University-Industry Technology Commercialization in Malaysia: Opportunities and Challenges

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Abstract: This study seeks to identify factors that enable and/or impede the commercialization of technologies from universities to industries, or referred to as university-industry technology commercialization (UITC), in Malaysia. Conducting qualitative case studies at four Malaysian public research universities, this study analysed how differential in the UITC performance of the four universities can be explained by the different institutional and environmental factors of the universities. The results of this study reveal that the performance of UITC at the universities is significantly affected by the existence of several gaps between the five groups of stakeholders of UITC in Malaysia; the scientists, the TTOs, the university managers, the industry and the government. Knowing these gaps may help policy makers and university managers to reflect their strategies and to alleviate the weak points in order to enhance performance of UITC in the country. Furthermore, the study also found several opportunities that, if properly utilized, may significantly improve the potential for university technologies to be successfully commercialized. The findings of this study, thus, offer substantial academic insights to academic entrepreneurship research and provide several important implications for technology transfer and commercialization of university-developed technologies.

Key words: Resources • Capabilities • Performance • University industry technology commercialization

INTRODUCTION

The use of intellectual property (IP) has become increasingly important and has increasingly been seen as an attractive instrument for accelerating technology transfer from university to industry or typically referred to as university-industry technology transfer (UITT) or university-industry technology commercialization (UITC). The past few decades witnessed a substantial rise in the rate of IP commercialization through licensing agreements between university and private firms, research joint-ventures, the formation of university-based start-up companies, investment in science parks, incubators and taking equity position in companies [1, 2]. These activities can potentially result in financial gains for the university and firms as well as external benefits for the surrounding communities through the creation of wealth and new jobs. According to Carlsson and Fridh [3] (p.202), “the technology transfer is even more important to the surrounding communities than to the universities because of the benefits it creates to the rest of the society”. As a result, the generation and exploitation of IP has become a central issue for universities, not only in the US and the UK but also at universities worldwide [4]. Various measures were taken to expedite the commercialization of research findings.

Performance of UITC: The performance of UITC has received a great deal of attention from scholars in the field of technology transfer, exhibited by a considerable number of empirical studies that have emerged in the literature to examine the factors, or typically referred to as the determinants, that associate with UITC performance. Among the main contributors are [5], [6] Siegel et al. (2003a,b), [1] Chapple et al. (2005), [7] Friedman and Silberman (2003), [3]Carlsson and Fridh (2002), [8] Thursby and Kemp (2002), [9] Thursby et al. (2001) and [10] Rogers et al. (2000). A review of the literature suggests that the performance of UITC has been quite widely studied in the US context and in selected EU
Serious efforts in the commercialization of IP have actually become a part of the Government’s overall plan for sustainable development with the launching of the Sixth Malaysia Plan [21]. It emphasized that public R&D programs should become more market-oriented by exploiting the commercialization of research and technology [19]. Universities have been encouraged to collaborate with industry and to develop initiatives to support UITC. The Government also introduced various types of incentives to encourage private involvement in R&D activities as well as to promote market-oriented R&D and technology development projects. Apart from various grant schemes, the Government has also established various institutions to facilitate commercialization activities and to provide assistance in obtaining financial resources such as loans and venture capital funding. Furthermore, the private sector has been encouraged to play a more active part in research and innovation. Despite these efforts, up to 2005 the IP creation and commercialization endeavours in general were found to be relatively few across the universities as well as within the GRIs in the country [19]. A survey of 5,332 projects funded by the IRPA under the Sixth and Seventh Malaysia Plans revealed that while 14.1% of these projects were identified as potential candidates for commercialization, only 5.1% were commercialized [21, 22]. The rate is even smaller under the Eight Malaysia Plan [23] where only 3.4% of the projects were commercialized. In the Ninth Malaysia Plan [24], the Government has emphasized on the capacity building of the national innovation system by increasing the rate of commercialization of research results and creating more science and technology based companies. Major universities and research institutions in the country have been encouraged to venture in new directions to exploit the wealth of knowledge they possess and to turn them into IP. It is believed that through technology commercialization that Malaysia could become more competitive relative to the developed nations in the context of indigenous technology development. As part of the plan to innovate, the Government has spent out a sum of MYR1.6 billion during the Eight Malaysia Plan specially dedicated for R&D and commercialization as compared to MYR1 billion during the Seventh Malaysia Plan. In addition, the First Science and Technology Policy has been revamped to enhance the process of commercialization. This includes the formation of the Ministry of Science, Technology and Innovation which shows the Government’s urgency and seriousness in the commercialization of technology from university to industry.
Furthermore, as one of its efforts to increase commercialization activities in universities the Government has encouraged all universities to set up a technology transfer office (TTO) to manage the commercialization of their research outputs. Many universities have, accordingly, established a TTO in order to encourage university researchers to consider commercialization and to support them through the commercialization process. The emergence of these intermediaries has been central in bringing university research to marketplace. The effort appears to be successful, given that there has been a trend for an increasing number of patent applications across the universities since the establishment of the TTOs, particularly in respect of the four research-intensive universities chosen for this study. Nevertheless, the number of IP commercialized remains relatively low, albeit different, across universities. Hence, there is a serious need to identify the factors that may influence the performance of the universities in UITC and the possible causes for the differences, so that efforts can be taken to enhance their performance. The overall aim of this study is therefore to inform understanding of the factors that may influence the UITC performance of the universities in Malaysia and the possible causes for the differences of their performance.

Theoretical Framework: This study, investigates the performance of UITC within the scope of the resource-based view (RBV) and institutional theory. Resource-based theories suggest that firms make economically rational choices that are shaped by the economic context of the firm. On the other hand, institutional theories outline that firms make normatively rational choices that are shaped by the social context of the firm. Both the RBV and the institutional framework has been criticized: the RBV for its not taking into account the context of resources acquisition [25] and the institutional framework for its focus on homogeneity and persistence of organizational forms [26]. Therefore, combining elements from these two frameworks in a conceptual model of a firm heterogeneity and similarity may shed light on how universities, in order to be competitive, make economically rational choices that are strongly constrained by their path-dependent resources and are significantly influenced by their internal and external institutional environment.

