

**PROFILING ICT ACADEMICS AT MALAYSIAN
RESEARCH UNIVERSITIES (RUs) ON THEIR
COMMERCIALIZATION APPROACHES
BASED ON PERSONAL ATTRIBUTES: A
GROUNDED THEORY STUDY**

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2015

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by

HAFIZUL OTHMAN

**Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy**

January 2015

ACKNOWLEDGEMENTS

My supervisor for my Masters Degree once said to me before I took up the PhD, “*PhD is a lonely journey.*” He was right as I only interacted with only a few people especially about my research. But, these few people have made this lonely journey to be full of joy especially with their assistance. Therefore, I would like to thank those people and the organizations who have provided me with the support, guidance and assistance needed to complete this lonely journey.

- First of all, I would like to thank my wife for her continuous support and understanding for sharing the inevitable sacrifices and challenges.
- I would like to thank my supervisor, Prof. Dr. Rosni Abdullah for sharing her vast knowledge and experiences to this research.
- I would like to thank my co-supervisor, Dr. Nasriah Zakaria for sharing her knowledge particularly the research methodology via GTM.
- I would like to extend my appreciation to my panels, Assoc. Prof. Muhammad Rafie Hj Mohd. Arshad, Dr. Vincent Khoo Kay Teong and Dr. Ahmad Suhaimi Baharudin. Their valuable thought and input during proposal review and research review have tremendously improved this research.
- I would also like thank my interviewees as their time and passions of telling their true story, and without it the findings of this research would not be what they are.
- Finally, I would like to thank the Malaysian government for their RMK-10 initiatives that give me a chance to be one of the 60,000 PhD holders by the year 2023 through MyBrain15 Scholarship.

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LIST OF ABBREVIATIONS

3K	Kesesuaian, Kemampuilikan, and Kecapaian
A	Attitude
CV	Curriculum Vitae
GLCs	Government-Linked Companies
CoE	Centre of Excellence
EU	European Union
FRGS	Fundamental Research Grant Scheme
GTM	Grounded Theory Method
ICC	Innovation and Commercialization Centre
ICT	Information Communication Technology
IS	Information System
IP	Intellectual Property
JIT	Just In Time
KPI	Key Performance Index
KPT	Kementerian Pengajian Tinggi
MOSTI	Ministry of Science, Technology and Innovation
MOA	Ministry of Agriculture
MoA	Memorandum of Agreement
MOOCs	Massive Open Online Courses
MOF	Ministry of Finance
MoU	Memorandum of Understanding
MSC	Multimedia Super Corridor
PBC	Perceived Behavioural Control

PGMC	Proton Green Mobility Challenges
PhD	Doctor of Philosophy
RA	Research Alliance
RMC	Research Management Centre
RU	Research University
RBV	Resource-Based View
R&D	Research and Development
SIRIM	Standards and Industrial Research Institute of Malaysia
SN	Subjective Norm
SOP	Standard Operating Procedure
STF	Systems Theory Framework
S&T	Science and Technology
TCE	Transaction Cost Economics
TPB	Theory of Planned Behaviour
TPM	Technology Park Malaysia
TTO	Technology Transfer Office
UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UPM	Universiti Putra Malaysia
US	United States
USM	Universiti Sains Malaysia
UTM	Universiti Teknologi Malaysia

PEMPROFILAN AHLI AKADEMIK ICT DI UNIVERSITI-UNIVERSITI PENYELIDIKAN MALAYSIA DAN PENDEKATAN KAEDAH- KAEDAH PENGKOMERSIALAN MEREKA BERDASARKAN SIFAT-SIFAT PERIBADI: SATU KAJIAN TEORI ASAS

ABSTRAK

Penglibatan dan pilihan dalam keusahawanan oleh ahli akademik amat jarang dilihat dari perspektif ahli akademik ataupun keupayaan individu akademik itu sendiri. Malah, pihak universiti amat kekurangan budaya pengkomersialan yang efektif. Oleh itu, kajian ini bertujuan untuk mendalami perspektif peringkat mikro bagaimana ahli akademik memilih kaedah-kaedah pengkomersialan dan mencadangkan satu pemahaman yang unik terhadap mereka. Projek kajian ini mengadaptasikan kaedah teori asas dengan kepelbagaian kes di lima buah universiti penyelidikan yang terdapat di Malaysia. Transkripsi dan pengekodan temu bual separa berstruktur dengan 42 ahli akademik membawa kepada penggunaan kod besar dan kecil ke arah membina teori dalam bentuk abstrak iaitu profil. Hasilnya, satu rangka kerja dan cadangan mewakili teori untuk pemprofilan kepada lima kategori, iaitu akademik yang mengajar, pengajar berkeusahawanan, penyelidik akademik, penyelidik berkeusahawanan dan usahawan akademik yang berusaha sendiri. Hasil kajian ini diharap dapat memberi satu penemuan baru dalam memahami ahli akademik terutama kepada pengamal (industri, kerajaan dan pentadbir universiti seperti Dekan dan TTO) bagi merangsang budaya pengkomersialan.

