

Enhancing Commercialization Level of Academic Research Outputs in Research University

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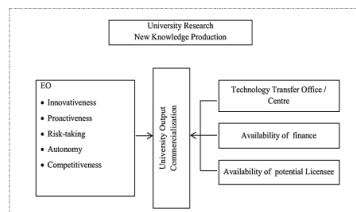
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Graphical abstract



Abstract

The aim of this study was to improve the commercialization level in Universiti Teknologi Malaysia (UTM). For achieving this goal various factors and issues were examined to identify how they affect the procedure of university commercialization. These factors include the role of technology transfer office /center, availability of finance, availability of potential licensee and entrepreneurial orientation (EO) among the university researchers. Among these four factors, this study focused more on EO among academic researchers and its effect on the commercialization rate. This study was based on a qualitative research method and was designed to use a case study approach. For investigating the factors and issues in this study, a total of ten face-to-face interviews were conducted. The respondents were chosen from inventors, researchers, academic entrepreneurs, and Technology Transfer Office staff in UTM. The researcher utilized the content-analysis approach to analyze the data obtained from the semi-structured interviews of the respondents. The results indicated that EO among the university researchers, the role of technology transfer office /center, the availability of potential licensee and availability of finance were significant to the research output commercialization at university. Overall, the most critical factor was availability of finance.

Keywords: Commercialization; Research University; Entrepreneurial Orientation (EO); Technology Transfer Office (TTO)

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1.0 INTRODUCTION

The commercialization of academic studies is to be treated “the process in which ideas, knowledge, and innovation would be conveyed to tangible assets [1] including benefits that satisfy society and economy at a large scale. The university R&D output is an important source of significant technological innovation. Universities are known as talent promoters in the knowledge economy, which are operating as an essential infrastructure towards building such capacities for nations and regions to survive and succeed in the knowledge economy [2]. Hence the commercialization of technological and scientific knowledge generated within universities, research centers, laboratories that are publicly funded research organizations is increasingly regarded via policymakers as input for regional economic growth to be sustainable and developed [3]. Traditionally, teaching and research have been the university’s main objectives but recently the commercialization of research results or entrepreneurial

science has emerged as a different role for universities in society [4].

Malaysian government allocated a sizable budget to support R&D and commercialization activities in research institutions, especially universities. However, it has been asserted that only a small percentage of the Malaysian universities R&D outcomes have been commercialized [5, 6]. Obviously, Malaysia is at the beginning journey of commercialization [7]. In addition, commercialization in research context is risky and costly [8]. Therefore, it is very important to identify factors affecting research output commercialization in the university. Recognizing these factors is beneficial for several groups. Researchers, academic entrepreneurs and technology transfer office/center staff obtain a better view on commercialization of their research outputs to correct their weaknesses and offer required changes in the performance.

A number of studies investigate the technology transfer and commercialization by universities [9- 14]. However, most of the studies come from developed nations. A developing country like

Malaysia is still behind in terms of its research capabilities. On the other hand, most of the literatures that are related to university research commercialization in Malaysia investigate institutional and external factors of technology transfer. Nevertheless, there is still a shortage in the amount of commercialized products in universities. Therefore, examining behavioral characteristics of university researchers can be crucial to enhance the university commercialization rate.

The aim of this study is to identify those factors affecting the commercialization of university research output from the perspective of academic researchers and entrepreneurs, and to examine how entrepreneurial orientations among university researchers affect commercialization in the university. In this paper, a conceptual model that illustrates the influential factors in terms of university commercialization was proposed.

■2.0 LITERATURE REVIEW

2.1 University Commercialization Definitions and Stages

Commercialization has been defined in a variety of ways. The very definition of “Research Commercialization” differs among the various approaches, and certainly across many disciplines addressing this subject [15]. Crabb defined commercialization as “the development of an idea to the point at which it may be sold as a standard product or service in quantity to an open and competitive market for creating revenue for the organization” [16]. This definition was also confirmed by Zhao [17] who declared research commercialization (RC) as the process in which an idea or research finding would be changed into commercial goods and services that produce wealth. Moreover, Thika [18] mentioned that “Research commercialization” is the process of changing academic findings and inventions into marketable products and services. On the other hand, commercialization consists of a wide and dynamic range of activities, such as the movement of tacit knowledge and experience from a given company to another [19]. Wittamore *et al.* [20] defined commercialization as “the process of taking new knowledge, products or processes from one entity to another in favor of benefit.” Golder *et al.* [21] contended that the process of commercialization starts when an idea or an innovation is sold for the first time. Furthermore, previous studies used introduction [22] and pioneer [e.g. 23-25] to describe this event. Moreover, Lam [26] stated that the majority of scientists viewed commercialization as an extension of their knowledge search activities. For this study, we used the definition by Rahal [27] which described university commercialization as a process of converting research discoveries from university to industry into useful products or practical applications.

