

IMPEDIMENTS OF TECHNOLOGY COMMERCIALIZATION: LESSONS FROM UNIVERSITIES AND RESEARCH INSTITUTIONS IN MALAYSIA

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ABSTRACT

Developing economies of the world are facing major challenges nowadays, particularly in relation to their roles and responsibilities in the national innovation system. Responding to these challenges the Malaysian government has drawn its attention to the creation of new knowledge by emphasizing the key agents—namely the universities and research institutions* (research organizations) where increasing concern about commercializing their research outputs has been spotlighted. However, despite the critical roles of the research organizations, the government has given very little attention towards identifying and improvising the challenges and barriers faced by these institutions in terms of commercializing their research output. It has also been noted that today the government has taken for granted that research organizations have a role in supporting innovation and technology commercialization in their local and national economies. In response to the above this study tries to supplement the research gap especially in identifying the major impediments of the research organizations in commercialization. Based on the interviews and case studies, findings show that lack of industry alliance, finance, poor structure of the technology commercialization office, poor information process, lack of demand oriented research and poor IP management are the major impediments in the process of commercialization among the research organizations. The findings of this study is useful in providing a better knowledge of the current system, which needs improvement to optimize the technology commercialization process towards developing indigenous technology capability. It is further argued that the success of technology commercialization is increasingly determined by the extent to which the research organizations could reduce the current barriers. Failures to correct these fundamental problems mean little progress can be achieved in commercialization of research outcomes.

JEL Classification: D23, L31, O31, O32

Keywords: Technology Commercialization, University-Industry Partnership, Innovation Management, Intellectual Property, Organizational practices

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1. INTRODUCTION

The emergence of an innovation driven economy is not a new subject of interest among the developed countries particularly via innovation to sustain their competitiveness in the global economy. However, in recent years this scenario has shown its presence among the developing countries including Malaysia. The success of some of the Asian countries such as South Korea, Taiwan and Singapore has proved the fact that innovation is not only dominant in the US and other European countries but also in Asia. With the right

* From this point onwards universities and research institutions will be classified as research organisations

mechanisms and channels, innovation could be brought to the market place with huge success. For instance, the techno entrepreneur's development models such as in Taiwan and Singapore have proved its success in the international arena.

The quest for the same kind of success enjoyed by some of these successful Asian countries has created a chain of effects in the other developing countries. Today, developing countries at large are seriously finding alternatives and outlining strategies to spur the process of innovation and technology commercialization. In Malaysia this process have started with the support of the government by establishing policies, programs, and research and development (R&D) funds. As part of the plan to innovate, the government has spelt out a sum of RM1.6 billion for the 8th Malaysia Plan that is to be specially allocated for R & D and commercialization of technology compared to RM 1 billion during the seventh Malaysia Plan (Malaysia, 2001). In addition the first Science and Technology policy has been revamped to cater to the process of commercialization (Ministry of Science, Technology and the Environment, 2003). Indubitably the formation of a new business development unit within the Ministry of Science, Technology and Innovation shows the government's urgency and seriousness in accelerating the commercialization of technology.

In an effort to create innovation, the government has emphasized on the key agents namely the research organizations, where increasing concern about commercializing their research outputs has been spotlighted¹. However it is found that the contribution of these research organizations to the technical improvement and the progress of commercialization of research outcomes is very much limited. For instance, a survey of 5232 projects implemented by the public research institutions and universities during the Sixth and Seventh Malaysia Plans revealed that 14.1 per cent of these projects were identified as potential candidates for commercialization whereas only 5.1 per cent was commercialized (Malaysia, 2001). Despite the traditional roles of the research organization, the government has given very little attention towards identifying and overcoming the challenges and barriers faced by these research organizations. It has also been noted that today the government has taken for granted that research organizations have a role in supporting innovation and technology commercialization in their local and national economies without giving due concern to why they are still incapable of doing so even after so much funds have been directed to them. One of the factors contributing to the lackluster result was the barriers faced by the research organizations to successfully commercialize their research outcomes (Malaysian Science and Technology Convention, 2002). Thus, this study impelled from the urgent need to discover the actual impediments of research organizations to commercialize their innovation.

This study was further motivated for the following reasons. First, due to the lack of information on technology commercialization and studies on research universities pertaining to the developing nations since abundance of literature is focused on more advanced nations (Nelson, 1959; Jaffe, 1989; Henderson et al, 1998; Rosenberg et. al, 1994; Mansfield, 1995; Jensen & Thursby, 2000; Nerkar & Shane, 2002). Second, while there are many national and industry surveys of the current state of science and technology practices in Malaysia, more ideographic studies are sorely lacking. Most of the previous surveys (Hii, 2003; Ministry of Science, Technology and Environment, 2003; Malaysian Science and Technology Convention, 2003; Danabalan, 1996; Soong, 1996; Thiruchelvam, 1995) rely solely on the broad practice of innovation and technology commercialization. Third, to supplement the research gap in the area of technology commercialization in Malaysia by identifying the major impediments of the research organization in commercialization. Lastly, although we claim that Malaysia has shifted from resource based to high technology manufacturing industries, technology transfer from multinational companies, development of indigenous technology or even the evidence of innovation led-growth is inadequate (Chandran et al, 2004; Rasiah, 2002 & Tidd et al 1999).