Powers and McDougall [27] stress that “Although the resource-based view of the firm was largely developed from studies of the for-profit sector, its application in higher education is useful for sharpening our understanding of organizational phenomenon, such as technology transfers that occurs there” (p.295). This is so because universities are now being in a competitive environment in which they are competing with each other for resources such as funding, leading scientists and top quality students, at least amongst universities that are seeking to advance their reputations for excellence. The competition, especially for financial resources, has become especially stiff when more institutions are seeking for limited funding. Furthermore, the culture of competition has increased due to the annual rankings published by respective agencies. Universities are also competing with each other in obtaining funding, competent TTO personnel and other organizational resources in order to pursue commercialization activities. On the other hand, institutional theory provides a useful framework for the study of UITC performance in that the environment where the universities are embedded exerts an influence on the ability of the universities to pursue commercialization activities.

Methodology: An in-depth qualitative case study was conducted at all the four research universities in Malaysia. The use of multiple-case studies is appropriate to enable research for similarities and differences in patterns across cases and to make sense of the findings beyond a specific case. Besides, triangulation of evidence in multiple-case studies provides results that are more robust than might be experienced when using a single case design [28, 29]. Primary data was collected from each university through in-depth face-to-face interviews with their TTO managers, selected academic scientists, their university administrators and the entrepreneurs/managers who had been associated with the respective universities. A total of 33 interviews were conducted and the interviews lasted ranging from 30 minutes to two hours. The format of the in-depth interviews was semi-structured, with a list of questions followed by a more conversational approach, to gain detailed information on issues of the study. Secondary data such as strategic plans and statistical reports of the offices and also annual reports published by the Ministry of Higher Education (MOHE) in Malaysia were also collected. Following Eisenhardt [29] the data was analyzed by first conducting within case analysis for each office to find themes emerged in the analysis, followed by cross-case analysis to make comparisons and to find patterns. Triangulation with secondary data was also conducted to increase the validity of the study. The findings presented below are based on the results of the case studies and integrated with the existing literature.
Factors that Influence UITC Performance

TTO Resources

Competencies and Experience of TTO Leader: The evidence collected suggest that the role of a TTO leader is critically important, at least in the context of this study, since an individual who has good understanding of the cultures of both academia and industry is tremendously needed to bridge the hitherto two distinctive and culturally divided worlds in Malaysia. It has been suggested in the literature that TTOs need to understand the cultures of both academia and industry [14, 27, 30-32]. This is fundamental to reduce the cognitive balances between firms’ managers or entrepreneurs and academic researchers [5]. In this respect, the findings of this study suggest that it would be most beneficial if the individual is equipped with industry as well as academic and commercialization experience, which means he or she is not merely a university professor. Interviews with the TTO directors imply that commercialization experience is imperative to provide good understanding of the issues and challenges of UITC. This experience may also allow the directors to better understand the needs and values of companies [5, 33].

Competencies and Experience of TTO Managers/Officers: Further analysis demonstrates the importance of engaging and retaining employees with related experience and competencies in order to develop a solid TTO team. Although it was considered that the competencies needed for IP commercialization were specific and had to be gained mainly through on-the-job training, hiring experienced employees was found to accelerate the development of the team. The combined competencies of the different individuals in the TTO team were observed as decisive in effectively facilitating UITC, particularly in providing quality services to the key stakeholders involved in commercialization processes; these competencies thus improved and accelerated UITC timeline at the university. It has been suggested that in order to have credibility and work cooperatively with academic researchers and industry representatives, TTO managers need to understand and have the respect of the academics and also have a good understanding and/or experience of the business world [34]. This can in turn facilitate them in undertaking their tasks efficiently and effectively.

Another finding in respect of TTO resources relates to the impact of hiring licensing officers with industry experience. The strategy to have recruited these officers at an early stage of resource development appeared to be practical since the direct commercialization of university IP across universities was initially addressed via licensing. In this respect, the findings suggest that TTOs that have recruited licensing officers with industry experience appeared to be able to perform more efficiently and effectively. On the other hand, due to lack of experienced legal officers, the other TTOs had to spend more time on legal due diligence. In addition, given that UITC is a relatively new phenomenon for the context of this study, higher legal expertise may be required to assist the university in negotiating licensing deals. In fact, it was suggested by the university respondents that the presence of these officers may prevent researchers from being manipulated by companies. Furthermore, outsourcing to external legal advisors is arguably less financially sensible than establishing in-house expertise given that specialist costs are typically high in the country. In any case, finding legal firms that have experience with the UITC sector and that can provide a service that responds to the needs of this sector is perhaps difficult, given the lack of expertise with respect to UITC within the country.

Conti and Gaule [33] in their comparative study of the licensing performance between US and EU TTOs found that the US TTOs employ more licensing officers with industry experience than the Europe TTOs. They were therefore more experienced in negotiating the financial clauses of licensing contracts. Similarly, Siegel, et al. [35] emphasize the importance of recruiting TTO officers with experience and skills in negotiation and boundary spanning. Furthermore, interviews conducted by Siegel, et al. [5] suggest that licensing officers with experience in the industry sector might better understand the needs and values of private companies. In line with this, the findings of this study suggest that employing experienced lawyers can likely enhance licensing activities due to the lawyers’ expertise and experience in negotiation and in understanding licensing contracts. Furthermore, given that many researchers have experienced being manipulated by companies, engaging experienced lawyers is especially crucial.

