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Market-Oriented R&D Commercialization at Public Universities and Government Research Institutes in Malaysia: Issues and Potential Research Areas

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Abstract: R&D commercialization has become an important topic not only to researchers but increasingly to policy makers interested in improving the National Innovation System (NIS) of a country so as to improve its global competitiveness. The main measure of the returns to R&D expenditure is the rate of successful commercialization of the research output. The objective of this study is to set the context in which efficient and effective R&D expenditures (measured by the rate of successful commercialization) in Institutions of Higher Learning (IHLs) and Government Research Institutes (GRIs) in Malaysia could potentially contribute to the enhancement of the country's NIS. The extensive literature review indicates a number of factors that affect the rate of R&D commercialization at IHLs and GRIs; market-orientation and industry relevance of the research outputs, the level of university-industry linkages and collaborations and availability of the appropriate resources and funding at the various stages of the commercialization process. A number of potential research areas were identified including, assessing the depth and richness of the linkages of the three components of Malaysia's NIS, identification of acknowledged cases of successful R&D commercialization at IHLs and GRIs and understanding the mechanism for the success, comparing success rates of R&D commercialization across major fields of research for IHLs and GRIs and identifying the underlying factors and benchmarking study of Malaysia's R&D commercialization versus those from more advanced economies. The proposed research areas in this study could provide needed information that would help with policy making for the government and related agencies to ensure Malaysia could advance from the current middle-income trap to the next level of knowledge-based economy.

Key words: Research and development, commercialization, innovation, market-orientation, Malaysia

INTRODUCTION

Malaysia's Gross Expenditure on Research and Development (GERD) for both the public and private sectors was RM10.6 billion in 2012, resulting in GERD/GDP ratio of 1.13; this ratio puts Malaysia ahead of countries such as Thailand (0.22) and Russia (1.09) but still far behind the Newly Industrialized Economies (NIEs) of Singapore (2.23 at number 12), Taiwan (3.02 at number 7) and South Korea (3.74 at number 3) (Fig. 1). The GERD/GDP ratio trend for Malaysia from 2002-2012 is shown in Table 1 generally there has been an upward trend in the GERD/GDP ratio since 2006.

Out of the 2012 R&D expenditure, the private sector (business enterprises) contribution amounted to RM6.89 billion (64.45%) followed by the Institutions of Higher Learning (IHLs) (There are twenty public universities in Malaysia, five of which are classified as Research Universities; these are, Universiti Malaya, Universiti Putra Malaysia, Universiti Kebangsaan Malaysia, Universiti Sains Malaysia and Universiti Teknologi Malaysia) with RM3.04 billion (28.67%) and the Government Agencies and Research Institutes (GRIs) (There are thirty three Government Agencies and Public Research Institutes in Malaysia; the major ones include Malaysian Agriculture Research Institute (MARDI), Palm Oil Research Institute of Malaysia (PORIM), Forest Research Institute of Malaysia (FRIM), Institute of Medical Research (IMR), Malaysian Rubber Board (MRB), Malaysian Industry Gov. Group For High Technology (MIGHT), Malaysian Technology Development Corporation (MTDC), Malaysian Institute for Microelectronic Systems (MIMOS) and Standards and Industrial Research Institute of Malaysia (SIRIM)) with RM0.73 billion (6.88%); thus, the public sector made up a fairly substantial 35.55% of the total R&D expenditure.

In recent years IHLs and GRIs are under pressure to commercialize research outputs so that public funds used for research are accountable. The aim is to commercialize