PROFILING ICT ACADEMICS AT MALAYSIAN RESEARCH UNIVERSITY (RUs) ON THEIR COMMERCIALIZATION APPROACHES BASED ON PERSONAL ATTRIBUTES: A GROUNDED THEORY STUDY

ABSTRACT

The academics entrepreneurial involvement and decisions are rarely made from the perspective of the academics or even through the individual's capabilities. In fact, universities are found to be lacking the effective nurturing culture for commercialization. Therefore, this research aims to explore the micro level perspective of how academics choose their commercialization approaches and propose a unique window of understanding the academics. This is a grounded theory research project that involves empirical setting of a multi-site case study carried out at five Malaysian Research Universities (RUs). The transcription and coding of semi-structured interviews with the total of 42 academics lead to the use of major and minor codes to inductively develop a mid-range theory to encapsulate their choices of commercialization approaches into a coherent and abstract format, profiling. Results of this explorative research suggest a framework and propositions that represents mid-range theory to profile the academics into five categories; teaching academics, entrepreneurial teachers, research academics, entrepreneurial academics, and self-endeavour academic entrepreneurs. The findings are expected to shed new light particularly to the practitioners (industry, government and university's management such as the Deans and TTO) to stimulate the culture of commercialization efforts.

CHAPTER 1: INTRODUCTION

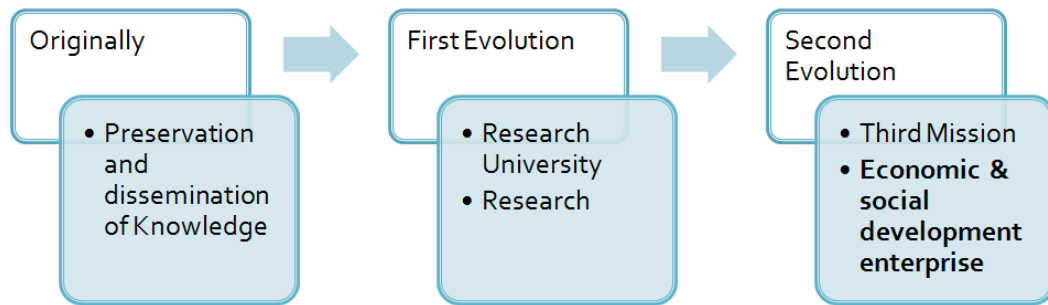
“Entrepreneurship is a Roller Coaster, Not a Cruise”, Vivek Wadhwa, Fellow, Arthur & Toni Rembe Rock Center for Corporate Governance at Stanford University.

1.1 Overview of Academic Entrepreneurship

Academic entrepreneurship is *“the leadership process of creating value through acts of organizational creation, renewal or innovation that occurs within or outside the university that results in research and technology commercialization”* (Yusof et al., 2010), also known as institutional entrepreneurship (Faltholm et al., 2010). In fact, another term for academic entrepreneurship is academic capitalism (Slaughter and Leslie, 1997; Zheng, 2010). According to some researchers, academic entrepreneurship only exists in an entrepreneurial university (Nelles and Vorley, 2010).

Originally, the university’s function is teaching but it had gone through the first evolution in the late nineteenth century to emphasize on research and is referred as research university (Etzkowitz, 1998). Later, the second evolution where the economic and social development enterprise become part of the missions and the university and is referred as the entrepreneurial university (Etzkowitz, 1998, 2003; Urbano and Guerrero, 2013). Siegel et al. (2007) however, regard this second evolution as just an entrepreneurial activity at universities. Some other scholars refer it as ‘knowledge valorisation’ (Leisyte, 2011) or the Third Mission (Laukkanen, 2003; Nelles and Vorley, 2010) which focuses on various approaches and channels of commercialization, specifically on licensing and spin-off activities (Rothaermel et

al., 2007). This economic and social development enterprise within universities has formed a new research discipline called academic entrepreneurship and recently has attracted interest from many scholars (Rothaermel et al., 2007). The summary of the evolution is shown in Figure 1.1.



* Adapted based on Etzkowitz (1998, 2003)

Figure 1.1: Evolution of University's Functions

Universities are the most important engines in engaging innovation in the regional and national economic development cycle of K-economy (Charles, 2006; Laukkanen, 2003; Mawson, 2007), as a provider to human capital and seed-bed of new firms (Meyer et al., 2003) especially, the research universities (Zucker et al., 1998). Their function and role in society is to foster creativity and responsiveness to changes in culture, ethical and also in scientific, technological and economic dimension (Goethner et al., 2009; Grigg, 1994). As such, the academics are expected to be more actively involved as well as giving higher commitment towards regional economic dimension of innovation for higher degree of academic entrepreneurship to occur. As Yusof and Jain (2010) point out, the higher the degree of academic entrepreneurship orientation, the higher the result of commercialization and technology transfer.

1.1.1 Malaysian's Context

Malaysia as one of the developing countries is also facing similar evolution but only within the last few years. Four universities have been pushed to become RUs under the Ninth Malaysian Plan (2006-2010) namely, Universiti Sains Malaysia (USM), Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM) and Universiti Putra Malaysia (UPM) (Majzub, 2008; Razak and Saad, 2007). Later, under the Tenth Malaysian Plan (2011-2015) Universiti Teknologi Malaysia (UTM) is also added (Ramli et al., 2013; Shah, 2010). Since then, various grants particularly for the commercialization have been introduced¹.