¹ In the developed nations, the government relies on the universities and research institutions. These research organizations have contributed significantly to the national innovation system. For example, a study by Mansfield (1991), on the impact of scientific research based mostly on patents, and publications show that US academic research benefited the new product development by around 11%, and new processes by around 9%. A similar study by Beise and Stahl (1999) in Germany shows the same results.

2. BRIEF REVIEW OF NATIONAL TECHNOLOGY AND INNOVATION PROGRESS

Understanding and realizing the importance of technology development, innovation and commercialization, in 1986 the Malaysian government formulated the First National Science and Technology Policy with the purpose of outlining a framework for science and technology development in Malaysia. This particular framework emphasizes on ensuring achievement of continuous scientific and technological development in accelerating economic growth, industrial development and creating a high-tech (advanced) society.

The National Science and Technology Policy was then incorporated into the Fifth Malaysian Plan (1986-1990) and in 1991, the National Action Plan for Industrial Technology Development was launched. This plan outlined the strategies for strengthening science and technology capabilities to overcome the structural weakness that have been associated with the national industrial development. During the Sixth Malaysian Plan (1991-1995), the goals set for science and technology were to obtain a continuous scientific and technological development in Malaysia by providing basic infrastructure incentives and supporting services to science and technology. Emphasis was made to ensure that public R&D programs become more market oriented by exploiting the commercialization of research and technology. The private sector, on the other hand, is expected to complement the Government in expanding the R&D and science and technology by using appropriate technology assimilation, diffusion and application. During the period of the Seventh Malaysia Plan (1995-2000), the focus was on economic growth and competitiveness by increasing productivity. It was recognized that Malaysia needed to develop its technology infrastructure further and expand its capacities for technology adoption and assimilation.

Malaysia has taken measures to increase the rate of commercialization of R&D outcomes. In this regard, business units at the research organizations have been reorganized and strengthened to facilitate the identification and implementation of market-oriented R&D projects through interaction among researchers and private sectors. To generate more R&D projects that can be commercialized, research organizations have been encouraged to place emphasis on research related to product and process development for the industries. To facilitate commercialization of R&D findings and technology, a sum of RM 610 million is allocated under the 8th Malaysia Plan. In addition, fiscal incentives are also provided to encourage venture capitals to invest in start-ups involving indigenous technology. As a consequence the Malaysian government over the last fifteen years has been placing appropriate mechanisms (funds and institutions) such as Intensive research in priority areas (IRPA), Industry Research and Development grant scheme (IGS), technology acquisition fund (TAF), S & T HRD fund, Malaysian Technology Development Corporation (MTDC), Malaysian Industry-Government group for High Technology (MIGHT) and technology incubators in research organizations.

3. DATA AND RESEARCH DESIGN

This study involved a survey research approach to perform a qualitative comparative analysis examining the impediments of technology commercialization among research organizations. The preferred qualitative methods used in this study are interview and case studies. These methods provide two distinct advantages. Firstly, the methods are more adaptable in dealing with the complex multiple realities of technology commercialization. Secondly, since there is no precisely clear idea or existing study on the barriers of technology commercialization we rely on the qualitative method to identify those barriers. This further provides a useful reality check on the actual situation on the barriers faced by the research organizations. Although our study is qualitative in nature, this caveat does not make this study less urgent. In fact it provides an exploratory discovery of the current state of barriers, which is vital to give some insight for future policy direction. In addition, the dynamics can only be understood and appreciated if a closer look is taken especially if case studies are incorporated due to the complexity of each case. Overall it is understood that the cases collected through interviews are more likely to paint a better picture of the actual state of technology commercialization. This is critical to formulate strategies and plans for the research organizations as well as for the nation.

The cases for this study were drawn from actual barriers faced by the research organizations. Face to face interviews with the technology managers and the head of consulting unit represent the information. This research uses the ethnographic interviewing techniques where it differs from the other type of interviewing

in that the interviewer slowly introduces new elements to assist the interviewee (James Spradley, 1979)². This method avoids having formal interrogation and help getting people talk about what they know.

The information for this study was collected in mid 2004 from various research organizations personnel mostly those involved in the process of technology commercialization. Technology commercialization decision makers from 5 universities, 4 research institutions, and 4 government agencies were interviewed to extract the information (Appendix A). The time span for the completion of the survey was around 6 months. Since some of the interviewees expressed their concern over confidentiality, some of the issues, which may reveal the respondents, were not reported in this study. The criteria used to outline the major barriers are based on the trend and frequency of occurrence of such barriers in all the research organizations. To avoid any biasness, the results were analyzed with extra caution since each case differs from another especially when dealing with different technology. Wherever possible, case studies were used to provide a clearer picture of the actual difficulties faced by the research organizations, thus making this study a unique one.