University commercialization may occur through various channels such as cooperation in research and development between academia and industry, university seminars, faculty consulting, high-technology firm spin-offs, scholarly journal publications, and technology licensing [27]. Commercialization encompasses both technology and business model [28]. The commercialization process differs from business to business because of diverse reasons and factors affecting this process, including nature of product, technology, experience, market characteristics, market competition, etc.

The university-based technology commercialization processes include discovery, presenting those discoveries to university commercialization arm, patentability evaluation, transferring and licensing IP to industry [29-31]. The work of Horng and Hsueh [32] on technology transfer of Taiwan universities suggested that the process of research development

and commercialization is summarized in three major stages: (1) the development and technological diffusion through the licensing to industry (2) patent filing and maintenance (3) technology commercialization and marketing. In addition, Bercovitz and Feldman [33] described technology transfer as a “two-phase process that involves first the production of knowledge and then its application and diffusion.”

2.2 Barriers to University Commercialization

Many researchers have pointed out a variety of problems that a university faces in the commercialization of its output. Study by Howells *et al.* [34] in the United Kingdom listed and prioritized these problems, including lack of capital funds, lack of marketing and development skills to find precise partners, problems related to Intellectual Property Rights (IPR), insufficient time commitment from academic staff, and the lack of expertise in business. In regard to developing countries, a parallel study also was conducted in Thailand [35]. A similar set of problems was identified as well, although a commitment to academic workload seems to be the most significant barrier to university commercialization.

Previous studies also indicate the absence of linkage between university and industry [36-39], lack of business skill to commercialize [40-43], the sheer volume of work and bureaucracy, the poor evaluation of the technology transfer office, and unavailability of technical skills to migrate from prototypes to commercial products [39] as barriers preventing academics from commercializing their research results.

2.2 Licensing

Licensing refers to a contractual method of applying IP by transferring rights to other firms while retaining ownership. This license usually is made based on mutual contract, and it needs the licensee to pay fees to the licensor [44]. Furthermore, most startups founded based on university-developed technologies will require a license from the university, even if a student or professor is both the inventor and the entrepreneur who brings the technology to market. However, most universities own the intellectual property since they provided the lab space, salaries, and other resources to conduct the research [27]. Many firms have a large number of unexploited or under exploited patents that a licensee may be able to utilize [44]. Licensing can form the core of a business model [45].

2.3 Spin-Offs

One of the important channels that universities use to commercialize its technology is spin-offs companies. Zhang [46] defined university spin-offs as companies founded by university employees and refer to their founders as academic entrepreneurs. On the other hand, Wright *et al.* [47] defined university spin-offs as new ventures that are dependent upon licensing or assignment of an institution’s IP for initiation. Spin-off company is a tool that can be used to quantify one impact of academic research, which can be directly and causally attributed to one country’s funding [48].

Wright *et al.* [47] discussed the different phases in spin-off development, drawing on evidence from nine cases. These phases include: (1) research phase, (2) opportunity-framing phase, (3) pre-organization phase, (4) reorientation stage and, finally, (5) sustainable returns phase. Many benefits can be obtained from spinning out R&D results. They include returns on R&D investment in bad and good times; greater satisfaction for the retention of good researchers; economic gains for the outside

community/world; and at universities, spin-off can sharpen a professor's perspective and create jobs for graduates [49].

2.4 Overview of University Research Commercialization in Malaysia

Malaysia has spent sufficient time and effort striving to create an economy which is based mostly on innovative ideas [50]. It can be seen in the Tenth Malaysia Plan (10MP: 2011-2015) that include strong emphasis on innovation, especially in intensifying research, development and commercialization (R&D&C) [51]. However, Malaysian development in IP and innovation commercialization is quite insufficient [7, 52, 53]. Patents that come out of university researches are in the early phase of promotion and are accompanied by risks and uncertainty in terms of the ability of these patents to be commercialized and marketable [7].

The analysis of Low *et al.* [39] indicated that the mechanism for commercialization as proposed by Bercovitz and Feldmann [33] is applicable in Malaysia universities with some additions. These mechanisms include personal endeavor, public presentation, sponsored research, licenses, patents, spin-offs, employed personnel, consultancy, informal discussion, technology transfer office. However, licensing activities among universities were very scarce. Therefore, the income from patent licensing appears to be negligible. Moreover, academic start-ups are very rare in Malaysia [54].