The findings of this study also suggest that employing experienced employees reduces the time and effort that has to be devoted to developing the productivity of the employees. The experience of the employees enables them to adapt and to learn faster than those with less experience [36-38]. On the contrary, employing less experienced employees had diverted the focus of respective TTOs from other important tasks, since a great amount of time and effort had to be devoted
to training the employees [39]. This could be attributed to the absorptive capacity of the less experienced staff. In addition, some offices had to cope with a high turnover of staff, thus further restricting their efforts of building a solid and effective team. As a result, they had to continuously struggle with a lack of competencies [14, 35, 40].

Leadership Skills of TTO Leader: The findings of this study also draw attention to the importance of leadership skills of a TTO director in developing a solid and effective TTO team in particular in the context of this study where, in general, engaging and retaining skilled staffs, in particular young qualified staffs, is relatively challenging. Accordingly, in order to motivate staff to perform and to stay, such efforts should be introduced. This can in turn minimize the problems of staff turnover and can help the development of a committed TTO team albeit consisting of relatively young and less experienced officers. Furthermore, it was considered that the competencies needed for IP commercialization can be gained mainly through on-the-job training, thus retaining trained staff is crucial. Not only that the cost of training and the time and efforts that have to be devoted to training can be reduced, this may also eliminate the perception that university TTOs are training schools for new graduates.

Institutional Resources
Committed University Leaders: The central finding of this study suggests the critical importance of having university leaders who are passionate towards driving forward academic entrepreneurship in their universities, as proposed in previous studies (e.g. [7, 8]) that entrepreneurial activities of a university are partly influenced by the entrepreneurial university administrators. It was observed that there were significant gaps between the levels of administrative support provided by the university leadership across the four universities in this study. While some universities seemed to receive remarkable support and commitment, other universities had to survive with lower levels of support. Furthermore, the results of this study suggest that some university administrators were willing to provide substantial resources in order to develop UITC in their universities. This may be attributed to the knowledge and understanding of the university administrators about UITC. In relation to this, Debackere and Veugelers [31] suggest that universities having a clear mission of technology transfer with strong support and leadership by university directives are more able to build a friendly environment to academic entrepreneurship. Barr, et al. [41] also found that leaders play a critical role in directing the path of a resource accumulation process in which the goals and the activities that a TTO pursues can be influenced, at least in part, by the convictions of their head [33].

Social Norms: An interesting finding that emerged from the interviews was the fact that in one of the universities, almost half of the patents were generated by one of the university centres of excellence headed by a leading scientist who appeared to be amongst the most productive scientist in the university as well as in the country with respect to IP commercialization. In addition, a number of leading scientists were also engaged by this centre as its management team. It is worth noting that the majority of the university’s flagship products originated from this centre. This finding indicates that researchers in the department or research centre where the head and peers of the research group are actively involved in UITC are more likely to develop disclosure behaviours and to engage in entrepreneurial activities. It has been suggested in the literature that the local reference group, or peer norms, play a significant role in influencing researchers’ decisions to participate in UITC [42-44].

In addition, it was found in the literature that researchers are more likely to disclose their inventions if they are trained at the institutions that have long-established and relatively successful technology transfer operations [42]. The finding of this study indicates a similar phenomenon. For example, one of the researchers interviewed, who was relatively younger than the other interviewees, appeared to have started patenting since he conducted his undergraduate study at a Japanese university. According to this researcher, patenting and IP commercialization is a common phenomenon across the universities in Japan. Taken together, these findings support the notion that commercialization culture can be developed at a department or research centre level.

This finding also draws attention to the important role of a department head in influencing the development of disclosure behaviour among the staff of the department [33, 41]. Consequently, it may be beneficial to identify or search for these prolific researchers since they are more likely to participate in entrepreneurial activities [45] and to become the potential role models that can inspire others to participate in entrepreneurial activities [46]. In addition, they may operate informally as mentors to other researchers [47]. However, the literature suggests that
little or no effort has been made in attracting these “self select” individuals [48]. This point was also emphasized by one of the TTO directors interviewed. According to this director, it is important to recognize this type of researcher rather than wait for the researchers to come forward, as they might decide to go elsewhere for assistance and sidestep their TTOs if not appropriately treated [2, 49-51]. In addition, given that very few of the researchers in the context of this study were among the group of prolific scientists, it is particularly crucial to identify these “rare species”, as termed by one academic researcher interviewed, in particular to head departments or research centres. Powers and McDougall [27], in fact, emphasize the paramount importance of building and maintaining a base of research leaders in their fields and carefully working with them on leveraging their research into commercially viable products. Also crucially important is “to give proper incentives to the right experts” in order to retain these research leaders.

**Individual Resources**

**Types of Researchers:** In accordance with Mustar, *et al.* [52], the findings of this study suggest that academic researchers were likely to be heterogeneous and could be characterized into three types or groups of researchers. The researchers in the first group were those with entrepreneurial drives, typically interested in commercialization and had established networks with potential commercialization partners. They were typically key researchers in their field, as has been suggested in prior research (e.g. [53-55]). These researchers appeared to be more independent of the TTO and only sought its assistance to patent and formalize contractual agreements or to prepare the “launching pad” for researchers to start off ventures. They were the habitual or novice entrepreneurs who might be more entrepreneurial in identifying new research areas and sources of funds [46, 56]. The creation of a new venture was more likely to be preferred by this group as a route to IP commercialization. However, it was acknowledged that these “self-select” researchers represented only a small subset of research communities within and across the universities in this study; this has also been indicated in previous studies (e.g. [50, 54, 57]).

The second group of researchers were those who lacked entrepreneurial drive but were driven by the need to see their inventions benefit the society. They were thus reluctant to participate deeply in entrepreneurial activities and were risk-averse. This group of researchers were typically relied upon the TTOs to help in identifying commercial opportunities for their research discoveries and to seek licensees or industry partners. Licensing or outright sale was most likely to be preferred by this group as the medium for commercialization. The third group were those without entrepreneurial drive and were relatively not interested in commercialization. This group of researchers were typically prone to perfecting research and publishing research results to be known among the academic circles [10, 58-61]. They had to be acculturated by the TTOs in order to develop entrepreneurial intent. The majority of the researchers in the context of this study appeared to belong to this group, as claimed by many respondents of this study.