4. FINDINGS

A question that arises here is whether the research organizations are well prepared for commercialization. It is notable that currently research organizations are not well positioned to commercialize their technologies. This problem directs us to ask why are they still lagging behind compared to many other developing nations? The answer lies in identifying the hindering factors which significantly influence research organizations effort in commercialization. The major impediments of the research organizations are further elaborated in the next section of this paper.

4.1 Industry Alliances

Previous research on innovation, widely recognized that linkages play a prominent role in the success of commercialization and knowledge transfer between research organizations and industries (Acs et al., 1994; Hagedoorn, ; Sveiby & Simons, 2002; Cohen et al, 2002; Meyer-Krahmer & Schmoch, 1998; Arundel & Geuna, 2004). In addition it is found that national innovation systems are significantly influenced by the collaborative research programs especially by creating and strengthening networks which are essential for breeding innovation clusters (Liyana S., 1995).

Others, Poyago-Theotoky, 2002; Brooks, 1994; Siegel et al., 2002 suggested that collaboration benefits universities in terms of revenue, licensing, equity, sponsored research, donations, technology development. Undeniably, high value of private gifts, grants and contracts is found to be the important mechanism in technology transfer (Rogers, et. al., 2000) On the other hand, by examining the source of the total productivity growth in licensing activities, Thursby, 2000b, indicated that increased business reliance on external R&D increases the licensing among universities.

Although a number of studies suggested the importance of industry alliance, evidence from the interviews proved that the extent of industry alliance in Malaysia is very much limited to consultation work. In addition, relatively most of the consultation work is actually done for the government agencies rather than for the industries. Almost all the research organizations agreed to not having significant linkages with the industries thus, amounting to the lack of industrial demand for the ideas and innovation of the research organizations. This is often found to be true, for both the public universities and research institutions. It is also found that, there is also very limited evidence on collaborative work which leads to pre seed funding by industries, joint ventures, and other forms of industrial alliances. This can be seen as a major barrier for the commercialization of technology by research organizations. It is also true that our national innovation system does not provide any avenue for such collaborative activities.

² See also Norman K. Denzin, (1996), *Interpretive Ethnography: Ethnographic Practices for the 21st Century*, Newbury Park, Sage Publications, Inc.

Further detailed interviews with the respondents revealed that there are few contributing factors for the low level of collaborative activities. Among them are conflict of interest between research organizations and the industries³. This is mainly due to the contradictory mission between the research organization, which operates as the provider of public goods, and the industry, which intend to use the research finding for oneself. On the other hand, conflicts also arise within the research organization as claimed by previous studies (Rogers et al, (2002) & Duke, 1995). For instance, Roger et al reported that conflict of interest created by faculty members, delays in publication may serve as potential problems for patenting and licensing activities, which normally requires a long waiting time.

Limited incentives to the collaborative work serves as another potential barrier for the lack of industry alliance among the research organizations. It is identified and recognized that the reward structure of the universities are still tailored towards teaching and consulting work which limits the efforts of collaboration activities.

Indeed, one of the business consulting unit managers remarked:

“...even if we identify potential consultation work for the industries, it is very difficult to find a suitable expert required by the industry. This is mainly due to the fact that university staff are burdened with teaching roles. Since promotion and other rewards are based on teaching, pure research work and publication most of the staff are not motivated to seek industry partners. However, in an event when a suitable expert is identified by our unit for consulting work, many of them were unable to cope with the strict due dates, long working hours, and high expectation of the industries. Many are reluctant to come out of the “comfort zone” to really work within the private sector environment”. (Interview, 2004)*

Another manager agreed;

“Researchers usually work in a confined situation (usually in the labs) without much interaction with the industries. This limits the capability and the applicability of their innovation. In fact, industries perception is that universities and research institutions will not be able to deliver the needs of the industries”. (Interview, 2004)

Limitations on creating industrial alliance prove to be a drawback for the research organizations in many aspects. Case 1 and 2 are used to further elaborate on the drawbacks of the lack of industrial alliance.

Case 1:

A group of researchers has successfully developed a robotic system that was able to carry a piece of objects to a designated location. This system has won several awards at the international and national level. In order to commercialize, a meeting was set up between the inventors and a panel representing the industries. However, when the idea was presented to the panel of industrial members, they were more keen on how this system could be useful and beneficial to the industries. This reflects the applicability of the system in the manufacturing floor. The inventors who did not have either industrial experience or alliance failed to make the system appropriate to the manufacturing floor. Thus, this lead to the failure of the technology to be commercialized by the inventors.

