is 0.85 ± 0.31 (i.e. mean difference and standard error). The industrial research has a medium effect (i.e. 0.38) on *Commercialisation Success* strategies based on Cohen's *d* effect size indices.

In summary, the findings of this research in relation to Research Objective 1 in relation to industrial experience (either working or conducting research) does contribute to innovation actors' behaviour and has a medium effect on innovation processes. Thus, these findings make a significant contribution to the body of knowledge. That is, interactions with industry have led to very important innovation actor's experiences and innovative behaviours towards commercialisation (Schäfer & Richards 2007).

6.3. Conclusions Related to Research Objective 2

The second objective of this research is now restated: To examine whether *Open Innovation, Collaborative Research Advantage* and *Strategic Leadership* influence *Commercialisation Success* strategies in the university. Three main conclusions can be made for Research Objective 2 based on the revised conceptual model shown in Figure 6.2.

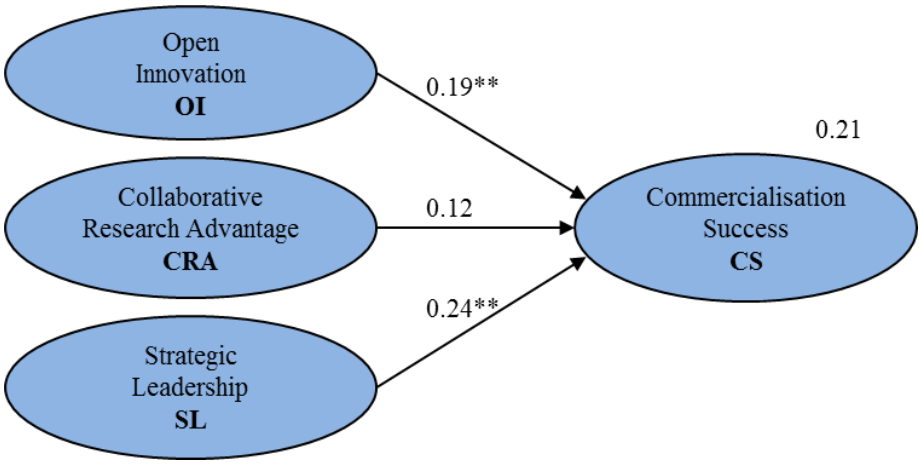


Figure 6.2: The innovation relationships model of a successful commercialisation developed for the research.
Note: The standardised regression weights (beta) estimated using AMOS 22, $^{**}p < 0.05$.

Based on Figure 6.2, *Open Innovation* and *Strategic Leadership* have a significant and positive influence on *Commercialisation Success*. This is not the case for *Collaborative Research Advantage* as previously outlined in Section 5.6.2.5. It is estimated that the predictors of *Commercialisation Success* explained 21% of its variance.

6.3.1. Open Innovation

The first conclusion relates to the significant relationship between open innovation practices and commercialisation success strategies. The literature defined open innovation as a way of conducting collaborative research for commercialising new innovation into markets where various actors interact or network (Bogers 2011; Østergaard 2009). Within the university context, researchers connect with other innovation actors for the purpose of forming knowledge partnerships (Hewitt-Dundas 2012). This suggests that greater commercial success is determined by networked research and innovation activities (Radosevic & Yoruk 2012). Open innovation is widely practiced through inbound and outbound modes (Chesbrough & Brunswicker 2014), where the use of inflows and outflows of knowledge accelerates organisational internal innovation for external application and commercialisation (Chesbrough 2007).

In this research and in confirmation of prior research, the findings suggest that open innovation significantly influences commercialisation success. University researchers do practice an open approach in innovation by sharing, promoting and

contributing ideas or other resources to people outside of the university. This is evident for outbound modes of open innovation practices for commercialisation. However, exploration of external resources (classified as inbound modes of open innovation practice) is not apparent in this research. The inbound practices examined in the research such as purchasing ideas (in the form of intellectual property), adopting ideas or getting input from others is not a significant practice within universities.

The strategies for commercialisation of university research outputs are either directly implemented through business development (i.e. forming joint ventures and spin-offs) or indirectly using licensing, commercialisation agents, participating in innovation exhibitions and providing other services such as training and consultation. Because academics are regarded as experts in specific knowledge, people from outside the university, such as government and industry, tend to seek their expertise instead of vice versa. In confirmation of prior literature, small and medium enterprises, for example, consider university experts as a source of innovation knowledge (Janeiro, Proença & Gonçalves 2013; Purcarea, Espinosa & Apetrei 2013). Thus, these findings make a significant contribution to the body of knowledge.

6.3.2. Collaborative Research Advantage

The second conclusion relates to the insignificant relationship between collaborative research advantage and commercialisation success. The literature emphasised the importance of collaborative research for commercialisation in particular during the production and marketing stage (Azmi & Alavi 2013). The process of commercialisation involves various sub-processes (West & Bogers 2013) and innovation actors (Perkmann et al. 2013). According to prior research, collaboration has the key advantage of bridging the knowledge and resources gap between academia and the business world. Innovative organisations are increasingly aware of the need to explore external resources and exploit their internal resources for effective research and commercialisation success (Grimaldi, Quinto & Rippa 2013). It was also suggested that universities collaborate with others (from industries in particular) in order to gain strong knowledge of current business practices and skills related to market trends, customer needs, investment and marketing information (Narayan 2011).

Nevertheless, the findings of this research are at odds with the literature noted above. This research found that collaborative research advantage does not influence commercialisation success. The collaborative advantages identified in the research pertain to establishing a research niche, improving product quality, reducing research costs and enhancing academic reputation. These collaborative advantages however, do not significantly influence commercialisation success. This finding is consistent with a study by von der Heidt and Scott (2009) where collaborative innovation is not directly associated with successful outcomes for commercialisation and business. Further, collaboration provides a basis for future competition (Wonglimpiyarat 2010).

One possible explanation for these findings is that the primary aim for university reserachers conducting collaborative research is for professional reasons rather than commercial. There is empirical evidence indicating that university commercialisation is influenced by intangible motivation (Aziz et al. 2013; Ismail 2012; Padilla-Mele´ndez & Garrido-Moreno 2012). For example, the non-pecuniary benefits that can motivate innovation actors related to sharing community of practices, learning new ideas, receiving supports (Antikainen, Mäkipää & Ahonen 2010) and gaining technological updates (Fiaz 2013). Thus, these findings are at odds with the literature noted earlier.

6.3.3. Strategic Leadership

The third conclusion relates to the significant relationship between strategic leadership and commercialisation success. The literature suggested that there is an increasing need for public universities to look for new funding arrangements by generating their own income (Blackman & Kennedy 2007) and conducting university research for economic rationality (Nonaka 1994). To accommodate these needs, the strategic objective of gaining commercial advantage is another strong priority for universities (Ab. Aziz et al. 2012). Therefore, universities increasingly require academic researchers with strategic leadership skills that can influence research cultures to be more commercially driven (Collier, Gray & Ahn 2011).

In confirmation of much prior literature, the findings in this research suggest that strategic leadership does significantly influence commercialisation success. Managing research and innovation in a not-for-profit organisation such as a public

university is challenging because of the bidirectional missions between meeting academic and industry needs. Leaders of universities need to strategically manage organisational missions as well as balance the needs of individual university researchers. Leadership is an important factor that influences research cultures that help organisations in prioritising and managing their innovation strategically (Mir & Rahaman 2006), through open communication, social networking and knowledge sharing (Asmawi, Zakaria & Wei 2013).

Many elements of leadership are relevant to innovation (Arad, Hanson & Schneider 1997). More broadly, these relate to shared values, styles, skills and structures (Johne & Snelson 1990). The strategies or leadership skills identified in this research are maximising potential resources, supporting innovative culture, setting out clear missions, managing conflicts, employing new approaches and promoting research networking. It is well noted from these findings that strategic leadership is a more dominant construct for managing commercialisation in public universities. The leaders need to strategically manage the situations and the multiple innovation activities that are highly integrated among various innovation actors, while aiming for effective and successful outcomes. The argument is that working with others can be a source of constructive conflict that needs to be managed strategically. Accordingly, the findings here add significantly to the existing literature, particularly specific strategic leader behaviour required to support commercialisation success.

6.4. Conclusions Related to Research Objective 3

The third objective of this research is now restated: To examine whether the innovation relationships model differs across two groups of *Innovation Actors*. The model consisted of *Open Innovation*, *Strategic Leadership* and *Commercialisation Success*. The two groups of *Innovation Actors* of interest are those with and without working experience in industry. This is an additional research objective developed during the research process based on the findings from Research Objective 1.

One main conclusion can be made for Research Objective 3. Although the level of consideration for adopting commercialisation success strategies is higher among university researchers with industrial working experience compared to those without industrial experience, it does not, however, relate to the overall inter-

relationships between the constructs examined. In other words, is the innovation relationships model of *Open Innovation*, *Strategic Leadership* and *Commercialisation Success* equivalent across two groups of Innovation Actors when grouped according to their industrial experience? This research finding showed a complex explanation that cannot be confirmed or unconfirmed by the literature. The findings indicate that prior working experience in the industry does not influence mutual sharing of resources (in relation to open innovation) or enculturation of effective innovation (in relation to strategic leadership).

There is no comprehensive empirical evidence in relation to the impact of industrial experience on open innovation practices, strategic leadership and successful commercialisation strategies. There is also little understanding related to how university researchers interact with industry and, when they interact, what types of tasks or activities they perform (Boardman 2009). Innovation is at the vanguard of industry commercialisation because it is connected to organisational productivity, commercial performance and competitive advantage. Innovative business cultures in industry are different to university innovation cultures that promote scientific research. It is possible however, that university researchers with working experience in industry have been exposed to business cultures that are more innovative in respect to commercialisation. Thus, this research makes a contribution to some extent to the current knowledge regarding the actual impact of industrial experience on commercialisation success.

6.5. Conclusions on the Research Problem

Chapter 2 concluded with a preliminary conceptual framework. This section presents a revised framework derived from the data analysis and discussions of the research objectives described earlier. Moreover, other literature has been incorporated here to support the explanations of the revised framework as shown in Figure 6.3. This final framework provides a basis for the conclusions about the research problem.

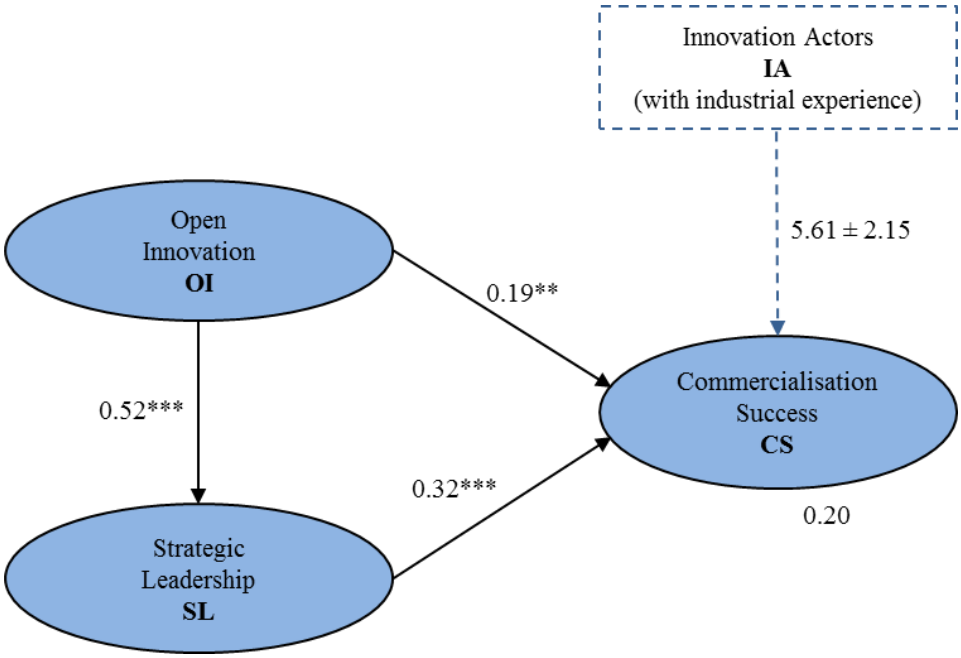


Figure 6.3: The revised, final conceptual framework.

Note: The standardised regression weights (beta) estimated using AMOS 22, $^{**}p < 0.05$, $^{***}p < 0.001$, (mean ± S.D.).

The research problem is now restated: There is ineffective management of social relationships within innovation networks that underpin successful commercialisation attempts. Scholars have defined *'commercialisation success'* as a strategy of introducing new ideas or innovation into the market for application (Gassmann & Enkel 2004). According to the literature, commercialisation problems emerge unless the commercialisation process is equipped with: (1) a pool of ideas generated through a series of research activities (Gallego, Rubalcaba & Hipp 2013), (2) intensive efforts towards production and marketing (Azmi & Alavi 2013), (3) integration of multiple innovation processes (West & Bogers 2013), and (4) involvement of various innovation actors (Perkmann et al. 2013) within a innovation network. The literature had suggested that commercialisation needs to be underpinned by open innovation to ensure process management efficiency (Lee et al. 2010). The concept of *'open innovation'* relates to innovating with partners where firms should apply internal and external ideas, resources and strategies for successful commercialisation (Chesbrough 2003b).

Within the Malaysian public universities context, there has been little progress in the commercialisation rate (Ab. Aziz et al. 2012; Govindaraju, Ghapar & Pandiyan 2009) with 95% of public university research outputs failing to be commercialised (OECD 2013). There is an increasing need for universities to generate their own

income (Blackman & Kennedy 2009), to increase the commercial value of their research outputs (Gertler 2010; Tether 2002) and to contribute to economic development (Roper & Hewitt-Dundas 2012). To accommodate these needs, universities require managers with strategic leadership skills that can influence research cultures to be more commercially oriented (Collier 2007), including being more open and networked (Ahn & York 2011; Asmawi, Zakaria & Wei 2013).

Based on Figure 6.3, three main conclusions can be made about the research problem. First, in support of prior literature, this research found that open innovation and strategic leadership have a significant influence on commercialisation success (R^2 = 20%). Second, strategic leadership emerged as a dominant factor because it has a direct relationship with commercialisation success and, more importantly, it mediates indirect relationships between open innovation and successful commercialisation. The intervening role of leadership demonstrated in this research supports previous studies that leaders mediate or enhance innovative behaviour for idea generation and application through openness and supportive work climates (Chou et al. 2010; de Jong & Den Hartog 2007). Third, university researchers (or innovation actors) with working experience in industry are more likely to adopt commercialisation success strategies. Thus, open innovation practices coupled with strategic leadership skills are able to advance effective management of innovation network relationships for commercialisation success. Accordingly, these findings make a major contribution to the knowledge bank about the link between strategic leadership, open innovation and commercialisation success within the Malaysian public university context.

This research also highlights the importance of individuals' behaviour in relation to open innovation practices (Salter, Criscuolo & Ter Wal 2014). As open innovation involves the sharing of various resources, strategic leaders are required to synergise the resources within networks of research intensive organisations (Patterson & Ambrosini 2015) where universities act as a knowledge 'manufacturer' and link between the science and the market (Asikainen 2015).

6.6. Contributions of the Research

In exploring the contributions of the research, the findings presented in Chapter 5 are examined together with the literature reviewed in Chapter 2.

The conclusions are organised based on the research objectives and the research problem outlined. Existing innovation studies may have investigated similar research problems, but they have not specifically investigated these problems from a socio-psychological perspective within a public university context. There is little or limited current empirical evidence pertaining to the research problem which potentially highlights the contributions of this research.

Overall, this research makes three contributions. First, minor contributions can be identified where the findings were at odds with the literature. Second, some contributions are made to the body of knowledge on open innovation and commercialisation where previous problems have been identified without empirical investigation. Third, a major contribution is made in advancing knowledge related to the role of leaders in enhancing open innovation networks (Patterson, Kerrin & Gatto-Roissard 2009) and the links between the independent and dependent variables as outlined in Figure 6.3. A summary of the conclusions and contributions is presented in Table 6.2.

Table 6.2: A summary of the conclusions and contributions of the research.

No	Conclusion on research objectives and problem	Contribution to innovation management knowledge
1	The *Commercialisation Success* strategies adopted by university researchers was the same irrespective of their age, gender, type of university, academic qualification, research expertise and academic position.	Minor
2	The *Commercialisation Success* strategies adopted by university researchers were different based on two characteristics: working experience with industry and conducting research for industry.	Major
3	*Open Innovation* has a significant and positive influence on *Commercialisation Success*.	Major
4	*Collaborative Research Advantage* does not significantly influence *Commercialisation Success.*	Minor
5	*Strategic Leadership* has a significant and positive influence on *Commercialisation Success.*	Major

Table 6.2: A summary of the conclusions and contributions of the research (continued).

No	Conclusion on research objectives and problem	Contribution to innovation management knowledge
6	Although the level of consideration for adopting *Commercialisation Success* strategies is higher among university researchers with industrial working experience compared to those without industrial experience, it does not however, relate to the overall inter-relationships between *Open Innovation, Strategic Leadership* and *Commercialisation Success*.	Some
7	*Strategic Leadership* emerged as a dominant factor because it has a direct relationship with *Commercialisation Success*. It also mediates an indirect relationship between *Open Innovation* and successful commercialisation.	Major

6.7. Implications of the Research

The research findings and contributions have implications for innovation and commercialisation management in public university sectors from a theoretical, methodological and practical aspect.

6.7.1. Theoretical Implications

There appears to be strong relationships between innovation performance and the social constructs of openness, trust, motivation and leadership in the literature. Scholars have suggested that open innovation has a significant influence on facilitating successful commercialisation (Chesbrough & Brunswicker 2014). Others have suggested that social interactions are the underlying principle for opening the innovation process (Neyer, Bullinger & Moeslein 2009), where constructs such as trust, motivation and leadership potentially influence the level of innovativeness among different types of innovators. For example, networking can promote social interactions which generate trust that is conducive to knowledge transfer and innovation (Pittaway et al. 2004). However, there are few studies that comprehensively

conceptualise social constructs such as openness, trust, motivation and leadership in association with commercialisation success. This is particularly the case within public universities in Malaysia. Thus, theory testing in this research has been challenged by the lack of focus in the extant innovation literature on building good social networks relationships for innovation and commercialisation purposes. Accordingly, this research has four implications for innovation theory.