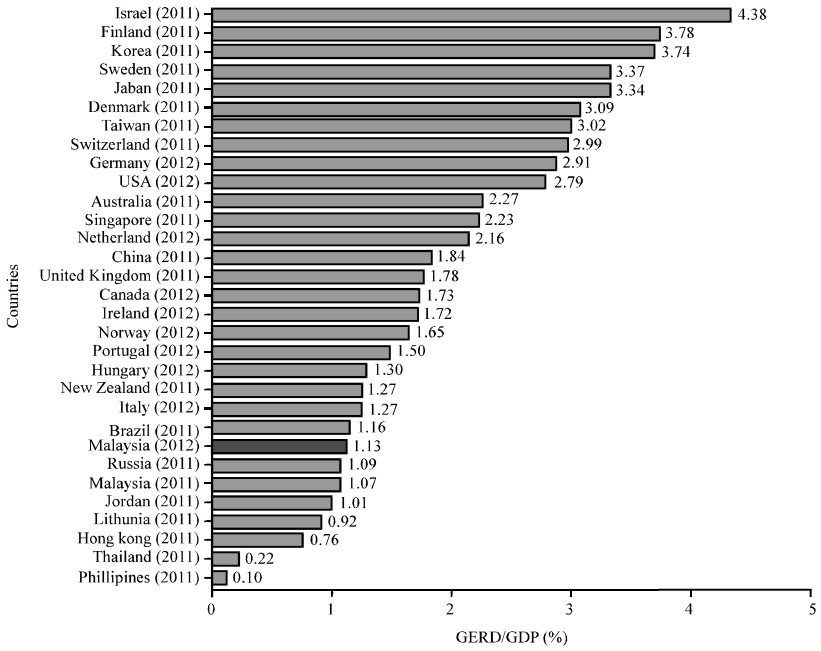

Fig. 1: International GERD/GDP of selected countries (2011/2012); IMD 2013. IMD World Competitiveness Yearbook 2013, 25th Edition)

Table 1: GERD/GDP ratio for Malaysia, 2002-2012

Year	2002	2004	2006	2008	2010	2012
GERD/GDP	0.69	0.63	0.64	0.79	1.07	1.13

MASTIC, National Survey of R&D in 2013

at least 10% of the research output. Apparently most of the research universities have yet to achieve this however, MARDI has reached 14.3% in recent years and this was assisted by the CRDF (one of the research grant schemes sponsored by MOSTI is Commercialization of R&D Fund (CRDF); it was introduced in 1997 to enable commercialization of research and is managed by the Malaysian Technology Development Corporation (MTDC). It provides grants to conduct market surveys and research, design processes and products and to conform to standardization requirements, including in the area of intellectual property rights) and TAF (Technology Acquisition Fund (TAF) was also introduced in 1997; it seeks to facilitate the acquisition of strategic and relevant technology by Malaysian companies so as to enhance their technological capacities and production processes. The TAF program has benefited many SMEs that have recognized the need to keep abreast of new technologies in order to compete globally) research funds provided by the Ministry of Science, Technology and Innovation (MOSTI) which helped to absorb the risk of investing in new technologies by private companies.

Table 2 provides the breakdown of 2012 R&D expenditure for IHLs by fields of research and Table 3, the breakdown for GRIs. The major fields of research for IHLs are engineering and technology and natural sciences

Table 2: IHL R&D expenditure according to the fields of research, 2012

FOR	Percentage
Engineering and technology	37.38
Natural sciences	17.29
Social science	9.58
Information, computer and communication technology	8.88
Economics, business and management	8.88
Biotechnology	5.84
Agriculture and forestery	4.91
Medical and health sciences	3.74
Humanities	3.50

Table 3: GRIs R&D expenditures according to the fields of research, 2012

FOR	Percentage
Natural sciences	20.15
Biotechnology	27.39
Agriculture and forestery	26.31
Medical and health sciences	9.30
Engineering and technology	6.56
Social science	2.24
Information, computer and cpmmunication technology	0.05

MASTIC, National Survey of R&D in 2013

while those for gris are natural sciences, biotechnology and agriculture and forestry. Given these circumstances, Malaysia thus, faces a double challenge in that its GERD's though they have been on the upward trend for the past 8 years, are still relatively low compared to the more advanced economies (e.g., the average of the OECD countries stood at 2.40 in 2012) and the NIEs in the East Asia region, i.e., South Korea, Taiwan and Singapore (the average GERD of 3 for 2012) and it was not able to realize the 10% minimum successful R&D commercialization rate for most of the IHLs and GRIs.

MOSTI in 2012 has identified the following challenges to be addressed so that the benefits and effectiveness of research funded by public R&D expenditure will achieve better returns: While there were significant technical contributions in Science and Technology (S&T) activities, the majority of R&D projects were not market-oriented and thus, not readily exploitable for commercial application and that the linkages with industry were essentially informal and joint or collaborative R&D was still negligible.

The assessments also pointed out that the limited commercialization progress of the public sector R&D was attributed mainly to the following two factors: Lack of industry-relevant R&D projects and limited availability of financial resources to fund the various stages of commercialization from the laboratory to the market place. These, naturally impede the government's efforts in developing Intellectual Capital Assets (ICA) of the country in order to be more competitive in the global economic arena which is increasingly becoming knowledge-based.