³ Friedman J et al, 2003, indicated that clear university mission as an important factor for university technology transfer.

* Interview with the Head of Consultation Unit, Public University

Case 2:

Due to the consumers' complaint on the irregularity of the Tenaga Nasional (electricity provider in Malaysia) staff in reading and charging the electricity usage, a group of researchers developed and invented a microchip. This chip can be embedded in the electricity meter where Tenaga Nasional could monitor the reading of the meters remotely and minimize the usage of workers going on their rounds from house to house. It was found that when this invention was proposed to the industries, they were reluctant to adopt the technology by saying that the costing is too high. They were more afraid of who was going to bear the cost of the chip and declined on grounds that the existing customers will not be prepared to bear the cost. This resulted in the failure of the invention to be successfully commercialized.

The failure of case 1 was solely due to lack of applicability of the technology for the industry whereas the second case was due to the costing of the technology. Both of these failures could have been avoided if industrial input and alliances were sought at the initial stage of the project.

Much of the lack of industrial alliance discussed above seems to amplify the weakness of the research organizations. However, it should be noted that industries also contributed to the limited evidence of collaborative effort. As mentioned, industries are very much reluctant to establish any kind of collaboration even though the universities attempt to link in many ways. One of the managers disclosed that:

".... although most of the time universities take the blame for not establishing linkages, it should be equally important to find out why industries are not attracted to link with public universities. Through my experience I find that industries do not understand "science" as how scientists and researchers perceive it. Most of the CEOs and managers of the firms have a business related qualification and background thus limiting the ability to understand the nature of science, which requires long term commitment. Those CEO's emphasizes on quick return and profit. As a result they rarely want to invest in either basic or applied research. Time has been the biggest obstacle in any science base research which leads to the concept of valley of death"⁴(Interview, 2004)

Looking from the industrial point of view, it is found that, industries have a different perception on the capabilities of the research organizations. For instance many perceive research organizations as slow because of the bureaucratic nature of the organizations. This does not suit the business environment that needs a fast decision in order to be competitive in the market. This is also reflected in the findings of the National Innovation survey (Ministry of Science, Technology and Environment, 2003). For example, although in the national innovation survey, industries indicated lack of skilled professionals as one of the major factors hindering the innovation in industries, it is found that they rarely seek skilled professionals from research organizations.

In addition, industries expectation on strong confidentiality & property rights, low awareness on the capacity of the public research organization and not considering public research organization's R&D expertise as the external suppliers of their R&D needs have become the major limitation of industrial alliances (Soong, 1996). Further, industries are expecting the public research organizations to upgrade existing technical testing facilities and equip up to date machinery. Indeed research organizations are also expected to actively involve in R&D activities in technologies of relevance to the industry.

The interviews with managers indicated that the large companies are placing to many conditions on collaborative work and in some cases larger firms are unwilling to collaborate because they have their own R&D division controlled by their headquarters. On the other hand, when public research organizations turn to the small and medium industries, it is found that they are reluctant due to the fact that their operations are more customer specific and do not actively seek research alliance. In addition, small and medium industries are established to supplement the MNC rather than to be innovative. They prefer on the shelf solutions

⁴ Jolly has indicated that in many sciences based technologies bringing idea to the market place in average requires 10 years.

compared to long-term relationships (Interview, 2004)*. Many of the innovative firms also consider vertical integration as more important compared to research organizations as a source for their innovative activities. In addition many of the larger multinational companies are not placing their R&D functions and other core functions in Malaysia resulting in only establishing an assembly line (Tidd et al. 1999). This indeed limits these companies to collaborate with research organizations.

4.2 Technology Transfer/Commercialization Office

With the concern of the importance of commercialization and partnership with industries, many research organizations have started to establish a technology transfer/commercialization (TCO) unit within the research organization. In fact the government's concern for low return on the R&D investment have contributed to the creation of the commercialization unit. These TCOs are given the mandate to identify and market the potential technologies and even to carry out other forms of activities such as legal advice and other supportive services. By the formation of TCO it is expected that more viable research findings would be commercialized which in return would generate a source of revenue and technology spillovers to the research organizations. As such in recent years, many academic researchers (Mowery, Nelson, Sampat & Ziedonis, 1999; Siegel et al., 1999; Rogers et al., 2000; Thursby et al., 2001; Carlson & Fridh, 2002; Saragossi et al, 2003; Coupé, 2003) turned their attention to investigate the impact of TCO on the technology commercialization and found the formation and structure of the TCOs is an important element in contributing towards commercialization of university findings.

Borrowing from this stream of literature we have investigated the role and structure of TCOs in research organizations in Malaysia by interviewing the technology commercialization managers. The central conclusion emerging from our field study is that many of the commercialization units in the public research organizations are ill structured. This is mainly due to the lack of motivation to commercialize research outcomes since the government backed most of these research organizations. There is no requirement by the government for the research organization to generate revenue out of their research outcomes. The same scenario was also reported in Siegel et al, 1999, that public universities focus less on university/industry technology transfer as a source of revenue than private universities. On the other hand Thursby, 2000b found that increase in willingness of faculty members and administrators to licenses increased the licensing activities among universities.