First, this research provides empirical evidence that *open innovation* and *strategic leadership* can be used to explain the outcomes of *commercialisation success* by at least 20%. Other explanations of antecedent or moderating variables influencing the relationships are not obvious in this research and could be explored in subsequent research. This finding indicates that openness and leadership have a direct bearing on successful commercialisation in Malaysian public universities. This research provides a systematically synthesised model of the inter-relationships between *open innovation, strategic leadership* and *commercialisation success.* The results are empirically tested in a non-industrial context such as public universities. However, it is well known that empirical management studies between two variables is dependent on a third variable (Dawson 2014).

Indeed, the second theoretical implication is with regard to the alternative model where *strategic leadership* has a more significant mediating (or indirect) effect on the relationship between *open innovation* and *commercialisation success*. This finding suggests that open innovation acted only as a "facilitator" (Rice et al. 2012) and that strategic leadership played the main predictive role that influences university innovation and commercialisation performance (Elenkov, Judge & Wright 2005). This research provides the first empirical investigation of the importance of leadership in mediating open innovation practices among Malaysian public university researchers leading to successful commercialisation strategies. This evidence provides an explanation of the organisational gap between innovation management and innovation performance while recognising the importance of strategy and leadership (Damanpour & Wischnevsky 2006) within a university context.

Third, the preliminary research framework conceptualised *trust in innovation* and *motivation to innovate* as having an association with commercialisation success. Trust is the key property of social relationships according to prior research as noted. Trust also was closely linked with people expectations and motivations regulated by

various types of obligations (Misztal 2013). The literature suggested that a culture based on trust can be more effective than monetary incentives (or motivations) in sustaining innovation (Barsh, Capozzi & Davidson 2008). Indeed, in many behavioural studies, motivation has been found to be one of the most confusing concepts (Shamir 1991). These mixed ideas confounded the roles of trust and motivation as conceptualised in this research. The factorial analysis conducted on the items that were used to measure *trust in innovation* and *motivation to innovate* revealed that both constructs emerged as a single construct namely *collaborative research advantage*. As commercialisation processes require collaborative efforts, the association between networked innovation actors creates complex social relationships (Tichy, Tushman & Fombrun 1979). Many studies examined trust or motivation in relation to innovation (e.g. Decter, Bennett & Leseure 2007; Plewa et al. 2013), but those studies were fragmented and none examined both constructs at once. Thus, the social constructs of trust and motivation might have multiple dimensions or overlapping definitions when examined simultaneously. This research found that these constructs can complicate the measurement procedures (Casanueva & Gallego 2010).

Finally, the fourth implication for theory concerns the other factors explaining about 80% of the variance in c*ommercialisation success*. A possible explanation of this variance is that successful commercialisation within a public university context has a broader definition, objective and strategy. For example, the objective of an innovation project is to solve a public health issue by collaborating with national policy makers which will benefit the society at large. Other innovation projects aim at generating income for the spin-off company by fulfilling industry demands with direct economic benefits. Each social and economic objectives, tangible and intangible resources, individual and organisational structures might be inter-related and co-contribute to such variance in c*ommercialisation success*. In addition, it is also well-known that innovation is a multifaceted phenomenon that has many antecedents (Becheikh, Landry & Amara 2006; Carmona-Lavado, Cuevas-Rodríguez & Cabello-Medina 2010).

In summary, this research confirmed that successful commercialisation is influenced by open innovation where sharing, promoting and contributing ideas and resources to people outside of universities are the most significant outbound mode of open innovation practices for commercialisation. More importantly, strategic

leadership has a greater direct and indirect influence on facilitating commercialisation success than open innovation. Leaders in university need to develop capabilities for successfully managing open innovation (Lichtenthaler 2011) by maximising resources, supporting innovative cultures and promoting research networking. Further, this research demonstrated the importance of industrial experience among university researchers in determining their decision for adopting commercialisation strategies. This research however, found that trust in innovation, motivation to innovate and collaborative research advantage do not necessarily influence successful commercialisation in Malaysian public universities.

6.7.2. Methodological Implications

This research espoused a pragmatic approach in investigating the problem of ineffective social relationships management within innovation networks. The latter concerned how Malaysian public universities can foster successful commercialisation. In so doing, the researcher used mixed-methods research by conducting expert interviews prior to the field survey. This practical orientation ensured the rigour and relevance of this research. Thus, this research has three methodological implications.

First, the earlier qualitative research used an expert interview technique for the purposes of confirming the preliminary conceptual framework and to refine the initial measurement instrument. Although the interviews were conducted with ten research participants among the targeted population, it allowed the researcher to confirm the relationships between the social constructs openness, trust, motivation and leadership within the context of Malaysia's public university's innovation and commercialisation management. In addition, the updated version of the survey instrument was not only based on the extant literature, but was also validated by information from the interviews content.

Second, quantitative research used a cross-sectional mail survey technique drawn from 222 research participants with a response rate of 17.4%. The reason for using a mail technique was that the pilot survey that used an online survey method showed a low response at just 3.3%. The survey technique was changed from online to mail survey in order to achieve a better response rate and thus a larger sample size that enabled reliable data analysis. The aims of this major research were to examine

the items' inter-correlations and the constructs' inter-relationships. In addition to descriptive and inferential analyses, factorial and structural analyses were also done on the final data set so as to increase the research validity and accuracy of the findings.

Finally, the third methodological implication was related to the potential mediating or moderating relationships between *strategic leadership*, *industrial experience*, *open innovation* and *commercialisation success*. These indirect relationships were proposed based on a single sample of 222 data collected in the research. In order for future research to be able to conduct a study on the mediation or moderation effects and test such complicated relationships, a larger sample size is needed (Fritz & MacKinnon 2007).

6.7.3. Practical and Policy Implications

The conclusions and contributions of this research provide benefits to Malaysian public universities in developing better practices and policies for innovation and commercialisation management. Specifically, this research has three implications for university researchers, managers and policy makers.

First, the implication for university researchers is related to using open innovation practices to facilitate successful commercialisation of research outputs. The findings of this research indicate that open innovation significantly influences commercialisation success. University researchers can benefit from an openness approach in innovation by sharing and contributing ideas (e.g. disclose their intellectual property) or other resources to people outside of universities. As two key components for commercialisation relate to ideas and collaboration, open innovation is closely linked with relational capability created through diverse social interactions (Owen-Smith et al. 2002). The purpose of such interactions is for complementing external as well as internal ideas, in order to advance the development and implementation of their innovation. Within the university context where economic benefit is a secondary aim for research and innovation, open innovation practices enable university researchers to serve the community, in this case the business community, in a more strategic way.

Indeed, coupled with a strategic leadership, open innovation offers a significant benefit to university researchers inclined towards commercially oriented research

activities. Generally, university research is not commercially-oriented that driven by economic needs (Ambos et al. 2008). The universities are cautious not to neglect their primary social responsibility of knowledge creation and dissemination. Open innovation practices alone do not guarantee successful commercialisation if university researchers have not strategically aimed their research to be more commercial-oriented. The research findings show that strategic leadership has a direct influence on successful commercialisation and an indirect influence by mediating the relationship between open innovation and commercialisation success. Therefore, university researchers need to improve their leadership skills, influence research cultures that are not just professional-oriented, but also open and commercially-oriented.

Moreover, university researchers are advised to gain industrial experience perhaps through industrial attachment and industry engagement programmes as an effective way to build mutual relationships with their business counterparts. The findings of this research demonstrate that university researchers with industrial experience have stronger inclination to commercialisation strategies compared to university researchers without industrial experience. There is evidence in the research that some university researchers, particularly those from a pure science and social science environment, have minimal or no experience with industry collaboration. The establishment of mutual relationships between academia and industry would close the gap in scientific and business knowledge (Rynes, Bartunek & Daft 2001) and complement the resources for organisations. Thus, universities cannot depend solely on physical resources such as technological and financial resources. Social resources embedded within relationships among innovative networks can be beneficial for advancing successful commercialisation outcomes.

The second implication of this research is for university managers. This is also applicable to academics who assume administrative roles. This research provides a guide on how to support good practices and develop relationships among innovation actors in innovation networks. Generally, managers need to understand how to enhance innovative behaviours among people (Patterson, Kerrin & Gatto-Roissard 2009). Specifically, with a better understanding of the complexity of public universities' research agendas (with both social and economic benefits), open innovation practices supported by strategic leadership facilitate stronger innovation

outcomes. As Adler and Seok-Woo (2002) suggested, managers should encourage social interactions among actors in order to promote better relationships within innovation networks.

The final model generated from this research shows that open innovation and strategic leadership have a positive influence on commercialisation success. The model focuses on socio-psychological elements of individuals with emphasis on openness and leadership behaviours. Managers need to focus on improving the innovation actors' social interactions that promote high innovative behaviours (Xerri 2012) in the innovation networks (Pittaway et al. 2004). The practical points relate to leading the innovation strategically by developing a strong innovation network comprised of diverse innovation actors (Barsh, Capozzi & Davidson 2008). The open research culture at universities should also be championed by top managers and leaders. This stands in direct contrast to the small group of university researchers who suggested that universities should remain independent from industrial complexity or else the outcomes could be compromised or corrupted.

Managers at university or project level should consider strategies that will encourage the development of continuous relationships between academia and industry. For example, human resource programmes specifically designed for developing business competencies among the university researchers (Helyer & Lee 2012) may be useful. Such programmes would be beneficial for university researchers to gain experience in commercialisation particularly those who have an entrepreneurial orientation (Aziz et al. 2013; Khademi et al. 2015) in taking their research outputs to market.

Thirdly, this research has implication for policy makers at university level and beyond. Universities should review their existing commercialisation policies by emphasising the need for an open approach in conducting research and innovation. Because public universities are largely funded by government, the national policies should consider flexible policy intervention (Arvanitis, Kubli & Woerter 2008) to support effective commercialisation in universities. For example, there should be a clear guideline or pathway for university researchers more inclined towards commercially-oriented research activities. The policy (new or existing) for university commercialisation should be designed together with university and industry managers in order to balance the academic and economic objectives, strategies and structures.

This policy can then be a reference point for both academics and industry when conducting collaborative innovation and commercialisation research.

6.8. Limitations of the Research

There are a number of limitations of the research for this thesis. First, an examination of the research constructs explained at least 20% of the constructs' inter-relationships (i.e. open innovation and strategic leadership on commercialisation success) among the eleven Malaysian public universities that participated in the research. That is, 80% of factors or alternative theories are not considered in the research which can potentially explain the phenomenon. For example, financial and technological factors are equally important in determining innovation performances (Lee et al. 2010).

The second limitation is in relation to the research participants. The preliminary conceptual framework was developed through extensive literature review and confirmed by expert interviews. The framework was then tested based on the data collected from 222 research participants. Thus, the generalisability of the findings is limited to the public university researchers' population in Malaysia with the same characteristics as demonstrated in the research. Explaining the commercialisation phenomenon from one group of participants (i.e. the university researchers) is insufficient. In particular, commercialisation involves multiple innovation actors from industries such as manufacturers, suppliers (Lawson et al. 2009), marketers and even customers (Laursen 2011).

Finally, the third limitation is due to biases commonly associated with behavioural research such as single-method bias (Podsakoff et al. 2003) and self-report bias (Donaldson & Grant-Vallone 2002). Using a cross-sectional self-administered survey technique exposes the research to such bias and limits the research findings for accurate interpretations, particularly in examining complex human behaviours or perceptions. In the research for example, two constructs that were initially conceptualised in the framework (i.e. trust in innovation and motivation to innovate) emerged as single constructs because of high inter-correlations between the items measured. In the end, the newly discovered constructs appeared as an insignificant factor in influencing commercialisation success. Although there were studies that support significant relationships between trust, motivation, collaboration and

innovation success, there was no evidence in the research and such concepts need to be revisited.

6.9. Recommendations for Future Research

As universities are placing more emphasis on commercialisation of research outputs, collaborations with other innovation actors (from industry in particular) are likely to become more prevalent. This will likely influence university researchers' interactions and relationships within research and innovation networks. As the commercialisation agenda in Malaysian public universities is progressing, studies should continue to examine the behaviours of university researchers and uncover ways of enhancing commercialisation success (Khademi et al. 2015).

Further research is needed to generalise the findings beyond the Malaysian public university context. While the field of innovation management is not new, research in open innovation is considered as only recent (Zhang, Ding & Chen 2014). Thus, future studies could replicate the research among private universities or research institutes, as well as industries that have collaborated with universities. The research could be replicated in other developing countries such as China or Thailand and in developed countries like Australia or Singapore. Moreover, to further validate the measurement instrument, a face-to-face survey technique is recommended to capture the real responses of participants for more accurate interpretations. Thus, the generalisability of the model to other populations remains to be determined.

Also, the significant mediating influence of strategic leadership on the relationship between open innovation and commercialisation success could be further explored. In this research, the model analysis was driven by both theories and data with the principle aim of specifying a model that is substantively meaningful, substantially well-fit and parsimonious as possible (Kline 2011, p. 8). Thus, future research could explore in detail how leadership regulates such relationships using a case study approach combined with network analysis technique that allow the generation of rich information about the complexity of the innovation phenomenon (Coulon 2005).

Another direction for future research relates to the cross-sectional nature of the research that assume model parameters are constant over time (Bowen & Wiersema

1999). Indeed, social relationships are built over time and implementations of innovation outputs are delayed – occur in later period or over multiple periods (Hambrick & Macmillan 1985). Thus, the responses given at a point of time might reflect a mixed or general perceptions about the constructs examined. The third recommendation is to further investigate the structure of the model in-depth using a longitudinal study that complements the myriad data lags. For example, a longitudinal study could be employed to investigate relationships at different commercialisation stages that allows conclusions about the causality explanations to be drawn.

Finally, future research could expand the model to include other constructs such as creativity, entrepreneurship (Chen 2007), adaptability, novelty and productivity, including other tangible resources such as technologies (Carmona-Lavado, Cuevas-Rodríguez & Cabello-Medina 2010) and intangible resources such as values (Landry, Amara & Lamari 2002). These factors could be added to the model and examined in order to reduce the unexplained variance in the existing model generated from this research. Management of network relationships for innovation is inherently difficult. University researchers and managers involved with such innovation networks need to learn core competencies for commercialisation related to business development, resources optimisation and market mechanisms.

In conclusion, while open innovation is considered as a modern concept to explain industrial innovation management strategies (Chesbrough & Brunswicker 2014) its practicality to knowledge intensive based sectors (the higher education institutions in particular) has yet to be fully explored. This research provides a model to understand the influences of open innovation and strategic leadership on commercialisation success within the Malaysian public university sector. The model is a major contribution to the body of knowledge on innovation management because it is the first model comprehensively conceptualised and rigorously generated using open innovation concept together with social constructs such as strategic leadership, including trust and motivation in examining commercialisation within a public university context.

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APPENDICES

Appendix A: List of public universities in Malaysia.

Note: RU – research focused university

1. Universiti Malaya (RU)
   Institute of Research Management & Monitoring
   Level 7, Kompleks Pengurusan Penyelidikan & Inovasi
   University of Malaya
   50603 Kuala Lumpur
   MALAYSIA
   ☎ +603-7967 4643
   🖷 +603-7967 4699
   ✉ pen_ippp @um.edu.my

2. Universiti Sains Malaysia (RU)
   Division of Research & Innovation
   Level 6, Chancellory
   Universiti Sains Malaysia
   11800 USM, Pulau Pinang
   MALAYSIA
   ☎ +604-653 3108/3988/5019
   🖷 +604-656 6466/8470
   ✉ rcmo@usm.edu.my

3. Universiti Kebangsaan Malaysia (RU)
   Centre of Research & Instrumentation Management
   Universiti Kebangsaan Malaysia
   43600 UKM Bangi, Selangor
   MALAYSIA
   ☎ +603-8921 3095
   🖷 +603-8921 3096
   ✉ drmc@ukm.edu.my

4. Universiti Putra Malaysia (RU)
   Research Management Centre
   Universiti Putra Malaysia
   43400 UPM Serdang, Selangor
   MALAYSIA
   ☎ +603-8947 1601
   🖷 +603-8945 1596
   ✉ dir.rmc@upm.edu.my

5. Universiti Teknologi Malaysia (RU)
   Research Management Centre
   Block F54, Graduate Centre Building
   Universiti Teknologi Malaysia
   81310 UTM Skudai, Johor
   MALAYSIA
   ☎ +607-553 7863
   🖷 +607-553 7811
   ✉ informc@utm.edu.my

6. Universiti Islam Antarabangsa Malaysia
   Research Management Centre
   International Islamic University Malaysia
   P.O. Box 10 50728 Kuala Lumpur
   MALAYSIA
   ☎ +603-6196 5002
   🖷 +603-6196 4862
   ✉ feedback.rmc@iium.edu.my

7. Universiti Malaysia Sarawak
   Research and Innovation Management Centre Universiti Malaysia Sarawak
   94300, Kota Samarahan, Sarawak
   MALAYSIA
   ☎ +6082-581 053
   🖷 +6082-581 155
   ✉ bfasih@rimc.unimas.edu.my

8. Universiti Malaysia Sabah
   Research and Innovation Centre
   Aras 5, Blok Utara, Bangunan Canselori
   Universiti Malaysia Sabah
   88400, Kota Kinabalu, Sabah
   MALAYSIA
   ☎ +6088-320 000 ext. 1328
   🖷 +6088-320 127
   ✉ ric@ums.edu.my

9. Universiti Teknologi MARA
Research Management Institute
Universiti Teknologi MARA (UiTM)
40450 Shah Alam, Selangor
MALAYSIA
☎ +603-5544 2094/2095
🖷 +603-5544 2096
✉ rmiuitm@salam.uitm.edu.my

10. Universiti Utara Malaysia
Research & Innovation Management Centre Universiti Utara Malaysia
06010 UUM Sintok, Kedah
MALAYSIA
☎ +604-928 4771/4768
🖷 +604-928 4756
✉ rimc@uum.edu.my