Literature review: In the 1970 and 80's, there was no real urgency to expect "returns" from R&D "investments" in public research institutions and universities in Malaysia in the form of commercialization. Policies at most of these institutions then were that the expected return from such research in the form of academic publications was quite acceptable; commercialization if any was a bonus. Deraman highlighted issues such as lack of mandate and interest for academicians/researchers to get involved beyond research into technology transfer, academic versus industrial research and weak linkages between university and private sector due to differences in their role and responsibility have hampered efforts at commercialization of R&D at one of the research universities.

However, with globalization and intense competition among nations in the global market place in the past two decades, it is fast becoming an imperative for a country to not only expect and actually realize "decent returns" from its investments in R&D but effective R&D now constitutes a critical factor contributing to a nation's competitiveness and thus, its economic well being. The barriers to successful R&D commercialization are especially challenging to developing countries like Malaysia (see for examples, Chandran where he highlighted barriers such as lack of funding and limited university-industry linkages among others, Kamisah Kormin and Ahmad Osman on the need for researcher's market-orientation knowledge and recognition of commercialization opportunity and Siti Aisah on the lack of commercialization behavior among academicians).

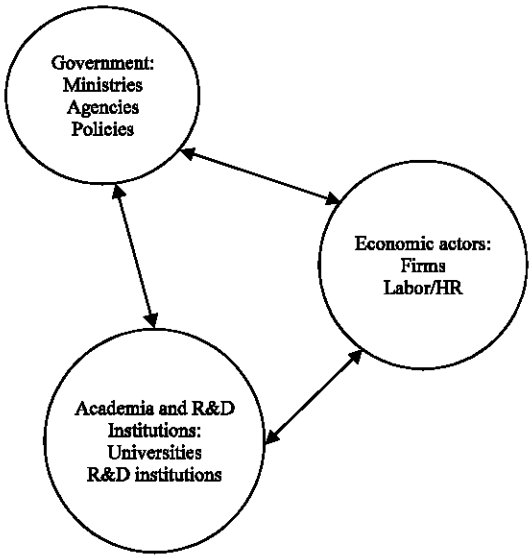

Fig. 2: The major actors in a national innovation system

A country's economic prosperity can generally be gauged from its GERD/GNP ratio and for most of the developed economies this ratio is in excess of 1.50% as indicated in Fig. 1. Both amount and effectiveness of R&D matter and for a country like Malaysia with a relatively low GERD/GNP ratio of 1.13%, an ineffective R&D could make its efforts to develop ICA much more difficult. And, a lack of industry-relevant or market-oriented R&D activities would result in low commercialization rates which translate into lower economic productivity for the country (i.e., basic economic maxim of non-optimal resource allocation). The linkage between R&D intensity and economic competitiveness at the country or macro level is reflected in the country's ability to form broad-based ICA which is facilitated by a national innovation system (Wong, 1999; Nelson and Rosenberg, 1993). Ritchie for example, argues that a superior national innovation system (National innovation systems consist of macro-level structure involving three major actors; the state (government and its institutions and policies), the economic actors (including business and labor) and the academia (including education and training (E&T and R&D). Frequent and dense cooperative linkages both formal and informal, among the actors would ensure a competitive national innovation system) has had significant contribution to Singapore's high level of Technical Intellectual Capital (TIC) and this in turn had enabled her to achieve newly industrialized economy status together with Taiwan and South Korea (the major components of a national innovation system are depicted in Fig. 2.

At the firm or micro level, studies by Franko (1989) and Geroski and Machin (1992) have demonstrated a link between R&D expenditures and subsequent sales revenues relative to those competitors who did not spend as much. Thus, the expected "ends" of R&D are "commercialization" and "innovation" and while there are diverse definitions and models for both a common theme between the two is "market acceptance". In a way, innovation can be seen as the outcome (product, process or technology) of a successful commercialization of R&D and the diffusion of that innovation implies acceptance by the market place.

And when it comes to successful innovation, the debates as to whether it is primarily a technology-push or market-pull phenomenon (supply- or demand-orientation, respectively) can be traced to the late 1950's (for proponents of technology-push (Jewkes *et al*., 1969; Carter and Williams, 1959; Mansfield, 1968) for market-pull arguments (Schmookler, 1966; Langrish *et al*., 1972) Project SAPPHO in 1972.

Later studies, notably by Mowery and Rosenberg (1979) and Cooper (1979) indicated that it is not a question of "either or" rather, both technology-push and market-pull are required conditions for successful innovation. These studies however, do not preclude the importance of customer input and involvement in successful innovation of industrial products as suggested by Hippel (1978) and Shaw (1986). In similar vein, Herbig and Day (1913) argue that the critical factor in the successful introduction of innovation is the match between the innovation and the market needs.