One of the managers of the technology transfer office quoted how his office got seriously involved in the commercialization process. He stated that:

"..... when the government initially announced the plan to corporatize the universities in 1996, our university actively started to source for external funding to protract the operation of the university. One of the main agendas put forward was to seek industrial participation and funding and to generate revenues through commercialization of research outcomes. This push factor created the awareness among the top management to place more effort on commercialization activities. However, when the government shelved the idea of corporatisation many of the universities fell into the comfort zone and are operating as the provider of public goods"

The above comment illustrated how the university was motivated to engage in commercialization activities. Indeed from the interview it is found that this university is doing fairly well in commercializing their research outcomes. Pressure applied to the university in return turns into a motivating factor to commercialize.

Previous studies by Siegel et al, (1999) and Kettler & Casper, (2001) supported the claim that staffing is one of the critical organizational factors serving as a barrier between research organizations and firms. Furthermore it is also evident that the TCOs would always fail to hire well-qualified staff due to lack of resources. Rogers et al., (2000) study confirms larger number of staff and higher average faculties salaries

* Interview with the marketing manager of a government body in charge of marketing new innovative technologies & products.

as a factor explaining the effectiveness of technology transfer by the technology transfer offices. The lack of staff in the TCO significantly affects the proper management of research organization's inventions. While many R&D system in the West evolved to the fourth generation⁵ it is found that most of the research organizations in Malaysia are almost at the first generation stage which accounts for the science based R&D labs without paying attention to the R&D management⁶. It is acknowledged that successful commercialization requires more than a good idea or new technology, it requires effective management, strategy, timing, marketing and coordination among organizations. These seem to be the significant challenges for research organizations in particular the TCOs, which have limited number of staff. Indeed the absence of adequate technology management practices at the visited research organizations particularly by TCOs was another major obstacle to commercialization.

As suggested by Friedman J. et al 2003; Carlsson et al, 2002 and Siegel et al., 2002, evidence from the interviews suggested that the lack of experience in commercialization holds true in many of the research organizations leading to lack of commercialization⁷. Many of the commercialization problems were unable to be solved due to the fact that the TCO office is lead by only one senior staff, usually an academician, with the help of inexperienced and young staff. Lack of staff and experience in the area such as marketing new innovations, negotiations and commercialization leads to many failures. These failures in return discourage the research organizations to undertake any commercialization activities in the future due to the low level of tolerance to failure and uncertainty. As a result, research organizations are found to avoid such activities and divert their effort to what they are good at usually, teaching and conducting basic research.

The following case shows how the lack of experience contributed to the failure of a joint venture. A manager of a consulting unit of a public university quoted that:

Case 3

..... we have tried to commercialize the invention however it was a failure due to improper and lack of experience in commercialization activities. For instance, we developed a technology, which was able to extract high quality product from a (we name it as XXY) with various grades. After the development of the technology we tried to go into a joint venture with a private company and the proposed share agreed upon was 60% private company, 30% our university and 10% for the body which sponsored the research. However, after the agreement we found that the organization was not motivated to commercialise the product and eventually tried to close the operation. It was found at a later stage that after adapting the know-how (the process of extraction), the organisation was eager to close operation to avoid sharing the profit. The reason put forward by the organization was that the operation is too costly.

It is usually an art to get the right partner failing which will turn the venture into a disaster. This art cannot be acquired by attending technology management seminars rather these skills are accumulated through years of experiences.

Although, many weaknesses of the technology transfer offices were highlighted, an over expectation of the TCOs should be avoided. This is due to the fact that many TCOs are still in the infant stage where many of them are newly established after the government's encouragement towards commercialization of research findings. Therefore it is reasonable to say that they are heading towards the right direction but taking into consideration the issues discussed earlier will definitely improve their performance.

Apart from the weakness of the TCOs it should be recognized that researchers and champions do play an important role in technology commercialization. Studies show that success in commercialization requires

⁵ Main features of fourth generation R&D is to find the market needs, consider technical feasibility and marketability at the very early stage (Miller, 1999).

⁶ See Badawy 1998 and Chanaron et al. for a complete discussion on technology management.