11. Universiti Pendidikan Sultan Idris
Research Management & Innovation Centre
Level 2, Chancellory Building,
Universiti Pendidikan Sultan Idris,
35900 Tanjong Malim, Perak
MALAYSIA
☎ +605-450 6417/6451/6469/6470
🖷 +605-459 4643
✉ ppp@upsi.edu.my

12. Universiti Sains Islam Malaysia
Research Management Centre
Aras 4,Bangunan Canselori
Universiti Sains Islam Malaysia
71800, Nilai, Negeri Sembilan
MALAYSIA
☎ +606-798 6647/6648/6649
🖷 ++606-798 8146
✉ rmc@usim.edu.my

13. Universiti Malaysia Terengganu
Research Management & Innovation Centre
Universiti Malaysia Terengganu
21030 Kuala Terengganu, Terengganu
MALAYSIA
☎ +609–668 3391/3495/3395
🖷 +609-668 3493
✉ pengarah-ppp@umt.edu.my

14. Universiti Tun Hussein Onn Malaysia
Office for Research, Innovation, Commercialization & Consultancy Management
Universiti Tun Hussein Onn Malaysia
86400 Parit Raja, Batu Pahat, Johor
MALAYSIA
☎ +607-453 8393/8394/8397/8398
🖷 +607-453 8399
✉ oricc@uthm.edu.my

15. Universiti Teknikal Malaysia Melaka
Centre for Research & Innovation Management
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya, 76100, Durian Tunggal, Melaka
MALAYSIA
☎ +606-331 6071/6092
🖷 +606-331 6075
✉ crim@utem.edu.my

16. Universiti Malaysia Pahang
Department of Research & Innovation
Universiti Malaysia Pahang
Lebuhraya Tun Razak
26300 Gambang, Kuantan, Pahang
MALAYSIA
☎ +609-549 2656/2088
🖷 +609-549 3382
✉ jpi@ump.edu.my

17. Universiti Malaysia Perlis

Centre for Entrepreneurship Development, Commercialisation & IP Management, Rumah Universiti, Universiti Malaysia Perlis, Kampus Kubang Gajah, 02600 Arau, Perlis
MALAYSIA

☎ +604-979 8525

🖷 +604-978 2749

✉ husnayaziz@unimap.edu.my

18. Universiti Sultan Zainal Abidin

Centre for Research & Innovation Management
Universiti Sultan Zainal Abidin
Kampus Gong Badak
21300 Kuala Terengganu, Terengganu
MALAYSIA

☎ +609-6663 941/105/106/107/108

🖷 +609-6622 142

✉ crim@unisza.edu.my

19. Universiti Malaysia Kelantan

Research Management & Innovation Center
Universiti Malaysia Kelantan
Locked Bag No. 36
Pengkalan Chepa
16100 Kota Bharu, Kelantan
MALAYSIA

☎ +609-771 7090

🖷 +609-771 7112

✉ research.pppa@umk.edu.my

20. Universiti Pertahanan Nasional Malaysia

Centre for Research & Innovation Management
National Defence University of Malaysia
Ground Floor, Research Management Complex
Camp Sungai Besi
57000 Kuala Lumpur
MALAYSIA

☎ +603-9051 3400 ext. 3085/3099

🖷 +603-9051 3084

✉ pppi@upnm.edu.my

Appendix B: The interview guide

Note: Including participant information sheet and consent form.

INTERVIEW NO. _____

I want to thank you for taking the time to meet with me today. My name is Arbaiah and I would like to talk to you about your experiences in conducting innovation research. Specifically, I am assessing the university researcher's practices when collaborating with others during innovation process that leads to commercialisation.

The interview should take about one an hour. I will voice-recording the session because I don't want to miss any of your comments, and taking some notes. All responses will be kept confidential. Your interview responses will only be shared with my research supervisor. I will ensure that any information in my report does not identify you as the respondent.

The interview is not expected to pose any risk to you. The questions are all based on your experiences and individual perceptions about innovation research. Participation is entirely voluntary. If you do not wish to take part, you are free to end the interview at any time.

Are there any questions about what I have just explained? Are you willing to participate in this interview?

[Taking the participant consent by signing off the Consent Form]

QUESTIONS

Q1. Can you tell me about your greatest innovation?
Probe Questions: What is the most innovative research you have ever conducted? What was the principle idea of the innovation?

Q2. Where did the idea of your innovation come from?

Q3. What did you do with the innovation?

Q4. How do you implement or move the innovative idea into reality?

Q5. Do you work in teams or conduct your innovation alone?
Probe Questions: During the innovation process, is anybody helped you? With whom?

Q6. Can you tell about a time when you worked with other people? What did you do?

Q7. When you collaborated with other people, how do you establish effective working relationships?

Q8. Innovation or applied research can be so complicated. How did you gain commitment?

Q9. When you were part of a work group that did not share the same mind-sets, how did you handle this situation?

Q10. What is your preferred way or strategy to exploit your intellectual property?

Before we end the interview, can I ask additional information on your career background?
(If NO, then close the interview. If YES, proceed with the following questions.)

1. How long you have been an academic researcher?
2. What is your main research area?
3. Do you have any experience working in industry?
4. Do you prefer basic or applied research?
5. How many innovations have you or your team developed?

Participants' Gender:

☐ Female
☐ Male

Finally, is there anything more you would like to add?

I will be analysing the information you gave me over the next 3-6 months. I will send you a summary report for review, if you are interested. Thank you for your time.

Location: _____

Start Time: _____ End Time: _____

The University of Southern Queensland

Participant Information Sheet

HREC Approval Number: H14REA145

Full Project Title: Facilitating university research for commercialisation: A social network approach for open innovation processes.

Principal Researcher: Arbaiah Abdul Razak

Other Researcher(s): -

I am currently undertaking a research for my PhD degree with University of Southern Queensland. The purpose of the study is to find out how university researchers conduct collaborative research for innovation and commercialisation. I am particularly interested to hear your experiences and opinions about building research network and relationships with other innovation actors. It is expected that findings from this study will be able to inform university researchers and managers about better research network governance in the future.

Therefore, I would like to invite you to take part in this research project.

1. Procedures

Participation in this project will involve:

- You being interviewed by me as the Principal Researcher. This interview would take about 60 minutes for one session only. The interview would be held at a time and place convenient to you. At the interview, you will be asked your experiences and opinions about conducting collaborative research for innovation and commercialisation. Among the questions are: What is your greatest innovation? What did you do with the innovation? Do you work in team or conduct your innovation alone?

- With your permission, the interview will be voice-recorded. I will transcribe the recording and write notes of your interview. All information which is collected during your interview session will be kept strictly confidential, and your name will be removed so that you cannot be identified.

- This research project will be monitored by my supervisor, and no one will have access to the interview recording or written notes except me and my supervisor. Your recording and notes will be kept in a locked and secure cabinet for a maximum period of five years, after which time it will be destroyed.

- In taking part in this project, you will be able to reflect on the importance of better network relationships among university researchers and other innovation actors, which can provide useful insights into your research and innovation processes. This would benefit you in managing effective research that can lead to successful commercialisation.

- Please note that occasionally interview about personal experiences can cause uncomfortable feeling. If you agree to be interviewed, I will provide the list of questions that will be asked and briefly

go through the questions before the interview begin. I assure you that I will treat all your responses with respect and keep all your information in confidential and anonymous.

2. Voluntary Participation

Participation is entirely voluntary. **If you do not wish to take part you are not obliged to.** If you decide to take part and later change your mind, you are free to withdraw from the project at any stage. If you choose to withdraw from this study, I will ask your permission to retain any data that have collected so far. Or if you decline this request, any information already obtained from you will be withdrawn and destroyed.

Your decision whether to take part or not to take part, or to take part and then withdraw, will not affect your relationship with the University of Southern Queensland and/or your university.

Please be assured that your involvement is voluntary, that there are no consequences if you decide not to participate. Please feel free to notify the researcher if you decide to withdraw from this study.

Should you have any queries regarding the progress or conduct of this research, you can contact the principal researcher:

Arbaiah Abdul Razak
School of Management & Enterprise
University of Southern Queensland
West Street, darling Heights
Toowoomba, 4350 QLD
Australia
Phone No.: +617 4687 5764
Mobile No. (Australia): +614 1255 1753
Mobile No. (Malaysia): +6019 989 0719
Email: Arbaiah.AbdulRazak@usq.edu.au

If you have any ethical concerns with how the research is being conducted or any queries about your rights as a participant, please feel free to contact the University of Southern Queensland Ethics Officer on the following details.

Ethics and Research Integrity Officer
Office of Research and Higher Degrees
University of Southern Queensland
West Street, Toowoomba 4350
Ph: +61 7 4631 2690
Email: ***ethics@usq.edu.au***

The University of Southern Queensland

Consent Form

HREC Approval Number: **H14REA145**

TO: Academic researcher in public university in Malaysia

Full Project Title: Facilitating university research for commercialisation: A social network approach for open innovation processes.

Principal Researcher: Arbaiah Abdul Razak

Associate Researcher(s): -

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I confirm that I am over 18 years of age.
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential.
- I understand that I will be audio taped during the study.
- I understand that the tape will be stored in digital form in a password protected computer at USQ. Only the principal researchers will have the access to the computer.

Name of participant…….....

Signed……**Date**…….

If you have any ethical concerns with how the research is being conducted or any queries about your rights as a participant, please feel free to contact the University of Southern Queensland Ethics Officer on the following details.

Ethics and Research Integrity Officer
Office of Research and Higher Degrees
University of Southern Queensland
West Street, Toowoomba 4350
Ph: +61 7 4631 2690
Email: ***ethics@usq.edu.au***

Appendix C: Summary of the interview notes

Q1:	Various types of innovation have been produced ranging from health, plant and chemical products, machine instrument to training software. These innovation outputs are registered as intellectual property of the universities in the form of patent, utility innovation, trademark, copyright, and trade secret.
Q2:	The innovative idea generally mooted from public issues or work visits. One case was initiated through laboratory discovery.
Q3:	All the innovations had completed product development phase. Half of the innovations have been successfully commercialised while the other half still in the pre-commercialisation phase.
Q4:	Most of the innovations undergone research, development and commercialisation processes within the universities. Except one case was fully developed in cooperation with industry where the innovator acted as consultant.
Q5:	All the innovators worked in team and they emphasised that a great innovation cannot be created alone.
Q6:	All the innovators connect with others (i.e. end user, client, student, non-government agency, industry, expert, manufacturer, and wholesaler) in order to develop the innovations.
Q7:	For establishing effective working relationship with others, the innovators emphasised values such as sincerity, trust, control, being open, listen to everyone, and build informal relationship, focus, team spirit, and positive thinking.
Q8:	To gain commitment from others, the innovators always get connected with team members, give motivation and advice to others, be friendly, plan and manage well, focus on individual interest and passion, and create win-win or flexible situation. Beside intangible benefits (e.g. advice), the innovators also considered tangible benefits such as co-authorship and monetary allowance.
Q9:	In a team research, the innovators would act as project leader with the responsibilities to set research vision and objective, to get collective agreement, to focus on individual strength, to find common ground, to link or bridge the gap between academic and industry, to create trustworthy working environment, and to manage group achievement.
Q10:	There are various commercialisation strategies preferred by the innovators including licensing out, self-manufacturing, using university intermediary agent, trade secret agreement, company spin-off, contract research, and even simply sharing the innovative idea with others.

Appendix D: The questionnaire form

SURVEY ON FACILITATING RESEARCH NETWORK FOR EFFECTIVE INNOVATION

Section A

For each of the following statements related to different ways of conducting innovative research, please indicate your frequency of action on these practices using the following scale.

No	Innovation practices	Never Do → Almost Every Time									
1	I establish formal research collaboration with other people for acquiring ideas/resources.	1	2	3	4	5	6	7	8	9	10
2	I explore ideas/resources from other people outside of the university e.g. industries.	1	2	3	4	5	6	7	8	9	10
3	I share my research ideas/resources to people outside of my department/university.	1	2	3	4	5	6	7	8	9	10
4	I promote my ideas/resources to people outside of the university e.g. industries.	1	2	3	4	5	6	7	8	9	10
5	I outsource section of my research project to people who have the appropriate resources.	1	2	3	4	5	6	7	8	9	10
6	I contribute my ideas and resources to others for their use or further development.	1	2	3	4	5	6	7	8	9	10
7	I purchase ideas (in the form of intellectual property) or concepts from other people.	1	2	3	4	5	6	7	8	9	10
8	I adopt ideas from other people for further research and development.	1	2	3	4	5	6	7	8	9	10
9	I get input from other people for improvement of my research ideas.	1	2	3	4	5	6	7	8	9	10

Section B

For each of the following innovation and commercialisation strategies, please **indicate your level of consideration** to adopt such strategy using the following scale.

No	Commercialisation strategies	Never Consider → Definitely Consider									
10	I involve industry for idea/technology consultation and development.	1	2	3	4	5	6	7	8	9	10
11	I expand idea/technology creation in collaboration with customers or end users.	1	2	3	4	5	6	7	8	9	10
12	I extend the usability of idea/technology for other services e.g. industrial testing or certification.	1	2	3	4	5	6	7	8	9	10
13	I participate in innovative exhibitions or start-up competitions for potential direct investments.	1	2	3	4	5	6	7	8	9	10
14	I use licensing agreements with suitable firms or commercial entities.	1	2	3	4	5	6	7	8	9	10
15	I further develop the idea/technology through commercialisation intermediaries/agents.	1	2	3	4	5	6	7	8	9	10
16	I form a company within the university structure for spin offs.	1	2	3	4	5	6	7	8	9	10
17	I establish joint ventures or business partnerships for idea/product development and marketing.	1	2	3	4	5	6	7	8	9	10
18	I supply or sell ready-made products to retailers or in the market.	1	2	3	4	5	6	7	8	9	10

"Innovation has nothing to do with how many R&D dollars you have.
When Apple came up with the iMac, IBM was spending at least 100 times more on R&D.
It's not about money. It's about the people you have, how you're led, and how much you get it."
– Steve Jobs (1955-2011): was an entrepreneur, inventor and co-founder, chairman, and CEO of Apple Inc.

Section C

Based on your opinion on collaborating with others in a research project, please **indicate your level of agreement** with the following statements.

	No	Statement	Strongly Disagree →									Strongly Agree
Trust in innovation	19	I simply enjoy sharing ideas with other researchers in a research project.	1	2	3	4	5	6	7	8	9	10
	20	I consider trusting other people when cooperating in a research project.	1	2	3	4	5	6	7	8	9	10
	21	I believe that greater chance for success depend on collaboration with others.	1	2	3	4	5	6	7	8	9	10
	22	I prefer an informal relationship when collaborating with other researchers.	1	2	3	4	5	6	7	8	9	10
	23	I need agreement in place for long term research collaboration.	1	2	3	4	5	6	7	8	9	10
	24	I set out clear objectives and expectations for other researchers.	1	2	3	4	5	6	7	8	9	10
	25	My research team and I share a communication system e.g. email group.	1	2	3	4	5	6	7	8	9	10
Motivation to innovate	26	Collaborating with others facilitates knowledge and technology transfer.	1	2	3	4	5	6	7	8	9	10
	27	Collaborating with others helps me to establish research niche and network.	1	2	3	4	5	6	7	8	9	10
	28	I build academic reputation and expertise the more I network.	1	2	3	4	5	6	7	8	9	10
	29	I can reduce research (tangible and intangible) costs by sharing the tasks.	1	2	3	4	5	6	7	8	9	10
	30	I can improve the quality of my innovation when I include others.	1	2	3	4	5	6	7	8	9	10
	31	I gain other related knowledge such as best practices, legislation and policies.	1	2	3	4	5	6	7	8	9	10
	32	I get financial support for research mainly through contract research.	1	2	3	4	5	6	7	8	9	10
	33	I able to use other resources e.g. laboratory facilities, organisational database.	1	2	3	4	5	6	7	8	9	10
Strategic leadership	34	I promote research networking and partnerships in research.	1	2	3	4	5	6	7	8	9	10
	35	I set out a clear mission and strategic directions for a research project.	1	2	3	4	5	6	7	8	9	10
	36	I maximise potential resources and core competencies.	1	2	3	4	5	6	7	8	9	10
	37	I support idea creation activities and promote an innovative culture.	1	2	3	4	5	6	7	8	9	10
	38	I manage conflicts arising from the research team members.	1	2	3	4	5	6	7	8	9	10
	39	I engage with all stakeholders regularly for their ideas and feedbacks.	1	2	3	4	5	6	7	8	9	10
	40	I employ new approaches to stimulate creativity of doing things.	1	2	3	4	5	6	7	8	9	10

Section D: Please provide your information on the following and **tick (✓) an item**.

Age:
[ ] ≤ 29 years
[ ] 30 – 39 years
[ ] 40 – 49 years
[ ] 50 – 59 years
[ ] ≥ 60 years

Ethnic:
[ ] Malay
[ ] Chinese
[ ] Indian
[ ] Others

Gender:
[ ] Male
[ ] Female

Type of University:
[ ] Research University
[ ] Comprehensive
[ ] Focused

Academic Qualification:
[ ] Doctorate
[ ] Master
[ ] Bachelor
[ ] Others

Research Expertise:
[ ] Sciences / Applied Sciences
[ ] Technology / Engineering
[ ] Social Sciences / Applied Arts
[ ] Others

Position Description/Rank:
[ ] Professor
[ ] Associate Professor
[ ] Senior Lecturer / Lecturer
[ ] Others

Industrial Experience
(working experience in industry/private organisation)**:**
[ ] Yes
[ ] No

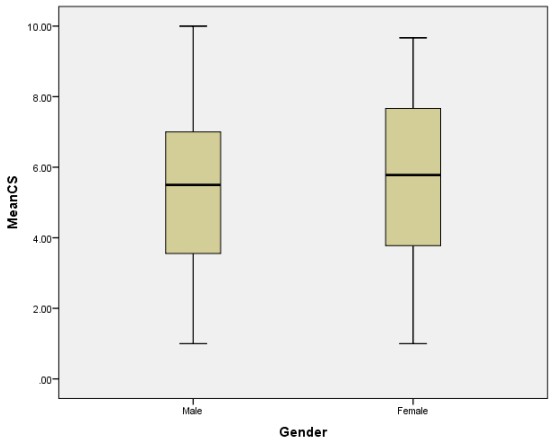
Industrial Research
(have conducted research for industry/private organisation)**:**
[ ] Yes
[ ] No

Finally, are there any other comments that you would like to offer?

