

Mechanism and Government Initiatives Promoting Innovation and Commercialization of University Invention

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ABSTRACT

This paper reviews the mechanisms and the Malaysian government initiatives to support commercialization and technology transfer from universities. To be more precise, this study attempts to demarcate the role of the Malaysian government by examining the initiatives for promoting commercialization of university research. Commercialization is still new in the Malaysian environment and undoubtedly requires a lot of support from the government to transform the Malaysian universities as centres for generating revenue. Commercialization has a positive impact on economic development and facilitates the exchange of knowledge with industries as well as the entrepreneurs. The main objective of this paper is to study whether the Malaysian government is aware of and supports this process by diverting resources from research to commercialization. The policy implications and suggestions for further research are outlined in the conclusion to this paper.

Keywords: Government initiatives, technology transfer, commercialization of Malaysian university research, promoting university inventions

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INTRODUCTION

Most of us will remember the significant date, 12 December 1980, when the U.S senate passed the University and Small Business Patent Procedures Act, also known as the Bayh Dole Act 1980. This Act removed the university rules to “say their

right” concerning inventions created from federal funding. It had a dramatic impact in that the Act transformed the organizational structure of universities. Many earlier scholars were concerned about the critical role that the Act played in shifting the universities from being a manufacturing and producing base into a technology base (Shane 2004; Miller 2005; Kenny & Patton 2008; Aldridge & Audretsch 2011).

The enactment of Bayh Dole Act 1980 was an essential landmark for universities in the U.S to incorporate commercialization and technology transfer (technology diffusion) into their research functions. This led to a rapid rise in commercial knowledge transfer from university to industry, through mechanisms such as, partnership, licensing agreement and university start-ups. This specific Act removed the barriers the universities had in interacting with the industry. The United States has become very advanced in technology transfer and commercialization because of this Act, which has been in effect for more than 30 years. Malaysia could duplicate this Act and apply similar principles, just as other countries such as Germany, Japan, Canada, India and Singapore have done. The Bayh Dole Act 1980 not only removed the limitations of university interactions with the industry but also enabled the university to become an industry partner as the industry could utilise the expertise of the university.

In the context of intellectual property ownership in Malaysia, there are acts that promote the commercialization of university research, namely the Patents Act 1983,

Copyright Act 1987 and Industrial Designs Act 1996. These Acts provide protection for the inventions from research conducted in the universities, like the Bayh Dole Act 1980. This reflects the recognition of the contributions of inventors and their creativity.

According to Freeman and Hagedoorn (1994), science has become an alternative engine of economic growth, in addition to the classic triumvirate of land, labor and capital. The Silicon Valley and Route 128 in the U.S have often been mentioned as the most productive areas of high-tech ventures, where the abundant academic research capacity contributes towards improvements in the industrial system (Mowery & Ziedonis 2002; Shane 2002). A greater focus on exploiting research findings is evident from the managerial changes between academics with respect to university-industry collaborative projects (Van Looy *et al.*, 2006). Given a knowledge-based economy, academic research institutions are no longer just venues for education, research and public services. They play a very important role in regional economic development and recruitment creation (Chrisman *et al.*, 1995; Etzkowitz 2003).

Commercialization of university research in Malaysia is still new. Most of the literature so far has focussed on the developed economies (Wan Mohd Hirwani *et al.*, 2011; Ismail *et al.*, 2011). The developing countries, until quite recently, had attached little importance to the role of universities as a source of knowledge and innovation for firms (Hershberg *et al.*, 2007).

Policymakers increasingly view universities as engines of economic progress, via the commercialization of intellectual property through technology transfer (Siegel & Phan, 2005). Numerous research universities have now formulated formal mission statements on the role and importance of technology transfer (Markman *et al.*, 2005). The main commercial components of university technology transfer are licensing agreements, research joint ventures, and university-based start-ups.

Policy makers are initiating these reforms both through changes in the academic system and instruments pertaining to research finance (Benner & Sorlin, 2007; Slaughter & Leslie, 1997) and also by setting up physical structures to assist such activities (Mian, 1997; Guston, 1999; Hellstrom & Jacob, 2003; Kenny & Patton 2008; Alice, 2011). Regulations are made both top down through the government as well as its agencies, when other initiatives are bottom-up, coming from individuals and also entities within the universities (Goldfarb & Henrekson, 2002).

There are several research gaps found based on previous research investigations. First, there is still a paucity of researches undertaken concerning the commercialization of Malaysian university research (Yusof *et al.*, 2009; Wan Mohd Hirwani *et al.*, 2011; Ismail *et al.*, 2011). It is true that commercialization of university research is still in its infancy stage in Malaysia as compared to other countries. However the Malaysian government has

begun to emphasize that universities in Malaysia should focus on transforming their research and innovations into products that generate additional income for the university. Secondly, earlier studies have mainly investigated academic research commercialization in the U.S., Europe, and Japan, and thus have not highlighted the implications for universities in the emerging economies (Anokhin & Wincent, 2012; Azagra-Caro, 2011; Rothaermel *et al.*, 2007). They only looked at the university generating spin-off/start-up companies to showcase their academic entrepreneurship (Shane, 2004b) and did not dwell on other mechanisms such as licensing and patenting. For Malaysia, it is very important to establish a strong foundation for commercialization. Finally Wan Mohd Hirwani *et al.* (2011) and Ismail *et al.* (2012) argued about the challenges to commercialization from agricultural inventions. However, they did not focus on other types of inventions available in Malaysia. In order to bridge the mentioned gaps in the literature, this study analyses and focuses on the mechanisms that the government uses to promote the commercialization of university research in Malaysia. It verifies the relationship between university and government in supporting commercialization and technology transfer. This will provide a better understanding of the commercialization process and assist the Malaysian government in drafting the new mission for Research Universities by incorporating the commercialization element as their additional task.