⁷ Many of the TCOs are still new and at the infancy. Previous studies supported the notion that older TTO tend to be better.

the involvement of researchers and requirement of a champion for the invention to be successfully commercialized (Schon, 1963; Howell et al, 1990; Markham, 2000; Markham, 2002;). Thus, the inventors task should be more than just inventing. This in return demands special skills and activities such as identifying potential of the idea to commercialize, laying a compelling business plan, assessing the risk, seeking approval for formal developments and many more. The field study suggested that researchers and scientists are merely interested in those activities since it requires more effort and time. The low awareness level among the researchers and scientists is found to be the main contributor to the lack of interest. For instance, many think that patenting activity is difficult and costly to perform. Indeed, it is discovered that the main purpose of them doing research is to disseminate research results in journals thus limiting their effort to market their research outcomes. This finding is in line with the previous work by Hii (2004) where 60% out of 383 agreed that marketing of their research findings to industry is not a requirement in their job. They usually think that TCOs should play the role of bringing those inventions to the market. On the other hand, the structure of the research organization limits the creation of champions. However, it is found that in one of the universities where a senior person attached with the university for more than 25 years was able to make fast decisions to the extent that permission of the higher authorities is sought after the decision has been made. This quick and risk taking nature of the champion has paved the way for his unit to commercialize a number of inventions in a short span of time.

4.3 Lack of Demand Oriented Research

It has been identified that out of 5232 projects implemented by research organizations only 5.1% were commercialized (Malaysia, 2001). However, from our field visits it was found that the sub sector palm oil accounted for the highest percentage of commercialization. The Malaysian Palm Oil Board (MPOB) has come up with more innovations compared to other industries. The question that arises here is what makes them so special to the extent that their commercialization rate accounted for around 12.1% and 30% in recent years (Malaysia, 2001 & Interview, 2004). There are a few underlying factors, which have contributed to the acceleration of technology commercialization. Firstly, Malaysia has the existing local palm oil industries platform, which is able to support the product innovation. This is further supported by a sound policy and a clear direction by the Malaysian government. On the other hand, finance has never been a problem for the MPOB since there is a continuous flow of funds from industries and from selling of palm oil slash. Indeed the industries willingness to adopt the new technology and processes developed by the scientists leads to successful commercialization. The big players especially industries like Guthrie, Golden Hope and others further support this by being the initiators of the new technology and product development.

Officer from MPOB,

“ The big players are one of the factors contributing to successful commercialization. We badly need industrial support since they are the end users of these technologies. If we concentrate on the areas where there is no strong industries platform and backing in the country then the whole game of commercialization will be a failure no matter how hard we try. In the case of MPOB we have been very lucky because industries have nowhere to go since this is a niche area of the country. Collaborative activities in particular have been the major contributing factor for our success right now. Indeed researchers and scientists who tailor their research towards industrial requirements have higher potential to commercialize their technologies. This is what we at MPOB are concentrating on”

The lesson learned here is that research organizations should focus their research work towards the industries, which has a comparative advantage in Malaysia. Previous research suggested that firms collaborate with research organizations to keep pace with competition. Thus, these industries are likely to find new innovative products because of the effect of globalization. In addition technologies that were developed to substitute imports would have a higher probability to be successfully commercialized. This is again due to the availability of well-established market in the country. However from the field visits, it was found that there was always an absence of demand-pull approach in research work and project selection where much of the research is more technology push orientated. It is basically vital for the research organization to identify their niche areas so that more concentration could be given to the fields that they are good at. Most of the successful commercialization was due to a more focused research with less

diversification (Jaffe, 2001) undertaken by the universities. This again depends on many factors such as availability of expertise, facilities and equipments, technical supports and others.

4.4 Finance

Studies show that finance is indeed an important component contributing to the success of commercialization. The degree of financing merely depends on the phase of research. A study by Norris & Vaizey, (1973), indicated that the research phase account for 5-10%; development for between 10-20% and commercialization between 70-85% of the total cost. This result seems to suggest that commercialization becomes the most expensive phase for a research project.. Indeed Rogers et al , 2002, found that universities that have more research resources were first to adopt the idea of having an office of technology licensing, thus making the technology commercialization process much smoother.

As such finance is the most needed ingredient to support the commercialization process. It is also found from the formal interviews with researchers, that frustration arises due to the lack of financial support given to commercialize their research findings. Researchers turning to Malaysia Venture Capital Management (MAVCAP) and other venture capitalists yield no significant help since most venture capitalists (VC) are low risk takers, and not prepared to wait for a long time. It is found that the level of capital required at the R&D stage is relatively small when compared to the capital investment at the testing and construction phases. As for the research organizations, the funds granted by the government are mostly for the early stage of research. One of the research officers indicated that

"funds were entirely used up at the initial stage of research, we face difficulties to acquire more funds during the prototype development and also for intellectual property protection. These difficulties hinder us from bringing the innovation to the market place. It is also important to note that only well protected innovation could be essentially adopted by the industries"

Another technology transfer officer commented that;

.... venture capitalists consist of private sectors mainly the banks and other institutions who are more interested in short term gains; they are mostly opportunists and merely commit towards the research project thus making the process of commercialization a difficult one. It is seldom that we come to an agreeable solution since most of the time they will lay too many conditions to protect their investment.

