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FROM LAB TO MARKET: CHALLENGES FACED BY ACADEMIC ENTREPRENEUR IN TECHNOLOGY TRANSFER PURSUIT

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ABSTRACT

The development of academic entrepreneurship is often benchmarked by the rate of patenting, licensing and spin-offs creation. However, these traditional indicators inherently require a long gestation period to materialize, thus creating a challenge to gauge the progress of novice universities. This paper preliminarily assesses the nature of academic entrepreneurship from a developing economy perspective and explore common challenges faced by academic entrepreneurs in bringing research discoveries from lab to market. Survey questionnaires were distributed to academic entrepreneurs of a public university in Malaysia and a series of answers to an open-ended question were analysed through content analysis. Although the results showed the rate of patents, licensing and start-up creations are modest, however, most of the scientists have made significant progress to the pre-commercialization stage by developing prototypes with commercial potential. The content analysis revealed that scientists' entrepreneurial characteristics and institutional support were among the main factors that affect the commercialization of research discoveries. These findings suggest for the relevant authority to take improvement measures to enhance the efficiency of Technology Transfer Office and for the private funders and government disbursing agencies to provide more transparency in decision criteria and to reduce the period of application process and approval results. Avenues for future research are recommended based on the findings derived from this single case study.

Keywords: Academic entrepreneur, academic entrepreneurship, knowledge transfer, technology commercialization

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1. INTRODUCTION

In the year 2014, the Malaysian Ministry of Science, Technology and Innovation (MOSTI) and the reports of Global Entrepreneurship Monitor (GEM) highlighted a gap of entrepreneurial activity rate between Malaysia and other countries (Nurul & Ng, 2014; Roland et al., 2011, Singer et al., 2015), despite the ratio of academic scientist to labour force that had quadrupled by the year 2006 (MASTIC, 2013a). Besides, the literature also acknowledges that the frequency of academic scientists' engagement in the entrepreneurial activity varies significantly across different universities (Aldridge & Audretsch, 2011; Budyldina, 2018; Di Gregorio & Shane, 2003, Siegel, 2018). For instance, there has been a variation in terms of the total number of spin-offs among 20 universities in the United States (O'Shea et al., 2005), total number of commercialized technologies among 18 universities in Malaysia (MASTIC, 2013b) including number of patents among public universities (MASTIC, 2016). The existence of such gap is partly due to limited contribution of scientists to transfer technology from research discoveries.

Furthermore, the literature still has a limited view on the academic entrepreneurship progress from the developing economies perspectives. In Malaysia, there have been sparse quantitative studies to recognize academic entrepreneurs and determinants of their technology transfer pursuit. Most of the empirical studies relating to the influence of individual-level factor, institutional supports and culture were conducted in the developed nations (Kirchberger & Pohl, 2016). Apparently, findings and implications from these studies might not be fully transferable or applicable to the context of Malaysian scientists. Hence, the reasons of the gap in the entrepreneurial activity rate are still ambiguous. Therefore, the purpose of this paper is to provide a preliminary assessment on the various types of entrepreneurial activity in the university. In addition, this study seeks to explore common issue and challenges faced by academic entrepreneurs in bringing research discoveries from lab to market. The outcome of this study provides future research with a general overview of several themes as possible factors that promote or hinder the involvement of academic scientists in technology transfer.

2. LITERATURE REVIEW

The role of academic scientists to act entrepreneurially serves as an antecedent of entrepreneurial activity that facilitates technology transfer from universities to the society. Indeed, the subject of academic entrepreneur presents one of the research interests within the field of academic entrepreneurship (Wright et al., 2012). However, the term academic entrepreneur is often used interchangeably without precision and embodying ambiguous concepts that have not been clearly be in unison. For instance, D'Este et al. (2012) and Marion et al. (2012) perceive academic entrepreneurs as scientists who are involved in the technology transfer activities, particularly in patenting, licensing and creation of start-ups. Apparently, this definition takes into account the three common indicators, which present the eventual outcomes of efforts undertaken by the scientists in their entrepreneurial pursuit. As these indicators inherently require a long gestation period to be materialized, identifying academic entrepreneurs among a population of scientists based on the definition given by D'Este et al. (2012) and Marion et al. (2012) would be challenging to universities that are novice in the academic entrepreneurship.