COMMERCIALIZATION OF MALAYSIAN UNIVERSITY RESEARCH

Commercialization of university research in Malaysia, when compared to countries such as United States and United Kingdom, is still new and at its infancy stage (Wan Mohd Hirwani *et al.*, 2011). There are five research universities in Malaysia and they receive funding from the government to conduct research every year. The five research universities are:

- Universiti Sains Malaysia (USM),
- Universiti Kebangsaan Malaysia (UKM),
- Universiti Malaya (UM),
- Universiti Putra Malaysia (UPM),
- Universiti Teknologi Malaysia (UTM).

Through commercialization, these research universities help recover the costs incurred by the government and at the same time contribute towards the economic growth of Malaysia. Universities in Malaysia are currently transforming their mission and vision to align with the commercialization objective (Wan Mohd Hirwani *et al.*, 2011), given that university-based research has thus far been severely neglected. Since 2008, the Malaysian Government has been promoting academic research and commercialization, especially by research institutions and research centres by providing more funding. The phrase “university-industry knowledge transfer” is used to depict a wide range of relationships at different levels, as well as the many activities directed towards

exchange of knowledge and technology, involving both the universities and firms. This includes the setting up of start-up firms interested in the commercial exploitation of university inventions, collaborative research among firms and academic institutions, contract research and academic consulting commissioned by industry, the development and commercialization of intellectual property rights on the part of universities, and other activities, such as co-operation in graduate education, advanced training for enterprise staff, and exchange of researchers between firms and universities (Jacobsson *et al.*, 2013). In the perspective of universities, these are often referred to as the “third stream” or “third mission”, terms that emphasize the role of universities as promoters of economic development, besides their two traditional missions of teaching and research (Lawton-Smith 2007).

There are several gaps that encumber the commercialization of university research. A study by Farsi *et al.* (2011) showed that there are three constraints that hinder the process of commercialization of university research. These are a) lack of intellectual property rights, b) the lack of funding sources to develop more new technologies and c) limited interaction with the industry. Furthermore, a research by Leisyte (2011) and Jacobsson *et al.*, (2013) pointed out the constraints in terms of policy covering the mission and activities of universities in driving the commercialization of university research. Constraints in terms of incentives and rewards have been raised by Rasmussen (2006); Alice (2011); and Perkmann *et al.*,

(2013). The study by Siegel *et al.*, (2003) explained that incentives and rewards should not only be in the form of money, but could be extended in the form of stock holdings to the university researchers. However, the study by O'Shea *et al.*, (2005) pointed out that incentives and rewards are important not only for the researchers but also for the Office of Technology Transfer who are managing the technology.

Malaysia hopes to gain leverage from the universities to promote economic development, in its endeavour to become a high nation economy. If this initiative succeeds, it would contribute towards sustaining the economy, increase productivity, create international brand names and diversify from labour-intensive assembly operations (Yusuf 2008). The transformation of the universities in Malaysia towards greater interaction and commercialization with the industry started in the 1990s and gained momentum during the economic crisis in 2008. With the new policies in place, all universities in Malaysia have begun to interact, communicate and create relationships with the industry to assist in the commercialization process.

There are varied definitions for an "academic entrepreneur". It has often been defined as a person involved in establishing start-up companies relating to their technology (Lockett *et al.*, 2005; Shane, 2004; Stuart & Ding, 2006). According to the explanation by Etzkowitz and Leydesdorff (2000), Etzkowitz (2003), the transformation of universities are affected by the following:

1. Teaching: this was the traditional role of the university until the late 19th century.
2. Teaching and research: these are new roles added to the mission of the university as the centre for creating new knowledge.
3. Teaching, research and direct contribution to social and economic development: this is what is known as the Third Mission of the university. This is an important element for a sustainable university in the 20th century.

The study by Shane (2004) mentioned that the process of creating academic entrepreneurs in universities is difficult and it takes time. This was reaffirmed by Anokhin & Frishammar (2011) who stated that the process of transformation of university researchers into entrepreneurs is dependent on the experience acquired by the researchers as well as the extent of the interactions with the industry. University researchers are more likely to be involved in commercialization if they have a close relationship and contact with the industry. The research by Alice (2011) mentioned that academic entrepreneurs do not have the expertise in convincing the industry to invest in product innovation research. This is because the expertise to interact and identify opportunities is different and is acquired through experience (Boardman & Ponomariov, 2009). In addition, another constraint is the attitude of the researchers who conduct non-profit oriented research (Arvanitis *et al.*, 2011,) and are only concerned with purely the academic value,

as noted by D'Este & Perkmann (2011). Siegel *et al.* (2003) suggested that one of the ways to address this constraint is to build an industrial network with support from the university. Researchers should also move and think like an entrepreneur to ensure the successful commercialization of university research. The university must also support the academic entrepreneur by providing more research grants and incentive rewards that would enhance the commercialization process.