**Network and Reputation of Researchers:** There was much evidence that the social network of researchers was utilized to attract potential licensees or industry entrepreneurs to develop and commercialize the technologies created by the researchers. It was acknowledged by the researchers interviewed that commercialization partners, while some were identified through TTOs and their marketing activities, were often identified through the formal and informal networking of the researchers. These networking have been established through programs such as contract research, consultancy activities, conferences, seminars and even community services, implying that formal and informal networking between academic researchers and local firms could promote UITC [9, 55, 58, 59]. In this respect, informal relationships and knowledge flows were enhanced through formal institutional ties that have been created with industry [27].

The researchers’ networking also includes personal contacts such as former students, colleagues or associates and even relatives or family members. This draws attention to the issue of trust that had typically been mentioned by the interviewees as a hindrance to potential joint-works between university researchers and industry players. In this respect, having bad experience while working with companies, some researchers had resorted to work with people that they knew and that they had already built relationship from the early stage of their technology development. Murray [62], in fact, shows that the social capital brought by university scientists contributes to developing trust and long-term links between industry and the scientific community. Furthermore, Mayer, *et al.* [63] emphasize that developing relationships with external resource providers from an early stage of technology development is decisive in order to develop trust, which appears to be one of the
barriers found in forming partnerships. Developing ties based on mutual trust can therefore enable resources to be accessed.

Nevertheless, in some universities, there appeared to be a heavy reliance of the researchers on the TTO to find them industry partners, often due to their workloads that had discouraged them from devoting much time in promoting their research discoveries and in seeking for potential industry partners to commercialize the discoveries. They seemed to claim that the responsibility of finding industry partners should be handed over to the TTO and the business arm of the university. These researchers were in fact the “technology originators” who had to depend on the “technology harvesters”, the TTO, to search for potential licensees [64]. In this regard, the technology harvester has to play an active role in identifying the potential value of a technology and link it with industry for exploitation. However, it was less likely for some TTOs to undertake this role effectively given their compelling problem of under-resourced and the excessive workloads of their staff.

Financial Resources: Financial resources, in general, were not highlighted either as an enabler or as an impediment to UITC. The limited importance put on financial resources was, perhaps, due to the existence of public policy programs supporting full costs of patent applications and the various types of commercialization-related grants provided by the Government. In this regard, most public universities in Malaysia tend to fully depend on federal budgets. The federal government is in fact the main source of their financial resources. However, academic respondents and entrepreneurs claimed that applying for funding was rather tricky due to several issues, the important ones of these being, apart from stiff competition: (1) Political influence, in which those who had built ties with politicians were perceived as having easier access to funding, (2) The lengthy and cumbersome procedures of fund application, which involved developing proposals and filling in too many forms.

With respect to industry funding, academic respondents expressed concern on the insufficient financial resources to move from the lab scale to the upscaling level given that most companies were not keen to invest in the “in betweens” stage of technology development. Furthermore, obtaining funding from large companies was observed as relatively difficult mainly due to issues regarding IP ownership. In this regard, companies often expect a full ownership of such IP making it difficult to negotiate with large companies let alone to receive commercialization funding form them.

Moreover, the majority of large companies in Malaysia were foreign-owned companies that were typically relied on their parent company R&D thus did not perform R&D in Malaysia, or even if they did conduct R&D, the focus was on value engineering - recreating the value of products - to increase the quality and the performance of the available products.

The SMEs, on the other hand, were claimed as lack the resources to become involved in R&D activities as well as lack the capabilities to use as levers the technological opportunities provided by the universities. Thus, accessing funding from SMEs were often perceived as less possible. Accessing investments form venture capitalists also appeared challenging given that typically venture capitalists did not have much confidence that scientific knowledge can be converted into business opportunities. Furthermore venture capitalists often wanted to see fast results, hence were reluctant to invest in long-term projects.

Institutional Factors

Strategic R&D&C Focus: The findings suggest that all of the universities in this study had a generic research portfolio. In fact, the public sector research in Malaysia is typically characterized by too many areas of funding and multiple research institutes/centres as well as being driven predominantly by the interest of researchers. However, there was evidence that university that had developed a specific technology focus for UITC or at least be quite specific in few domains of research appeared to be more successful at commercializing their IP.

Strategic Market Orientation: Further analysis suggests that universities that have developed strategic market orientation by producing industrial-relevant technologies to meet the needs of specific target markets were more successful at commercializing those technologies. In addition, some universities appeared to have widened their market space beyond the local markets by creating new market opportunities that had not been addressed by their competitors. In this regard, they only allowed high quality technologies that have significant commercial value and that meet the needs of the customers in the selected markets to be patented and commercialized. This was done by creating high quality innovations that are accessible and affordable to the, mostly poor, customers and therefore create new market opportunities [11].
However, some universities appeared to focus on developing technological products that meet the needs of the local markets. Yet, interviews suggest that Malaysian local markets are too small. Thus there is a need for universities to create products that cater for bigger markets in order to attract the industry to commercialize the products given that the industry participants were particularly concerned with the profitability of the products. Heirman and Clarysse [65] emphasize that venture capitalists tend to invest in start-ups that target mainstream, international and global markets of a significant size. Accordingly, in order to attract research funding and to capitalize on the IP generated, universities should focus primarily on generating world-class research and critical mass in areas of expertise, as recommended by Wright, et al. [39].

**Strategic Collaboration:** It was also observed that the universities that have established collaborations with either national or international collaborators were more successful at IP commercialization. In this regard, Lai and Yap [15] conducted a study of Singaporean research centres and industries and argued that the ideal technology transfer mode seemed to be joint projects among research centre and companies in which relevant facilities and expertise complemented each other. Reducing risks through such collaboration can encourage the use of technology transfer as a motivational mechanism for industries and universities. In fact, financial risk is the critical factor to be considered in technology transfer and it could be decreased by sharing R&D costs and facilities. In particular, for the context of this study where resources are relatively limited, strategic collaborations would be a critical success factor for UITC.