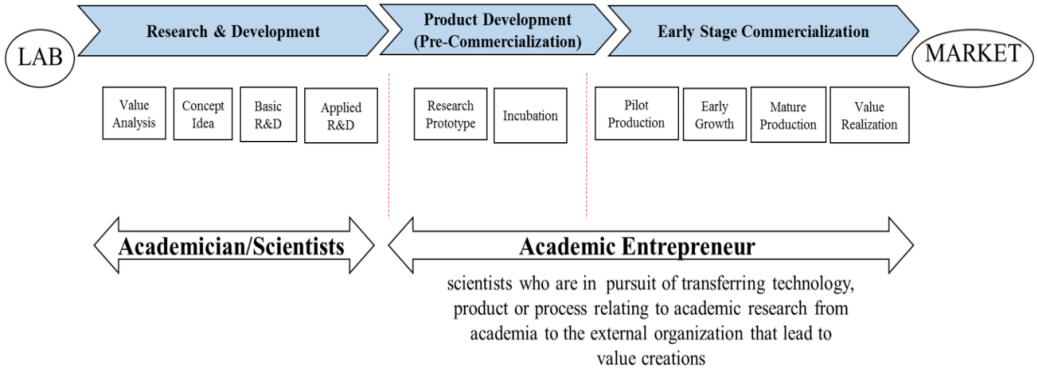
Barth and Schlegelmilch (2013) provide another definition of academic entrepreneur as, "an occupational profile for an actor being scientifically active and at the same time working as entrepreneur". In this sense, scientists act entrepreneurially to generate economic value from their academic research while at the same time retaining their traditional academic role in teaching and research. These scientists may derive monetary returns either through licensing agreement or spin-off ventures creation (Lacetera, 2009). However, while some of them may choose to become the founding entrepreneur of the new venture (Adams & Baughman, 2005; Chrisman et al., 1995), it is quite common for some of them to disengage the entrepreneurial role at this stage and collaborate with surrogate entrepreneurs instead (Franklin et al., 2001). Consequently, although the definition given by Barth and Schlegelmilch (2013) is the most precise produced so far, the interpretation could be broadened because scientists may not always be working as entrepreneur simultaneously.

In this study, academic entrepreneur is interpreted from the perspective of process model of scientists' technology transfer pursuit (Figure 1) and defined as scientists who are in pursuit of transferring technology, product or process relating to academic research from academia to the external organization that lead to value creations. This definition is similar to Matveev (2002), who suggests academic entrepreneur as scientists who put effort to transform their expertise and research findings into intellectual property, marketable products and economic development (Feldmann, 2014).

It is worth highlighting that in some cases, academic entrepreneurs may not yet have reached the eventual outcomes of applying patent, licensing and creating spin off. Therefore, as illustrated in Figure 1, this definition acknowledges academic entrepreneurs' technology transfer pursuit in a multistage technology transfer process (Wood, 2011; Bradley et al., 2013), that qualifies them to be regarded as academic entrepreneur if they have reach the pre-commercialization stage and have developed research prototype. According to an example of successful academic entrepreneurs' learning experiences (Abd Rahim et al., 2015), scientists themselves are the key actors (Jain et al., 2009) who first commence research that produces promising discoveries and innovations with commercial application. In the pursuit of technology transfer from lab to market, these scientists further develop their innovation beyond the lab's environment to meet the real customer expectations (Abd Rahim et al., 2015). Until the innovation is developed to high potential, then only it is recommended to engage with Technology Transfer Office (TTO) for IP protection and subsequent early stage commercialization process (Wood, 2011).