The research agenda is not the sole requirement of a university but to fulfil the Third Mission, the entrepreneurial universities. This is obvious through government's strategies in the Ninth and Tenth Malaysian Plan to focus on the innovation ecosystems where the emphasis are on universities' research and development (R&D), and commercialization (MOSTI, 2009b). In fact recently, the Prime Minister's reminder is very clear for research commercialization during the launching of the first Triple Helix model in Malaysia, Proton Green Mobility Challenges (PGMC) 2012 (Abdullah and Nasiruddin, 2012). In addition, various incentives and policies such as pre-seed funds have also been formulated by Malaysian Government to transform to K-economy. Among the targeted impacts areas in information communication technology (ICT) sector are smart agriculture, logistics systems, financial services, HALAL² and manufacturing. Various infrastructures have been developed such as incubators, Technology Park and Centre of Excellence (CoE) to enhance and facilitate the commercialization. However, what

¹ Grants are offered by various government agencies such as MOSTI, MOA and MOF to tackle

² HALAL originated from an Arabic phrase that means allowed or permitted by Islamic Law. Refer to JAKIM (2011)

is left out could be the culture of enterprise to both encourage and enable academics and students commercializing their intellectual properties and inventions (Kirby, 2006). According to Jain et al. (2009) the faculties within a university or rather called as academics are the key actors. In fact recently, Malaysia Ministry of Education Director General reminds the academics of the 3K (Kesesuaian, Kemampuilan, and Kecapaian) fulfilment where the research is not only for academic purpose, but needs to be used in reality (Anon, 2012). Therefore, the readiness of Malaysian academics along with their RUs to face the challenges and obstacles are still uncertain.

1.1.2 Contradictions

There are contradictions of opinions and trade-off among scholars on whether academics should be involved in entrepreneurship. On one side, they believe that the primary motive of the academics should be the recognition within the scientific community such as publications in top-tier journals, presentation at prestigious conference and research grants (Siegel et al., 2003b). The involvement in entrepreneurship would make their time and effort diverted away from original mission of university's research and educational system (Nelson, 2004; Toole and Czamitzki, 2007).

Others however, find that there is no such trade-off (Elfenbein, 2007). A case study by Ranga et al. (2003) on Belgium's largest university for instance, shows that the number of basic research and applied research increased simultaneously (positively correlated) even though the university has gone through the process of entrepreneurship for the last 30 years. In fact, numerous other studies also show that the number of application research does not have any trade-off with

basic/fundamental research (Breschi et al., 2007; Looy et al., 2003) or potential conflict of interest with their original norms of teaching and research (Ambos et al., 2008; Lowe and Gonzalez-Brambila, 2007). Regardless of the trade-off, Etzkowitz (2011) believes that commercialization should be part of normative change and it does not mean abandoning the academy.

The approaches to commercialization may be in the form of internal, quasi-internal, external and informal/backdoor. There are also various respective channels to the approaches and the factors that influence them. Past studies on factors or determinants are policies and acts (Leisyte, 2011), locations of science parks (Wright et al., 2007b), locations of new firms (Audretsch et al., 2005b), and personal attributes (Lam, 2011; Lawson and Sterzi, 2012). Although, there are a numbers of studies on the personal attributes as determinants of one or some of the commercialization approaches, the study on how the attributes contribute to the choices of commercialization approaches is still limited with exception of Audretsch et al. (2005a). Therefore, within this research, holistic view of the academics' personal attributes shall be studied on their choices of commercialization approaches.

1.2 Research Motivations

There are two reasons that motivate this research. First, the academics are the key actors and as such it is critical to focus on them (Goktepe-Hulten, 2008; Jain et al., 2009) who are often neglected (Goktepe-Hulten, 2007; Rothaermel et al., 2007). In addition, the attributes at the individual-level have stronger impact or more important determinants than the department or universities' characteristics (Clarysse et al., 2011; D'Este and Patel, 2007; Gambardella et al., 2008).

Second, past studies have been focusing on how to change an academic to be an entrepreneur (Kirby, 2006). Hussain et al. (2013) regard it as a paramount task while colleague of Meyer (2011) feels that “*changing a university is like moving a cemetery.*” Both try to warn us the difficulties of changing the academics as well as the systems within a university. Thus, the curiosity is whether we could profile them and then only stimulate the culture of commercialization approaches that suits the heterogeneity of individuals rather than changing them to become entrepreneurs.

1.3 Research Problems

The problems to commercialization are very wide and highly unattainable within a single research. Therefore, this research tries to uncover the micro level perspective which is the academics as they are the key actors to the commercialization processes. In other words the individual academics are chosen as the **who** of the unit to be investigated. This research tackles three main problems:-

- (a) Academics’ entrepreneurial decisions are well understood within the context of constraints imposed by university but not via individual’s capabilities and the university’s culture (Renault, 2006).
- (b) The expectations of academics’ involvement in commercialization are often made from the management perspective but rarely from the perspective of academics themselves (Chanthes, 2010).
- (c) Universities are lacking the effective nurturing culture for commercialization (Zhao, 2004).

1.4 Research Questions

The research questions are motivated by the suggestion made by Audretsch et al. (2005a). They suggest that *“the future research needs to further probe why and how scientists choose to commercialize their research, what commercialization route they select, what mode of commercialization is most effective, and how university governance and public policy can promote such commercialization efforts.”*

Therefore, the research questions for this research are:

- (a) How do academics’ personal attributes influence their entrepreneurial decisions?
- (b) How do academics choose what commercialization approaches to get involved in?
- (c) How could the management nurture such commercialization efforts?

1.5 Research Objectives

The research objectives are explorative in nature and mainly to examine the perceptions and experiences of academics on their choices of commercialization approaches. Moreover, Markman et al. (2008) suggest further study should probe into the heterogeneity of entrepreneurial teams and experience, and incentives at individual-level that influence their entrepreneurial decision. Therefore, the research objectives are:-

- (a) To explore the heterogeneity of academics personal attributes that influences their entrepreneurial decisions.
- (b) To propose a unique window of understanding the diversity of academics personal attributes on their choices of commercialization approaches.

- (c) To propose the culture of commercialization approaches that suits the heterogeneity of individuals.