Over the years, universities have been pressured to transform from being ivory towers to manufacturing enterprises (Etzkowitz 1998, Etzkowitz 2003; Powers 2005). The crucial problem in linking university scientists with the industry is the tacit nature of their knowledge. The role of scientists is to enhance their research that is relevant to the private sector and effectively transfer their knowledge and findings (Dietz & Bozeman 2005). Scientists are evaluated based on the knowledge that they have generated. Hence, the research findings are limited to being published in journals or being patented (Agrawal & Henderson 2002). This logic is implicit in life cycle theories that maintain that junior researchers focus on building reputation in academia while later in their careers they capitalize on their expertise by reaching out to industry (Colombo & Piva 2012; Semrau & Werner 2012).

MECHANISM BY GOVERNMENT

In order to sustain and enhance the commercialization process and technology

transfer, the government has introduced several mechanisms. The main focus of the Malaysian government currently is to build an innovative and creative society. The Malaysian National Innovation Center (MyNIC) has been set up and it is expected to boost the innovative spirit among Malaysians. The purpose of this center is to enhance their knowledge about innovations which are vital for growth and development. The establishment of a National Innovation Centre (MyNIC) network of Centres of Excellence and Innovation (i-Coe), the Government has indicated that it aims to internalise innovation as a practice among the people.

The Malaysian Prime Minister Datuk Seri Najib Tun Razak, at a press conference after chairing a meeting of the National Innovation Council at the Putra World Trade Centre (PWTC), said that:

“Innovation is to be done that is comprehensive in the sense that it is not limited to science and technology.....It involves comprehensive innovations in areas covering governance, social, rural, village, industrial corporate, education, health care, transportation, social safety nets and branding”

During the same function, the Prime Minister's also mentioned that Quality Day was changed to National Innovation Day. This showed that Malaysia is serious in embedding innovation and science into

the society and creating awareness among the people. The Malaysian government has already engaged to become an intermediary between the universities and the industries to promote commercialization activities.

Establish Technology Transfer Office (TTO)

It is notable that now almost every university has established the Technology Transfer Office (TTO) to accelerate the technology transfers process. The TTO would be the best platform to assist researchers to engage with the industry. Many scholars have recognised the importance of having a TTO to promote commercialization and technology transfer (Arvanitis *et al.*, 2011; Ismail *et al.*, 2012; Perkmann & Salter, 2012). TTOs play an important role in managing the long process of knowledge transfer given their personnel skills and governance structure (O'Shea *et al.*, 2008, Swamidass & Vulasa, 2008; Woolgar, 2007). They often are the first place where invention disclosure occurs and the potential for commercialization is assessed. In addition, many TTOs provide seed money for further work on inventions, assistance in business planning, introduction to venture capitalists, assistance in recruiting start up teams, and providing incubator space (Alice 2011). However, there is an emerging consensus among researchers that most TTOs lack the necessary resources and competencies (Swamidass & Vulasa 2008). Besides problems associated with skill and budget shortages, TTO staff are pressured for time. As a result, they might succeed in patenting inventions but may have limited

resources for marketing them to potential licensees and investors (Swamidass & Vulasa, 2008; Wright *et al.*, 2008b).

The discoveries and innovations these researchers produce, later become the technologies which TTOs seek to commercialize. Technology Transfer Offices become aware of new discoveries and innovations either because the faculty are actively interested in commercialization or because the aforementioned Bayh-Dole Act has resulted in university policies that often require research faculty to disclose newly-discovered innovations to the TTO. In some cases, the research faculty are not particularly motivated to disclose their innovations, and if university policy does not require disclosure the technology is very likely to remain 'on the shelf' (Ahrweiler *et al.*, 2011). Once an innovation is disclosed, TTO staff members would commence an extensive review process to determine whether the innovation is worth the time, effort, and expense required to secure intellectual property (IP) protection. The outcome of this review process is either rejection or the submission of a formal application for intellectual property protection (Carlsson & Fridh, 2002). A rejection by the TTO does not necessarily mean that the innovation would never be commercialized; rather, the IP typically reverts back to the researcher and it becomes his or her responsibility to individually pursue IP protection or engage in commercialization. Since they must individually bear the costs and risks of pursuing IP protection and

commercialization activities at this juncture, the faculty members are usually quite reluctant to proceed on their own (O’Shea *et al.*, 2008).

Research Grant

There are many research grants that have been provided by the Malaysian government for research universities (Hock *et al.*, 2012). These research grants could be used to expand their research work from basic to applied research and also for developing prototypes to attract venture capital. To maximize economic growth potentials, academic institutions must seek new opportunities to reduce lag time in acquiring new knowledge (Ismail *et al.*, 2012). The development of optimal research practices and procedures at universities would not only facilitate the licensing of new technologies to commence start-ups but could also lead to the commercialization of new applications that improve living conditions and promote job creation.

Firms established from the research endeavours of our universities have

introduced important new drugs and devices to the market. Some have provided the society an access to new markets which were created as outcomes of new corporations such as Netscape and Google. Others have served as a catalyst for the semiconductor industry, for firms such as Cadence and Synoposes, and the clean-tech industry, for firms such as A123 Systems. Many of these enterprises are categorized as high growth firms and have become integral to economic development, generating a large number of new jobs each year.