Hence, as summarized in Figure 1, scientists' role in academic entrepreneurship begins with their early accomplishments in value analysis, concept idea, basic and applied researches that make a successive headway into the product development stage (MTDC, 2015). Developing a research prototype marks, the beginning of product development beyond the lab's environment to meet customer expectation, which is essential in scientists' journey to bring their innovation closer to the market (Abd Rahim et al., 2015). Altogether, Mitchell and Singh (1996) view this entire route of technology transfer as, "a process of acquiring ideas, augmenting them with complementary knowledge, developing and manufacturing saleable goods, and selling the goods in the market." (Mitchell & Singh, 1996, p. 170).

Figure 1: The Roles Distinction Between Academic and Academic Entrepreneur in Their Technology Transfer Pursuit From Lab To The Market (Abd Rahim et al., 2015; MTDC, 2015).



While the success of university in the entrepreneurial activity is commonly measured with indicators such as number of start-ups, patents and license revenues, these outcomes are mostly possible if the scientist had first developed potential prototype, technology or process that could stand-alone or used with other technologies that can be commercialized by the industry. Indeed, Siegel and Wright (2015), in their work on the assertion to rethink academic entrepreneurship, claimed that benchmarking of entrepreneurial activities based on the metrics of patenting, licensing, and start-up activity as in the United States and Canada may not be the full set of true outcomes of academic entrepreneurship.

Furthermore, these traditional indicators often require a long gestation period (Reynolds et al., 2004) to be materialized, thus present challenges in gauging the progress of entrepreneurial activity, especially for universities that are novice in academic entrepreneurship. In response to this literature gap, this paper examines academic entrepreneurship in a much wider spectrum of entrepreneurial activities, by including scientists' progress in developing commercial opportunities such as technological solution ideas and potential prototypes, in addition to the formal technology transfer outcomes like number of starts ups, patents and licensing revenue.

Theoretically, the psychology model of planned behaviour has been the prevalent approach to explain and predict the behaviours of individuals. The Theory of Planned Behaviour (TPB) by Ajzen (1991) theorizes that two facets, which are intention to perform a behaviour and perceived control over the behaviour, precede the behaviour of consideration. This theory implies that a transformation of academic entrepreneurs among scientists is a planned behaviour that may results either from an intentional process in which the scientists cognitively plan to perform the entrepreneurial behaviours. This intentional process is affected by exogenous influences of desirability and feasibility towards the entrepreneurial behaviour. As a rule, the more favourable the entrepreneurial act to a scientist (attitude toward the act), the greater the perceived social pressure to perform such entrepreneurial act (subjective norm), and the perceived ease to perform the entrepreneurial acts (perceived behavioural control), consequently, the stronger is the scientists' intention to get involved in the entrepreneurial activity. Alternatively, the TPB also infers that scientists' entrepreneurial behaviours, which are reflected in their technology transfer

pursuit, may also be preceded by scientists' perceived behaviour control. In other words, scientists' perceived feasibility, or increased feeling of control that the pursuit to transfer technology from their research discoveries is achievable, is a contributing factor that results in scientists' engagement in entrepreneurial activity. This theoretical approach provides the foundation in the present study that scientists' perceived feasibility towards the entrepreneurial act itself is an important precursor of their formation into academic entrepreneurs. Consequently, the search of challenging factors affecting scientists' engagement in entrepreneurial activity is focused on the determinants that increase their perceived feasibility of the technology transfer pursuit.