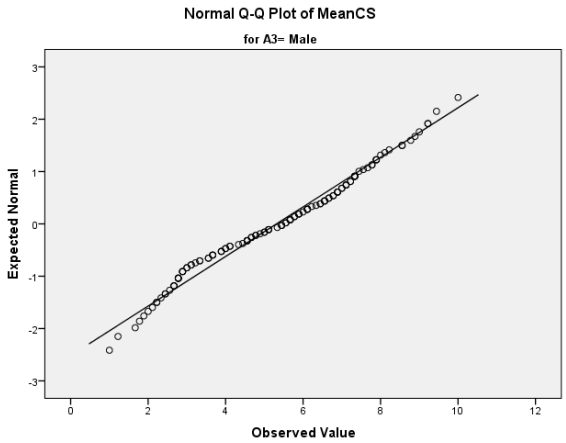
Thank you for your time and effort to complete this survey. Your cooperation is valued and very much appreciated!

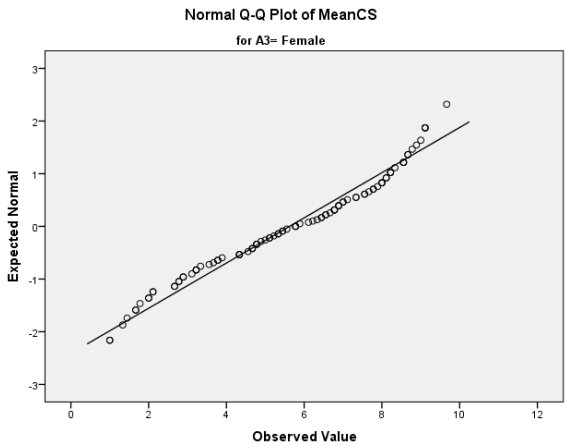
Appendix E: Normality assessment by SPSS 22

Boxplots for the mean values of *Commercialisation Success* (i.e. the dependent variable) grouped by gender show no outliers.

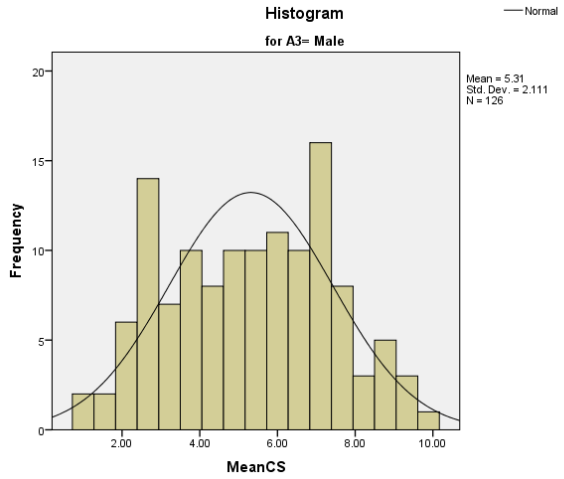


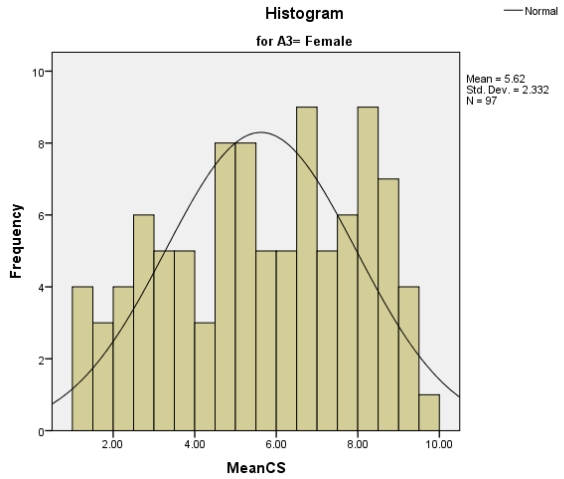
Q-Q plots for the mean values of *Commercialisation Success* for each gender show an approximate normality.





Histograms for the mean values of *Commercialisation Success* for each gender show an approximate normality.





Appendix F: Varimax rotation matrixes by SPSS 22

All 40 items

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O5 O6 O7 O8 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T22 T23
T24 T25 M26 M27 M28 M29 M30 M31 M32 M33 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O5 O6 O7 O8 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T22 T23
T24 T25 M26 M27 M28 M29 M30 M31 M32 M33 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
M27	.785	.162	.215	.075	.082	.238	.004	.200
M30	.784	.101	.163	.149	.014	.147	.102	.049
M26	.782	.167	.227	.023	.015	.122	.028	.042
T21	.765	-.034	.184	.134	.137	-.125	.076	.018
M29	.727	.170	.216	-.015	.100	.098	-.003	.248
M28	.681	.202	.320	.075	.185	.143	-.121	-.030
M31	.620	.160	.142	.112	.095	.148	.026	.090
T19	.574	-.071	.066	.423	.082	.027	.154	-.031
T20	.566	.074	.175	.243	.070	-.056	.053	.090
T25	.527	.175	.220	.108	.339	-.037	.154	-.192
C17	.114	.899	.098	-.053	.033	.089	.125	.002
C14	.060	.854	.143	.127	.086	.021	.125	.025
C15	.145	.851	.134	.099	.108	.042	.048	.047
C16	.052	.818	.112	-.002	.091	.039	.188	-.091
C18	.024	.788	.150	-.048	.065	.135	.220	-.024
C12	.142	.697	.083	.372	-.014	-.066	-.140	.224
C13	.170	.696	.180	.198	.129	.021	-.006	-.010
C10	.184	.692	.069	.358	-.102	.003	-.176	.237
C11	.190	.653	.025	.479	.094	-.034	-.153	.169
L38	.268	.250	.751	.153	.002	.046	.099	.082
L36	.259	.147	.731	.173	.351	-.025	-.003	.115
L37	.349	.089	.720	.184	.133	.036	-.084	.095
L40	.283	.217	.699	.199	.017	.062	.030	-.003
L35	.399	.115	.643	.235	.309	.058	-.011	.155
L34	.412	.171	.530	.273	.153	.106	-.038	.314
L39	.295	.354	.527	.261	-.206	.013	.261	.028
O3	.223	.053	.170	.787	-.135	.063	.112	-.052
O4	.120	.261	.215	.771	.028	-.037	.065	-.026
O6	.053	.046	.179	.703	.158	.195	.286	.103
O2	.032	.276	.175	.619	.049	.202	-.122	.158
O1	.251	.109	.201	.604	.151	.165	-.020	.068
T23	.270	.198	.118	.015	.742	-.058	.070	.057
T24	.304	.128	.329	.161	.670	-.040	.059	.138
O8	.127	.113	.088	.129	-.086	.771	.119	.026
O9	.324	.040	.018	.309	-.006	.725	.033	.006
T22	.427	.093	.081	.005	-.099	-.100	.623	.077
O7	-.131	.189	-.096	.131	.209	.269	.622	.199
O5	.131	.194	.076	.372	.126	.191	.438	.016
M33	.206	-.016	.296	.050	.163	.260	.055	.717
M32	.214	.202	.106	.132	.007	-.242	.307	.655

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.

Remove O7

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O5 O6 O8 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T22 T23
T24 T25 M26 M27 M28 M29 M30 M31 M32 M33 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O5 O6 O8 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T22 T23 T24
T25 M26 M27 M28 M29 M30 M31 M32 M33 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
C17	.901	.099	.088	-.047	.055	.104	.024	.129
C14	.858	.070	.150	.128	.067	.006	.017	.049
C15	.852	.144	.136	.096	.106	.041	.049	.014
C16	.822	.034	.097	.012	.117	.055	-.061	.193
C18	.793	-.002	.129	-.029	.101	.157	.014	.229
C13	.695	.161	.178	.192	.144	.030	-.001	.003
C12	.695	.171	.110	.345	-.056	-.091	.181	-.226
C10	.690	.209	.092	.330	-.138	-.014	.199	-.240
C11	.652	.216	.048	.454	.056	-.056	.134	-.236
M30	.103	.774	.163	.148	.031	.161	.066	.134
T21	-.032	.769	.193	.127	.130	-.124	.023	.088
M27	.160	.768	.214	.070	.109	.258	.215	.046
M26	.164	.763	.225	.016	.049	.146	.062	.107
M29	.168	.707	.213	-.021	.131	.123	.268	.051
M28	.196	.677	.332	.055	.196	.148	-.036	-.070
M31	.160	.621	.149	.106	.093	.149	.091	.019
T20	.079	.601	.202	.231	.010	-.088	.057	-.041
T19	-.064	.584	.074	.427	.067	.018	-.028	.112
T25	.178	.511	.212	.118	.364	-.025	-.161	.192
L38	.250	.251	.747	.154	.022	.061	.098	.138
L36	.146	.252	.734	.170	.350	-.024	.119	-.005
L37	.086	.345	.727	.170	.132	.042	.090	-.053
L40	.219	.292	.711	.190	-.005	.053	-.017	.016
L35	.114	.399	.653	.229	.302	.052	.149	-.032
L34	.171	.419	.544	.262	.134	.097	.298	-.085
L39	.361	.284	.521	.270	-.196	.028	.051	.271
O3	.058	.221	.168	.789	-.126	.069	-.040	.102
O4	.265	.112	.209	.772	.044	-.027	-.008	.062
O6	.058	.037	.161	.734	.177	.202	.137	.216
O2	.276	.042	.184	.608	.033	.192	.141	-.184
O1	.111	.256	.207	.600	.144	.157	.062	-.067
T23	.201	.260	.112	.030	.745	-.062	.077	.022
T24	.132	.302	.329	.171	.661	-.050	.147	-.006
O8	.119	.126	.082	.147	-.088	.767	.026	.048
O9	.044	.328	.019	.316	-.010	.717	-.003	-.031
M33	-.014	.178	.280	.066	.190	.284	.744	.016
M32	.212	.203	.097	.154	.008	-.231	.685	.224
T22	.109	.378	.038	.057	-.033	-.051	.172	.669
O5	.206	.084	.037	.418	.196	.228	.091	.448

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Remove O8

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O5 O6 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T22 T23 T24
T25 M26 M27 M28 M29 M30 M31 M32 M33 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O5 O6 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T22 T23 T24
T25 M26 M27 M28 M29 M30 M31 M32 M33 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
C17	.906	.130	.081	-.026	.030	.027	.067	-.111
C14	.856	.061	.152	.125	.085	-.003	.065	.029
C15	.850	.140	.136	.099	.123	.034	.038	.045
C16	.829	.059	.094	.025	.084	-.055	.086	-.184
C18	.804	.049	.117	.003	.045	.035	.089	-.254
C13	.694	.155	.179	.194	.157	-.008	.007	.025
C12	.687	.132	.123	.321	-.011	.151	-.077	.289
C10	.676	.163	.102	.314	-.055	.144	-.017	.395
C11	.642	.170	.060	.433	.115	.100	-.081	.306
M27	.165	.812	.212	.115	.084	.232	.023	-.066
M26	.168	.789	.234	.044	.035	.067	.065	-.090
M30	.102	.786	.172	.176	.041	.046	.141	-.030
M29	.170	.725	.217	.004	.123	.268	.073	-.016
M28	.197	.699	.336	.079	.184	-.004	-.116	-.030
T21	-.049	.686	.218	.104	.240	-.061	.262	.213
M31	.158	.633	.151	.133	.099	.083	.049	.027
T19	-.072	.543	.091	.425	.124	-.081	.185	.081
T20	.059	.519	.222	.209	.129	-.029	.190	.334
O9	.061	.486	-.019	.436	-.139	.097	-.238	-.276
T25	.171	.471	.224	.111	.415	-.190	.175	-.063
L38	.255	.255	.749	.164	.016	.105	.093	-.103
L36	.143	.218	.734	.162	.383	.124	.021	.024
L37	.082	.325	.728	.173	.161	.094	-.008	.074
L40	.213	.272	.714	.195	.035	-.031	.062	.073
L35	.116	.391	.653	.236	.303	.172	-.042	-.018
L34	.172	.421	.543	.276	.132	.311	-.040	.064
L39	.359	.260	.532	.274	-.154	-.005	.307	-.016
O3	.057	.199	.182	.790	-.100	-.075	.119	.028
O6	.070	.067	.152	.765	.126	.155	.099	-.233
O4	.262	.068	.223	.755	.085	-.045	.099	.065
O2	.274	.050	.174	.628	.041	.147	-.121	.148
O1	.112	.263	.204	.619	.138	.074	-.068	.026
T23	.196	.219	.106	.019	.778	.077	.039	-.014
T24	.126	.256	.326	.160	.698	.147	.030	.021
M33	.003	.251	.252	.122	.105	.795	-.002	-.130
M32	.202	.108	.111	.116	.114	.562	.508	.247
T22	.103	.319	.052	.054	.055	.041	.750	-.116
O5	.228	.150	.027	.461	.098	.124	.197	-.487

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 10 iterations.

Remove M32

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O5 O6 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T22 T23 T24
T25 M26 M27 M28 M29 M30 M31 M33 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O5 O6 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T22 T23 T24
T25 M26 M27 M28 M29 M30 M31 M33 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
C17	.904	.116	.076	-.035	.025	.071	.134
C14	.857	.065	.152	.122	.087	-.027	.048
C15	.852	.146	.137	.096	.122	.001	.009
C16	.823	.039	.080	.014	.075	.033	.213
C18	.798	.022	.107	-.011	.037	.134	.242
C12	.698	.154	.140	.329	.008	.021	-.252
C13	.695	.153	.173	.189	.159	.004	.017
C10	.690	.204	.129	.327	-.037	-.063	-.286
C11	.652	.196	.073	.440	.129	-.027	-.255
M27	.169	.798	.209	.108	.078	.285	.045
M30	.105	.786	.165	.172	.029	.086	.137
M26	.168	.775	.221	.036	.020	.153	.117
T21	-.040	.734	.224	.111	.234	-.177	.077
M29	.176	.724	.224	.000	.121	.256	.035
M28	.195	.679	.310	.070	.165	.109	-.037
M31	.162	.637	.149	.131	.088	.087	.018
T20	.072	.573	.236	.221	.136	-.198	-.060
T19	-.067	.566	.088	.426	.114	-.107	.113
T25	.168	.481	.202	.104	.391	-.140	.222
L38	.255	.249	.746	.157	.020	.136	.143
L36	.145	.228	.733	.159	.391	.095	.008
L37	.086	.334	.726	.172	.165	.066	-.047
L40	.215	.289	.710	.194	.027	-.069	.015
L35	.119	.385	.646	.230	.311	.201	-.011
L34	.180	.425	.554	.275	.144	.261	-.100
L39	.362	.284	.541	.273	-.159	-.072	.242
O3	.060	.210	.181	.790	-.105	-.079	.097
O4	.265	.086	.225	.756	.082	-.091	.053
O6	.070	.048	.152	.755	.130	.232	.225
O2	.281	.058	.184	.631	.050	.087	-.195
O1	.115	.258	.199	.617	.138	.098	-.055
O9	.056	.417	-.050	.420	-.149	.365	.025
T23	.196	.232	.101	.013	.771	.051	.043
T24	.130	.269	.326	.156	.704	.111	.014
M33	.014	.238	.296	.118	.140	.711	-.040
T22	.110	.370	.084	.055	.062	-.104	.620
O5	.222	.102	.014	.441	.097	.327	.477

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Remove T22

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O5 O6 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T23 T24 T25
M26 M27 M28 M29 M30 M31 M33 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O5 O6 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T23 T24 T25
M26 M27 M28 M29 M30 M31 M33 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
M27	.803	.164	.202	.121	.074	.034	.274
M30	.796	.105	.163	.186	.035	.009	.067
M26	.789	.177	.218	.062	.023	-.044	.119
M29	.732	.173	.212	.011	.118	.024	.257
T21	.721	-.067	.220	.073	.244	.171	-.111
M28	.688	.191	.311	.078	.165	.022	.060
M31	.642	.159	.153	.141	.089	.020	.043
T19	.572	-.078	.094	.422	.124	.062	-.132
T20	.547	.020	.232	.150	.140	.331	-.103
T25	.502	.189	.209	.138	.407	-.109	-.194
C17	.133	.916	.077	.001	.027	.003	.040
C16	.070	.851	.083	.070	.082	-.099	-.029
C14	.071	.846	.154	.124	.088	.140	-.028
C15	.149	.839	.139	.096	.121	.147	-.007
C18	.060	.837	.107	.062	.043	-.170	.057
C13	.142	.670	.176	.172	.157	.210	.037
C12	.115	.624	.137	.245	-.005	.504	.117
C10	.153	.604	.132	.225	-.051	.575	.050
C11	.155	.575	.074	.354	.116	.520	.056
L38	.263	.262	.741	.174	.027	-.025	.142
L36	.223	.132	.728	.142	.392	.094	.138
L37	.325	.064	.725	.146	.166	.127	.100
L40	.299	.212	.720	.195	.037	.017	-.109
L35	.380	.100	.637	.213	.309	.118	.242
L39	.306	.374	.548	.300	-.143	-.044	-.104
L34	.415	.152	.548	.252	.136	.170	.287
O6	.073	.083	.154	.798	.135	-.073	.166
O3	.214	.042	.196	.785	-.096	.111	-.128
O4	.089	.242	.238	.745	.089	.156	-.131
O1	.247	.082	.205	.592	.134	.201	.091
O2	.027	.226	.196	.579	.039	.339	.103
O5	.155	.274	.002	.538	.108	-.284	.263
O9	.427	.059	-.045	.454	-.157	-.035	.284
T23	.238	.203	.099	.028	.772	-.020	.037
T24	.264	.119	.318	.145	.703	.089	.148
M33	.226	.003	.274	.126	.117	.053	.773

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.