Table 1 shows the type and number of research grants provided by the Malaysian government to support the innovation, technology and commercialization process. The total research funding amounts to more than USD 200 million and this is one of the measures under the Government Transformation Plan (GTP) initiated by the fifth Prime Minister of Malaysia. More than 1000 research findings have been identified as being eligible to enter the commercialization stage and these research grants would be used to fund

TABLE 1
List of Research Grants Provided by the Malaysian Government

Research Fund	Date of Approval	Amount
FRGS (Fundamental Research Grant Scheme)	2006	USD 98,635,538.70
ERGS (Exploratory Research Grant Scheme)	2011	USD 98,635,538.70
PRGS (Prototype Research Grant Scheme)		
LRGS (Long Term Research Grant Scheme)		
Incentive Research	2011	USD 13,480,190.29
Special Fund From Ministry of Higher Education	2011	USD 32,878,512.90
TOTAL		USD 243,629,780.60

Source: Ministry of Higher Education Malaysia (www.mohe.gov.my/)

that process. The Malaysian Government recognizes the importance of innovation in the development of the country and it is noteworthy that a similar approach is used by the universities in the United States and other European countries.

Rewards and Incentives

Establishing institutional structures and providing incentives to promote commercialization of research findings could bring benefits to a university as a whole. Industrial linkages offer additional incentives to attract and retain talented faculty members and students. Despite the time involved, entrepreneurial faculty members tend to have higher scholarly productivity than others. They often reinvest “profits” in lab equipment and engage additional postdoctoral researchers, enabling them to conduct further research and experiments (Blumenthal, 2003; Jackson & Audretsch, 2004; Poyago-Theotoky *et al.*, 2002). Normally, a firm is always willing to pay for a more valuable innovation, and so the TTO has a vested interest in declaring that it has a path-breaking discovery. If the university is better informed than the firm on the value of the innovation, it could use royalties to denote the value of the innovation (Macho-Stadler *et al.* 2007). Indeed, under fixed payment arrangements, the TTO receives its money upfront, independently of the firm's revenues, while under a variable payment agreement, the amount is dependent upon the firm's output. Hence, royalties link the TTO's profits to the value of the innovation, and thus, their

inclusion in the payments would signify the high-quality of the innovation.

However, there are risks involved. The traditional commitment of a university to the integrity of scientific research could come into conflict with the new financial interests of the profit oriented companies. The threat to integrity could emerge through various mechanisms of support for research from the industry. This could lead some faculty members to wittingly or unwittingly bias their findings in the firms' favour, and the relationships could hamper the openness of communication within the research environment (Blumenthal, 2003; Gassol, 2007; Link & Scott, 2003; Poyago-Theotoky *et al.*, 2002). The risks could undermine the public's faith in the university research enterprise and public funding.

Research shows that incentives are important in terms of explaining variations in relative performance and has a positive relationship with commercialization (Debackere & Veugelers, 2005; Woolgar, 2007; Wright *et al.*, 2008a). Additional incentives are required to attract faculty participation in commercializing important inventions, including royalties and equity. Although the vast majority of agreements (in the U.S.) include royalty payments, contracts with equity have been shown to be Pareto superior to those with royalties (Jensen and Thursby 2001, Thursby and Thursby 2004). The distribution of royalty rates between inventors and the university also could influence the inclination of the faculty to exploit academic inventions. It is clear that allowing the faculty to

retain a higher share would lead to more invention disclosures (Tang *et al.*, 2012; Link and Siegel, 2007; Ponomariov, 2008). Spin-offs started by enterprising faculty as well as graduates license university IP to commercialize inventions. These ventures are often assisted by incubators, venture capital funds or equity financing (to cover up front costs of start-up firms), and business support systems established by the university. These policies, together with the commercial orientation of university research and its intellectual eminence, determine why some institutions generate more new spin-offs than others (Shane 2004). Another important constraint concerns how commercial pursuits are rewarded in the promotion process, as patenting and consulting do not receive as much merit as publishing and research activities (Renault, 2006, Wright *et al.*, 2008). Moreover, the attitude of many faculty members against commercial involvement, lack of research focus on urgent industry needs, unbalanced distribution of benefits, and inadequate IP protection are among some of the main obstacles of an academic spill over (Liu & Jiang 2001).

Other mechanisms

i. Technology Licensing Agreement

Technology licensing agreements have proven to be an effective mechanism for the commercialization of university-held innovations (Agrawal, 2006; Thursby & Thursby, 2007). Technology licensing agreements facilitate commercialization of university innovations by transferring

the innovation knowledge to an external party in return for a fixed fee or continuing royalty payments. From the perspective of the university, technology licenses are often preferred because they increase speed to market, allow for optimization of multi-partner relationships, and minimize financial risks (Kim *et al.*, 2012; Zhao, 2004). In the case of Malaysia, a country bound by regulations derived from the British system, licensing has drawbacks, such as the licensing approach where the university innovations are often not well developed, the licensing fees could be difficult to value a priori, and there is substantial variability in the degree of involvement research faculty members (Thursby & Thursby, 2005). Indeed, research indicates that only about half of university license agreements have resulted in successful commercialization (Agrawal, 2006). This must be acknowledged by the university and it should provide a feasible arrangement to facilitate engagement with the industry.