3. METHODOLOGY

Online survey questionnaires were distributed to 115 academic entrepreneurs of one public research university in Malaysia (University A). These academic entrepreneurs are scientists from engineering and technology academic departments who have been involved in the technology transfer pursuit and have at least developed potential prototype, product, technology or process that can be commercialized by the industry. There were two questions posed to the respondents to gain a preliminary outlook on the various types of entrepreneurial activity in the university as well as to explore common issue and challenges faced by academic entrepreneurs. First, respondents were asked to rate their frequency of involvement in 6-items for knowledge transfer activities and 6-items for technology transfer activities within a period of the previous five to ten years according to a 6-point Likert scale ranging from (1) never to (6) always. These 6-items for technology transfer activities are developed solutions that can enhance the product of other industry, developed potential prototype, technology or process which can be commercialized to the industry, applied patent (patent filing), registered patent (patent granted), licensed to other organization and created spin-off companies to commercialize research products. On the other hand, the 6-items for knowledge transfer activities are published research results in academic writings, conducted training, involved in contract research, given consultation services, participated in research collaboration with other faculty and industry. Second, an open-ended question was included to have participants describe the factors that they think would increase or hinder participation of academic scientists in the technology transfer activities. 65 out of the 115 respondents provided answers to this open-ended question and the data were analysed through content analysis.

4. RESULTS AND DISCUSSION

4.1. Entrepreneurial Activity in University

The frequencies of 115 academic entrepreneurs' involvement in the technology transfer activities are summarized in Table 1. It was recorded that they were involved more frequently in developing potential prototype that can be commercialized to the industry (31.3%), in developing technology or know-how that enhance the product of other industry (27.8%) and in filing patent for their research findings (32.2%). This is given by the highest percentage of respondents scoring 'always' (more than six times) in each of these activities. However, majority of the scientists (31.3%) did not obtain patent based on their response of 'never' for item 4.

Furthermore, majority of the respondents did not license (50.4%) or create start-ups (53%) to commercialize research findings.

The findings provide evidence congruent with Abreu and Grinevich (2013) that informal knowledge transfer and formal technology transfer are two mechanisms in which academic research are exploited into profits as well as into values creation to the diverse community. In terms of informal knowledge transfer, the results reveal that most respondents were considerably active in publishing their research results in the academic writing (98.3%) and giving consultation services to the government agencies, private or industrial firms (62.7%). These findings, in line with prior research, suggest that scientists' traditional role to contribute to the advancement of new knowledge is not jeopardized by their simultaneous engagement in the entrepreneurial activity (Shibayama, 2012; Van Looy et al., 2004, Bercovitz and Feldmann, 2008). However, this result is contrary to Moog et al. (2015), who denoted that scientists who invest heavily in producing more publications are less likely to be active in the other form of entrepreneurial activity. This discrepancy could be attributed to how scientists perceive their professional role identities orientation whether to be traditional, entrepreneurial or hybrid in deciding boundaries between involvement in knowledge and technology transfers (Lam, 2010).

In terms of formal technology transfer, although the rate of patents granted, licensing to other organizations and start-up creations are modest, however, almost 85% of the scientists' have made progress to the pre-commercialization stage by developing prototypes with commercial potential. These results seem to be consistent with other research which found only a small proportion (less than 20%) of patented technologies that are exploited via licensing to other companies or commercialized through start-ups were at the prototype stage (Ismail et al., 2015).

These findings also imply that a transition from product development stage into successful commercialization requires a substantial amount of time, technical and financial resources. During this transition, some products need to be developed beyond the lab's environment to meet customer and regulation expectations. Moreover, the nature of academic research that is predominantly aimed towards extending the frontier of scientific knowledge rather than towards a commercial end may further aggravates the gap in this transition. Hence, the balance between theoretical and applied research should be observed and structured through institutional support system.