1.6 Research Scope

The scope of this research is limited to only cover the ICT faculties in all five Malaysian RUs; USM, UM, UKM, UPM and UTM. In addition, the view taken is only at the individual-level of perspective, and therefore it may exclude or least emphasize on structural/institutional and regional levels of perspectives. It also takes a common perspective of technological innovation-development as a linear process, from basic research, to applied research, to development, to commercialization and thus may not fully take into account of external environmental factors (Rogers et al., 2001). Since one of the purposes of this research is to derive the mid-range theory about profiling, the findings may only be applicable for analytic generalization and not statistical generalization.

1.7 Definition of Terms

Two terms are often used interchangeably in the study of academic entrepreneurship; knowledge transfer and commercialization. Knowledge transfer is a wider definition which refers to the dissemination of knowledge from universities into society through various mechanisms including publication, student training program, informal faculty relationships, technology licensing, and academic entrepreneurship, among others (Hayter, 2010). Commercialization on the other hand can be broadly defined as conversion of new scientific knowledge into commodity (Baumann et al., 2002) or it can also be narrowly defined as to generate some kind of fees or revenue (The Boston Consulting Group, 2011). The Ministry of Science,

Technology and Innovation (Malaysia) or MOSTI uses broader term where they define commercialization is about “*taking the idea to an outcome - whether a product, service, process or organisational system to market by way of licensing, assignment, spin-off, or joint ventures*” (MOSTI, 2009a). The definition is also consistent with what Zhao (2004) defines which is “*a process of developing new ideas and/or research output into commercial products or services and putting them on the market. It covers intellectual property (IP) transfer and development, as well as the provision of consulting services that rely primarily on technological innovation.*” Therefore, in this context the term commercialization is defined as taking the idea based on a research to an outcome that can be products, services or documents (such as guidelines or best practices) for the industrial or public benefit regardless of the financial return.

The terms used to refer to the individuals who work in the ivory towers also varies with respect to their involvement and commitment towards research and commercialization activities. Commonly, the terms are; academic scientists, researchers, inventors and entrepreneurial academics which refer to the faculty members who are mostly researchers, administrators, students and the organisation on overall. Meyer (2003) for example, distinguishes academic entrepreneurs to those who try to initiate their research output in the forms of start-up or spin-off while entrepreneurial academics to those who adopt their basic research agenda without growth motive or leaving the academia. In this research, the terms academics shall be used to represent wider scope who are either active or non active in commercialization but limited to the teaching and research faculties of a university and not the administrations or the students.

1.8 Contributions

There are three contributions from this research:

- (a) To contribute to the body of knowledge where this research is expected to inductively derive mid-range theory of academics or profiling based on personal attributes through grounded theory methodology (GTM) with extended to the case studies.
- (b) To shed new light on the way in which the academics choose their commercialization approaches.
- (c) To give recommendation to the practitioners (industry, government and university's management such as the Deans and Technology Transfer Office (TTO)) where knowing specific attributes of an academic would help them to nurture such commercialization efforts.

1.9 Organisation of Thesis

This thesis is structured into six chapters. Chapter 2 is about the literature review. Literature survey is carried out for the formation of commercialization approaches topology. Literature survey is also carried out to identify and classify various academics' personal attributes which become the priori constructs for the research. Then, the literature survey of similar works in profiling of the academics is also done to support one of the gaps for this research. Chapter 3 is about the research methodologies. Qualitative research using Grounded Theory Methodology (GTM) with extended to case study is adopted. Chapter 4 covers data collection and analysis. Chapter 5 presents the results and discussions of the research findings and lastly, Chapter 6 presents the conclusion and contributions of this research.

CHAPTER 2: LITERATURE REVIEW

“If you steal from one author it’s plagiarism; if you steal from many it’s research”,
Wilson Mizner - An American playwright, raconteur and entrepreneur.

2.1 Chapter Overview

The main objective of this chapter is to present multiple disciplinary perspectives on deriving constructs for profiling academics on their choices of commercialization approaches. This chapter also discusses the gaps within the body of knowledge. The purpose is to review whether the work of profiling academics based on their personal attributes has been attempted and how this research will contribute new input to the body of knowledge.

This chapter begins with an overview of the models and perspectives pertaining to the research within the domain of academic entrepreneurship in section 2.2. Then, it follows with the main section of literature reviews which is divided into three sub sections. First, review of past articles about various commercialization approaches in Section 2.3. In Section 2.4, it discusses common personal attributes extracted from entrepreneurship psychology, employability assessment, and career and counselling theory and Section 2.5 discusses these attributes within the domain of entrepreneurship. Second, the literature review where the analysis of articles from the past 13 years is presented in Section 2.6. Here, the empirical findings on personal attributes of academics that are significant or predictors to commercialization are identified and classified. Third, the literature review of past articles on profiling the academics is given in section 2.7.

2.2 Models and Perspectives

Within the research in academic entrepreneurship discipline, various models have been introduced such as Linear Model, Mode 1 and Mode 2 of knowledge productions. In the nineties the Triple Helix Model was introduced and recently, the Quadruple Helix Model.

(a) Mode 1 and Mode 2 of Knowledge Production

Gibbons et al. (1994) introduced two approaches of knowledge production; Mode 1 is characterized by a cleavage between academic and society where the generation, application, and exploitation of knowledge are carried out separately while Mode 2 operates within a context of application in that problems which are not set within a disciplinary framework. Mode 2 is not to replace Mode 1 but a trans-disciplinary rather than mono or multidisciplinary framework (Gibbons et al., 1994). The core idea of both Mode 1 and Mode 2 is “*about the demise of universities, scientific disciplines and academic laboratories; and a rise in interdisciplinary, economically and socially-relevant research themes, and the appearance of perpetually fluid business-linked research task-forces, in the framework of a new kind of socially useful epistemology*” (Shinn, 2002).