An interesting development in the mid-to-late 1970's was the notion that there are no "Grand Theories" of innovation which apply equally well in all cases. Downs and Mohr (1976) proposed the Contingency Model of innovation which holds that innovation is a process contingent on various situation-specific factors.

Nelson and Winter (1977) suggested an Interactive Model of the innovation process, consisting of a unique system having two major sub-systems; a firm and its "selection environment", a term they used to indicate the external system with which the firm is interacting; this could be markets of potential customers of the firm's innovative and existing products or it can also be non-market influence groups such as government agencies, pressure groups, etc. The interactive nature of the innovation process is supported by Isherwood (1984) in a study of the process of industrial innovation among companies in Canada, the US and the UK. In particular she noted that "The process of (industrial) innovation represents the confluence of technological capabilities and market needs within the framework of the innovating firms. Innovation is seen as a logically sequential though not necessarily continuous process, requiring a complex net of communications both intra and extra organizational, linking in-house functions within the firm and the firm to the scientific and technological community and the work of the market-place".

Putting these previous studies in the context of the national innovation system presents a clear perspective as to the "required ingredients" for successful innovation at both the macro (state) and micro (firm) levels: productive interactions among the actors of the national innovation system are keys to higher levels of successful commercialization of R&D and the subsequent innovations.

This scenario points to the importance of knowledge interactions and information flows among the actors within a national innovation system. These interactions and flows between two of the actors, namely the industry and the academia have attracted considerable research attention. The focus of most of the studies has been on the university-industry interactions and their impact on R&D commercialization and innovation (Rasiah and Chandran, 2009) for the case of Malaysia for developing countries in general (Guimon, 2013) for Japanese case (Feller *et al*., 2002; Schmoch, 1999; Mansfield, 1968). While many of these studies were based on detailed analysis of science-industry links in narrowly defined fields of R&D, Schartinger *et al*. (2002) have attempted to look at broader sectoral patterns and the corresponding determinants for different types of knowledge interactions between universities and industry in Austria. Audretsch *et al*. (2002) and Sakakibara (1997) on the other hand, studied the government-industry interactions in the form of public sponsorships on private sector R&D and their commercialization in the US and Japan, respectively.

Market-orientation and R&D commercialization: The concepts of market-orientation and R&D commercialization have been explored by a number of researchers in the past two decades (for more recent examples refer to Lewrick *et al*. (2011). The concept of market-orientation and its positive impact on business performance was empirically tested by Narver and Slater in 1990. In their study, the constructs of market-orientation were identified as customer orientation, competitor orientation and inter-functional coordination.

Another variant of the concept made popular by Hamel and Prahalad (1994) involved "market

experimentation" or "probe and learn" process. The concept of market-orientation and its variants were later incorporated into R&D commercialization studies as researchers recognized the need for "market acceptance" of the inventions or R&D outputs for them to qualify as commercially viable, i.e., the transition from invention (R&D) to innovation (market place).

Veldhuizen in their study of New Product Development (NPD) of high-tech products among dutch high-tech firms found that the use of market information in the commercialization stage is directly and positively associated with product advantage. In addition, acquiring customer information is associated directly with product advantage. Somehow, just collecting information on needs directly from customers is sufficient to produce a product that offers benefits not available from competing products thus, under-pinning the importance of market-orientation in successful.

In the study by Lewrick *et al.* (2011), they found that different constructs of market orientation have different impact on; two types of innovation: incremental versus radical innovation and two types of companies: start-ups versus mature companies. The key research results are that strong competitor orientation, a key ingredient of market orientation, has positive relationship to incremental innovation for start-up companies but it is contra productive for mature companies. In mature organizations a strong customer orientation is associated with radical innovation. The need for IHLs in Malaysia to be market-driven in their R&D commercialization process was highlighted by Asma where she argued for a need of paradigm shift from traditional view of research at most IHLs: a R&D discovery has no valueuntil it can benefit the public; publishing and winning gold medals for the products created are not enough it has to be commercialized; research performed must be client-based rather than researcher based and it must be priority driven rather than investigator driven. She also suggested that the researcher must be able to write a business plan for the product/finding to be commercialized NPD (Herbig and Day, 1913).

In another study by Aniza on selected research universities in Malaysia, strategic market orientation was found to be a critical success factor in R&D commercialization. Those universities that have developed strategic market orientation by producing industry-relevant technologies to meet the needs of specific target markets were more successful at commercializing those technologies.