Table 1: Frequency Analysis of Scientists' Involvement in Knowledge and Technology Transfer

		Frequency					
	Items	Never	Very rarely	Rarely	Occasi-onally	Very frequently	Always
1	Published research results in academic writings	0	0.9	0.9	6.1	18.3	73.9
2	Conducted training*	7.8	19.1	15.7	20.9	13.0	23.5
3	Involved in contract research*	9.6	12.2	33.9	11.3	16.5	16.5
4	Given consultation services/ technical advices*	10.4	17.4	9.6	15.7	17.4	29.6

		Frequency					
	Items	Never	Very rarely	Rarely	Occasi-onally	Very frequently	Always
5	Research collaboration with other faculty or institution.	7.8	11.3	17.4	29.6	16.5	17.4
6	Research collaboration with industry.	11.3	20.9	8.7	21.7	15.7	21.7
7	Developed potential prototype/ product/ technology / process that can be commercialized by the industry.	14.8	9.6	8.7	19.1	16.5	31.3
8	Developed solutions (technology or know-how) that can enhance the product of other industry.	0	22.6	23.5	19.1	7.0	27.8
9	Applied patent (patent filing)	14.8	11.3	6.1	12.2	23.5	32.2
10	Registered patent (patent granted)	31.3	14.8	22.6	7.8	16.5	7.0
11	Licensed to other organization	50.4	23.5	13.0	7.8	2.6	2.6
12	Created spin-off companies	53.0	27.0	10.4	8.7	0.9	0

4.2. Challenges in Bringing Research Discoveries from Lab to Market

Table 2 presents the content analysis results that were coded into institutional support's theme and scientists' entrepreneurial characteristics themes. Two sub-categories for institutional support were funding and TTO. As for TTO, four sub-themes frequently recurred among respondents. The sub-theme relating to staff efficiency (EFF=39%) had the highest frequency of recurrence, followed with programs that are organized to increase scientists' understanding about commercialization process (PGM=22%) and general supports (GS=22%), with the least relating to marketing services (MSVC=17%).

As for funding, three sub-themes frequently recurred among respondents. The ease of getting funding in terms of application process (EGFAP = 50%) was the sub-theme with highest frequency of recurrence. These respondents thought that the application process presents a deterring factor to their technology transfer pursuit. Funding type was the sub-theme with second highest frequency of recurrence (FT=30%), in which some respondents thought that funding for travelling, networking, product packaging, exhibition and prototype development should be made available or increased. Apart from that, few respondents thought that the ease of getting funding in terms of decision criteria and process (EGFDC=20%) is another deterring factor to their technology transfer pursuit.

As for scientists' entrepreneurial characteristics, the four sub-themes were risk-taking (RT=43%), self-motivation (MOT=29%), self-directed learning (SDL =14%) and knowledge in business (BK=14%). Considering the risk-taking attribute, academic entrepreneurs often encounter with uncertainty relating to the usefulness of the technology, its commercial application and replication in the industry since technologies are usually transferred at an infancy stage (Kirkman, 2013; Jensen et al., 2003). Disinclination to commit resources into the unknown possibilities presents one of the challenges that must be overcome by academic entrepreneur to realize a successful technology transfer.

Table 2: Qualitative Insights from the Open-Ended Question Coded into Themes

Main theme	Sub-theme	Frequency of recurrence	Key issues
Institutional support (TTO)	Marketing service (MSCV)	17%	– Lack of marketing staff for exhibitions – Insufficient promotional activities of research being conducted at university A to the industries
	Staff efficiency (EFF)	39%	– Lack of support and poor backup team – Staffs have little knowledge and interest on commercialization – Staffs are not that keen to keep close monitoring of IP – Slow response or inadequate advice on IP management – TTO management should not be among academicians as they tend to be theoretical
	Program to increase understanding about commercialization (PGM)	22%	– Insufficient training to provide suitable knowledge, skills and hands-on experience to academician
	General support (GS)	22%	– Needs representatives from every research areas who are good in selling products. The representatives will represent researchers in the commercialization processes – Clear planning / coaching / managing / monitoring on commercialization path is needed
Institutional support (Funding)	Funding type (FT)	30%	– Lack of funding for traveling, networking, participating in exhibition and product packaging. – Need financial support more on prototype research (costly precision machining)
	Ease of getting fund: Application process (EGFAP)	50%	– Application process for both pre-commercialization and commercialization funds is tedious and requires plentiful document support such as technology validation and market validation. – Long processing period