In Malaysia, like other developing countries, the problems of commercialization are felt to be inadequate infrastructure, lack of market research, inexperience on the part of venture capitalists, poor links between universities and firms, little market awareness and commercial motivation on the part of R&D staff, insufficient seed-level development funding and business angel investments (there are fewer than 150 business angel investors in Malaysia) [49, 54].

Malaysian Government has provided different types of funding, grants and other financial incentives enabling universities to innovate and seek business opportunities [5, 54]. Ministry of Higher Education introduced different schemes namely FRGS, ERGS, LRGS and PRGS [55] to fill the gap between university R&D activities and the programs providing suitable situations for commercialization and business creation [5]. Furthermore, Malaysia established some institutions and mechanisms to develop commercialization of R&D. Some of these relevant agencies and mechanisms include Intensification of Research in Priority Areas (IRPA) fund, the Industry Research and Development Grant Scheme (IGS), the Multimedia Super Corridor (MSC), the Research and Development Grant Scheme (MGS), the Demonstrator Application Grant Scheme (DAGS), the Malaysia Technology Park (TPM), the Malaysia Technology Development Corporation (MTDC), the Human Resource Development Scheme (HRDS), the Industrial Technical Assistance Fund (ITAF) and the Malaysia Industry Government Group for High Technology (MIGHT), Ministry of Science, Technology and Innovation (MOSTI), Malaysia Biotechnology Corporation (MBC), The Malaysian Institute of Microelectronic Systems (MIMOS), Malaysia Venture Capital (MAVCAP), and Malaysia External Trade Development (MATRADE) [49, 54]. Through financing plans and programs, the government is moving towards achieving a competitive advantage as an industrialized hub in accordance to Malaysian vision 2020 [54].

2.5 Factors Affecting University Research Commercialization

Previous studies sought to find significant factors that may affect the commercialization process aiming to justify the reasons

behind their success or failure. However, as there is no longer an agreement on the commercialization process, former researchers have reached diverse conclusions on this issue. Despite the fact that the firms and industry are by nature different, especially from place to place, there are similarities between the factors affecting the research commercialization process in university. Based on the review of previous research, we recognized four factors: role of technology transfer offices/ center of university, availability of finance, availability of potential licensee, EO among academic researchers.

3.0 CONCEPTUAL FRAMEWORK

3.1 Role of Technology Transfer Offices/Center of University

Technology transfer centers (TTC) are incorporated with several departments from both public and private sectors working on research and transforming procedures from academia to industry. In fact, they are concentrated on knowledge oriented services at various stages of the innovation process [56]. In addition, Technology Transfer (TT) infrastructure intends to be part of a technology transfer, which finally enhance and simplify alliance operations in a given context. Therefore, they are incorporated with regional economies, and their corporate governance intends to include stakeholders from the local public and private sectors [57].

Comacchio *et al.* [58] in their study draw attention to the multiple roles undertaken by TTC in a local innovation system. In this regard, they categorize TTC into several groups including experimental station, sciencepark and technology hub, technology transfer office, business incubator, business innovation center, chamber of commerce special agency and laboratory, territorial development enterprise, topic centre, multi-sector center, public research organization, and laboratory.

Previous studies have reported several roles for technology transfer office (TTO). The TTO is taken as representing the university technology transfer activity in a regional area [59]. In this respect, the TTO has a significant influence as a translator between the two parties [60-61]. TTOs traditionally have been the more popular mode for commercialization since it serves as the gateway to university inventions, establish linkages between the university [62-63] and industry and validating university-industry relationships [40]. Other services that are provided by TTO include handling and stimulating patent application issues [63-64], labor assistance on assorted paperwork, educating and encouraging faculty members about patenting opportunities, managing licensing and all other patent related legal tasks, introducing and reinforcing university intellectual policy, building personal connections with faculty members, informing them about university policy changes, federal policy trends (i.e. Bayh-Dole Act), and industry technology requirements (i.e. licensing demand) [63]. Moreover, TTO serves as a filter by helping faculty decide whether the technology has commercial potential or not [65].

Numerous studies have shown the positive correlation between the presence of TTO and the increase in the number of university patents [66]. It means the efficiency of the TTO effects faculty patent intention, motivation, and experience to a large degree [63, 67]. In addition, private sectors feel it is easier and faster to build a research joint venture with a university TTO that had worked on a cooperative research before [64, 66, 68].

3.2 Availability of Finance

There must be a source of financial support for all ventures so that they can “pump prime” the activities that ultimately provide them enough revenue and also sufficient economic power to pay for materials, services and labor [69]. Based on the survey of TTOs, Wright *et al.* [47] argued that the most important sources of funding for university spin offs (USOs) are seen to be government grants, university challenges funds (UCFs), venture capital (VC) and joint ventures between the university and an outside firm. Wright *et al.* [70] showed a lack of funding is often seen as a major barrier to start up activity by TTO managers.