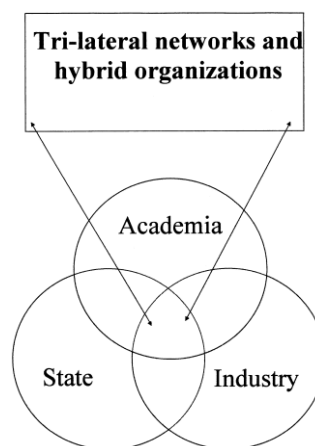
(b) Linear Model

Linear Model explains how the initial basic research started in the laboratories and later expanded and applied for further enhancement. In linear Model, an independent organisation of usually government affiliated agencies is formed to facilitate the viability of the technology. The basic research will be further enhanced to suit or use in bigger scope of technology so that it has commercial value. According to the authors of Triple Helix model, Etzkowitz and Leydesdorff (2000),

the Linear model of ‘technology push’ and ‘market pull’ was however, not enough to diffuse commercialization of university research findings.

(c) Triple Helix

Triple Helix model is built upon the traditional Linear model by incorporating interactive and recursive factors (Etzkowitz and Leydesdorff, 1998). It demonstrates the equal power of partners among universities – industry – government (Etzkowitz and Leydesdorff, 2000). Triple Helix can work on different relationship too; statist, laissez-faire or hybrid. Nowadays, the most popular is hybrid where each partner taking the role of the other and hybrid organizations emerge at the interfaces as shown in Figure 2.1.



** Adapted from Etzkowitz and Leydesdorff (2000)*

Figure 2.1: Triple Helix Model with Hybrid Organization

(d) Quadruple Helix

Quadruple Helix, the modification of Triple Helix, has four modifications made; introduces society as the fourth strand, occurs in doublets or binomials, organizes in a hierarchic mode, and takes the form of temporary segmented phases (Marcovich and Shinn, 2011). According to MacGregor et al. (2010), the fourth

pillar organizations which are independent, not-for-profit, member-based organizations are vital in enabling innovation and amplifying its impacts. Consumers as the join force in product and services development process can also be the fourth (Kostiainen and Sotarauta, 2003).

Mode 1 knowledge production is rather associated to Linear model of technology push whereas Mode 2 is more problems oriented within university sphere (Lunderquist and Waxell, 2010) and as such mostly viewed at structural level of perspective. Triple Helix model on the other hand, is often viewed at organizational/regional and structural level. Among the regional level perspective of studying the Triple Helix model are in Portugal (Marques et al., 2006), US (Kim et al., 2011), Australia (Jaaniste, 2009), Sweden (Ruuska and Teighland, 2009), and Malaysia (Razak and Saad, 2007).

At individual-level perspectives however, theories either from other bodies of knowledge or new emerging theories help to explain academic entrepreneurial behaviour are the common themes (Goethner et al., 2012). Due to these commonalities, this research will adopt individual-level of perspectives to generate mid-range theory. Before reviewing past articles at individual-level perspectives, the commercialization approaches are first discussed to understand the variation of possible channels available for the academics to commercialize their research. Some of the concepts for evolution of academic entrepreneurship, models, levels of perspectives and theories are summarized in Figure 2.2. In this research the focus shall be the individual-level of perspectives to derive a mid-range theory.

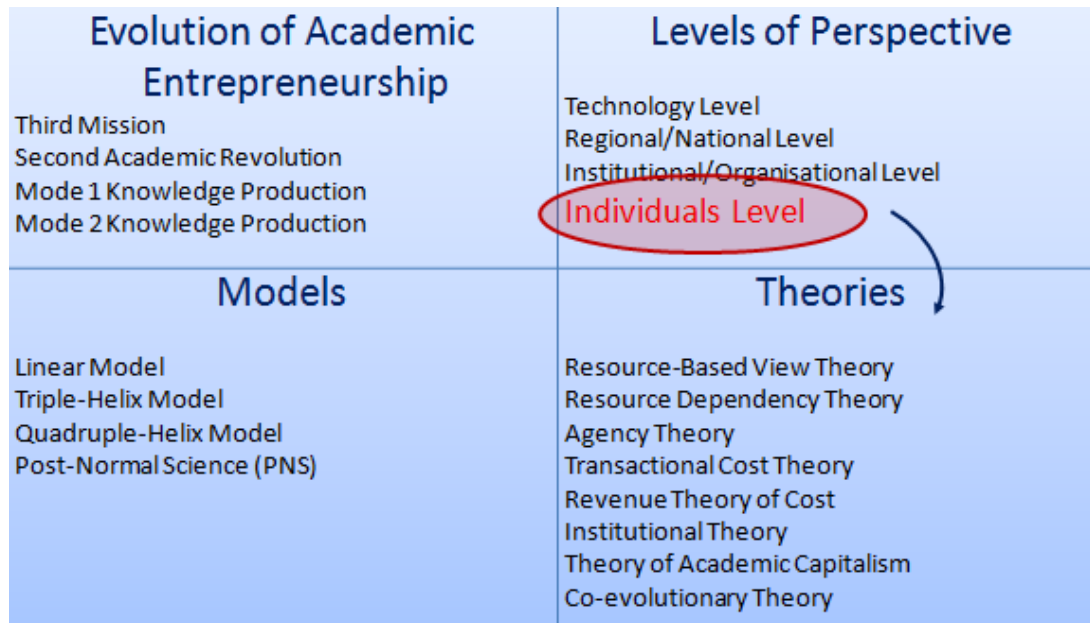


Figure 2.2: Academic Entrepreneurial Concepts

2.3 Several Approaches to Commercialization

The categories and terms used by scholars to classify approaches of commercialization are found to be varied. Table 2.1 summarizes articles from the past ten years where authors categorize the channels and sub-channels. Landry et al. (2010) categorize six broad knowledge transfer activities into two broad activities; commercial (patenting, spin-off, and consulting) and non-commercial (publication, teaching and informal knowledge transfer) activities. Siegel et al. (2007) categorize them as formal and informal. Geenhuizen (2010) however, identify four paths of knowledge valorisation. Markman et al. (2008) on the other hand, distinguish commercialization into three different main approaches; internal, quasi-internal and external. In this research, the approaches of commercialization shall be used to ensure the consistency throughout the thesis.