Main theme	Sub-theme	Frequency of recurrence	Key issues
	Ease of getting fund: Decision criteria (EGFDC)	20%	– Vague decision criteria for successful applicants
Scientists' entrepreneurial characteristics	Risk taking (FT)	43%	– Willingness to commit resource into unknown – More comfortable working in labs and not that comfortable venturing into the unknown
	Business knowledge (BK)	14%	– Technical oriented and lack of business knowledge
	Self-directed learning (SDL)	14%	– Researchers themselves have to find answers to questions like market analysis, business model, financial plan, management plan, sustainable technology road maps, strategies and risk mitigation.
	Self-motivation (MOT)	29%	– Requires passion and determination

Besides, along the journey to bring innovations from lab to the market, scientists may also be facing with knowledge gap due to their unfamiliarity in entrepreneurship that is beyond their scientific expertise. Some of the respondents highlighted the challenge to take own initiative in figuring answers to questions like market analysis, business model, financial plan, sustainable technology road maps, strategies and risk mitigation. These initiatives to identify learning needs and to acquire learning resources is a self-directed learning (Brookfield, 2009) that has been associated with entrepreneurial performance (Tseng, 2013).

5. CONCLUSION

An intersection between the domains of theory, method and context constitute a contribution that this study has made. The findings on entrepreneurial activities constitute a contextual contribution, corroborating the ideas of Siegel and Wright (2015) that the development of academic entrepreneurship in a university is not merely reflected in terms of higher number of commercialized products, number of start-ups, patents and licensing revenue. Instead, the findings revealed that academic scientists are involved in various types of entrepreneurial activity ranging from knowledge transfer to technology transfer as mechanisms to translate academic research into values creation. In terms of methodological contribution, rather than relying on those four common measures (applied patent, registered patent, licensed to other organizations, created spin-offs), this study instead developed additional measures that include scientists' progress in developing commercial opportunities such as technological solutions, ideas and potential prototypes, as indicators of technology transfer outcomes reported by the scientists. By extending these measures of technology transfer, this study provides a new perspective to address

the challenge in gauging the progress entrepreneurial activity especially in the university that are novice in academic entrepreneurship. Academic entrepreneurs are recognized among academic scientists who have reached the pre-commercialization stage and have developed research prototype. This paper provides preliminary qualitative insights on the influencing and hindering factors to academic entrepreneurs' technology transfer pursuit in commercializing their research discoveries. In the context of University A, it was found that institutional support and scientists' entrepreneurial characteristics were the main issues to technology transfer pursuit. The findings regarding the institutional supports suggest for the relevant authority to take improvement measures to enhance the efficiency of TTO. In terms of funding, it is recommended for the private funders or government disbursing agencies to provide more transparency decision criteria and to reduce the period of application process and approval results, in a way to prevent scientists from being discouraged to pursue the technology transfer activities. Nonetheless, it is worth to highlight that these findings only provide a general overview of several key themes as possible determinants of academic entrepreneurs' involvement in technology transfer pursuit in the context of University A. Hence, this study provides some basis to develop a conceptual framework and to design a more in-depth questionnaire survey or interview in the future studies. Future studies may also explore the relationship between scientists' entrepreneurial characteristics and their involvement in the entrepreneurial activity to transfer technology from research discoveries. For instance, while previous research has examined opportunity recognition capacity as a critical skill of academic entrepreneurs (Fernández-Pérez et al., 2015; Clarysse et al., 2011), future studies may focus on the possibility of relationship between this ability to identify commercial opportunity of research and self-directed learning (Keith et al., 2016; Feldmann, 2014). By augmenting the literature gap on the limited evidence of precursor to academic entrepreneurs' opportunity recognition capacity (George et al., 2014), this future research is paramount to provide insightful recommendations to the practice regarding the aspect of human capital development strategy in addressing the gap of entrepreneurial activity rate between countries.

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