Roberts [71] indicated the differences between the US and Europe in the availability of personal capital to start a business. The personal capital of young entrepreneurs is generally higher in the US, with funding from “family, friends and fools” (3F) more in evidence than in Europe. High-tech entrepreneurs in the US stress the importance of networking as a source of finance prior to seeking venture capital finance. Another study by Wright *et al.* [47] presented evidence from the UK on the actual sources of equity finance for investments in new and established spin-offs. In terms of new companies attracting equity finance based on priority was University Challenge Fund, VC, industrial partner, business angel. In terms of existing spin-offs, that is companies established prior to financial year 2002, VC finance was the most popular source of funds with followed by UCFs, business angel and industrial partner respectively. As a consequence, most venture capitalists are willing to invest in existing spin-offs rather than new ones, and new USOs need to be supported from universities.

3.3 Availability of Potential Licensee

A market research phenomenon is considered as one of the successful keys in the commercialization process of research output. Industrial research teams usually take the research process from the very beginning that they recognize a problem with reasonable solutions [72]. However, satisfying customer needs for the products and services is one of the major generations of R&D [73-75]. On the other hand, achieving competitive advantage through successful new-product development and commercialization requires a convergence innovation, opportunity scanning, and exploitation capabilities [76]. In the marketing literature, having a market orientation and being market driven [77] have been widely accepted as precursors to creating competitive advantage through innovation and new-product development.

According to Xue [78] in a study conducted in China, one of the main problems with China’s innovation system is that industry does not have sufficient R&D ability, which is a common concern for most companies in China. Hence, commercializing the patents is needed by industry companies from universities. For universities, these enterprises can be considered to be a potential market for university commercialization. It is a fact that the enterprises need scientific and technological achievements arising from universities. Technology contracts and joint research can help inventors to collaborate with industry, which can facilitate inventors to begin small size high-tech advanced enterprise [78]. However, Colyvas *et al.* [79] found in some cases that industries used a technology before they patented it. In special cases, where the invention has high and urgent potential market value, some industries “booked” the technologies and developed it before they patented it even though the invention was still at the embryonic level, simply because it was profitable to do so.

On the other hand the main reason why university technologies are not being exploited is that they did not show any

commercial value, and were so embryonic that they demonstrated insufficient proof of concept [29, 66, 80]. University research commercialization cannot be implemented successfully because a lot of scientific research generated by colleges and universities does not meet the actual needs of enterprises and the market. Furthermore, many university inventions are typically the sort of technology push which is mainly looking for a market, but not the type of market pull where the market searches for new inventions [81].

Sometimes, researchers lack market research and relevant understanding of the industrialization information. Luan *et al.* [82] demonstrated those industries, and market requirements need to be considered by university researchers to commercialize the patent at the very beginning stage in order to generate beneficial knowledge. In other words, the approach is the combination of research knowledge and industry market demand, which is used for increasing the opportunities to achieve their research commercialization.

3.4 Entrepreneurial Orientation (EO) among Academic Researchers

Like the definitions of entrepreneurship, the key processes and behaviors that researchers and inventors in universities use when acting toward commercialization activities have been defined differently and with slight variations. As examples, Covin and Slevin [83] used the label entrepreneurial posture to describe a firm’s leaders’ risk taking, innovation, and pioneering behaviors; Lumpkin and Dess [84] used the term entrepreneurial orientation to describe five key entrepreneurial processes, including autonomy, innovativeness, risk taking, proactiveness, and competitive aggressiveness. Naman and Slevin [85] used the term entrepreneurial style to describe a firm’s business risk taking, competitive proactiveness, and innovativeness.

Five entrepreneurial dimensions as defined by Lumpkin and Dess [84] are (a) autonomy; (b) innovativeness; (c) risk-taking; (d) proactiveness and (e) competitive-motivated. A number of researchers [85-89] have used three dimensions-innovation, risk-taking, and proactiveness in their studies to assess entrepreneurial behaviors. However, Lumpkin and Dess [84] added two new aspects, autonomy and competitive-motivation to them. This study also chooses five dimensions to evaluate the presence of entrepreneurial orientation among academic researchers.

3.5 Innovativeness

Lumpkin and Dess [84] comprehend innovativeness as “a firm’s tendency to engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products, services, or technological processes. Innovativeness represents a basic willingness to depart from existing technologies or practices and venture beyond the current state of the art.”