Remove M33

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O5 O6 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T23 T24 T25
M26 M27 M28 M29 M30 M31 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O5 O6 O9 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T23 T24 T25
M26 M27 M28 M29 M30 M31 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
C17	.910	.139	.084	-.009	.032	-.092
C14	.854	.069	.155	.126	.090	.046
C15	.848	.148	.142	.100	.123	.054
C16	.833	.071	.083	.045	.087	-.175
C18	.813	.069	.112	.034	.050	-.255
C13	.687	.142	.184	.187	.159	.115
C12	.677	.121	.152	.298	-.004	.371
C10	.665	.153	.136	.282	-.052	.463
C11	.628	.155	.083	.404	.117	.396
M27	.166	.819	.228	.133	.082	-.023
M30	.099	.797	.179	.186	.039	-.024
M26	.167	.795	.234	.058	.029	-.072
M29	.173	.746	.242	.022	.126	-.029
T21	-.054	.704	.213	.081	.239	.209
M28	.186	.687	.324	.078	.167	-.002
M31	.157	.642	.158	.139	.092	.003
T19	-.073	.561	.064	.413	.123	.107
T20	.053	.533	.215	.174	.135	.358
T25	.169	.484	.189	.106	.403	-.068
L38	.252	.267	.757	.173	.028	-.080
L36	.135	.222	.743	.154	.391	.061
L37	.070	.322	.738	.161	.165	.102
L40	.205	.283	.704	.185	.031	.029
L35	.107	.389	.665	.233	.312	.057
L34	.169	.431	.567	.278	.142	.108
L39	.361	.294	.534	.282	-.146	-.070
O6	.075	.087	.158	.790	.144	-.164
O3	.050	.203	.174	.782	-.097	.070
O4	.253	.076	.225	.745	.087	.083
O2	.261	.031	.207	.615	.041	.224
O1	.101	.249	.215	.612	.137	.115
O5	.238	.176	.046	.515	.123	-.438
O9	.055	.450	-.012	.462	-.143	-.141
T23	.195	.236	.108	.020	.773	-.033
T24	.123	.268	.337	.155	.706	.055

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

Remove O9

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O5 O6 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T23 T24 T25 M26
M27 M28 M29 M30 M31 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O5 O6 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T23 T24 T25 M26
M27 M28 M29 M30 M31 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
C17	.911	.133	.088	-.013	.037	-.074
C14	.853	.078	.148	.136	.082	.047
C15	.847	.154	.137	.106	.118	.060
C16	.835	.071	.083	.047	.085	-.168
C18	.816	.066	.115	.032	.051	-.242
C13	.685	.148	.181	.192	.155	.117
C12	.671	.129	.146	.306	-.009	.373
C10	.659	.153	.136	.281	-.047	.474
C11	.623	.158	.083	.403	.121	.405
M27	.167	.820	.223	.125	.072	-.020
M26	.168	.805	.221	.062	.004	-.087
M30	.099	.799	.171	.180	.026	-.022
M29	.173	.755	.230	.025	.108	-.033
T21	-.057	.720	.198	.091	.216	.187
M28	.187	.696	.315	.081	.151	-.011
M31	.157	.641	.155	.131	.089	.017
T19	-.074	.580	.046	.424	.092	.075
T20	.049	.539	.211	.174	.129	.354
T25	.170	.505	.174	.123	.373	-.104
L38	.252	.280	.748	.184	.013	-.090
L37	.069	.324	.742	.156	.172	.114
L36	.133	.236	.740	.162	.389	.057
L40	.204	.287	.704	.183	.031	.034
L35	.105	.399	.662	.235	.309	.056
L34	.167	.435	.565	.276	.140	.113
L39	.362	.302	.526	.287	-.162	-.077
O3	.048	.220	.159	.793	-.125	.045
O6	.075	.096	.152	.791	.131	-.169
O4	.250	.100	.207	.764	.059	.056
O2	.256	.032	.207	.612	.048	.243
O1	.098	.255	.210	.611	.132	.119
O5	.242	.187	.033	.521	.102	-.443
T23	.194	.238	.115	.016	.784	-.023
T24	.121	.282	.334	.163	.704	.051

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

Remove O5

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O6 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T23 T24 T25 M26
M27 M28 M29 M30 M31 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O6 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T23 T24 T25 M26 M27
M28 M29 M30 M31 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
M27	.819	.153	.228	.109	.070	.077
M26	.804	.174	.223	.063	.002	-.012
M30	.797	.088	.178	.166	.025	.061
M29	.755	.151	.243	-.012	.103	.096
T21	.721	-.092	.197	.079	.224	.158
M28	.696	.186	.310	.091	.153	.033
M31	.640	.158	.149	.148	.094	.027
T19	.575	-.037	.018	.508	.110	-.091
T20	.540	-.014	.204	.160	.142	.308
T25	.502	.222	.157	.186	.380	-.167
C17	.133	.915	.085	-.002	.034	.091
C16	.069	.864	.080	.070	.080	-.021
C18	.063	.858	.114	.058	.043	-.086
C14	.077	.825	.149	.121	.080	.230
C15	.154	.819	.135	.097	.118	.229
C13	.148	.653	.174	.190	.160	.244
L38	.280	.247	.758	.162	.006	.043
L36	.236	.118	.739	.156	.389	.093
L37	.325	.045	.739	.150	.176	.124
L40	.287	.219	.688	.225	.038	-.007
L35	.397	.074	.672	.200	.306	.151
L34	.435	.143	.561	.276	.145	.148
L39	.301	.367	.528	.289	-.165	.029
O3	.213	.050	.148	.820	-.116	.072
O6	.085	.102	.160	.795	.127	-.055
O4	.092	.230	.206	.758	.062	.176
O2	.029	.191	.206	.581	.056	.359
O1	.250	.056	.216	.580	.135	.233
T23	.235	.202	.118	.016	.783	.005
T24	.279	.103	.341	.141	.702	.105
C10	.155	.533	.135	.218	-.037	.645
C12	.130	.548	.158	.218	-.006	.618
C11	.157	.507	.088	.334	.128	.603

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

Remove T23

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O6 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T24 T25 M26 M27
M28 M29 M30 M31 L34 L35 L36 L37 L38 L39 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O6 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T24 T25 M26 M27 M28
M29 M30 M31 L34 L35 L36 L37 L38 L39 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
M27	.814	.153	.243	.110	.083
M26	.795	.175	.207	.076	-.010
M30	.791	.089	.187	.164	.066
M29	.750	.152	.265	-.009	.100
T21	.725	-.093	.271	.064	.172
M28	.696	.188	.345	.088	.039
M31	.641	.157	.166	.151	.035
T19	.586	-.043	.064	.490	-.068
T20	.537	-.015	.253	.151	.315
T25	.531	.220	.278	.151	-.138
C17	.135	.916	.080	-.001	.096
C16	.078	.865	.090	.067	-.012
C18	.069	.860	.105	.061	-.082
C14	.079	.826	.159	.121	.234
C15	.158	.819	.156	.097	.236
C13	.154	.653	.217	.178	.254
L36	.240	.130	.833	.139	.087
L37	.311	.059	.761	.155	.103
L35	.395	.084	.749	.185	.146
L38	.255	.262	.712	.188	.011
L40	.269	.232	.651	.251	-.034
L34	.425	.151	.588	.273	.140
T24	.321	.103	.564	.084	.139
L39	.272	.377	.426	.332	-.001
O3	.203	.047	.100	.835	.070
O6	.097	.099	.196	.781	-.041
O4	.093	.227	.212	.761	.180
O2	.024	.190	.218	.580	.358
O1	.252	.054	.256	.572	.241
C10	.139	.531	.123	.224	.641
C12	.115	.547	.155	.220	.615
C11	.156	.502	.134	.323	.615

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

Remove L39

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O6 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T24 T25 M26 M27
M28 M29 M30 M31 L34 L35 L36 L37 L38 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O6 C10 C11 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T24 T25 M26 M27 M28
M29 M30 M31 L34 L35 L36 L37 L38 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
M27	.814	.150	.246	.110	.084
M26	.797	.164	.203	.065	.014
M30	.791	.085	.188	.162	.067
M29	.749	.151	.272	-.008	.099
T21	.724	-.090	.277	.073	.147
M28	.694	.189	.348	.090	.033
M31	.642	.150	.166	.145	.053
T19	.581	-.031	.072	.503	-.108
T20	.541	-.023	.250	.148	.319
T25	.525	.238	.283	.169	-.193
C17	.136	.916	.080	-.001	.104
C16	.077	.869	.091	.070	-.014
C18	.067	.863	.107	.061	-.076
C14	.082	.822	.156	.120	.244
C15	.160	.818	.157	.098	.240
C13	.150	.665	.229	.194	.218
L36	.234	.141	.841	.150	.053
L37	.308	.057	.766	.154	.108
L35	.391	.093	.755	.196	.113
L38	.257	.247	.705	.169	.060
L40	.275	.207	.634	.221	.042
L34	.423	.153	.592	.276	.131
T24	.313	.132	.576	.117	.043
O3	.204	.038	.096	.825	.096
O6	.092	.111	.201	.792	-.074
O4	.093	.225	.213	.760	.183
O2	.023	.191	.225	.586	.348
O1	.250	.058	.261	.579	.221
C10	.146	.517	.119	.219	.664
C12	.121	.537	.153	.219	.628
C11	.159	.501	.137	.332	.599