Table 2.1: Various Approaches to Commercialization

No	Categories	Modes	Source
1.	Modes of Commercialization	a) Internal approaches b) Quasi-internal approaches c) External approaches	Markman et al. (2008)
2.	Paths of Knowledge Valorisation	a) Licensing of a patent to a firm b) University-business collaboration c) Graduates working in business sector d) Spin-off	Geenhuizen (2010)
3.	Types of Informal Technology Transfer	a) Transfer of commercial technology b) Joint publications c) Industry consulting	Link et al. (2007); Siegel et al. (2007)
4.	Types of Spin-out	a) Consultancy b) Development company c) Software d) Product-based company e) Infrastructure creation.	Druilhe and Garnsey (2004)
5.	Configuration of Start-up	a) Venture capital-backed b) Prospectors c) Product start-up d) Transitional start-up	Heirman and Clarysse (2004)
6.	Types of Spin-outs	a) Infrastructure or platform companies b) Product companies c) From product to platform companies d) Prospector	Mustar et al. (2006)
7.	Modes of Spin-off	a) Orthodox b) Hybrid c) Technology	Nicolaou and Birley (2003)
8.	Approaches to Collaborations or Industry Linkages	a) Collaborative research b) Contract research c) Consulting	Bercovitz and Feldman (2006); D'Este and Patel (2007); D'Este and Perkmann (2011); Debackere and Veugelers (2005); Weiping (2009); Wright et al. (2008)
9.	Types of Open Innovation	a) Outside-in b) Inside-out	Chiaroni et al. (2011)
10.	Types of Consulting	a) Opportunity-driven b) Commercialization-driven c) Research-driven	Perkmann and Walsh (2008)
11.	Categories of Knowledge Transfer Activities	a) Publications b) Teaching c) Informal knowledge transfer d) Patenting e) Spin-off formation f) Consulting	Brennan et al. (2005); Landry et al. (2010); Murray and Graham (2007)
12.	Types of Academic Entrepreneurship	a) Large-scale science project b) Supplemental income augmentation c) Industrial support d) Patenting e) Direct commercial involvement	Laukkanen (2003)
13.	Types of Partnership	a) Rights-oriented b) Tapping-in c) Contracting for innovation	Casper and Miozzo (2013)

There are two possible reasons of classification variation among scholars. One is due to the complexity of technology transfer. Direct and indirect form of technology transfer tends to be associated with the dichotomy between tacit and explicit knowledge (Wright et al., 2008). Another possible reason is due to the definition of technology transfer and commercialization. Technology transfer is a broader concept and is defined as the dissemination of knowledge from universities into society through various pathways including publication, student training program, informal faculty relationships, technology licensing, and academic entrepreneurship (Hayter, 2010). Commercialization on the other hand, is specifically focused on the process of turning specific discoveries and inventions into marketable products and services; generally through licensing, patents or start-ups/spin-offs. Some scholars define commercialization to include research link with industries (Harman, 2010). In fact, commercialization is by-product of the main task; teaching and research (Goktepe-Hulten, 2007). In this context where the ecosystem of research and technology commercialization are viewed as a whole, the definition of research commercialization covers all approaches and channels of commercialization that has economic value either directly or indirectly which requires tacit and explicit knowledge to come together. As such it covers patenting, licensing, consulting, spin-off, start-up, collaborations and open science as well as joint publications.

Although other approaches are also mentioned by some scholars such as sabbatical (Debackere and Veugelers, 2005), meeting and conference (D'Este and Patel, 2007; Weiping, 2009), external teaching (Klofsten and Jones-Evans, 2000; Landry et al., 2010), serendipity (Bercovitz and Feldman, 2006), and student industrial training (Schartinger et al., 2002), they are not covered due to their

'original' norms of university's mission or are regarded as minor implication to the commercialization. But, awareness of the possibility on the emerging of these approaches during data analysis will be given attention.

Based on previous studies as listed in Table 2.1, the topology for research commercialization approaches are derived as shown in Figure 2.3. The topology demonstrates holistic flow of paths taken by academic to commercialize their research. The topology is divided into four main approaches, three are mainly based on Markman et al. (2008); internal, quasi-internal, and external while the remaining one is the addition of informal mode. Some modification and addition to the original approaches are made to suit the overall commercialization topology. Since "*the use of categories such as 'channels' and 'mechanisms' is sociologically imprecise*" (Perkmann and Walsh, 2007), the term approaches is used as a guidance to determine various options of commercialization activities. It should be noted too that the interpretation of the topology should not be restricted to be solely distinct and discrete but interdependent and mutually reinforcing. This is due to the effect of complementarities, substitution and independence of complex interactions among multiple forms of knowledge transfer (Landry et al., 2010). In fact, the models of knowledge productions may also depend on the flow of channels taken by the academics. Different approaches of commercialization may suit different models. Patenting and licensing for instance, may suit linear model if the research starts within the universities laboratories and later obtain the patent and license for specific companies. Collaboration on the other hand, may follow Triple Helix models if the three parties are involved and later follow linear model of patenting and licensing. The following sub sections will discuss each approach and some issues of choices at individual-level of perspective.