An innovative orientation is not specific solely to the introduction of new products. An innovative orientation describes the range of processes impacting design technology, manufacturing processes, distribution channels, and/or promotional strategies that are implemented to improve organizational efficiency and productivity effectiveness [90]. Similarly, Sawhney *et al.* [91] discussed innovativeness as more than just new-product development, but as also broadening the breath of the construct to include innovation in services, channels, brands, etc.

3.6 Proactiveness

Since the early stages of entrepreneurship research, proactiveness has been referred to as an integral element in this field [92-93]. Proactiveness leads to first-mover advantages as the best strategy to capitalize on market opportunities, which will exploit market asymmetries and capture unusually high profit margins [94]. The initiative to anticipate and pursue opportunities is an important ingredient to entrepreneurship. Moreover, Proactiveness reflects initiative in the entrepreneurial process. Proactiveness serves an important function for entrepreneurs in that it encompasses the vision and imagination that are needed to pursue market opportunities [84].

As stated by Lumpkin and Dess [84] proactiveness refers to a firm's future looking perspective, anticipating upcoming demands, seeking opportunities in the pursuit of new-ventures, or the introduction of new branded goods and services to a firm's competitive resources. On the other hand, Miller and Friesen [95] associate proactiveness with shaping the environment by introducing novel products, technologies, or administrative techniques. The definition of proactiveness by Venkataraman [96] refers to processes aimed at anticipating and acting on future needs.

According to Lumpkin and Dess [84], there is a profound distinction between proactiveness and competitiveness. While Covin and Slevin [86] often use these terms interchangeably, Lumpkin and Dess [84] feel that "proactiveness refers to how a firm relates to market opportunities in the process of new entry. It does so by seizing the initiative and acting opportunistically in order to "shape the environment, that is, to influence trends, perhaps, even create demand. Competitive aggressiveness, in contrast, refers to how firms relate to competitors, that is, how firms respond to trends and demand that already exist in the marketplace."

3.7 Risk-taking

Risk-taking has contextual meaning, generally implying the willingness of a firm, given the uncertainty, to take bold action, support risky projects, commit resources, and move into new markets towards meeting organizational objectives [84, 97]. Lyon *et al.* [98] defined Risk-Taking as "borrowing heavily, committing a high percentage of resources to projects with uncertain outcomes, and entering unknown markets." The riskaverse individual prefers to engage in careful study, deliberation and investigation of an opportunity prior to making a decision. In contrast, the risk taker is inclined to engage business-related uncertainty in a less calculated and more spontaneous manner [99; 100].

Early research on Risk-Taking assumed that people have a natural propensity to be risk averse [101]. Many times, Risk-Taking is pursued primarily upon entry into a market, or when the pressures of maintaining a status quo strategic orientation threatens a critical market share. Effective Risk-Taking, whether high or low, is often characterized by a modest level of calculation. Even among those who are considered to be high risk-takers, risk is pursued primarily based on whether the assumption

of risk is likely to lead to short-term or long-term gains, or necessity, rather than an innate desire [102].

3.8 Autonomy

One of the antecedents of entrepreneurship is the "freedom granted to individuals and teams who can exercise their creativity and champion promising ideas. ... autonomy refers to the independent action of an individual or a team in bringing forth an idea or a vision and carrying it through to completion"[84].

Scholars have illuminated the notion of autonomy in two different ways. First, autonomy was described as an entrepreneurial strategy-making mode, where a leader takes decisive and risky actions [103]. This type of autonomy comes from the top of an organization. Second, lower levels of the organization create and push forward an idea, which emphasizes the importance of autonomy to organizational members, and the freedom to act independently [84].

Summarizing, autonomy means that ability and will have to be self-directed in the pursuit of opportunities, individually and in the context of an organization that could otherwise constrain ideas [84]. However, there are arguments that too much room for autonomy and lack of guidance can be counterproductive and may lead the research work into a direction where its results will not be rewarded [104].

3.9 Competitiveness

Competitive aggressiveness, or competitiveness, relates to "a firm's propensity to directly and intensely challenges its competitors to achieve entry or improve position that is to outperform industry rivals in the marketplace" [84]. It is characterized by "responsiveness, which may take the form of head-to-head confrontation, ..., or reactive" [84].

Among all the dimensions identified by Lumpkin and Dess [84], competitiveness is clearly the one which is most related to profit-seeking company's operation in a free capitalist marketplace. While the other behavioral attitudes can be better generalized across organizations (proactiveness, innovativeness, autonomy, and risk taking), competitiveness requires market competition.