**Organizational Capabilities**

**Technology Selection:** Markman, et al. [50] stress that the active participation of university inventors is an important determinant of the speed of commercialization. When inventors collaborate actively with their TTOs, technologies tend to be commercialized faster and earn higher revenues. However, the results of this study suggest that all the four TTOs had initially faced difficulties in persuading researchers to patent their research outcomes. Their main task, therefore, was to stimulate the motivation of the researchers as well as that of the students to participate in commercial activities through the creation of an institutional entrepreneurial culture, which involved a critical shift of mind set among the researchers [5, 7, 61, 66, 67]. Consistent with prior research (e.g. [8, 58, 68]), it was found in this study that traditionally the primary mission of most researchers was to engage in teaching and research and they were therefore facing an “identity crisis” over their academic roles. There was also much evidence that university researchers resisted to engage in UITC because of their excessive workloads. Furthermore, the fact that tenure and promotion policies give greater weight to publication than to commercialization activities also led researchers to focus on publication for professional advancement, as also discovered in previous studies (e.g. [32, 50, 61, 68]).

In relation to this, researchers appeared to be reluctant to patent their technologies due to a misunderstanding that patenting could delay publications [8]. There was much evidence that most researchers in this study were unaware that patents and publications could result from the same underlying research effort [45, 69, 70]. The TTOs had therefore undertaken efforts, to varying degrees, to develop the awareness of researchers of opportunities to exploit their innovations. They have to also convince the researchers about the importance of protecting their research outputs and how the offices could assist them with IP commercialization. With the cooperation of a number of government agencies, this was done by organizing serial talks, faculty road shows, training seminars and workshops across the universities. It was recognized that the processes involved were challenging and tiring, but they had to be executed in order to ensure that the researchers received suitable information. This supports the notion that providing incentives to encourage a climate of academic entrepreneurship takes time and effort [5, 6]. Accordingly, TTOs have to devote some effort and time to actively encourage researchers to disclose their research outcomes and thus elicit the technological resources from the university laboratory [35, 60].

The results of this study demonstrate how efforts undertaken by all four TTOs had shaped the behaviour of the academic researchers, in varying degrees, to become involved in patenting activities despite the existence of “identity crisis” [4, 52, 56, 71, 72], demonstrated by the increased number of patent applications at all four universities. This result supports the finding by Thursby and Kemp [8] that the increase of commercialization activities can be partly attributed to the changing environment within universities. Similarly, Jacob, et al. [73] suggest that the adaptation of the university culture is imperative in transforming universities to be more entrepreneurially oriented.
A notable finding that has emerged from the interviews is the high selectivity approach adopted by some universities in “picking” technologies that warrant further protection and commercialization efforts. It appears that in order to “maintain the quality” of the patents, universities only selected technologies that were believed to have high commercial value and that could generate substantial income to the universities. They believed that it is not financially sensible to invest their scarce resources to patent technologies that will be “sitting on the shelves”. This practice differed from that of the other universities which seemed to focus on the quantity of the patents, perhaps due to their broader objectives of patenting, which include the creation of an image of the university and the acknowledgement of the contributions of researchers. According to Macho-Stadler, et al. [74], one of the ways to create an image or reputation is through shelving inventions. The findings of this study suggest that pressures from the Government may also be a reason that impelled the universities to increase the number of their patents. In this regard, Powers and McDougall [27] suggest that the patent strategy of universities may vary tremendously. While some universities may simply pursue a numbers game, some others may concentrate on patenting technologies applicable to a specific industry. In any case, opting for this “numbers game” appeared to increase the level of stock of unused technologies within the universities of this study.

It has been suggested in the literature that there is a need for universities to realistically match their objectives in UITC with appropriate resources and capabilities they are able to generate, particularly when the universities are facing resource constraints [40, 75-77]. Adopting high selectivity and high support policies has been proposed to benefit universities located in a weak entrepreneurial environment [75]. Similarly, for the context of this study, implementing a more selective approach for the choices about what to patent and commercialize appeared to be appropriate to optimizing the universities’ scarce resources. Furthermore, focusing on the technologies that have promising commercial value can increase the possibility of the technologies being commercialized and thus minimize the problem of having a high level of unused technologies. This also implies that it is not the number of the patents that matters but how applicable the technology is to industry context [34].

Furthermore, being selective appeared to be vital given that inventions with good commercial potential were rarely produced in universities. There was much evidence that the products developed were, in general, unable to stimulate interest in industry due to the technologies being, often, not applicable to companies. The researchers were seen to develop products based on their interest and often with less market orientation. The products were also claimed to be too academic in terms of their purposes and were developed mainly to answer the ranking of the universities and the researchers’ KPIs. Although most researchers seemed to think that their research findings were ready to be used and marketed by companies thus waited for the companies to take their products, the fact seems to be that what the researchers think the industry needs is often not what the industry really needs. Accordingly, if the mission of a TTO is to commercialize university research, better quality research output which meets the requirements of the industry could generate more work for them [34].

**Technology Marketing:** A further analysis indicates that the IP marketing in general was conducted via national and international exhibitions and tradeshows, discussions with industry and business-matching events organized by the ministries and other fund providers. Other channels of communication included websites, advertisements, press conferences, brochures distributed to companies and other kinds of publications. The UITC literature suggests that the ability of TTOs to perform marketing activities is largely dependent upon the resources provided by their universities [14, 27, 35, 50, 78]. In the case of this study, due to the excessive workloads of the TTOs couple with their less experienced staff, pro-active marketing was less likely to be conducted by most of the offices. Yet, a TTO’s active role in marketing is, arguably, critical at least for the context of this study where most researchers were seen as rarely to disseminate knowledge to wider audiences or to inform companies directly about it as they did not have the business skills and knowledge.