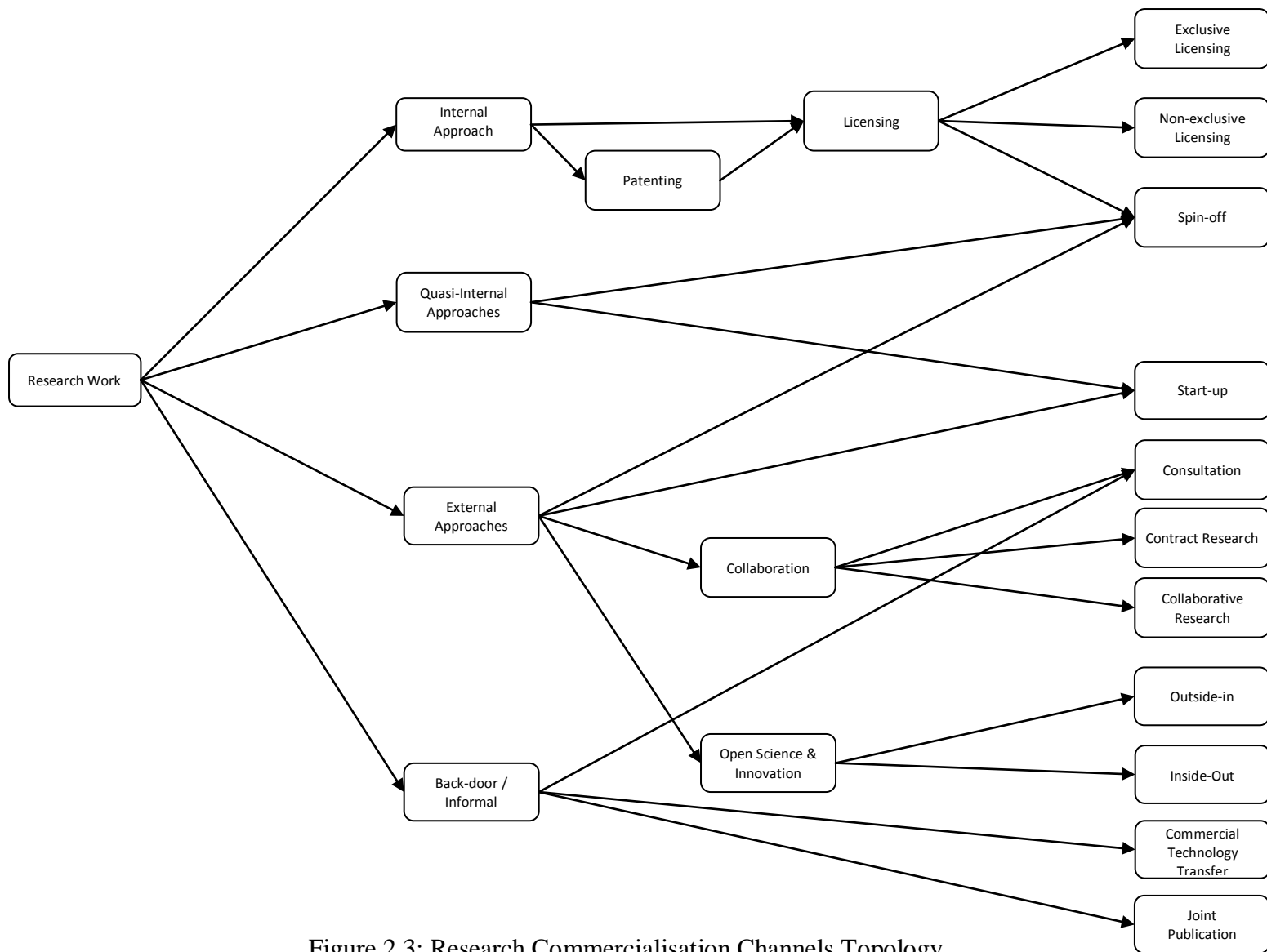


Figure 2.3: Research Commercialisation Channels Topology

2.3.1 Internal Approaches

Internal approaches refer to activities of commercialization that are done mostly by the university. In order to facilitate the process of commercialization, TTOs are created due to the need of separated entity between education and economic enterprise within the university. The overall functions of TTOs are defined as “*facilitating faculty disclosure of inventions, evaluating those inventions disclosed, as well as finding licensees and executing contracts on behalf of the central administration for the university*” (Jensen et al., 2003). Since academics and industries speak different languages (Siegel et al., 2007), TTOs have to act as intermediary who play a role as boundary spanner (Wright et al., 2008). Nowadays, most major universities have their own TTOs (Renault, 2006). The key modes of commercialization within the internal approaches are licensing and patenting.