ii. University Spin-off

University spin-offs constitute the entrepreneurial route to commercializing public research. They are initiated either directly by the researcher (or laboratory) that made the discovery or by the university's TTO. A spin-off agreement involves the TTO and the researcher as well as one external financier, who are either a venture capitalist (VC) or a business angel (BA). VCs are "formal" early-stage investors who create funds that pool and manage money. BAs are "informal" wealthy individuals

who invest their own funds in a small set of new business ventures. Given that spin-offs have a gestation period to become profitable and lack tangible assets, debt financing by banks is typically not an option. Spin-off contracts are more complex than licensing agreements. They allocate both cash flow rights and control rights, the latter of which might or might not be associated with cash flow rights, to the principal participants (i.e., the TTO, researcher and VC or BA) and possibly also to the manager who is hired to run the venture. It is customary to distinguish two types of shares, namely, financial shares, which are directly related to the capital invested, and founder shares, which compensate for the intellectual property, brought in by the researcher(s) and owned by the university's TTO.

The rather high level of scientific, financial and commercial uncertainty implies that each step in the venture could lead to the renegotiation of previous contracts and/or an increase in the financing of the spin-offs; new financial shares issued, and new partners included. Also, a successful spin-off must determine its exit strategy either through acquisition by an existing company or through an Initial Public Offering (IPO). Given the different objectives that the participants in such contracts usually have, each renegotiation generates conflict, since decisions that benefit one participant does not necessarily benefit the others.

CHALLENGES IN COMMERCIALIZATION OF UNIVERSITY INVENTIONS

An obstacle that prevents the faculty members from being involved with the industries is their academic freedom which allows them the flexibility to conduct research without any consideration for commercial gains (Tang *et al.*, 2012). The collaborations between the university and the industry would sustain if the researcher feels that the industry shows an interest in their inventions (Lee & Yang, 2000). Previous research shows that academic researchers' attitudes towards the coll ties with the industry sponsors are largely positive, especially when funding is indirectly related to their research, disclosure is agreed upfront, and ideas are freely publicized (Glaser & Bero 2005). As pointed out by Meyer (2005), most academic researchers in Germany regard obtaining additional funding for research and opportunities to learn from the industry as the main motives for engaging with industry. A qualitative study by Owen-Smith and Powell (2003) lends support to the view that most academics involved in commercialization of university research are attracted by monetary considerations. These authors highlighted that life sciences are more valuable because the patents on their own generate monetary rewards for the researchers which could enhance their income levels. However the situation is different in the physical sciences where it is less attractive because of lower monetary pay-offs and research is therefore pursued

primarily to develop relationships with fihe , gain access to equipment or exploit other research-related opportunities (Owen-Smith & Powell 2003).

IMPLICATIONS

As mentioned earlier , commercialization of university researches and innovations is of paramount importance, both practically and theoretically. The study by Chiesa and Piccaluga (2000) is of the view that the changes that occur due to scientific findings in the form of new applications, have benefitted the country, however the process is often hampered in terms of ownership of intellectual property. The study by Liu and Jiang (2001) concluded that there is a conflict between the needs of the market and the focus of many researchers. According to researchers, the industry does not require high technology but basic technology that could increase productivity of their company (Liu & Jiang 2001). This statement is also supported by Ismail *et al.* (2012) who state that it is important for both parties to understand and tolerate each other so that both could gain from making significant contributions to the country. Collaboration between industry and university researchers would strengthen relationships. This would enable the researchers to build and enhance their reputation and if they have a product for commercialization it will be easier for it to be accepted by the industry (Perkmann *et al.*, 2011; Hock *et al.*, 2012; Perkmann & Salter, 2012). The research by Bray and Lee (2000) proposed two commercialization strategies for university research, which

are : i) a traditional licensing strategy that includes an up-front license issue fee for the use of the technology and a royalty on sales and ii) an alternative strategy of taking equity in the company formed. Their research showed that the higher the percentage of shares in the company, the higher would be the returns for the university. However, their research analysis is based on a very limited number of cases and further studies are needed to draw conclusions on the relationship between commercialization strategy and income generation.

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CONCLUSION

In conclusion, we feel that there is a strong case to be made for the benefits of commercialization of research in universities, to various potential stakeholders. As discussed, those who choose to be directly involved in the process obtain several gains. Furthermore, there are also untold benefits to the communities, regions, and nations in which these entrepreneurial endeavours occur. Challenges do exist, however, and the process of academic entrepreneurship is not as efficient or as effective as it could be. It is hoped that this article provides a better understanding of the mechanisms that the government should place emphasis upon and the academic

entrepreneurship process, difficulties faced and recommendations to overcome them, as well as the potential benefits to be gained as academics and practitioners strive to develop improved models of academic entrepreneurship. University administrators have become more willing to engage in commercial pursuits and set up enterprises. Clearly, the government has a high stake in such pursuits, as it perceives the role of universities as beyond human resource training and basic research. In particular, investment priorities for elite institutions of higher education and critical policies for rewarding commercialization are largely decided by the central government. One of the criteria for assessing the performance of universities and their administrators is commercialization of research and the tangible contributions to local economies. These policy directions, together with the need for universities to diversify revenue sources and pursue economic gains, have jump started and sustained a growing level of research commercialization nationally.