**Technology Matching:** It has been suggested that finding licensee companies or industry entrepreneurs who are capable of commercializing their technologies is one of the most important competencies of TTOs [50]. Thus, managing a TTO requires special skills to facilitate the matching of the technologies created in universities to business needs and also to provide assistance in the commercialization and pricing of the technologies [34]. However, these special skills were less likely to be present in young and fresh graduates, which limited the ability of majority of the TTOs in this study, to conduct effective
negotiations with potential licensees or industry partners. In any case, the matching process was typically involved linking patented technologies with licensees or industry partners that have the matching resources and capabilities to develop or co-develop the technologies depending upon the methods chosen for commercialization. Usually, it was conducted with the presence of the TTO, the researchers who developed the technologies and also the potential licensee or industry partner and would typically take more than once. Choices related to mediums of commercialization were likely to be determined by the university’s perceptions of the expected financial returns from the technologies commercialized and their expectation on the active participation of university inventors.

There was much evidence to suggest that besides the deficiencies of skills and competencies to conduct effective negotiations amongst their staff, the TTOs also had to face several obstacles in linking university researchers with potential licensees or industry entrepreneurs mainly due to issues of IP valuation and the difference of perceptions and motivations between both sides.

**Valuation:** IP issues were typically acknowledged as the cause of difficulties TTOs encountered when dealing with industry entrepreneurs. While the TTOs claimed that entrepreneurs were often not willing to pay the requested price, or were sometimes tended to prefer to obtain the technologies for free, the entrepreneurs argued that TTOs were tended to overstate the commercial value of their patents although the technologies still needed further improvements and their commercial opportunities were still in vague. As a result, price haggle was always seen to obstruct successful negotiations. Because of this, some universities had opted to sell or license their technologies “as cheaply as possible to encourage more participation from the companies” through which the confidence and trust of the industry can be developed towards accepting the technologies created in universities.

**Difference of Perceptions/Motivations:** In general, the results of this study suggest that there was a problem of perceptions on both sides about the capability of each to create stable and durable links with each other. While the entrepreneurs always appeared to be sceptical of the quality of the technologies created in universities, the university researchers always seemed to be sceptical of the entrepreneurs’ intentions to market their technologies. Their lack of trust with each other appeared to hinder the development of a relationship to develop and commercialize the products created in universities. There was also much evidence to suggest that most companies simply did not know about the possibilities of UITC from universities. In fact, there were companies that did not actually know what happen in the universities with respect to technology creation. This had in turn affected their perception towards the role of universities and university researchers in UITC.

The difference of perceptions between both sides may also be attributed to the difference between engineering and science in which these two areas are genuinely different activities, one belonging mainly in business and the other mainly in universities. In this respect, each builds on its own achievement in the course of its development, and neither are conceived as a part, or the application of the other. The findings suggest that university researchers normally conduct basic scientific research which usually either in very broad areas, or in very specialized and specific areas. On the other hand, companies seemed to prefer their engineers to solve technical problems and to conduct value engineering in order to improve processes or products, rather than dealing with scientific theories. Thus, they did not normally expect to use scientists to do the value engineering for them. Furthermore, the research findings of the university scientists were normally presented in the form of scientific knowledge and not in the form of designs or prototypes to show how the knowledge could be used. Moreover, it was observed that companies were often reluctant to use new discoveries and other kinds of new knowledge from universities because it was assumed that most universities do research that are not relevant to their needs. In this respect, the evidence suggests that companies generally favour more applied research whereas university researchers aimed to discover and test new knowledge as their major contribution.

The findings also suggest that there appeared to be a wide gap in understanding between the pursuit of knowledge by university researchers and that of profit by companies and venture capitalists leading to major differences between their motivations. On the one hand, industry typically seeks competitive advantage, which generally being derived from valuable, rare and difficult to imitate resources and capabilities [79]. Thus, heterogeneity and appropriability are vital to increase shareholders’ value [80]. On the other hand academic researchers tend to seek peer recognition and thus may lack interest in appropriability. The bottom line for companies and venture capitalists was financial capital
and speed of achieving UITC in terms of its processes and management thus they tended to expect fast responses from universities. Whereas, universities would typically require time to complete research projects thus had difficulties in meeting the industry’s needs. Furthermore, some university research findings were seen by companies as not going to result in profits for them.

**Boundary Spanning:** It was observed that the role of the TTOs in assisting researchers to develop new ties with potential industry and funding partners was a precursor to stimulating entrepreneurial activities for the context of this study, as has also been suggested in the literature [13, 56, 81]. Given the traditionally non-commercial environment of this context, researchers face major challenges in developing social capital [52, 54, 82]. There was evidence that networks of most researchers in this study were typically constrained to the narrow research community networks built to perfect their research and to gain recognition among the academic circle [46] with exception to those that have involved in UITC. Yet social capital is important for the creation of ventures based upon university research [46]. Furthermore, the absence of trust was found in this study to be one of the barriers in finding industry partners. Developing strong ties with industrial actors may therefore lead to relationships based on mutual trust which can in turn enable resources to be accessed [57, 63, 83].

All of the offices therefore appeared to assist, in varying degrees, in establishing the networks and helping the initial interaction between academic researchers and potential industry partners [5, 14, 31, 32]. The linkage or brokerage activities [46] to provide a medium for developing new ties were typically carried out via participation in trade exhibitions at national and international levels. One interesting insight that emerged from this study is the establishment of the match-making programs conducted by the related ministries. In these programs, researchers were matched with potential industry partners to commercialize their inventions. These efforts appeared to be fruitful in that a number of linkages had been developed through the programs.