Potential research opportunities: The purpose of the above literature review is to set the context in which the Malaysian national innovation system and its actors could be analyzed with regards to the issues in the commercialization of R&D at IHLs and GRIs. As can be surmised by now the success of the R&D commercialization at IHLs and GRIs depends, among others on the interactions between the three components of the national innovation system, i.e., Government-Academia and research institutions economic actors. Naturally studies on the interactions involving all the three actors or any two of them and their components at both the macro and micro levels need to be done to assess the competitiveness of the Malaysian national innovation system.

Thus, potential research areas could be conducted at the macro/policy level and the micro/specific unit level (i.e., IHL and/or GRI level). Specific research areas could include the following: identification of acknowledged cases of market-oriented R&D output at IHLs and GRIs that resulted in successful commercialization and to conduct in-depth multiple case studies to understand the underlying mechanism, key success factors and relevant variables.

Assessing the linkages (depth and richness) between acknowledged cases of successful R&D commercialization at IHLs and GRIs with other components of the national innovation system, e.g., firms and the market place involving successfully meeting latent or expressed needs of target customers.

Assessing the rates of successful R&D commercialization at IHLs and/or GRIs as a group or focusing on the research universities or individual research universities/GRIs and to solicit feedback from the responsible units within these organizations on the reasons for their success.

Identification of internal and external factors limiting R&D activities in IHLs and GRIs, thus constraining successful R&D commercialization. The focus here, however is on the reasons for the lack of market or industry-orientation in R&D activities, implying a lack of interactions and/or weak linkages between two specific components of the national innovation system, e.g., IHLs/GRIs representing the academia and firms, representing the economic actor.

Comparing success rates of R&D commercialization across major fields of research for IHLs and GRIs (Table 2 and 3) and identifying the underlying factors. Other areas could include identifying (and measuring the relative importance and presence/absence of where appropriate). The specific components/variables of the linkages that have been cited in the literature as contributing to productive interactions but are lacking in the Malaysian case, e.g., access to new ideas and

expertise, access to equipment and/or facilities, collaborative and contract research, opportunity for joint projects, joint publications, etc. The reasons for the lack of interactions and weak linkages along the identified variables from the perspectives of both the academia and industry. Other factors or variables influencing this lack of IHLs/GRIs-industry R&D interactions, e.g., government policies and incentives, organizational structures, availability of funding, etc.

RESULTS AND DISCUSSION

Another potential area involves private universities linked to Government-Linked Companies (GLCs) and assess how their R&D commercialization rates are compared to IHLs, e.g., UNITEN, Multi Media University and University Technology PETRONAS. Also, assessing whether GRIs which are linked directly to industry, i.e., strong industry linkages, e.g., MPOB have better records in terms of conducting market-oriented R&D and successful R&D commercialization versus Public Universities and GRIs without direct link to industries. Yet another possible area is in developing benchmarking criteria that could be used to assess the degree of market-orientation in R&D activities which could in turn, increase the rates of successful R&D commercialization at IHLs and GRIs.

The possible research approaches that can be used in these possible research areas cut across the spectrum; qualitative to quantitative and combination of the two from single and multiple case studies to surveys and other quantitative methods. Case studies could be useful when the research objectives include trying to understand the underlying mechanism, key success factors and relevant variables or in assessing the linkages between acknowledged cases of successful R&D commercialization with another component of the national innovation system, i.e., firms and the market place. Quantitative methods such as surveys might be possible using MASTIC's database of R&D projects consisting of >1,000 projects for GRIs >5,000 projects for IHLs and >3,000 projects for the private sector.

CONCLUSION

Given the constraints that Malaysia faces in terms of its relatively low GERD/GDP ratio compared to the advanced economies and NIEs, improving R&D commercialization rates at IHLs and GRIs which are <10% in recent years to say, 20% in the next five years, would greatly enhance the competitiveness of the country's national innovation system. This in turn would create new innovations which could spur economic growth and its spill-over effects; more importantly, this would provide potential solution to the middle-income trap which Malaysia is currently experiencing, i.e., losing traditional manufacturing jobs to countries with lower production costs and at the same time not having enough knowledge/innovation-based new businesses to move it to the next economic development ladder.

Studies in the national innovation system and particularly in R&D commercialization among IHLs and GRIs while not providing a panacea to the current dilemma of middle-income trap would definitely set the right agenda for Malaysia in getting on with the knowledge-based economic development for the next decades or so. The proposed research areas above could provide some badly needed information that would help with policy making for the government and related agencies.

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