REFERENCES

- Agrawal, A., (2006). Engaging the inventor: Exploring licensing strategies for university inventions and the role of latent knowledge. *Strategic Management Journal*, 27, 63-79.
- Agrawal, A., & Henderson, R. (2002). Putting patents in context: Exploring knowledge transfer from MIT. *Management Science*, 48, 44-60.
- Ahrweiler, P., Pyka, A., & Gilbert, N. (2011). A New Model for University-Industry Links in Knowledge-Based Economies. *Journal of Product Innovation Management*, 28, 218-235.
- Aldridge, T. Taylor, & Audretsch, David. (2011). The Bayh-Dole Act and scientist entrepreneurship, *Research Policy*, 40(8), 1058-1067.
- Alice Lam. (2011). What motivates academic scientists to engage in research commercialization: 'Gold', 'ribbon' or 'puzzle'?. *Research Policy*, 40(10), 1354-1368.
- Anokhin, S., & Wincent, J. (2012). Start-up rates and innovation: A cross-country examination. *Journal of International Business Studies*, 43, 41-60.
- Anokhin, S., Wincent, J., & Frishammar, J., (2011). A conceptual framework for misfit technology commercialization. *Technological Forecasting and Social Change*, 78(6), 1060-1071.
- Arvanitis, Spyros, Woerter., & Martin. (2011). Exploration or Exploitation of Knowledge from Universities: Does it Make a Difference? *KOF Working Papers*, 322, 201-205.
- Azagra-Caro, J. M. (2011). Do public research organisations own most patents invented by their staff?. *Science and Public Policy*, 38, 237-250.
- Benner, M., & S. Sörlin, 2007, Shaping strategic research. *Power, resources, and interests in Swedish Research Policy*. *Minerva*, 45, 31-48.
- Blumenthal, D. (2003). Health policy report: Academic-industrial relationships in the life sciences. *New England Journal of Medicine*, 349, 2452-2459.
- Bray, M. J., & Lee, J. N. (2000). University revenues from technology transfer: Licensing fees vs. equity positions. *Journal of Business Venturing*, 15(5-6), 385-392.
- Carlsson, B., & Fridh, A.C. (2002). Technology transfer in United States universities - A survey and statistical analysis. *Journal of Evolutionary Economics*, 12, 199-232.
- Chrisman, J. J., Hynes, T., & Fraser, S. (1995). Faculty entrepreneurship and economic development:

- The case of the University of Calgary. *Journal of Business Venturing*, 10, 267-281.
- Chiesa, V., & Piccaluga, A. (2000). Exploitation and Diffusion of Public Research: The Case of Academic Spin-off Companies in Italy. *R&D Management*, 30(4), 329-339.
- Colombo, M. G., and Piva, E. (2012). Firms' genetic characteristics and competence-enlarging strategies: A comparison between academic and non-academic high-tech start-ups. *Research Policy*, 41, 79-92.
- Craig Boardman & Branco Ponomariov. (2009). University researchers working with private companies" *Technovation*, 29(8), 142-153.
- Debackere, K., & Veugelers, R. (2005). The role of academic technology transfer organizations in improving industry science links. *Research Policy*, 34, 321-342.
- D'Este P, & Perkmann M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer*, 36, 316-339.
- Dietz, J., & Bozeman, B. (2005). Academic careers, patents, and productivity: industry experience as scientific and technical human capital. *Research Policy*, 34, 349-367.
- Etzkowitz, H. (1998). The norms of entrepreneurial science: Cognitive effects of the new university-industry linkages. *Research Policy*, 27, 823-833.
- Etzkowitz, H. (2003). Innovation in innovation: The Triple Helix of university-industry-government relations. *Social Science Information Sur Les Sciences Sociales*, 42, 293-337.
- Etzkowitz, H., & L. Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "mode 2" to a Triple Helix of university-industry-government relations. *Research Policy*, 29, 109-123.
- Farsi, Jahangir Yadolahi, Meisam Modarresi, & Hadi Zarea. (2011). Obstacles and Solutions of Commercialization of University Research. *Case Study of Small Businesses Development Center of University of Tehran*, pp. 1-23.
- Freeman, C., & Hagedoorn, J. (1994). Catching up or falling behind: Patterns in international interfirm technology partnering. *World Development*, 22, 771-780.
- Glaser, B. E., & Bero, L.A. (2005). Attitudes of academic and clinical researchers toward financial ties in research. *A systematic review: Science and Engineering Ethics*, 11, 553-573.
- Goldfarb, B., & Henrekson, M. (2003). Bottom-up versus top-down policies towards the commercialization of university intellectual property. *Research Policy*, 32, 639-658.
- Guston, D. H. (1999). Stabilizing the boundary between US politics and science: the role of the Office of Technology Transfer as a boundary organization. *Social Studies of Science*, 29, 87-111.
- Hellström, T., Jacob, M., & Wenneberg, S.B. (2003). The 'discipline' of post-academic science: Reconstructing the paradigmatic foundations of a virtual research institute. *Science and Public Policy*, 30, 251-260.
- Hershberg, E., Nabeshima, K., & Yusuf, S. (2007). Opening the Ivory Tower to Business: University-Industry Linkages and the Development of Knowledge-Intensive Clusters in Asian Cities. *World Development*, 35, 931-940.
- Horowitz Gassol, J. (2007). The effect of university culture and stakeholders' perceptions on university-business linking activities. *The Journal of Technology Transfer*, 32, 489-507.
- Hock, Low, Amran Rasli, & Aslan Amat. 2012. Knowledge Determinant in University Commercialization: A Case Study of Malaysia Public University. *Procedia Social and Behavioral Sciences*, 40, 251-257.