4.0 PROPOSED CONCEPTUAL MODEL

The aim of this study is to improve the commercialization rate in university, and for achieving this goal the factors affecting commercialization of output in university should be determined. Moreover, one of the important factors that this study focuses on it is EO among academic researchers. Therefore, conceptual model of this study illustrates four factors that are perceived as influential to the university commercialization. These factors include the role of technology transfer office /center, availability of finance, availability of potential licensee and EO among academic researchers. Figure 1 depicts the conceptual model for this study. Dashed lined represents the scope of this study.

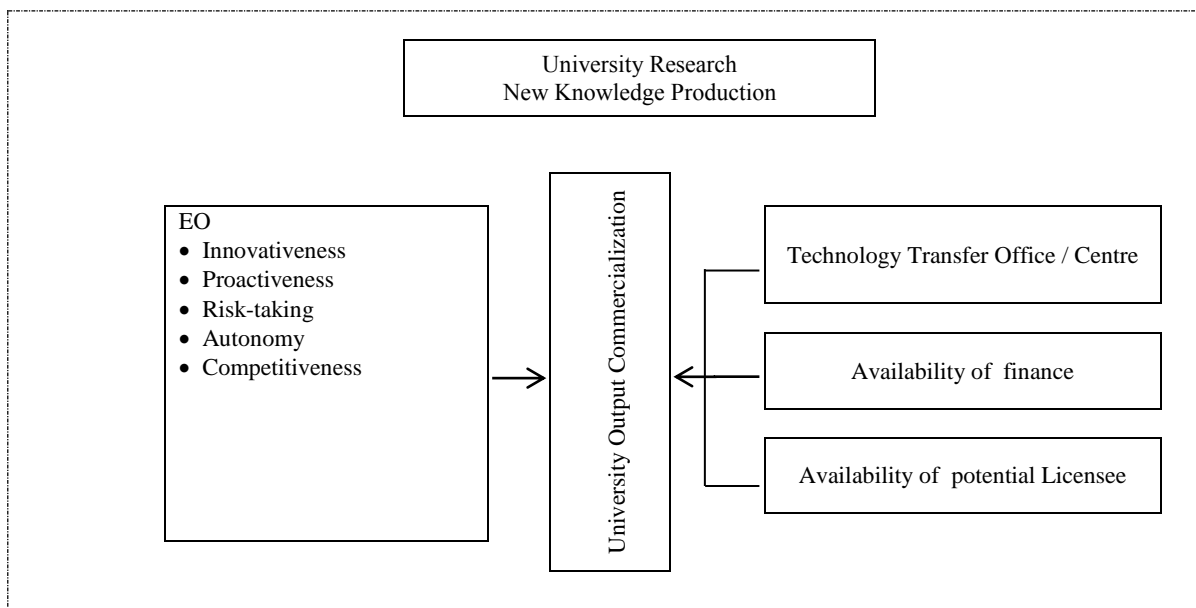


Figure 1 The proposed conceptual model

5.0 RESEARCH METHODOLOGY

This study was based on a qualitative research method and was designed to use a case study approach. Creswell [105] compared the use of case studies to other designs and suggested that case studies were unique because they focus on a clear boundary of activity that can be studied, and that can provide different perspectives on the problem. Researchers who choose the case study approach are more inclined to view the world as complex and with multiple dimensions [106]. Yin [107] claimed that the use of case studies is preferable when the researcher has little control over the phenomenon and may provide a greater understanding through a holistic study of life events and an understanding of the complexity of those events.

This research is motivated to take one of the Malaysian universities to examine the factors to improve commercialization rate. The decision to choose the Universiti Teknologi Malaysia (UTM) as a single case study was mainly because of the nature of qualitative research that requires a smaller sample size [108]. Therefore, the research population includes inventors, researchers, academic entrepreneurs, and technology transfer office staff, which are operating directly and indirectly in the commercialization of university research output at UTM.

UTM has a strategic orientation for research, development and commercialization centered on an entrepreneurial culture, collaborative effort and engagement of parties beyond the university [5]. UTM's R&D and commercialization activities are managed by various policies, including IP Commercialization Policy, Intellectual Property Policy, and R&D Policy. UTM research culture is operating through several (11) research alliances, centers of excellence, faculties and university academic institutions. The research management center (RMC) is responsible for R&D activities in UTM. Furthermore, UTM contributes to enhance R&D through initiatives such as Universiti Teknologi Malaysia Institutional Repository (UTM-IR), UTM Idea Bank, and UTM's Technovation Park. In addition, a variety of funding and grants are provided to promote R&D activities in UTM. Sources of Research Funding in UTM are MOSTI, Ministry of Higher Education (MOHE), Ministry of Agriculture and Agro-Based Industry, Malaysia (MOA), UTM grant, and Contract Research. The ICC or Innovation & Commercialization

Centre is a unit established by UTM, which is committed to develop and commercialize UTM's research products via its newly formed and diversified units, including innovation point, incubation, innovation prototype development, business training and IP development units.