Nevertheless, there was much evidence to suggest that establishing links between university researchers and industry entrepreneurs through boundary spanning activities, albeit crucial, was relatively challenging to the TTOs due to their excessive workloads and lack of skilled staff. Accordingly, they had to depend on traditional ways such as trade exhibitions and competitions to introduce university researchers and their products to external parties. Furthermore, given that the TTOs were university representatives, they tended to be biased towards guarding the interest of the university actors and thus, arguably, did not normally try to understand the needs and interests of the industry, in particular the SMEs. This may explain why some of the business negotiations failed or at least took so much time to complete. It can be seen that not only that the TTOs have yet to develop marketing capabilities, they have yet to develop boundary spanning capabilities as well.

**Managerial Capabilities:** According to Amit and Schoemaker [84] and Barney [79], the prudent combinations of organizational resources that improve productivity processes are likely to become capabilities that an organization performs especially well. This claim is in line with at least some evidence from this study. It was apparent in some universities that their speed of decision making had expedited their commercialization timeline [50]. In particular, the speed of response to customers, which was enabled by the presence of empowerment and trust from the university administrators, had enabled some TTOs to gain trust from their customers, in particular the business community and thus increasing the credibility of the offices as well as that of the universities. Furthermore, it was reported in the literature that trust in the role of TTOs in UITC is an important incentive for researchers to transfer technologies through these offices [34, 50]. This was evident at some other universities where the researchers appeared to be quite reluctant to work with their TTOs due to the inefficiencies of the TTOs. Yet, the active participation of researchers in UITC is required in order to increase the speed of innovation and the effectiveness of a TTO [50].

The managerial practices of some universities allowed the creation of competencies that enabled a better exploitation of their technological resources [85]. In fact, a lack of speed was claimed by the interviewees in this study as one of the main impediments to UITC. There was evidence to suggest that some TTOs had missed a number of business deals due to some companies were not willing to wait and had searched elsewhere for alternative technologies. This is so because speed is expensive in terms of companies’ money and time. Markman, *et al.* [50] indeed suggest that “time” is a resource and when combined with the capability of the TTOs can create competitive advantage. They also report that the speed of the TTOs in bringing new technologies
to the marketplace can significantly impact on performance. Thus, these competencies are considered to be among the main competencies that should be developed by TTOs in order to enhance UITC performance [50].

Environmental Factors

R&D Capability of Industry: The launching of IMP2 reflects the Malaysian government concern at that time with the state of industrial development and more importantly the future role of manufacturing. The latter was expected to become the catalyst towards becoming a fully industrial country. However, Malaysia’s domestic industries tend to lack sophisticated technological and commercial expertise. In fact it was claimed that the Malaysian local industries are “twenty years behind” the technologies created in the universities. Therefore, the industries in particular the SMEs were not ready to invest in any new technologies due to the high costs and risks involved. Moreover, not all companies were able to use complex fundamental knowledge created in universities. On the other hand, while large domestic companies were typically conducted their own research, the MNCs were seen as either carrying out their R&D outside of Malaysia or only conducted value engineering locally. In this regard, the tendency for large companies to undertake their own research, while small companies are unlikely to conduct research, is similar in Malaysia to that in more developed companies, but probably more pronounced.

Interviews suggest that due to their lack of in-house R&D, companies often dependent upon technologies developed by external researchers. However, given that their preference was more on incremental (or imitative) innovation and acquisition of foreign technology as their primary innovation strategies, they may have failed to make use of relevant discoveries, invention and knowledge produced by local universities. There was also evidence to suggest that the SMEs tended to prefer importing technologies and conducting reverse engineering. These were done by developing their capabilities in selecting, acquiring, assimilating and adapting imported technologies and thereafter innovate themselves.

Furthermore, although the Government had made efforts by providing various grants such as TAF, CRDF and TechnoFund to enhance the capacities of SMEs to pursue the development phase and to commercialize some of the new technologies and products developed in universities (and GRIIs), companies were seen as rather reluctant to really engage in R&D. Instead they were more interested in seeing ready-made products, ready to be sold immediately, without them needing to do any more work on it. There was also much evidence to suggest that companies often misused the grants received to pay for other operating expenses of their companies.

Venture Capital Market: The venture capital market in Malaysia, in general, was not really moving and the venture capitalists were seen by respondents as risk-averse and did not believe that science can generate profits. Heirman and Clarysse [65] suggest that venture capitalists tend to invest in start-ups that target mainstream, international and global markets of a significant size. Nonetheless, given that knowledge-based innovations normally take a long period before they can see profit, venture capitalists, in particular in Malaysia, were not so keen in entering long-term and expensive investments. The UITC literature suggest that, typically, venture capitalists are not interested in investing in early stage hi-tech start-ups [56, 81] whereas a large share of university technologies are at early stage [32]. Thus, accessing financial resources from the venture capital market may be the most significant difficulty facing universities not only in the UK [81], but also in Malaysia.

As an effort to overcome this problem, the Government had launched government-backed venture capitalists, yet the impact was still small and access to pre-seed capital remains a bottleneck for high-tech start-ups. The findings also suggest that the universities in this study had established their own venture capital company through the universities’ holding companies but the amount provided was relatively limited, thus not everyone was able to have a share of the “small pie”. It appears that constraints access to finance is a major barrier to the development of UITC in Malaysia. This is exacerbated by the fact that bank loans are out of reach for small and new firms and the cost of capital is prohibitive for many firms.

The Role of Government: Although the Government appeared to have provided various supports to enhance UITC in the country, several issues regarding the role of the Government in supporting UITC have emerged from the interviews. These are presented below:

Strategic Focus and Direction: Evidence suggests that there were inconsistencies between policies and Malaysia Plans resulting not only confusion amongst academic researchers and industry about the focus of the government but it also triggered off lose of trust towards the government. Certain fields of R&D may take more than
five years to complete. A change of policies may therefore affect the progress of these types of research given that R&D expenditure by the government was allocated based on strategic priorities. In this case, a change of priorities would affect the development of the fields of R&D that used to be priorities in the prior Malaysia Plan. Furthermore, some of the Government efforts may not be relevant to the fact that the government tended to focus on more advanced technologies. Yet, some of the technologies were not relevant to companies.