- Ismail K., Tengku Azhar, T. N., Yong, C. Y., Aslan, A. S., Omar, W. Z., Majid, I., & Ajagbe, A. M. (2012). Problems on Commercialization of Genetically Modified Crops in Malaysia, *Procedia-Social and Behavioral Sciences*, 40, 353-357.
- Ismail, K., Majid, I. A., & Wan Omar, W. Z. (2011). The commercialisation process of patents by universities. *African Journal of Business Management*, 5(17), 7198-7208.
- Jackson, N., & R. Ward, 2004, A fresh perspective on progress files-a way of representing complex learning and achievement in higher education. *Assessment and Evaluation in Higher Education*, 29, 423-449.
- Jacobsson, Staffan, Åsa Lindholm-Dahlstrand, & Lennart Elg. (2013). Is the commercialization of European academic R&D weak?. A critical assessment of a dominant belief and associated policy responses. *Research Policy*, 42(4), 874-885.
- Jensen, R., & Thursby, M. (2001). Proofs and prototypes for sale: The licensing of University inventions. *American Economic Review*, 91, 240-259.
- Kenny, M., & Patton, D. (2008). Reconsidering the Bayh-Dole Act and the current university technology licensing regime. *Research Policy* 16(4), 641-655
- Kim, H., Huang, M., Jin, F., Bodoff, D., Moon, J., & Choe, Y.C. (2012). Triple helix in the agricultural sector of Northeast Asian countries: a comparative study between Korea and China. *Scientometrics*, 90, 101-120.
- Lawton Smith, H., (2007). Universities, Innovation and territorial development: A review of the evidence. *Environment and Planning C*, 25, 98-114.
- Lee, W. H., & Yang, W. T. (2000). The cradle of Taiwan high technology industry development - *Hsinchu Science Park (HSP)*. *Technovation*, 20, 55-59.
- Leisyte, Liudvika. (2011). University commercialization policies and their implementation in the Netherlands and the United States. *Science and Public Policy*, 38(6), 437-448.
- Link, A. N., & Siegel, D.S. (2007). *Innovation, entrepreneurship, and technological change*. United Kingdom: Oxford University Press, Oxford.
- Link, A. N., & Scott, J.T. (2003). U.S. science parks: The diffusion of an innovation and its effects on the academic missions of universities. *International Journal of Industrial Organization*, 21, 1323-1356.
- Liu, H., & Jiang, Y.Z. (2001). Technology transfer from higher education institutions to industry in China. *Nature and implications: Technovation*, 21, 175-188.
- Lockett, A., Siegel, D., Wright, M., & Ensley, M.D. (2005). The creation of spin-off firms at public research institutions: Managerial and policy implications. *Research Policy*, 34, 981-993.
- Machostadler, I., Perezcastrillo, D., & Veugelers, R. (2007). Licensing of university inventions: The role of a technology transfer office. *International Journal of Industrial Organization*, 25, 483-510.
- Markman, G. D., Gianiodis, P. T., Phan, P. H., & Balkin, D.B. (2005). Innovation speed: Transferring university technology to market. *Research Policy*, 34, 1058-1075.
- Markus Perkmann, Valentina Tartari, Maureen McKelvey, Erkko Autio, Anders Broström, Pablo D'Este, Riccardo Fini, Aldo Geuna, Rosa Grimaldi, Alan Hughes, Stefan Krabel, Michael