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

Remove C11

```
FACTOR
  /VARIABLES O1 O2 O3 O4 O6 C10 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T24 T25 M26 M27 M28
M29 M30 M31 L34 L35 L36 L37 L38 L40
  /MISSING LISTWISE
  /ANALYSIS O1 O2 O3 O4 O6 C10 C12 C13 C14 C15 C16 C17 C18 T19 T20 T21 T24 T25 M26 M27 M28 M29
M30 M31 L34 L35 L36 L37 L38 L40
  /PRINT INITIAL CORRELATION KMO REPR AIC EXTRACTION ROTATION
  /FORMAT SORT
  /PLOT EIGEN ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Rotated Component Matrix[a]

	Component			
	1	2	3	4
M27	.817	.169	.235	.114
M26	.800	.162	.195	.048
M30	.795	.098	.178	.161
M29	.751	.181	.257	.014
T21	.726	-.047	.268	.109
M28	.699	.190	.342	.078
M31	.646	.157	.157	.139
T19	.590	-.064	.062	.451
T20	.543	.061	.240	.225
T25	.531	.172	.288	.084
C17	.137	.915	.074	-.022
C14	.084	.859	.147	.137
C15	.162	.854	.147	.115
C16	.080	.837	.087	.017
C18	.071	.820	.098	-.001
C13	.154	.703	.217	.215
C12	.123	.668	.153	.329
C10	.148	.660	.116	.343
L36	.243	.152	.837	.160
L37	.317	.083	.760	.180
L35	.400	.115	.754	.212
L38	.265	.259	.695	.178
L40	.284	.220	.618	.230
L34	.432	.178	.585	.292
T24	.319	.134	.578	.113
O3	.217	.054	.080	.819
O4	.106	.256	.199	.769
O6	.106	.079	.190	.739
O2	.033	.280	.201	.664
O1	.261	.109	.244	.617

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

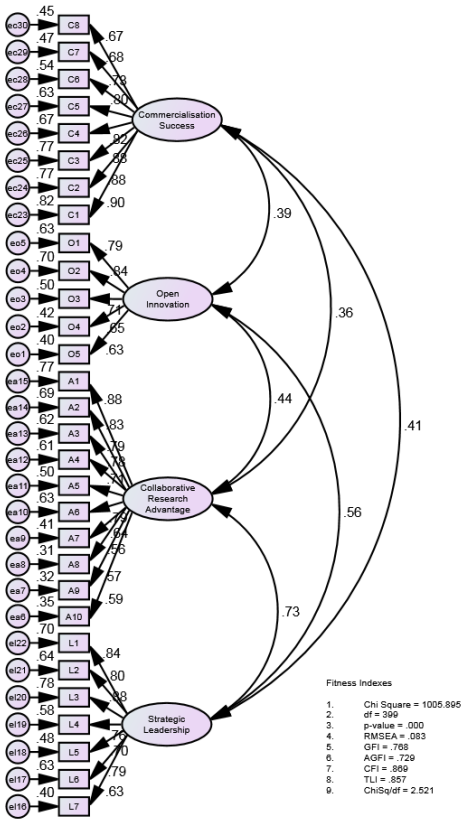
Appendix G: Measurement model estimates by AMOS 22

Analysis of the hypothetical relationships involved four latent constructs with initial 30 measurement items as listed below.

No.	Construct	Item
1	**Commercialisation Success**	C1. I establish joint ventures for idea/product development and marketing.
2		C2. I use licensing agreements with suitable firms or commercial entities.
3		C3. I further develop the idea through commercialisation intermediaries/agents.
4		C4. I form a company within the university structure for spin-offs.
5		C5. I supply or sell ready-made products to retailers or in the market.
6		C6. I participate in innovative exhibitions/competitions for investment opportunity.
7		C7. I extend the usability of idea for other services e.g. industrial training.
8		C8. I involve industry for idea/technology consultation and development.
9	**Open Innovation**	O1. I share my research ideas/resources with others outside of my university.
10		O2. I promote my ideas/resources to people outside of the university e.g. industries.
11		O3. I contribute my ideas/resources to others for their use or further development.
12		O4. I explore ideas/resources from others outside of the university e.g. industries.
13		O5. I establish formal research collaboration with others for acquiring resources.
14	**Collaborative Research Advantage**	A1. Collaborating with others helps me to establish research niche and network.
15		A2. Collaborating with others facilitates knowledge and technology transfer.
16		A3. I can improve the quality of my innovation when I include others.
17		A4. I can reduce research (tangible and intangible) costs by sharing the tasks.
18		A5. I believe that greater chance for success depend on collaboration with others.
19		A6. I build academic reputation and expertise the more I network.
20		A7. I gain other related knowledge such as best practices, legislation and policies.
21		A8. I simply enjoy sharing ideas with other researchers in a research project.
22		A9. I consider trusting other people when cooperating in a research project.
23		A10. My research team and I share a communication system e.g. email group.
24	**Strategic Leadership**	L1. I maximise potential resources and core competencies.
25		L2. I support idea creation activities and promote an innovative culture.
26		L3. I set out a clear mission and strategic directions for a research project.
27		L4. I manage conflicts arising from the research team members.
28		L5. I employ new approaches to stimulate creativity of doing things.
29		L6. I promote research networking and partnerships in research.
30		L7. I set out clear objectives and expectations for other researchers.

All 30 items

Standardized Regression Weights: (Group number 1 - Default model)



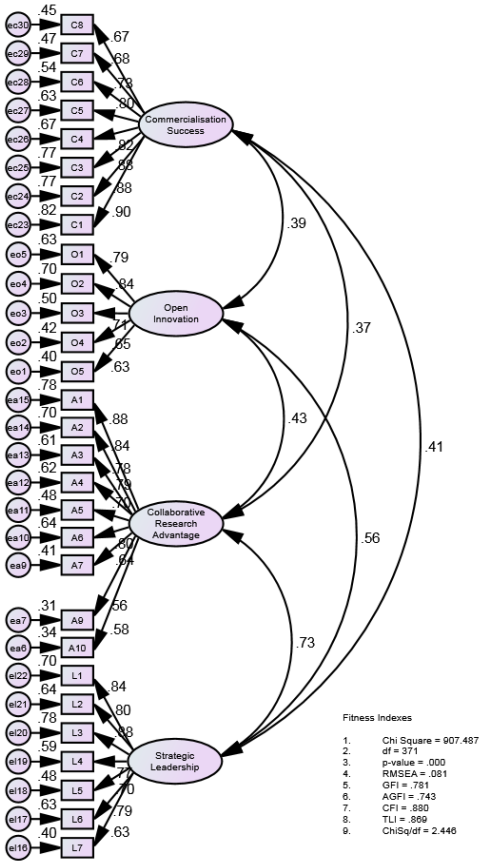
		Item Loadings	Estimate
O5	<---	Open_Innovation	.634
O4	<---	Open_Innovation	.646
O3	<---	Open_Innovation	.706
O2	<---	Open_Innovation	.838
O1	<---	Open_Innovation	.795
A7	<---	Collaborative_Research_Advantage	.642
A6	<---	Collaborative_Research_Advantage	.795
A5	<---	Collaborative_Research_Advantage	.705
A4	<---	Collaborative_Research_Advantage	.783
L6	<---	Strategic_Leadership	.794
L5	<---	Strategic_Leadership	.696
L4	<---	Strategic_Leadership	.765
L3	<---	Strategic_Leadership	.882
L2	<---	Strategic_Leadership	.800
C2	<---	Commercialisation_Success	.878
C3	<---	Commercialisation_Success	.877
C4	<---	Commercialisation_Success	.819
C5	<---	Commercialisation_Success	.797
C6	<---	Commercialisation_Success	.733
C7	<---	Commercialisation_Success	.684
C8	<---	Commercialisation_Success	.672
C1	<---	Commercialisation_Success	.903
A1	<---	Collaborative_Research_Advantage	.878
A2	<---	Collaborative_Research_Advantage	.831
A3	<---	Collaborative_Research_Advantage	.789
A10	<---	Collaborative_Research_Advantage	.589
A9	<---	Collaborative_Research_Advantage	.567
A8	<---	Collaborative_Research_Advantage	.560
L1	<---	Strategic_Leadership	.837
L7	<---	Strategic_Leadership	.630

Covariances: (Group number 1 - Default model)

		Modification Indices	M.I.	Par Change
ec30	<-->	Open_Innovation	15.761	.653
ec29	<-->	Open_Innovation	12.757	.595
ec29	<-->	ec30	52.308	1.589
ec28	<-->	Open_Innovation	4.437	.341
ec28	<-->	ec29	4.478	.458
ec27	<-->	ec30	10.081	-.734
ec27	<-->	ec29	16.898	-.963
ec26	<-->	ec30	10.687	-.718
ec26	<-->	ec28	6.553	-.553
ec26	<-->	ec27	12.134	.814
ec25	<-->	ec28	4.467	.360
ec25	<-->	ec26	4.724	-.379
ec24	<-->	ec25	4.208	.288
ec23	<-->	Open_Innovation	14.188	-.501
ec23	<-->	ec29	13.856	-.657
ec23	<-->	ec28	4.035	-.344
ec23	<-->	ec27	18.952	.803
ec23	<-->	ec26	25.982	.891
ec23	<-->	ec25	4.233	-.280
el22	<-->	Strategic_Leadership	5.611	.121
el22	<-->	Collaborative_Research_Advantage	8.629	-.160
el21	<-->	el22	14.567	.203
el20	<-->	el21	4.852	-.105
el19	<-->	Commercialisation_Success	5.841	.431
el18	<-->	ec28	4.908	-.348
el18	<-->	el20	11.565	-.237
el18	<-->	el19	4.140	.192
el17	<-->	Strategic_Leadership	5.834	-.145
el17	<-->	Collaborative_Research_Advantage	4.944	.142
el17	<-->	el22	14.923	-.233
el17	<-->	el20	7.505	.148
el16	<-->	el21	6.068	-.194
el16	<-->	el20	5.778	.165

Modification Indices			M.I.	Par Change
el16	<-->	el19	17.063	-.382
ea14	<-->	ec25	5.601	-.205
ea14	<-->	ec23	8.729	.258
ea14	<-->	el22	7.734	-.147
ea14	<-->	ea15	22.646	.211
ea13	<-->	ea14	7.075	-.148
ea12	<-->	ec25	4.284	.204
ea12	<-->	ea13	5.512	.149
ea11	<-->	Commercialisation_Success	8.697	-.525
ea11	<-->	ea15	5.753	-.129
ea11	<-->	ea14	9.344	-.195
ea11	<-->	ea13	4.811	.147
ea10	<-->	ea14	10.536	.184
ea10	<-->	ea13	5.205	-.136
ea9	<-->	el21	5.828	.181
ea9	<-->	el20	15.701	-.259
ea9	<-->	ea14	4.668	-.158
ea9	<-->	ea13	20.062	.344
ea8	<-->	Commercialisation_Success	7.284	-.600
ea8	<-->	Open_Innovation	25.411	.615
ea8	<-->	ec23	5.405	-.303
ea8	<-->	el22	4.076	-.160
ea8	<-->	el19	4.797	-.210
ea8	<-->	el17	9.343	.282
ea8	<-->	ea13	4.045	.168
ea8	<-->	ea12	6.036	-.223
ea8	<-->	ea11	8.009	.271
ea8	<-->	ea10	6.931	-.225
ea7	<-->	ec30	6.985	.469
ea7	<-->	ec24	4.199	.301
ea7	<-->	ec23	8.158	-.410
ea7	<-->	ea14	6.333	-.222
ea7	<-->	ea11	18.783	.457
ea7	<-->	ea8	10.057	.417
ea6	<-->	el17	4.312	-.220
ea6	<-->	el16	9.826	.417
ea6	<-->	ea12	5.695	-.249
eo5	<-->	Commercialisation_Success	9.091	-.650
eo5	<-->	Strategic_Leadership	4.090	-.153
eo5	<-->	el22	9.638	-.238
eo5	<-->	el17	5.694	.214
eo5	<-->	el16	6.521	-.286
eo5	<-->	ea14	4.474	.164
eo5	<-->	ea8	12.379	.408
eo4	<-->	Commercialisation_Success	5.155	.491
eo4	<-->	ea15	4.180	-.135
eo4	<-->	eo5	6.430	.271
eo3	<-->	ec30	5.454	-.395
eo3	<-->	ea8	10.016	.397
eo2	<-->	Commercialisation_Success	7.040	.680
eo2	<-->	ec30	14.180	.699
eo2	<-->	eo5	9.487	-.406
eo1	<-->	Collaborative_Research_Advantage	4.851	.216
eo1	<-->	ea10	5.912	.246
eo1	<-->	eo4	13.697	-.498
eo1	<-->	eo2	12.181	.565

Remove A8



Standardized Regression Weights: (Group number 1 - Default model)

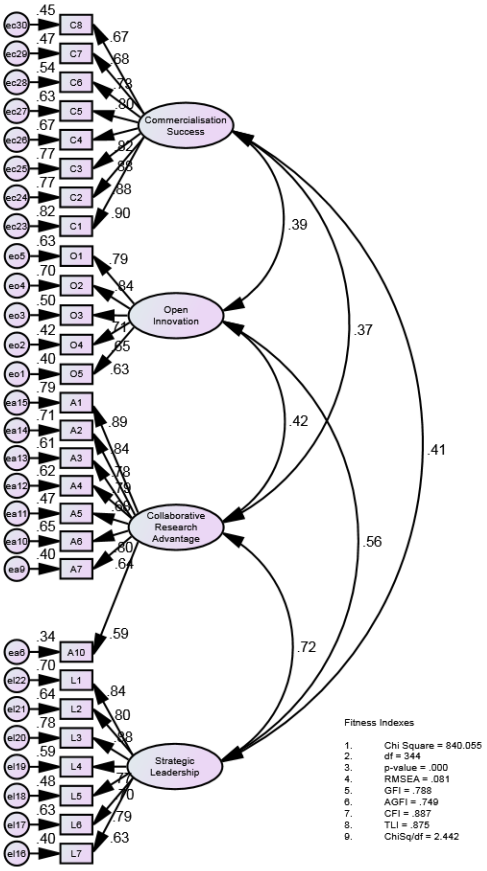
Item Loadings			Estimate
O5	<---	Open_Innovation	.633
O4	<---	Open_Innovation	.646
O3	<---	Open_Innovation	.706
O2	<---	Open_Innovation	.839
O1	<---	Open_Innovation	.794
A7	<---	Collaborative_Research_Advantage	.639
A6	<---	Collaborative_Research_Advantage	.802
A5	<---	Collaborative_Research_Advantage	.696
A4	<---	Collaborative_Research_Advantage	.788
L6	<---	Strategic_Leadership	.793
L5	<---	Strategic_Leadership	.696
L4	<---	Strategic_Leadership	.765
L3	<---	Strategic_Leadership	.881
L2	<---	Strategic_Leadership	.801
C2	<---	Commercialisation_Success	.878
C3	<---	Commercialisation_Success	.878
C4	<---	Commercialisation_Success	.819
C5	<---	Commercialisation_Success	.797
C6	<---	Commercialisation_Success	.733
C7	<---	Commercialisation_Success	.684
C8	<---	Commercialisation_Success	.672
C1	<---	Commercialisation_Success	.903
A1	<---	Collaborative_Research_Advantage	.882
A2	<---	Collaborative_Research_Advantage	.836
A3	<---	Collaborative_Research_Advantage	.782
A10	<---	Collaborative_Research_Advantage	.584
A9	<---	Collaborative_Research_Advantage	.556
L1	<---	Strategic_Leadership	.837
L7	<---	Strategic_Leadership	.630

Covariances: (Group number 1 - Default model)

Modification Indices			M.I.	Par Change
ec30	<-->	Open_Innovation	15.928	.656
ec29	<-->	Open_Innovation	12.763	.595
ec29	<-->	ec30	52.292	1.588
ec28	<-->	Open_Innovation	4.476	.343
ec28	<-->	ec29	4.474	.458
ec27	<-->	ec30	10.092	-.734
ec27	<-->	ec29	16.897	-.963
ec26	<-->	ec30	10.696	-.718
ec26	<-->	ec28	6.549	-.553
ec26	<-->	ec27	12.147	.814
ec25	<-->	ec28	4.460	.360
ec25	<-->	ec26	4.717	-.378
ec24	<-->	ec25	4.227	.289
ec23	<-->	Open_Innovation	13.989	-.497
ec23	<-->	ec29	13.895	-.658
ec23	<-->	ec28	4.055	-.345
ec23	<-->	ec27	18.948	.803
ec23	<-->	ec26	25.987	.891
ec23	<-->	ec25	4.262	-.281
el22	<-->	Strategic_Leadership	5.353	.118
el22	<-->	Collaborative_Research_Advantage	8.090	-.157
el21	<-->	el22	14.414	.202
el20	<-->	el21	4.828	-.105
el19	<-->	Commercialisation_Success	5.802	.429
el18	<-->	ec28	4.926	-.348
el18	<-->	el20	11.494	-.236
el18	<-->	el19	4.085	.191
el17	<-->	Strategic_Leadership	5.362	-.139
el17	<-->	Collaborative_Research_Advantage	4.249	.133
el17	<-->	el22	14.814	-.233
el17	<-->	el20	7.755	.151

Modification Indices			M.I.	Par Change
el16	<-->	el21	6.078	-.194
el16	<-->	el20	5.825	.165
el16	<-->	el19	17.166	-.383
ea14	<-->	ec25	5.931	-.209
ea14	<-->	ec23	7.746	.241
ea14	<-->	el22	8.769	-.156
ea14	<-->	el16	4.022	-.154
ea14	<-->	ea15	19.676	.193
ea13	<-->	ea14	6.587	-.144
ea12	<-->	ec25	4.298	.203
ea12	<-->	ea13	5.770	.153
ea11	<-->	Commercialisation_Success	9.146	-.544
ea11	<-->	ea15	4.635	-.116
ea11	<-->	ea14	8.233	-.184
ea11	<-->	ea13	6.555	.175
ea10	<-->	ea14	8.330	.161
ea10	<-->	ea13	5.262	-.137
ea10	<-->	ea12	5.583	-.150
ea9	<-->	el21	5.799	.181
ea9	<-->	el20	15.222	-.256
ea9	<-->	ea14	4.860	-.161
ea9	<-->	ea13	21.309	.360
ea7	<-->	ec30	7.036	.475
ea7	<-->	ec24	4.216	.304
ea7	<-->	ec23	8.590	-.424
ea7	<-->	ea14	5.312	-.203
ea7	<-->	ea11	20.850	.491
ea6	<-->	el16	9.775	.417
ea6	<-->	ea12	5.636	-.247
eo5	<-->	Commercialisation_Success	9.147	-.651
eo5	<-->	el22	9.699	-.239
eo5	<-->	el17	5.796	.216
eo5	<-->	el16	6.436	-.285
eo5	<-->	ea14	5.935	.188
eo4	<-->	Commercialisation_Success	5.149	.489
eo4	<-->	ea15	4.412	-.137
eo4	<-->	eo5	6.445	.271
eo3	<-->	ec30	5.443	-.394
eo2	<-->	Commercialisation_Success	7.079	.681
eo2	<-->	ec30	14.193	.699
eo2	<-->	eo5	9.457	-.405
eo1	<-->	Collaborative_Research_Advantage	5.086	.223
eo1	<-->	ea10	5.813	.241
eo1	<-->	eo4	13.674	-.498
eo1	<-->	eo2	12.212	.566

Remove A9



Standardized Regression Weights: (Group number 1 - Default model)

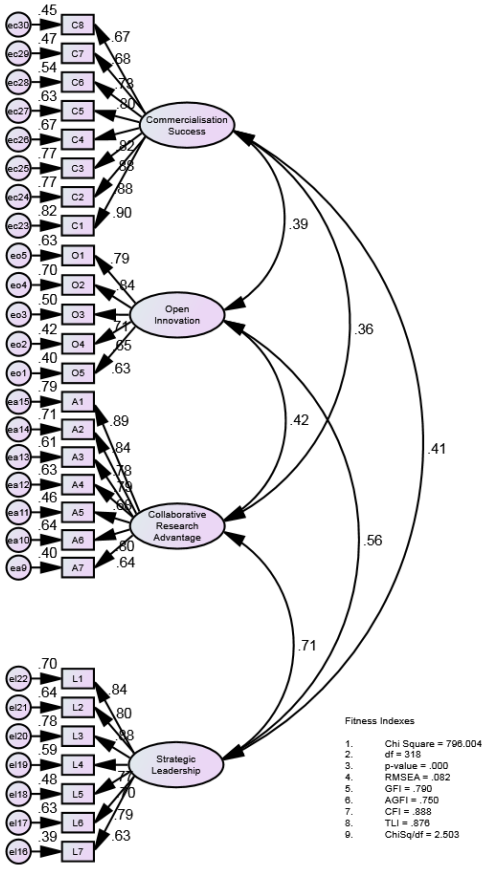
Item Loadings			Estimate
O5	<---	Open_Innovation	.633
O4	<---	Open_Innovation	.646
O3	<---	Open_Innovation	.706