Creswell [109] observed that it is often necessary to gain access to data via a gatekeeper. Table 1 shows the list of portfolio IPRs provided by the Innovation and Commercialization Centre (ICC) at UTM. Units of analysis were chosen among categories number one to six. In the current study, the Director of ICC plays the role of gatekeeper, which provided sufficient information regarding innovation commercialization process.

Table 1 Latest statistics on IPR UTM until September 15, 2011 (Source: ICC-UTM 2011)

No	Category	National	International
1	Patent Pending	694	3
2	Patent Granted	39	1
3	Utility Innovation Pending	8	0
4	Utility Innovation Granted	1	0
5	Industrial Design Application	7	0
6	Industrial Design Registered	5	0
7	Trademark Application	22	0
8	Trademark Registered	19	0
9	Copyright	1363	0
10	Layout-Design of Integrated Circuit	12	0
Total		2170	4

In this study, a total of nine inventions was chosen. To answer the research question in this study, three sub-samples (unexploited inventions; inventions that were exploited through spin-off companies and inventions that were exploited through licensing to established companies) were purposely chosen. Three inventions were unexploited and six inventions were exploited (four inventions that were licensed to spin-offs and two inventions that were licensed to established companies). Overall, a total of ten interviews were conducted including nine with inventors and

one officer from ICC. Respondent’s academic backgrounds were from electrical engineering, mechanical engineering, photogrammetry and laser scanning, civil engineering, chemical engineering, biomedical and physics. Moreover, the position of ICC staff was IP manager. Overall, the respondents were divided into four groups.

Ten interviews were conducted for investigating these four factors, including role of technology transfer office /center, availability of finance, availability of potential licensee and EO among university researchers. Interview guides were used with a standardized open-ended question for each group. The decision to apply semi-structured interview method and open questions was needed since this study required both specific information as well as broader views of the phenomenon under study. The interviews ranged from 30 minutes to one and half an hours and were recorded and transcribed for further analysis.

In this study, the researcher adopted Miles and Huberman’s [110] qualitative analysis method as the leading framework in analyzing the qualitative data. A qualitative data analysis consists of three stages: data reduction, data display, and conclusion drawing [110].

6.0 FINDINGS AND DISCUSSIONS

From the interviews, it was found that university commercialization have been affected by four factors; role of Technology Transfer Office /Center, availability of finance, the availability of potential licensee and EO among the university researchers, which are embedded to several critical issues. The findings also suggested that the most important factor of university commercialization at UTM is the availability of finance, which is followed by role of Technology Transfer Offices/Center of the university and availability of potential licensees. Table 2 indicated the summary of the findings based on the four factors. Overall 90% of respondents critically commented on the issues of the role of technology transfer offices/ center of the university, 100% commented on the issues of availability of finance, 90% commented on the availability of the potential licensee and 82% commented on EO among academic researchers.

Table 2 Summary of the Findings

No	Issues Respondents	Role of Technology Transfer Offices/ Center of University	Availability of Finance	Availability of potential licensee	EO among Academic Researchers				
					Innovativeness	Proactiveness	Risk-taking	Autonomy	Competitiveness
1	M1		√			√		√	√
2	M2	√	√	√	√	√	√	√	√
3	M3	√	√	√	√	√	√	√	√
4	M4	√	√	√	√	√	√	√	√
5	R1	√	√	√	√			√	
6	R2	√	√	√	√		√	√	√
7	T1	√	√	√	√	√		√	
8	T2	√	√	√	√	√	√	√	√
9	T3	√	√	√	√	√	√	√	√
10	P1	√	√	√	-	-	-	-	-
Percentage (%)		90%	100%	90%	89%	78%	67%	100%	78%
					82%				

(Source: Compile from the interview)

The fund is considered essential at each stage toward university commercialization. Technology Transfer Office also plays a key role in the university commercialization. Table 3 presents a detailed summary of the major themes, and the issues based on the findings.

Currently, government supports R&D and commercialization in UTM. On the other hand, the interaction between R&D and commercialization has been strengthened at UTM. The inventors often regard their commercial activity as a good way to validate their research, and this interaction is certainly beneficial for technology improvement. Inventors try to enhance commercialization of local technology for the purpose of national interest. In addition, inventors strive to decrease dependency on foreign technologies, and in contrast, they try to increase belief in domestic technologies. However, the university commercialization rate is still considered to be relatively low. Many university inventions cannot be commercialized into the market due to lack of funds, unavailability of potential licensees, inefficiency of technology transfer office and absence of entrepreneurial behaviors among researchers.