Another setback of the research organizations is their attitude in relying on government-sponsored research. They seldom get funding from the industries thus making the process of commercialization impossible. It should be recognized that more R&D funding from industries and federal sources should be the contributing factor towards technology transfer (Roger et al, 2000). However, success in industry-sponsored research requires flexibility in intellectual property policy & understanding of industry needs. The research should be fast, relevant and focused. Indeed scientists should listen to the industry and not assume for himself or herself what is best for the industry. (Clare A. G.,1998)

4.5 Information Process

A study by Drejer & Jorgensen, 2005, found that lower collaboration between public and private research organizations is due to lack of proper mechanism such as simple information channels to ensure that firms know the benefits of collaboration, guidelines for organizing collaborative projects, public co-funding and conflict resolution. In fact, lessons from the long-established companies such as IBM, GE Merck suggested that improvement in technology commercialization depends on improved information process (improve communication and sharing of information) and improved technology acquisition process such as understanding of how to gain new technology from the best source to reduce risk, costs and time (MacLachlan A., 1998).

On the other hand, studies also suggested that reduction in traveling, time and communication & information expenses are one of the important factors for effective relationship between partners. (Katz, 1994; Landry et al, 1996; Fritsch & Schwirten, 1999) Indeed, Logar, (2001), pointed out that many

institutions of higher education do not view their role as promoting the commercialization process, and do not have in place a structure to support the commercialization process. Thus, institutions have either ignored or overlooked the potential of commercializing faculty research Lane & Lubatkin, 1998, found marketing activities by research organization as an important component to strengthen collaboration especially in providing and letting the industries know the research organization's capability.

Our field study indicates the same phenomena among research organizations where there is a gap in terms of information dissemination to the industries. This turns out to be the biggest hurdle for the research organizations in commercializing their findings.

A business development unit manager of a private company indicated:

“..... it is most often difficult to locate an expert in the universities and research institutions for collaborative work. If we surf the website of a particulate university the academic staff details and information are usually not found. There is no one-stop center for the industries to search for information about research work among the university staff. This prevents us from searching for a research partner from the universities; although one can visit the respective universities or departments,”

From the visits it was found that research organizations lack marketing skills and are poor in disseminating information to the industries. They rarely promote their expert skills to the industry. A better expert database or system needs to be established to foster relationship with the industries leading to commercialization success. Interviews with the business unit managers who are in charge of bringing the innovation to the market place revealed that the most often used channels of promoting their innovation is by displaying those technologies in road shows, exhibitions and seminars. In consequence, these inactive ways of marketing bring limited success. A more proactive measure should be adopted by the research organizations to market their technologies. Perhaps developing a specialized marketing arm for all the research organizations would serve the purpose.

Indeed, we also uncovered the absence of active information networks among experts in local universities, research institutions, science parks, and incubators. Most of the research works are confined to members of the own university limiting the exchange of knowledge for feasible research outcomes. In addition, the applicants of the national research fund program, Research in Priority Areas Fund (IRPA) are mostly from the same organization. Thus, it is proposed that encouragement for mixture of research members from various organizations would be highly needed to commercialize potential technologies for market needs. Indeed, using case studies Numprasertchai & Igel, 2004, showed how collaboration and knowledge management practices benefited the Thai universities.

4.6 Intellectual Property Management

Intellectual property (IP) is often the edge that sets successful industries and universities at zenith and as world markets become increasingly competitive, protecting the intellectual property becomes essential. However in Malaysia the awareness among researchers is still low in understanding IP. Field study indicated that on many occasions it was found that researchers barely do a patent search before embarking into a research work. Patent search has become the last stage in the commercialization process. On the contrary according to Kwa (2004), in order for the technology to be commercialized by universities, initial patent search by the researchers is essential. This is due to the fact that patent search will stop the researcher from reinventing the wheel; creating the same technology that is available in the market. Thus, much time, effort and money will be wasted if this happens. In addition, patent search has been one of the requirements in the National University of Singapore before granting any research grants to the researchers.

The awareness and understanding of patent search is very important, as it will ensure the product developed from the university research lab can be granted an IP protection. This further boosts the confidence of the industries in bringing the product to the market place. Michael (2005) argued that it could be really difficult

if one is trying to get investors unless one can ensure that an invention is patentable. On the other hand, patentability search is also very crucial as to facilitate licensing or sale of your invention

Apart from the lack of awareness on IP, it is also found that the issue of where the IP should be parked is crucial for the commercialization process. Many agreed that the IP should belong to the university and it should be managed by a private entity within the university.

For instance, the Head of the technology commercialization office in one of the public universities agreed that:

".....IP should belong to the universities since it will serve as an incentive for the universities to move forward and commercialize their research findings. One of the weaknesses in the existing university-industry grants funded by the government is that the government are also interested in sharing the IP with the universities. Thus, in many instances we do not pursue this and get less involved in the joint grants since it is not attractive enough for us (the university and researchers) to indulge in such activities."