2.3.1.1 Licensing and Patenting

Thursby and Thursby (2002) define three stages of process for any research to get licensing; disclosure, patenting and licensing agreement. The first stage is the disclosure where the academics report their potential commercial discovery to TTO by providing some information such as the invention, inventors, funding sources, potential licensees, and barriers to potential patent. The second stage is the patent application where the TTO personnel will help the academic on behalf of the university to apply for patent upon evaluation of possible commercial viability of the discovery. Usually time lag would occur between application and issuing of the patent. In Elfenbein (2007) analysis of application submitted to the US Patents and Trademark Office (USTPO) for example, it takes an average of 2.2 to 4.3 years. Thus, it is not surprising that licensing agreement mostly precedes the patent grant

and sometimes without it. The final stage of licensing is the decision to either license to specific companies with different shares options or to set up university-owned companies (spin-offs). Usually, if the inventors do not have the motivation to be entrepreneurs and are not willing to take risks, the licensing will be granted to the established companies. Markman et al. (2005b) categorize three licensing strategies which depend on the stages of technology developed; licensing in exchange for sponsored research, licensing for equity in a company, and licensing for cash. Based on the strategies and stages of technology, three licensing options are available.

(a) Exclusive licensing

License is granted to only one company which usually happens when the investment to develop the technology is high risk. The university and the academics would then rely on royalties as an income. The royalties for University of Edinburgh for instance, vary between fifteen to twenty percent which are shared between the academics, academics' faculty and university general funds (Ismail and Omar, 2008). In Stanford and MIT for examples, the academic will get 33% share of the royalty and can increase up to 93% upon Initial Public Offering (IPO) (Edwards et al., 2006).

(b) Non-exclusive Licensing

Non-exclusive licensing occurs when licence is granted to many companies and usually the royalty rates are lower compared to exclusive licensing, ranging from five to seven percent (Ismail and Omar, 2008). Study by Aulakh et al. (2010) shows that non-exclusive licensing is preferred when the licensed technology has greater potential to produce differentiated products, or when there is greater threat of substitutive technologies entering the market.

(c) Spin-off

The license can also be awarded to a newly set-up companies (university spin-off) where the university and the academics may share some interest (ownership). According to Ismail and Omar (2008), academics' aspirations and commitments are the main determinants of forming spin-off.

Patenting is important for commercialization (Falholm et al., 2010; Geuna and Muscio, 2009). However, it is a minority activity where majority of the academics never patent (Agrawal and Henderson, 2002). A study by Lach and Schankerman (2008) shows that stronger royalty incentives generate greater licensing income. A study by Mahagaonkar (2010) on the other hand, shows that invention disclosure and patenting need not be necessarily driven by monetary interest but rather as reputations. Interestingly, a study by Goktepe-Hulten and Mahagaonkar (2010) shows that academics without industrial cooperation would choose patenting for signalling reputation but those with industrial cooperation would rather choose some other paths of earning monetary gain.

2.3.2 Quasi-Internal Approaches

In Quasi-internal approaches, the activities of commercialization are partly done by university and partly done by external parties such as industry or government agencies. The key facilitating mechanism to stimulate technology commercialisation within quasi-internal approaches is business incubator (Markman et al., 2008). The fundamental function of incubation is the educational process to train individuals and to educate organisations in adequate functioning, but then broadening the function from making advanced research knowledge into firms to translating knowledge into new organisational entities (Etzkowitz et al., 2005). Many

universities have established their own internal incubators to foster the creation of start-up companies based on university-owned or licensed technologies (Markman et al., 2008). Recently, University-based incubators have played a critical role in nurturing the IT and Internet-based venture business (Lee and Osteryoung, 2004). Within quasi-internal approaches, the main activities are university spin-offs and start-ups.

2.3.2.1 University Spin-offs

The terms university spin-offs and spin-outs are occasionally used interchangeably. Spin-offs are the “*new ventures that are dependent upon licensing or assignment of the institution’s intellectual property for initiation*” (Lockett and Wright, 2005). However, sometimes spin-offs are created without formal licensing from the university in which IP was created (Aldridge and Audretsch, 2010). The set up of spin-off companies is to distinguish the entities between the academics, external parties (industries) or the collaboration of both parties. Mustar et al. (2006) identify four main approaches to company formation; infrastructure or platform companies, product companies, companies that move from product to platform, and prospector companies. Druilhe and Garnsey (2004) however, suggest five types of spin-offs; consulting companies, development companies, products companies, software companies and infrastructure creation.

There are many successful university spin-offs such as Lycos and Digital Equipment Corporation (DEC) (Zheng, 2010), Cadence Design Systems, Cisco Systems, Digital Equipment Corporation, Google, Silicon Graphics, Sun Microsystems, and Yahoo (Kenney and Goe, 2004). University spin-offs are the most viable and important channels of commercialization (Prodan and Drnovsek,

2010; Wright et al., 2004), but it is a rare event (Agrawal and Henderson, 2002; Geuna and Muscio, 2009).

2.3.2.2 Start-ups

Compared to spin-off, university start-ups are firms which are formed by the academics and “*students of the university but not based around university-owned IP*” (Minshall et al., 2007). Start-ups are generally smaller companies and do not have such a complex growth path or very ambitious business model (Wright et al., 2008). Google Incorporation is an example of start-up where it started off in 1998 from an idea of two Doctor of Philosophy (PhD) students from Stanford University and funded from investors and utilized incubators at Silicon Valley (Hof, 2008). There are four different starting up configurations mainly based on their starting up resources as suggested by Heirman and Clarysse (2004); VC-backed start-ups, prospectors start-up, product start-up and transitional. They argue that the starting up resources such as financial and human resources determine the variation of start-up companies.

2.3.3 External Approaches

Within external approaches, the activities of commercialization are done mostly by external parties. Among the key facilitating mechanisms in the externalization approaches are the research parks and research clusters. Research parks are property-based organisations which aim to accelerate innovation and resource sharing. They are usually large-scale projects that house a spectrum of entities, including corporate units, government labs, and medium and small firms. A research park should have three basic components; grow mechanism, level of technology capabilities and nature of its integration with national or global markets