The Management of Commercialization Grants: Interviews suggest that there were negative perceptions of those ministries involved in UITC: in particular the fund providers (e.g. MOSTI, MOHE, MTDC). It was claimed that many research grants did not actually reach the companies that really needed them. This is so because the grants were often awarded based on politically related criteria. The findings also suggest that the grants provided by the ministries were not effectively monitored leading to manipulation of grants by companies. Many companies were seen as not sincere and used the grants to pay for other operating expenses of their companies. Furthermore, researchers were concerned about the management of public funding given that there were too many agencies and/or ministries that involved in the management of public funding schemes, thus creating confusion among applicants and resulting in a number of inefficiencies such as difficulties in identifying suitable funds, long bureaucratic delays in approval and disbursement of funds and lack of transparency in fund approval.

The Distribution of R&D Grants: The university researchers interviewed were also concerned about the apparently imbalance distribution of funding for different types of research, in particular between the fundamental and the applied research. It was claimed that the government did not have a distribution formula with respect to funding that aligns with the objectives of the country in UITC. It can be seen that there was a big divide between the types of research conducted in university and in industry. While most of the fundamental and basic research activities were undertaken by universities (and GRIs), most of the applied research and experimental development were undertaken by the business enterprises. Although fundamental research is undoubtedly crucial to generate the technologies that are novel in nature, but they are often a long away from products with commercial potential [13, 32, 39, 68, 86], thus limited the generation of industry-relevant technologies.

Furthermore, unlike in most advanced scientific nations, the majority of R&D personnel of this country, almost 85%, are in the public sector (in universities and GRIs). This helps to explain why most fundamental research are conducted in universities given that the focus of most university researchers is on developing basic research and raw technologies with little consideration of the needs of the customers [32]. On the other hand, companies appeared to focus on hiring engineers given that most of their innovations activities are towards product and process improvement instead of generating new products. They were therefore largely relying on their own resources and capabilities without the need to use research from universities. This had restricted interactions between both sides.

Lack of Integration between Government Agencies/Ministries: The findings of this study suggest the existence of a gap in the understanding of the officers in the government agencies/ministries. While trying to help the universities and companies to become more innovative and profitable, their lack of experience, expertise and understanding on how to go about undertaking their roles effectively were seen to cause much problem instead of assistance. At the same time, given that many of them wanted to be seen to be doing something and partly to achieve their KPIs, they tended to be too active and too keen to impose solutions from above leading to the creations of so many agencies with often overlapping roles. Accordingly, instead of simply ensuring that the relevant knowledge and expertise were available to companies and universities, along with competent sources of finance; they may create structures, institutions and procedures for stimulating, channelling, managing and controlling innovation leading to complications in accessing the knowledge. This may also exacerbate the already poor bureaucratic system of the government agencies causing more delays in processes. Furthermore, the existence of too many institutions to cater for the needs of the universities and industry may dilute resources and may raise the problem of coordination and focus given that every institution would have its own set of priorities.

Lack of Expertise Amongst Government Agencies/Ministries: The findings offer little evidence to show that effective mechanisms had been used by the
government agencies/ministries to screen for more “appropriate research projects” that may lead to the generations of “more appropriate technologies” partly because evaluation was typically done by those lacking the necessary knowledge and expertise. It was claimed that due to their lack of expertise, the officers appointed for specific tasks were tended to approve research projects “that they understand” thus underscored the importance of other, often more sophisticated, research projects. In fact, some interviewees expressed concern about the development of UITC as a whole due to the inappropriate background and experience of those appointed to undertake the roles of developing UITC at the national level.

Absence of Policies/Guidelines/Frameworks: The interviews suggest that the failure of the respective ministries to provide guidelines with respect to commercialization management structure had obstructed the development of a clear and well-defined organizational structure for university technology transfer. There was also an issue raised by the interviewees about the country’s grant system which apparently did not have a strategic distribution formula or frameworks, perhaps because there were too many agencies and ministries involved in the management of the grants resulting in many inefficiencies. There was also concern about the absence of an effective framework not only at institutional but also at national level on how to go about undertaking UITC and its “best practice”.

The Development of Local Industries: The researchers were also seen to be concerned about the current slow development of local industries given that the focus of the Government was on attracting foreign companies to invest in the country. It was feared that depending too much on foreign investments may negatively affect the future growth of local companies. Furthermore, the action taken by the government to continuously invite foreign investments into the country and thus “we have never learned our lesson yet” was seen as unhelpful to the development of local technologies.

Government’s Pressure: The flow of scientific knowledge to at least some industrial sectors has clearly been a concern to the Malaysian government. Policies have been changed and the roles of different institutions have been created to support commercialization. The formation of spin-off and start-up companies and technology licensing are all more likely to produce useful technological change in the country because they are active processes that commit and involve top managers and professionals directly. Yet, as the R&D expenditure was apparently increasing, the government was increasingly concerned about research results that were untapped by companies. Accordingly, the Government had put more pressures for universities to enhance UITC. Yet, to universities, the Government had often been unrealistic in its expectation causing pressures to researchers to meet their KPIs.

CONCLUSION

This purpose of this study is to identify the factors that enable and/or impede the commercialization of technologies from universities to industries, The results of this study reveal that the performance of UITC at the universities taking part in this study is significantly affected by the existence of several gaps between the five groups of stakeholders of UITC in Malaysia; the scientists, the TTOs, the university managers, the industry and the government. Knowing these gaps may help policy makers and university managers to reflect their strategies and to alleviate the weak points in order to enhance performance of UITC in the country. Furthermore, this study also found several opportunities that, if properly utilized, may significantly improve the potential for university technologies to be successfully commercialized. The findings of this study, thus, offer substantial academic insights to academic entrepreneurship research and provide several important implications for technology transfer and commercialization of university-developed technologies.

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