This claim is also supported by (Goldfarb B. and Henrekson M., 2002) where it is found that commercialization is more effective, when IP is awarded to universities especially in the American university system.

On the other hand, the head of the consulting unit who is involved in evaluating potential research output argued:

"..... to ensure proper commercialization of research output the IP should be parked with the private entity established by the universities. If the IP belongs to the university then there is a conflict of interest since universities motive is to offer public goods."

In conclusion, research organizations are found to be lacking in the management of IP thus preventing technology commercialization to be successful. It is essential that a well-trained team be formed to manage the IP issues, for the research organizations to move forward in their quest for commercialization.

5. DISCUSSION AND RECOMMENDATIONS

It should be stressed that research organizations in Malaysia would find themselves to difficult to pursue technology commercialization without the cooperation of industries. As such, research organizations should recognize and mitigate the potential barriers (internal and external) hindering the process of technology commercialization. In relation to the most frequently mentioned barriers noted in terms of commercialization, this study recommends some solutions to overcome the potential impediments.

It is proposed that a focus be established by the research organizations to accelerate industry alliances. This should start from identifying the core strength of the university in terms of human resources, facilities such as equipments, and labs until the development of strategies for specific industry in which the research organization has the strength. More emphasis should be given to these leading disciplines as it has more potential for commercialization. Although this might narrow the focus to several disciplines it has the potential to provide better returns for the research organizations. Research organizations should also think of restructuring the internship programs where more room for industrial attachment by the faculty members should be encouraged.

It is also found that research organizations work in isolation without a proper network mechanism among themselves. In accelerating the industrial alliance it is recommended that these research organizations be more aggressive in finding suitable partners by collaborating among them. Perhaps creation of a center or association similar to the Association of University Technology Manager in the US or the Korea Technology Transfer Center (Yon , 2004) would provide more avenues for research organizations to share information and to find suitable partners. This center can also play the role of information disseminator to the inexperienced staff of the research organizations. On the other hand many research organizations involved in commercialization do not use intermediaries e.g. technology brokers to facilitate technology

commercialization. The heavy reliance on the technology commercialization units within the research organizations was due to the lack of such brokers in Malaysia. It is recognized that indeed technology brokers serve as very important agent in the technology commercialization process in the developed countries. This private sector entity would function more commercially and efficiently compared to the research organizations. Thus there is an urgent need to encourage these entities to take off in Malaysia since many of the research organizations are lacking the experience in commercialization.

More importantly a better information-clearing house needs to be established. This unit would function not only as an information dissemination center but also as a catalyst to encourage better interaction between the researchers and the businessmen. Nevertheless, incorporating a better technology management infrastructure such as research assessment exercise, requirements for linkages for project selection and funding⁸, and others could improve the current rate of commercialization.

6. CONCLUSIONS

The present study considers the major impediments of research organizations in commercializing their innovations. On the basis of interviews with a number of research organizations, a series of impediments were identified. The conclusion drawn from this study is that limited industry alliance, poor structure of TCO, lack of finance, information process, demand oriented research and poor IP management serve as major impediments of research organizations. Although this study notably identifies the major impediments, it is important to remark on some of the limitations for further consideration. The first is to look at the overall picture of technology commercialization from various perspectives. It is therefore suggested that an empirical study with a larger number of respondents from industry, venture capitalists, funding agencies, universities and research institutions be included to capture the whole scenario of technology commercialization. This indeed is likely to imprison the existing gaps between the involved parties. While our study is preliminary, considering that only a limited number of research organizations were interviewed, the conclusions we reach are nevertheless promising. It is indeed our future aim to explore in detail the same issue empirically once solid foundations on the impediments are constructed. On the other hand, the trend of these impediments seems to be existence in many other research organizations thus making this study an important piece of work.

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⁸ In UK, research assessment exercise contributed to the improvement of quality and quantity of research (Smith E.B., 2004) whereas in Japan linkages has be made as one of the requirements in expediting research funds (Takayuki, 2002)

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Appendix A: List of Organization Interviewed

Organization

Universities

University of Malaya*
 University Putra Malaysia*
 National University of Malaysia*
 University Technology Malaysia
 University Technology of MARA

Research Institutions

Malaysian Agricultural Research & Development Institute (MARDI)*
 Malaysian Palm Oil Board (MPOB)*
 Standards and Industrial Research Institute of Malaysia (SIRIM)

Government Agencies

Ministry of Science, Technology and Innovation, Malaysia
 Intellectual Property Corporation of Malaysia (PHIM)

* In a number of organizations at least two or three high ranking personnel were interviewed especially from the technology transfer/commercialization office, consultancy units and business development units. Some of the firms' points of views were obtained in an informal manner by interviewing the business development unit managers of private firms. (The names of the organizations are not disclosed in this paper)