The findings of this study reveal the same issues as stated by previous researchers [47, 58, 60-61, 63- 65, 72, 78, 81-82, 84, 94-96, 98-112].

Table 3 Four major themes

No	Main Theme		Sub-Themes
1	Role of Technology Transfer Offices/ Center of University		<ul style="list-style-type: none"> ➤ Bridge between the industry sector and academia ➤ The establishment of Innovation and Commercialization Centre ➤ Mediator between the inventor and venture capitalist /investor ➤ Facilitate the IP application process ➤ Identify and evaluate potential product for commercialization ➤ Motivate the inventors ➤ Assist to make prototype and to have business plan ➤ Find a way to commercialize ➤ Marketing the patent ➤ Coordinate licensing to established companies ➤ Organize spin off formation ➤ Organize course training ➤ Negotiation at business aspect ➤ TTO need to be better staff with professionals
2	Availability of Finance		<ul style="list-style-type: none"> ➤ Government funding ➤ funding from MTDC for spin off companies ➤ funding from industry through collaboration ➤ Barriers to the industry fund ➤ Limitation of financial resources ➤ Effects of fund limitation ➤ Royalty share
3	Availability of potential licensee		<ul style="list-style-type: none"> ➤ Opportunity recognition for R&D and commercialization ➤ Considering market requirement ➤ Identifying potential licensee and demand ➤ Mechanisms to identify potential licensee ➤ Lack of demand and difficulty in identifying potential licensee
4	EO among Academic Researchers	Innovativeness	<ul style="list-style-type: none"> ➤ Developing existing technology ➤ Experimenting with new methods ➤ Innovative techniques ➤ Importance of innovation in research ➤ Achieving novel research result
		Proactiveness	<ul style="list-style-type: none"> ➤ Anticipating new research trends ➤ Anticipating future need of human and create demand ➤ Leading the research field
		Risk-taking	<ul style="list-style-type: none"> ➤ Committing resources to uncertain research projects ➤ Restrictions on financial risk ➤ Exploiting new research opportunities and methods
		Autonomy	<ul style="list-style-type: none"> ➤ Having independence in determining the content of research ➤ Having opportunity to apply for research funding
		Competitiveness	<ul style="list-style-type: none"> ➤ Comparing research quality and result ➤ Willingness to rapidly develop research results ➤ Transferring knowledge to the industry as an obligation

(Source: Compile from the interview)

8.0 CONCLUSION

The study revealed that EO among the university researchers, the role of technology transfer office /center, the availability of potential licensee and availability of finance were significant to the research output commercialization at university. Overall, the most critical factor that affects university commercialization is the availability of finance. Funding has an impact on the commercialization process at the university from the beginning until the invention has been pushed into the market. One of the current situations is that academic research is faced with shortage of government funds for further development. Most university research requires the support of industry for commercialization. The absence of university-industry linkage creates limited access to industrial funding. A lot of university research output cannot be commercialized through licensing to established industries or spin off formation due to lack of funding from government and industry.

Technology Transfer Office/Center of the university has an effect on the university commercialization. In fact, TTO accelerates the commercialization process by providing services in several aspects. Some of these services are facilitating IP

application issues, motivating academics, coordinating licensing, organizing spin off companies, and marketing the inventions. TTO can be considered by many scholars as an effective bridge between industry and academia. Furthermore, the establishment of ICC is considered as a long-term strategy for enhancing the commercialization rate in UTM.

The availability of potential licensees is also regarded as a critical factor. Initial awareness of the market potential of invention effects the success of invention commercialization. Therefore, considering the industry requirement and recognizing opportunity is crucial in the commercialization process. Overall, identifying potential licensees is considered as an essential step before commercializing the invention.

EO is regarded as a key behavioral factor for researchers and inventors in universities when they are acting toward commercializing their inventions. A series of behaviors such as a tendency to support innovative ideas (innovativeness), boldness and tolerance for the risk (risk-taking), effort to take every opportunity to outperform competitors (competitiveness), making decisions independently (autonomy), and having future looking perspective (proactiveness), positively affect commercialization activities.

This study was conducted only at UTM and is a typical example of commercialization. In this study the number of respondents was also limited to scientists, inventors and TTO staff. Moreover, the public respondents were also limited to UTM. In addition, the research only used one method to analyze the result of the study. Therefore, limitations emerge when there is no quantitative side of the research design used in this study based on the classification derived from content analysis of semi-structured interviews.

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