O2	<---	Open_Innovation	.839
O1	<---	Open_Innovation	.794
A7	<---	Collaborative_Research_Advantage	.635
A6	<---	Collaborative_Research_Advantage	.804
A5	<---	Collaborative_Research_Advantage	.682
A4	<---	Collaborative_Research_Advantage	.787
L6	<---	Strategic_Leadership	.793
L5	<---	Strategic_Leadership	.696
L4	<---	Strategic_Leadership	.766
L3	<---	Strategic_Leadership	.881
L2	<---	Strategic_Leadership	.801
C2	<---	Commercialisation_Success	.878
C3	<---	Commercialisation_Success	.877
C4	<---	Commercialisation_Success	.819
C5	<---	Commercialisation_Success	.797
C6	<---	Commercialisation_Success	.733
C7	<---	Commercialisation_Success	.684
C8	<---	Commercialisation_Success	.672
C1	<---	Commercialisation_Success	.904
A1	<---	Collaborative_Research_Advantage	.886
A2	<---	Collaborative_Research_Advantage	.843
A3	<---	Collaborative_Research_Advantage	.779
A10	<---	Collaborative_Research_Advantage	.587
L1	<---	Strategic_Leadership	.838
L7	<---	Strategic_Leadership	.629

Covariances: (Group number 1 - Default model)

Modification Indices			M.I.	Par Change
ec30	<-->	Open_Innovation	16.022	.658
ec29	<-->	Open_Innovation	12.791	.596
ec29	<-->	ec30	52.309	1.589
ec28	<-->	Open_Innovation	4.478	.343
ec28	<-->	ec29	4.478	.458
ec27	<-->	ec30	10.088	-.734
ec27	<-->	ec29	16.892	-.963
ec26	<-->	ec30	10.693	-.718
ec26	<-->	ec28	6.560	-.554
ec26	<-->	ec27	12.127	.814
ec25	<-->	ec28	4.464	.360
ec25	<-->	ec26	4.719	-.379
ec24	<-->	Collaborative_Research_Advantage	4.027	-.190
ec24	<-->	ec25	4.255	.290
ec23	<-->	Open_Innovation	13.984	-.497
ec23	<-->	ec29	13.909	-.658
ec23	<-->	ec28	4.076	-.346
ec23	<-->	ec27	18.907	.802
ec23	<-->	ec26	25.936	.890
ec23	<-->	ec25	4.280	-.282
el22	<-->	Strategic_Leadership	5.281	.118
el22	<-->	Collaborative_Research_Advantage	8.119	-.159
el21	<-->	el22	14.420	.202
el20	<-->	el21	4.840	-.105
el19	<-->	Commercialisation_Success	5.752	.426
el18	<-->	ec28	4.928	-.349
el18	<-->	el20	11.413	-.236
el18	<-->	el19	4.092	.191
el17	<-->	Strategic_Leadership	5.328	-.140
el17	<-->	Collaborative_Research_Advantage	4.260	.135
el17	<-->	el22	14.830	-.233
el17	<-->	el20	7.771	.151

Modification Indices			M.I.	Par Change
el16	<-->	el22	4.018	.153
el16	<-->	el21	5.992	-.193
el16	<-->	el20	5.899	.166
el16	<-->	el19	17.173	-.383
ea15	<-->	ec29	4.778	.199
ea14	<-->	ec25	5.957	-.207
ea14	<-->	ec23	6.748	.222
ea14	<-->	el22	8.867	-.154
ea14	<-->	ea15	15.566	.168
ea13	<-->	ea14	7.735	-.154
ea12	<-->	ec25	4.570	.210
ea12	<-->	ea13	6.336	.162
ea11	<-->	Commercialisation_Success	8.708	-.540
ea11	<-->	Strategic_Leadership	4.098	.132
ea11	<-->	ea14	6.867	-.168
ea11	<-->	ea13	8.636	.206
ea11	<-->	ea12	4.381	.156
ea10	<-->	ea14	6.541	.140
ea10	<-->	ea13	5.245	-.137
ea10	<-->	ea12	5.928	-.155
ea9	<-->	el21	6.034	.185
ea9	<-->	el20	15.121	-.256
ea9	<-->	ea14	5.399	-.168
ea9	<-->	ea13	22.301	.372
ea6	<-->	el16	10.064	.423
ea6	<-->	ea12	5.891	-.253
eo5	<-->	Commercialisation_Success	9.153	-.651
eo5	<-->	el22	9.692	-.239
eo5	<-->	el17	5.836	.217
eo5	<-->	el16	6.398	-.284
eo5	<-->	ea14	6.494	.194
eo4	<-->	Commercialisation_Success	5.122	.488
eo4	<-->	ea15	4.858	-.143
eo4	<-->	eo5	6.443	.271
eo3	<-->	ec30	5.434	-.394
eo2	<-->	Commercialisation_Success	7.060	.679
eo2	<-->	ec30	14.202	.699
eo2	<-->	eo5	9.452	-.405
eo1	<-->	Collaborative_Research_Advantage	4.756	.219
eo1	<-->	ea10	6.230	.249
eo1	<-->	eo4	13.658	-.498
eo1	<-->	eo2	12.223	.566

Remove A10



Standardized Regression Weights: (Group number 1 - Default model)

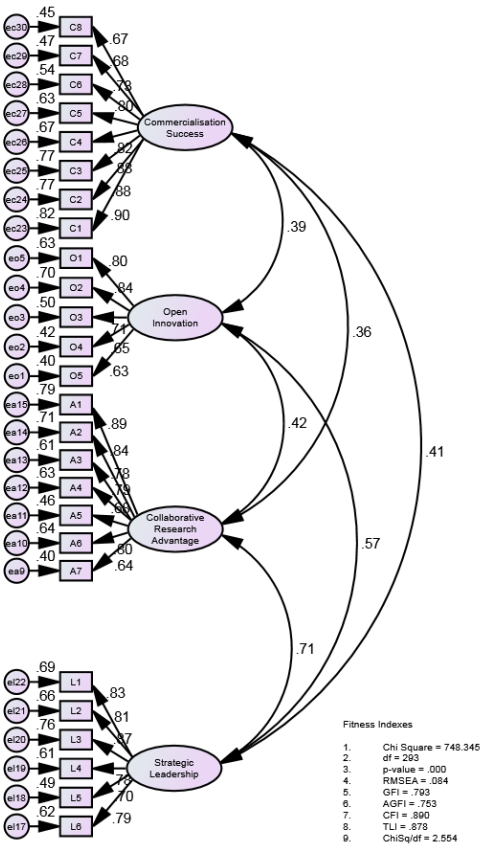
Item Loadings			Estimate
O5	<---	Open_Innovation	.633
O4	<---	Open_Innovation	.647
O3	<---	Open_Innovation	.706
O2	<---	Open_Innovation	.839
O1	<---	Open_Innovation	.794
A7	<---	Collaborative_Research_Advantage	.635
A6	<---	Collaborative_Research_Advantage	.799
A5	<---	Collaborative_Research_Advantage	.682
A4	<---	Collaborative_Research_Advantage	.794
L6	<---	Strategic_Leadership	.793
L5	<---	Strategic_Leadership	.696
L4	<---	Strategic_Leadership	.766
L3	<---	Strategic_Leadership	.881
L2	<---	Strategic_Leadership	.801
C2	<---	Commercialisation_Success	.878
C3	<---	Commercialisation_Success	.877
C4	<---	Commercialisation_Success	.819
C5	<---	Commercialisation_Success	.797
C6	<---	Commercialisation_Success	.733
C7	<---	Commercialisation_Success	.684
C8	<---	Commercialisation_Success	.672
C1	<---	Commercialisation_Success	.904
A1	<---	Collaborative_Research_Advantage	.888
A2	<---	Collaborative_Research_Advantage	.842
A3	<---	Collaborative_Research_Advantage	.782
L1	<---	Strategic_Leadership	.837
L7	<---	Strategic_Leadership	.628

Covariances: (Group number 1 - Default model)

Modification Indices			M.I.	Par Change
ec30	<-->	Open_Innovation	16.032	.658
ec29	<-->	Open_Innovation	12.758	.595
ec29	<-->	ec30	52.301	1.589
ec28	<-->	Open_Innovation	4.487	.343
ec28	<-->	ec29	4.474	.458
ec27	<-->	ec30	10.081	-.734
ec27	<-->	ec29	16.901	-.963
ec26	<-->	ec30	10.686	-.718
ec26	<-->	ec28	6.553	-.553
ec26	<-->	ec27	12.140	.814
ec25	<-->	ec28	4.464	.360
ec25	<-->	ec26	4.715	-.378
ec24	<-->	ec25	4.238	.289
ec23	<-->	Open_Innovation	13.954	-.496
ec23	<-->	ec29	13.916	-.658
ec23	<-->	ec28	4.063	-.345
ec23	<-->	ec27	18.934	.803
ec23	<-->	ec26	25.963	.891
ec23	<-->	ec25	4.267	-.282
el22	<-->	Strategic_Leadership	5.456	.121
el22	<-->	Collaborative_Research_Advantage	8.645	-.166
el21	<-->	el22	14.378	.202
el20	<-->	el21	4.924	-.106
el19	<-->	Commercialisation_Success	5.739	.426
el18	<-->	ec28	4.905	-.348
el18	<-->	el20	11.339	-.235
el18	<-->	el19	4.099	.191
el17	<-->	Strategic_Leadership	5.739	-.146
el17	<-->	Collaborative_Research_Advantage	4.940	.147
el17	<-->	el22	14.933	-.234
el17	<-->	el20	7.673	.150

Modification Indices			M.I.	Par Change
el16	<-->	el22	4.151	.155
el16	<-->	el21	5.901	-.191
el16	<-->	el20	6.089	.169
el16	<-->	el19	16.980	-.381
ea15	<-->	ec29	4.255	.188
ea14	<-->	ec25	6.038	-.209
ea14	<-->	ec23	6.741	.223
ea14	<-->	el22	7.874	-.146
ea14	<-->	ea15	15.806	.170
ea13	<-->	ea14	8.355	-.161
ea12	<-->	ec25	4.606	.208
ea12	<-->	ea13	5.042	.143
ea11	<-->	Commercialisation_Success	8.403	-.531
ea11	<-->	Strategic_Leadership	4.556	.140
ea11	<-->	ea14	6.608	-.166
ea11	<-->	ea13	8.449	.203
ea10	<-->	ea14	7.832	.156
ea10	<-->	ea13	4.890	-.133
ea10	<-->	ea12	6.349	-.160
ea9	<-->	el21	5.812	.182
ea9	<-->	el20	15.130	-.256
ea9	<-->	ea14	5.303	-.167
ea9	<-->	ea13	22.100	.369
eo5	<-->	Commercialisation_Success	9.123	-.651
eo5	<-->	el22	9.692	-.239
eo5	<-->	el17	5.846	.217
eo5	<-->	el16	6.381	-.284
eo5	<-->	ea14	6.194	.191
eo4	<-->	Commercialisation_Success	5.116	.488
eo4	<-->	ea15	4.523	-.138
eo4	<-->	eo5	6.448	.271
eo3	<-->	ec30	5.432	-.394
eo2	<-->	Commercialisation_Success	6.950	.674
eo2	<-->	ec30	14.192	.699
eo2	<-->	ea14	4.025	-.182
eo2	<-->	eo5	9.464	-.406
eo1	<-->	Collaborative_Research_Advantage	4.627	.218
eo1	<-->	ea10	6.376	.255
eo1	<-->	eo4	13.646	-.497
eo1	<-->	eo2	12.220	.566

Remove L7



Standardized Regression Weights: (Group number 1 - Default model)

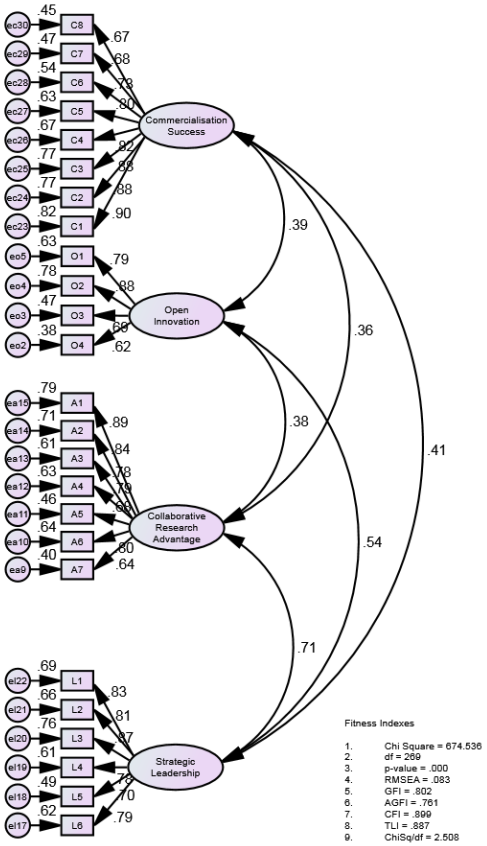
Item Loadings			Estimate
O5	<---	Open_Innovation	.632
O4	<---	Open_Innovation	.646
O3	<---	Open_Innovation	.705
O2	<---	Open_Innovation	.839
O1	<---	Open_Innovation	.795
A7	<---	Collaborative_Research_Advantage	.635
A6	<---	Collaborative_Research_Advantage	.799
A5	<---	Collaborative_Research_Advantage	.681
A4	<---	Collaborative_Research_Advantage	.794
L6	<---	Strategic_Leadership	.790
L5	<---	Strategic_Leadership	.701
L4	<---	Strategic_Leadership	.780
L3	<---	Strategic_Leadership	.871
L2	<---	Strategic_Leadership	.810
C2	<---	Commercialisation_Success	.878
C3	<---	Commercialisation_Success	.877
C4	<---	Commercialisation_Success	.819
C5	<---	Commercialisation_Success	.797
C6	<---	Commercialisation_Success	.733
C7	<---	Commercialisation_Success	.684
C8	<---	Commercialisation_Success	.672
C1	<---	Commercialisation_Success	.904
A1	<---	Collaborative_Research_Advantage	.888
A2	<---	Collaborative_Research_Advantage	.842
A3	<---	Collaborative_Research_Advantage	.782
L1	<---	Strategic_Leadership	.832

Covariances: (Group number 1 - Default model)

Modification Indices			M.I.	Par Change
ec30	<-->	Open_Innovation	15.927	.657
ec29	<-->	Open_Innovation	12.739	.595
ec29	<-->	ec30	52.300	1.589
ec28	<-->	Open_Innovation	4.416	.341
ec28	<-->	ec29	4.473	.458
ec27	<-->	ec30	10.093	-.734
ec27	<-->	ec29	16.912	-.963
ec26	<-->	ec30	10.679	-.718
ec26	<-->	ec28	6.547	-.553
ec26	<-->	ec27	12.140	.814
ec25	<-->	ec28	4.460	.360
ec25	<-->	ec26	4.707	-.378
ec24	<-->	ec25	4.240	.290
ec23	<-->	Open_Innovation	13.891	-.496
ec23	<-->	ec29	13.915	-.658
ec23	<-->	ec28	4.068	-.345
ec23	<-->	ec27	18.914	.802
ec23	<-->	ec26	25.986	.891
ec23	<-->	ec25	4.273	-.282
el22	<-->	Strategic_Leadership	4.504	.111
el22	<-->	Collaborative_Research_Advantage	7.033	-.153
el21	<-->	el22	13.383	.195
el20	<-->	el21	4.867	-.107
el19	<-->	Commercialisation_Success	5.739	.418
el18	<-->	ec28	5.221	-.358
el18	<-->	el20	9.885	-.226
el17	<-->	Strategic_Leadership	6.257	-.153
el17	<-->	Collaborative_Research_Advantage	5.622	.159
el17	<-->	el22	11.803	-.213
el17	<-->	el20	10.769	.185
ea15	<-->	ec29	4.267	.188

Modification Indices			M.I.	Par Change
ea14	<-->	ec25	6.094	-.210
ea14	<-->	ec23	6.732	.223
ea14	<-->	el22	8.502	-.154
ea14	<-->	ea15	15.511	.168
ea13	<-->	ea14	8.448	-.161
ea12	<-->	ec25	4.607	.208
ea12	<-->	ea13	5.118	.144
ea11	<-->	Commercialisation_Success	8.317	-.529
ea11	<-->	Strategic_Leadership	4.241	.135
ea11	<-->	ea14	6.643	-.167
ea11	<-->	ea13	8.557	.205
ea10	<-->	ea14	7.710	.154
ea10	<-->	ea13	4.823	-.133
ea10	<-->	ea12	6.309	-.160
ea9	<-->	el21	6.023	.183
ea9	<-->	el20	13.680	-.252
ea9	<-->	ea14	5.395	-.168
ea9	<-->	ea13	22.159	.370
eo5	<-->	Commercialisation_Success	9.387	-.659
eo5	<-->	el22	11.023	-.258
eo5	<-->	el17	4.859	.200
eo5	<-->	ea14	6.046	.188
eo4	<-->	Commercialisation_Success	5.159	.490
eo4	<-->	ea15	4.483	-.137
eo4	<-->	eo5	6.241	.266
eo3	<-->	ec30	5.412	-.393
eo2	<-->	Commercialisation_Success	7.002	.677
eo2	<-->	ec30	14.179	.699
eo2	<-->	ea14	4.061	-.183
eo2	<-->	eo5	9.582	-.408
eo1	<-->	Collaborative_Research_Advantage	4.914	.226
eo1	<-->	ea10	6.419	.256
eo1	<-->	eo4	13.518	-.495
eo1	<-->	eo2	12.291	.568

Remove O5



Standardized Regression Weights: (Group number 1 - Default model)

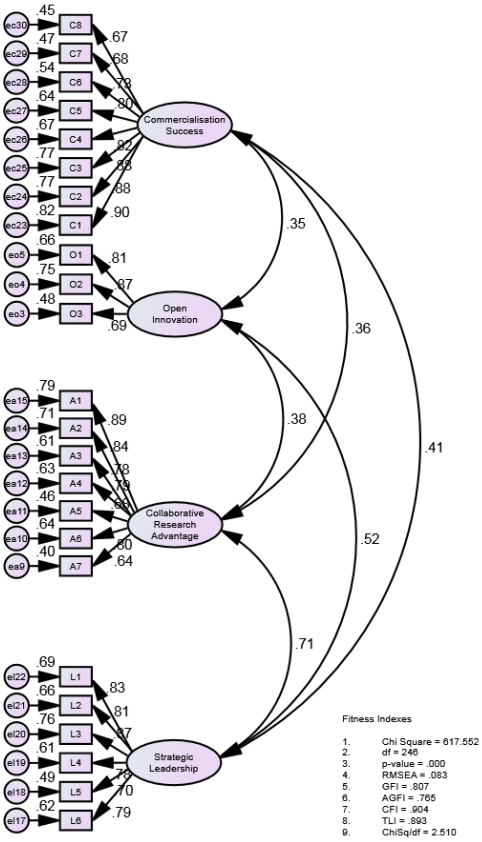
Item Loadings			Estimate
O4	<---	Open_Innovation	.615
O3	<---	Open_Innovation	.689
O2	<---	Open_Innovation	.883
O1	<---	Open_Innovation	.791
A7	<---	Collaborative_Research_Advantage	.635
A6	<---	Collaborative_Research_Advantage	.799
A5	<---	Collaborative_Research_Advantage	.681
A4	<---	Collaborative_Research_Advantage	.794
L6	<---	Strategic_Leadership	.789
L5	<---	Strategic_Leadership	.701
L4	<---	Strategic_Leadership	.780
L3	<---	Strategic_Leadership	.871
L2	<---	Strategic_Leadership	.811
C2	<---	Commercialisation_Success	.878
C3	<---	Commercialisation_Success	.877
C4	<---	Commercialisation_Success	.819
C5	<---	Commercialisation_Success	.797
C6	<---	Commercialisation_Success	.733
C7	<---	Commercialisation_Success	.684
C8	<---	Commercialisation_Success	.672
C1	<---	Commercialisation_Success	.904
A1	<---	Collaborative_Research_Advantage	.888
A2	<---	Collaborative_Research_Advantage	.842
A3	<---	Collaborative_Research_Advantage	.782
L1	<---	Strategic_Leadership	.833

Covariances: (Group number 1 - Default model)

Modification Indices			M.I.	Par Change
ec30	<-->	Open_Innovation	15.895	.661
ec29	<-->	Open_Innovation	12.453	.593
ec29	<-->	ec30	52.253	1.587
ec28	<-->	ec29	4.465	.457
ec27	<-->	ec30	10.124	-.735
ec27	<-->	ec29	16.938	-.964
ec26	<-->	ec30	10.762	-.720
ec26	<-->	ec28	6.572	-.554
ec26	<-->	ec27	12.115	.813
ec25	<-->	ec28	4.488	.361
ec25	<-->	ec26	4.703	-.378
ec24	<-->	ec25	4.302	.292
ec23	<-->	Strategic_Leadership	4.436	-.184
ec23	<-->	Open_Innovation	11.851	-.461
ec23	<-->	ec29	13.993	-.660
ec23	<-->	ec28	4.070	-.345
ec23	<-->	ec27	18.919	.802
ec23	<-->	ec26	25.882	.889
ec23	<-->	ec25	4.225	-.280
el22	<-->	Strategic_Leadership	4.054	.106
el22	<-->	Collaborative_Research_Advantage	7.265	-.155
el21	<-->	el22	13.021	.192
el20	<-->	el21	4.895	-.107
el19	<-->	Commercialisation_Success	5.803	.419