- Kitson, Patrick Llerena, Francesco Lissoni, Ammon Salter & Maurizio Sobrero. (2013). Academic engagement and commercialisation. *A review of the literature on university–industry relations Research Policy*, 42(2), 423-442.
- Meyer, M. (2005). *Instruments of transformation: Developing a self-assessment tool for entrepreneurial universities*, pp.195-199.
- Mian, S. A., 1997, Assessing and Managing the University Technology Business Incubator: An Integrative Framework. *Journal of Business Venturing*, 12, 251-285.
- Miller, A. (2005). Repairing the Bayh-Dole act - a proposal for restoring non-profit access to university science. [Forum] *Intellectual Property and Technology Forum* at Boston College Law School. pp.93-100.
- Mowery, D. C., & Ziedonis, A.A. (2002) Academic patent quality and quantity before and after the Bayh-Dole act in the United States. *Research Policy*, 31, 399-418.
- O’Shea, R. P., Chugh, H., & T. J. Allen, T.J. (2008) Determinants and consequences of university spinoff activity: A conceptual framework. *Journal of Technology Transfer*, 33, 653-666.
- O’Shea, R. P., Allen, T.J.,Chevalier, A., & Roche, F. (2005). Entrepreneurial orientation, technology transfer and spinoff performance of U.S. universities. *Research Policy*, 34, 994-1009.
- Owen-Smith, J., & Powell, W.W. (2003). The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity. *Research Policy*, 32, 1695-1711.
- Perkmann, M., & Salter, A. (2012). How to create productive partnerships with universities, *MIT Sloan Management Review*, 53, 79-88.
- Ponomariov, B. L., (2008). Effects of university characteristics on scientists’ interactions with the private sector: an exploratory assessment. *Journal of Technology Transfer*, 33, 485-503.
- Powers, J. B. (2005). Buying in or selling out? The commercialization of the American Research University. *Review of Higher Education*, 29, 138-139.
- Poyago-Theotoky, J., Beath, J., & Siegel, D.S. (2002). Universities and fundamental research: Reflections on the growth of university-industry partnerships. *Oxford Review of Economic Policy*, 18, 10-21.
- Rasmussen, E., Moen & Gulbrandsen, M. 2006. Initiatives to promote commercialisation of university knowledge. *Technovation*, 26(4), 518-533.
- Renault, C. S. (2006). Academic capitalism and university incentives for faculty entrepreneurship. *Journal of Technology Transfer*, 31, 227-239.
- Rothaermel, F. T., Agung, S. D. & Jiang, L. (2007). University entrepreneurship: a taxonomy of the literature. *Industrial and Corporate Change*, 16(4), 691-791.
- Semrau, T., and Werner, A. (2012). The two sides of the story: Network investments and new venture creation. *Journal of Small Business Management*, 50, 159-180.
- Shane, S. (2004). Encouraging University Entrepreneurship? The Effect of the Bayh Dole Act on University Patenting in the United States. *Journal of Business Venturing*, 19(1), 127-41.
- Shane, S. (2002). Executive Forum: University technology transfer to entrepreneurial companies. *Journal of Business Venturing*, 17, 537-552.
- Shane, S. (2004b). Academic Entrepreneurship: University Spinoffs and Wealth Creation. *Journal Technology Transfer*.
- Siegel, D. S, Waldman, D. A., Atwater, L. E., & Link, A. N. (2003). Commercial knowledge transfers from universities to firms: Improving

- the effectiveness of university-industry collaboration. *Journal of High Technology Management Research*, 14(1), 111-133.
- Siegel, D. S., & Phan, P.H. (2005). Analyzing The Effectiveness Of University Technology Transfer: Implications For Entrepreneurship Education, In G. D. Libecap, (Ed.). University Entrepreneurship And Technology Transfer. *Advances In The Study Of Entrepreneurship Innovation And Economic Growth*, 16, 1-38.
- Slaughter, S., & Leslie, L.L. (1997). *Academic Capitalism: Politics, Policies, and the Entrepreneurial University*. Baltimore: Johns Hopkins University Press.
- Stuart, T. E., & Ding, W.W. (2006). The social structural determinants of academic entrepreneurship: an analysis of university scientists' participation in commercial ventures. *American Journal of Sociology*, 112, 97-144.
- Swamidass, P. M., & Vulasa, V. (2008). Why university inventions rarely produce income? Bottlenecks in university technology transfer. *The Journal of Technology Transfer*, 34, 343-363.
- Tang, J., Kacmar, K.M.M., & Busenitz, L. (2012). Entrepreneurial alertness in the pursuit of new opportunities. *Journal of Business Venturing*, 27, 77-94.
- Thursby, J. G., & Thursby, M.C. (2004). Are faculty critical? Their role in university-industry licensing. *Contemporary Economic Policy*, 22, 162-178.
- Thursby, J. G., & Thursby, M.C. (2005). Pros And Cons Of Faculty Participation In Licensing, in G. D. Libecap, (ed.). University Entrepreneurship and Technology Transfer. *Advances in the Study of Entrepreneurship Innovation and Economic Growth*, 16, 187-210.
- Thursby, J. G., & Thursby, M.C. (2007). University licensing. *Oxford Review of Economic Policy*, 23, 620-639.
- Van Looy, B., Callaert, J., & Debackere, K. (2006). Publication and patent behavior of academic researchers: Conflicting, reinforcing or merely co-existing?. *Research Policy*, 35, 596-608.
- Wan Mohd, H.W.H., Noor, I.Y., Zinatul Ashiqin Zainol, Mohd, N.A.R., Nizam, A.R., Mujani, W.K., & K. Jusoff, K. (2011). Challenges in Commercialization Agriculture Invention. *World Applied Science Journal*, 7.
- Woolgar, L. (2007). New institutional policies for university-industry links in Japan. *Research Policy*, 36, 1261-1274.
- Wright, M., Vohora, A. & Lockett, A., (2004). The formation of high-tech university spinouts: The role of joint ventures and venture capital investors. *Journal of Technology Transfer*, 29, 287-310.
- Wright, M., Clarysse, B., Lockett, A., & Knockaert, M. (2008a). Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries. *Research Policy*, 37, 1205-1223.
- Wright, M., Liu, X.H., Buck, T., & Filatotchev, I. (2008b). Returnee entrepreneurs, science park location choice and performance: An analysis of high-technology SMEs in China. *Entrepreneurship Theory and Practice*, 32, 131-155.
- Yusuf, S. (2008). Intermediating knowledge exchange between universities and businesses. *Research Policy*, 37, 1167-1174.
- Yusof, M.S.S., & Leilanie Mohd. (2009). An integrated model of a university's entrepreneurial ecosystem. *Journal of Asia Entrepreneurship and Sustainability*, 5(1), 57-77.
- Zhao, F. (2004). Commercialization of research: A case study of Australian universities. *Higher Education Research and Development*, 23, 223-236.