el18	<-->	ec28	5.172	-.356
el18	<-->	el20	9.660	-.223
el17	<-->	Strategic_Leadership	6.054	-.152
el17	<-->	Collaborative_Research_Advantage	5.905	.164
el17	<-->	el22	11.917	-.214
el17	<-->	el20	11.073	.188
ea15	<-->	ec29	4.373	.191

Modification Indices			M.I.	Par Change
ea14	<-->	ec25	6.105	-.210
ea14	<-->	ec23	6.626	.221
ea14	<-->	el22	8.653	-.155
ea14	<-->	ea15	15.472	.168
ea13	<-->	ea14	8.421	-.161
ea12	<-->	ec25	4.577	.208
ea12	<-->	ea13	5.119	.144
ea11	<-->	Commercialisation_Success	8.186	-.523
ea11	<-->	Strategic_Leadership	4.410	.139
ea11	<-->	ea14	6.664	-.167
ea11	<-->	ea13	8.585	.205
ea10	<-->	ea14	7.685	.154
ea10	<-->	ea13	4.784	-.132
ea10	<-->	ea12	6.361	-.160
ea9	<-->	el21	5.995	.182
ea9	<-->	el20	13.681	-.252
ea9	<-->	ea14	5.387	-.168
ea9	<-->	ea13	22.215	.370
eo5	<-->	Commercialisation_Success	10.616	-.701
eo5	<-->	Collaborative_Research_Advantage	4.823	.184
eo5	<-->	el22	13.065	-.282
eo5	<-->	el17	5.533	.214
eo5	<-->	ea14	5.396	.178
eo4	<-->	Commercialisation_Success	4.111	.418
eo3	<-->	ec30	4.655	-.370
eo2	<-->	Commercialisation_Success	6.566	.670
eo2	<-->	ec30	14.349	.720
eo2	<-->	ec26	4.654	-.416
eo2	<-->	ea14	4.154	-.189

Remove O4



Standardized Regression Weights: (Group number 1 - Default model)

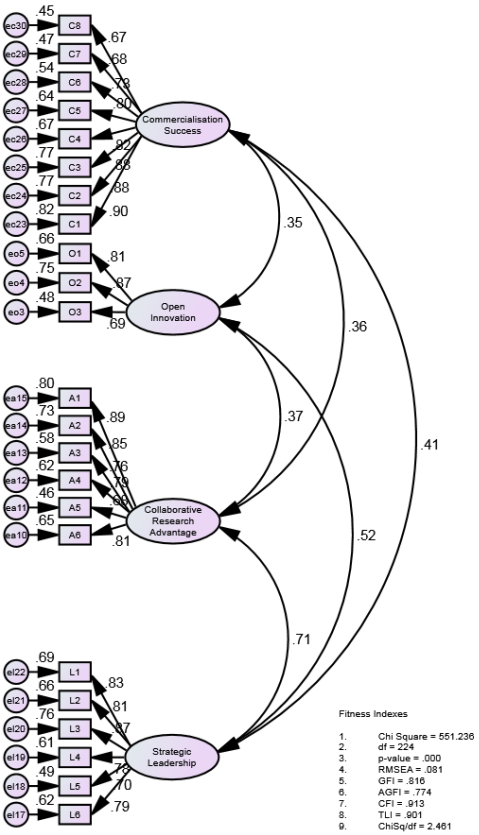
		Item Loadings	Estimate
O3	<---	Open_Innovation	.692
O2	<---	Open_Innovation	.869
O1	<---	Open_Innovation	.815
A7	<---	Collaborative_Research_Advantage	.635
A6	<---	Collaborative_Research_Advantage	.799
A5	<---	Collaborative_Research_Advantage	.681
A4	<---	Collaborative_Research_Advantage	.794
L6	<---	Strategic_Leadership	.789
L5	<---	Strategic_Leadership	.700
L4	<---	Strategic_Leadership	.781
L3	<---	Strategic_Leadership	.871
L2	<---	Strategic_Leadership	.811
C2	<---	Commercialisation_Success	.878
C3	<---	Commercialisation_Success	.877
C4	<---	Commercialisation_Success	.820
C5	<---	Commercialisation_Success	.797
C6	<---	Commercialisation_Success	.733
C7	<---	Commercialisation_Success	.683
C8	<---	Commercialisation_Success	.671
C1	<---	Commercialisation_Success	.904
A1	<---	Collaborative_Research_Advantage	.888
A2	<---	Collaborative_Research_Advantage	.842
A3	<---	Collaborative_Research_Advantage	.782
L1	<---	Strategic_Leadership	.833

Covariances: (Group number 1 - Default model)

		Modification Indices	M.I.	Par Change
ec30	<-->	Open_Innovation	11.909	.604
ec29	<-->	Open_Innovation	11.926	.613
ec29	<-->	ec30	52.507	1.595
ec28	<-->	ec29	4.573	.464
ec27	<-->	ec30	10.025	-.732
ec27	<-->	ec29	16.859	-.961
ec26	<-->	ec30	10.640	-.716
ec26	<-->	ec28	6.567	-.554
ec26	<-->	ec27	11.907	.804
ec25	<-->	ec28	4.601	.366
ec25	<-->	ec26	4.775	-.381
ec24	<-->	ec25	4.405	.296
ec23	<-->	Strategic_Leadership	4.970	-.195
ec23	<-->	Open_Innovation	10.724	-.462
ec23	<-->	ec29	13.943	-.658
ec23	<-->	ec28	4.097	-.346
ec23	<-->	ec27	18.539	.792
ec23	<-->	ec26	25.466	.879
ec23	<-->	ec25	4.381	-.285
el22	<-->	Strategic_Leadership	4.137	.108
el22	<-->	Collaborative_Research_Advantage	7.201	-.155
el21	<-->	el22	13.074	.192
el20	<-->	el21	4.895	-.107
el19	<-->	Commercialisation_Success	5.714	.419
el18	<-->	ec28	5.082	-.353
el18	<-->	el20	9.547	-.222
el17	<-->	Strategic_Leadership	6.191	-.155
el17	<-->	Collaborative_Research_Advantage	5.765	.162
el17	<-->	el22	11.931	-.214
el17	<-->	el20	11.029	.188
ea15	<-->	ec29	4.316	.190
ea14	<-->	ec25	6.155	-.211

Modification Indices			M.I.	Par Change
ea14	<-->	ec23	6.637	.221
ea14	<-->	el22	8.768	-.157
ea14	<-->	ea15	15.484	.168
ea13	<-->	ea14	8.450	-.161
ea12	<-->	ec25	4.573	.208
ea12	<-->	ea13	5.117	.144
ea11	<-->	Commercialisation_Success	8.366	-.533
ea11	<-->	Strategic_Leadership	4.368	.139
ea11	<-->	ea14	6.664	-.167
ea11	<-->	ea13	8.572	.205
ea10	<-->	ea14	7.692	.154
ea10	<-->	ea13	4.801	-.132
ea10	<-->	ea12	6.334	-.160
ea9	<-->	el21	6.049	.183
ea9	<-->	el20	13.598	-.251
ea9	<-->	ea14	5.401	-.169
ea9	<-->	ea13	22.185	.370
eo5	<-->	Commercialisation_Success	8.634	-.629
eo5	<-->	Collaborative_Research_Advantage	4.238	.171
eo5	<-->	ec26	4.231	-.322
eo5	<-->	el22	14.526	-.293
eo5	<-->	el17	5.492	.210
eo5	<-->	ea14	4.512	.161
eo4	<-->	Commercialisation_Success	9.738	.675
eo4	<-->	ec30	7.135	.418

Remove A7



Standardized Regression Weights: (Group number 1 - Default model)

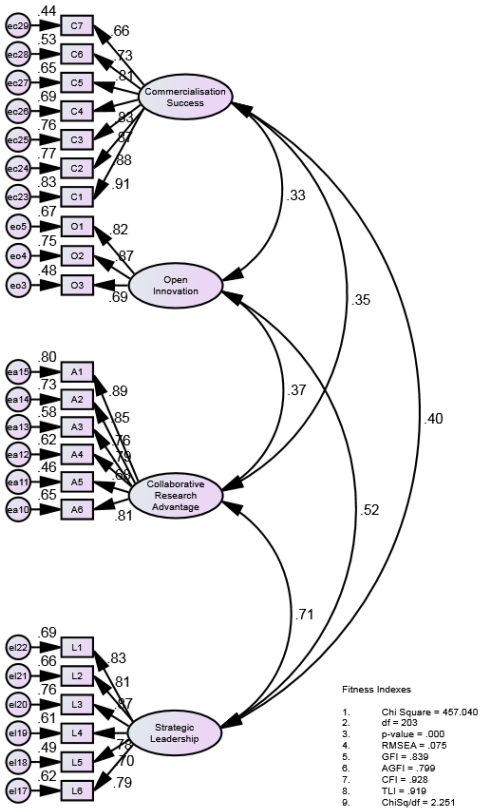
		Item Loadings	Estimate
O3	<---	Open_Innovation	.692
O2	<---	Open_Innovation	.869
O1	<---	Open_Innovation	.814
A6	<---	Collaborative_Research_Advantage	.806
A5	<---	Collaborative_Research_Advantage	.676
A4	<---	Collaborative_Research_Advantage	.786
L6	<---	Strategic_Leadership	.789
L5	<---	Strategic_Leadership	.700
L4	<---	Strategic_Leadership	.781
L3	<---	Strategic_Leadership	.872
L2	<---	Strategic_Leadership	.810
C2	<---	Commercialisation_Success	.878
C3	<---	Commercialisation_Success	.877
C4	<---	Commercialisation_Success	.820
C5	<---	Commercialisation_Success	.797
C6	<---	Commercialisation_Success	.733
C7	<---	Commercialisation_Success	.683
C8	<---	Commercialisation_Success	.671
C1	<---	Commercialisation_Success	.904
A1	<---	Collaborative_Research_Advantage	.895
A2	<---	Collaborative_Research_Advantage	.853
A3	<---	Collaborative_Research_Advantage	.763
L1	<---	Strategic_Leadership	.833

Covariances: (Group number 1 - Default model)

		Modification Indices	M.I.	Par Change
ec30	<-->	Open_Innovation	11.938	.605
ec29	<-->	Open_Innovation	11.934	.613
ec29	<-->	ec30	52.501	1.594
ec28	<-->	ec29	4.571	.463
ec27	<-->	ec30	10.042	-.732
ec27	<-->	ec29	16.875	-.962
ec26	<-->	ec30	10.660	-.716
ec26	<-->	ec28	6.581	-.554
ec26	<-->	ec27	11.889	.804
ec25	<-->	ec28	4.607	.366
ec25	<-->	ec26	4.767	-.380
ec24	<-->	ec25	4.428	.297
ec23	<-->	Strategic_Leadership	5.019	-.196
ec23	<-->	Open_Innovation	10.656	-.460
ec23	<-->	ec29	13.948	-.658
ec23	<-->	ec28	4.102	-.346
ec23	<-->	ec27	18.520	.791
ec23	<-->	ec26	25.442	.878
ec23	<-->	ec25	4.352	-.284
el22	<-->	Strategic_Leadership	4.193	.109
el22	<-->	Collaborative_Research_Advantage	7.408	-.159
el21	<-->	el22	13.363	.195
el20	<-->	el21	4.947	-.108
el19	<-->	Commercialisation_Success	5.674	.418
el18	<-->	ec28	5.078	-.354
el18	<-->	el20	9.674	-.223
el17	<-->	Strategic_Leadership	5.892	-.151
el17	<-->	Collaborative_Research_Advantage	5.334	.158
el17	<-->	el22	11.831	-.213
el17	<-->	el20	10.822	.185
ea15	<-->	ec29	4.647	.194
ea14	<-->	ec25	5.549	-.197

Modification Indices			M.I.	Par Change
ea14	<-->	ec23	6.972	.222
ea14	<-->	el22	9.256	-.158
ea14	<-->	ea15	9.302	.125
ea13	<-->	ea14	6.330	-.141
ea12	<-->	ec25	5.356	.228
ea12	<-->	ea13	8.962	.199
ea11	<-->	Commercialisation_Success	7.898	-.522
ea11	<-->	Strategic_Leadership	4.864	.147
ea11	<-->	ea14	7.701	-.177
ea11	<-->	ea13	11.318	.245
ea11	<-->	ea12	5.237	.173
ea10	<-->	ea14	4.649	.116
ea10	<-->	ea12	6.135	-.158
eo5	<-->	Commercialisation_Success	8.597	-.628
eo5	<-->	Collaborative_Research_Advantage	4.289	.174
eo5	<-->	ec26	4.236	-.322
eo5	<-->	el22	14.540	-.294
eo5	<-->	el17	5.511	.211
eo5	<-->	ea14	4.878	.164
eo4	<-->	Commercialisation_Success	9.679	.673
eo4	<-->	ec30	7.143	.418

Remove C8



Standardized Regression Weights: (Group number 1 - Default model)

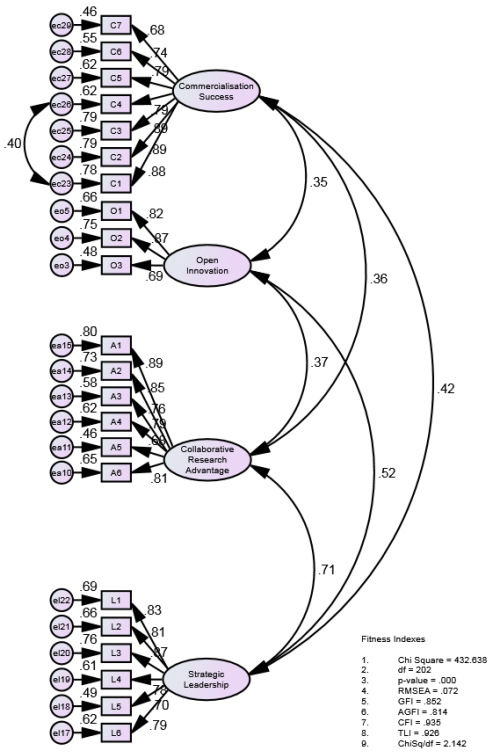
Item Loadings			Estimate
O3	<---	Open_Innovation	.693
O2	<---	Open_Innovation	.867
O1	<---	Open_Innovation	.816
A6	<---	Collaborative_Research_Advantage	.806
A5	<---	Collaborative_Research_Advantage	.676
A4	<---	Collaborative_Research_Advantage	.786
L6	<---	Strategic_Leadership	.789
L5	<---	Strategic_Leadership	.699
L4	<---	Strategic_Leadership	.781
L3	<---	Strategic_Leadership	.872
L2	<---	Strategic_Leadership	.810
C2	<---	Commercialisation_Success	.876
C3	<---	Commercialisation_Success	.874
C4	<---	Commercialisation_Success	.831
C5	<---	Commercialisation_Success	.808
C6	<---	Commercialisation_Success	.726
C7	<---	Commercialisation_Success	.660
C1	<---	Commercialisation_Success	.909
A1	<---	Collaborative_Research_Advantage	.895
A2	<---	Collaborative_Research_Advantage	.853
A3	<---	Collaborative_Research_Advantage	.763
L1	<---	Strategic_Leadership	.833

Covariances: (Group number 1 - Default model)

Modification Indices			M.I.	Par Change
ec29	<-->	Open_Innovation	13.010	.661
ec28	<-->	Open_Innovation	4.107	.355
ec28	<-->	ec29	7.357	.610
ec27	<-->	ec29	13.578	-.869
ec26	<-->	ec28	7.335	-.579
ec26	<-->	ec27	7.776	.624
ec25	<-->	ec29	4.063	.368
ec25	<-->	ec28	6.367	.440
ec25	<-->	ec26	7.054	-.458
ec24	<-->	ec29	5.542	.442
ec24	<-->	ec27	5.622	-.444
ec24	<-->	ec25	5.854	.348
ec23	<-->	Strategic_Leadership	5.119	-.196
ec23	<-->	Open_Innovation	8.029	-.398
ec23	<-->	ec29	7.643	-.495
ec23	<-->	ec27	12.920	.639
ec23	<-->	ec26	18.854	.730
ec23	<-->	ec25	5.157	-.308
el22	<-->	Strategic_Leadership	4.171	.109
el22	<-->	Collaborative_Research_Advantage	7.453	-.160
el21	<-->	el22	13.330	.194
el20	<-->	el21	4.970	-.108
el19	<-->	Commercialisation_Success	5.513	.418
el18	<-->	ec28	4.832	-.349
el18	<-->	el20	9.665	-.223
el17	<-->	Strategic_Leadership	5.869	-.151
el17	<-->	Collaborative_Research_Advantage	5.365	.158
el17	<-->	el22	11.833	-.213
el17	<-->	el20	10.836	.186

Modification Indices			M.I.	Par Change
ea15	<-->	ec29	4.605	.199
ea14	<-->	ec25	5.747	-.203
ea14	<-->	ec23	7.077	.221
ea14	<-->	el22	9.275	-.158
ea14	<-->	ea15	9.313	.125
ea13	<-->	ea14	6.340	-.141
ea12	<-->	ec25	4.999	.223
ea12	<-->	ea13	8.958	.199
ea11	<-->	Commercialisation_Success	8.127	-.537
ea11	<-->	Strategic_Leadership	4.868	.148
ea11	<-->	ea14	7.712	-.177
ea11	<-->	ea13	11.310	.245
ea11	<-->	ea12	5.234	.173
ea10	<-->	ea14	4.647	.116
ea10	<-->	ea12	6.137	-.158
eo5	<-->	Commercialisation_Success	8.652	-.638
eo5	<-->	Collaborative_Research_Advantage	4.253	.173
eo5	<-->	el22	14.654	-.294
eo5	<-->	el17	5.513	.211
eo5	<-->	ea14	4.892	.164
eo4	<-->	Commercialisation_Success	9.226	.669

Reset ec23-ec26



Standardized Regression Weights: (Group number 1 - Default model)

Item Loadings			Estimate
O3	<---	Open_Innovation	.693
O2	<---	Open_Innovation	.868
O1	<---	Open_Innovation	.815
A6	<---	Collaborative_Research_Advantage	.806
A5	<---	Collaborative_Research_Advantage	.676
A4	<---	Collaborative_Research_Advantage	.786
L6	<---	Strategic_Leadership	.789
L5	<---	Strategic_Leadership	.700
L4	<---	Strategic_Leadership	.781
L3	<---	Strategic_Leadership	.872
L2	<---	Strategic_Leadership	.810
C2	<---	Commercialisation_Success	.887
C3	<---	Commercialisation_Success	.891
C4	<---	Commercialisation_Success	.789
C5	<---	Commercialisation_Success	.789
C6	<---	Commercialisation_Success	.743
C7	<---	Commercialisation_Success	.677
C1	<---	Commercialisation_Success	.881
A1	<---	Collaborative_Research_Advantage	.895
A2	<---	Collaborative_Research_Advantage	.853
A3	<---	Collaborative_Research_Advantage	.763
L1	<---	Strategic_Leadership	.833

Covariances: (Group number 1 - Default model)

Modification Indices			M.I.	Par Change
ec29	<-->	Open_Innovation	12.251	.629
ec28	<-->	ec29	4.457	.459
ec27	<-->	ec29	13.431	-.887
ec26	<-->	ec27	6.924	.592
ec23	<-->	Open_Innovation	6.914	-.354
ec23	<-->	ec29	4.147	-.347
ec23	<-->	ec27	12.694	.643
el22	<-->	Strategic_Leadership	4.060	.107
el22	<-->	Collaborative_Research_Advantage	7.533	-.161
el21	<-->	el22	13.321	.194
el20	<-->	el21	4.895	-.107
el19	<-->	Commercialisation_Success	5.379	.398
el18	<-->	ec28	5.128	-.352
el18	<-->	el20	9.637	-.223
el17	<-->	Strategic_Leadership	5.858	-.151
el17	<-->	Collaborative_Research_Advantage	5.395	.159
el17	<-->	el22	11.871	-.213
el17	<-->	el20	10.877	.186
ea15	<-->	ec29	5.179	.208
ea14	<-->	ec25	5.266	-.188
ea14	<-->	ec23	5.924	.195
ea14	<-->	el22	9.263	-.158
ea14	<-->	ea15	9.376	.125
ea13	<-->	ea14	6.319	-.141
ea12	<-->	ec25	4.833	.213
ea12	<-->	ea13	8.939	.199
ea11	<-->	Commercialisation_Success	7.314	-.491
ea11	<-->	Strategic_Leadership	4.879	.147
ea11	<-->	ec27	4.485	-.309
ea11	<-->	ea14	7.729	-.177
ea11	<-->	ea13	11.280	.244
ea11	<-->	ea12	5.204	.172
ea10	<-->	ea14	4.667	.116
ea10	<-->	ea12	6.159	-.159

Modification Indices			M.I.	Par Change
eo5	<-->	Commercialisation_Success	8.076	-.595
eo5	<-->	Collaborative_Research_Advantage	4.176	.172
eo5	<-->	el22	14.642	-.294
eo5	<-->	el17	5.531	.211
eo5	<-->	ea14	4.892	.164
eo4	<-->	Commercialisation_Success	8.876	.632