

Impacts of Technology Assessments on Firm Performance

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Abstract. Technology assessment is crucial in managing technology for the purpose of technology exploitation. Technology is considered one of the important elements to evaluate performance and gain competitive advantage. This purpose of this study is to analyse the impact of technology assessment towards firm's performance and identify the most prevalence indicator that available for organizations to measure their performance. Furthermore, this study also identifies the current assessment practices that create competitive advantage. This research used qualitative method to gain data and used purposive sampling to select the respondents. The respondents consist of two spin off company listed under ICC UTM involving in skincare and wellness products. The findings show that technology assessment give impact either positive or negative towards firm performance. Besides that, this study able to analyse the important factors of technology assessment that can contribute NTBFs to gain better performance and create competitive advantage in marketplace.

INTRODUCTION

Technology is known as knowledge or science that needs to be applied to a definite purpose. Assessment of technology is one of a crucial tool that all organizations need to focus on to define the suitability of current technology used within a system of organization to achieve better performance and simultaneously creating competitive advantage [1]. The assessment evaluated the needs and competitiveness of current technology and its management process. This will lead to better performance in the future. According to Stewart [2], assessments involve organization's members shared the same mission even though working the different area of expertise. Technology assessment (TA) is also an input for decision making and it is answered some uncertainties which to be more efficient and effective towards improving firm's performance [3]. Besides, other issues concerned about technology assessment were circulated on the issues of quality, scarcity of resources, the viability of the technology, strategy development, and benchmarking [2] and its relations towards organization performance, regardless operation, market or financial [4].

However, to find an appropriate assessment measures which are feasible to be linked to performance for the purpose of achieving competitive advantage is crucial [5]. Normally, the problem occurs when managers failed to assess the implementation of technology that eventually will be effected an organization in daily operation and will put the organization left behind the other competitor competing in the same industry. Thus, it leads to the next problem - is there any relationship between performance measurement to firm's performance. The problem above struck debate on what is the effective measurement for organizational to decide on the technology exploitation [2]. Most measurements circulated on financial indicator yet non-financial indicators also important because it leads to be more action and future oriented in order to improve organization's technological capabilities in terms of planning and strategy implementation [5]. The objectives of the study include the following:

RO1. To analyse the impact of technology assessment towards firm's performance.

RO2. To identify the most prevalence indicator that available for organization to measure their performance.

RO3. To identify the current assessment practices that create competitive advantage.

Performance Indicators

Basically, performance measurement is a tool to quantify the efficiency of resources used and effectiveness of the process that will impact on product or service offered [6]. The indicator assists organization's objectives find the actual condition that happened in the company in the certain period of time and pushed the company to come out the variety

of solutions for the purpose of surviving and sustaining competition from their strongest rival. These indicators cover both financial and non-financial aspects.

Financially, profitability ratios measure the total effectiveness of management in generating profits on sales, equity, assets, and owner's investment and considered as the most challenging and critical, especially for small and medium sized enterprises [7] [8] [9]. Profitability is the monetary reflection on variables such as risk, expected demand, industry profit, technology cycles and competition density.

Growth ratio and profitability have a strong relationship due to the mechanism of higher level of profitability lead to increased growth rate [10] [11]. As growth covers market-share growth, asset growth, net revenue growth, net income growth and number of employee growth [4] it has great influence on profitability ratios.

Another financial indicator is the market value that identified through terms of earning per share, stock price improvement, dividend yield, stock price volatility, and market value added [4]. Market value indicators reflect the capabilities of business and its competency in creating a unique way to utilize resources. The other performance indicator is termed as competitive advantage indicators which measures the ability of organizations to gauge customers' and employees' satisfaction, managing environmental issues and social performance. These indicators are non-financial indicators that aims to see how internal resources, especially technology are able to be exploited in achieving high customers and employees' satisfaction, reduce and react to environmental pollution plus its capability to have a positive image in the society.

Technology Assessment (TA) Scale

Based on various yet limited literatures available on how technology should be assessed, it is found that early studies circulate on the appropriate approach to value technology. Schot and Rip [12] for example reviewed past studies and identified several approaches of TA, namely awareness TA, strategic TA, constructive TA and interactive/participatory TA. All these are based on the philosophy aiming to reduce (human) error and costs.

Later, Jolly [13] [14] [15] able to build a strong foundation in the aspect of providing an appropriate scale in assessing technology. His researches construct the scales required in TA. The scale is divided into two parts which addressed technology attractiveness and technology competitiveness. Jolly [15] emphasized that technology attractiveness does not depend on the firm's action due to the reason that it is beyond control (external variable) while, technology competitiveness depends on the firm's decision and behavior and it is within the firm's control [15]. Based on the author's early publication [13], 16 indicators are used for depicting technological competitiveness and another 16 are being used for describing technological attractiveness.

Technology Attractiveness

Technology Attractiveness depends more on the firms' external features [15]. The 16 indicators are being divided into four elements which are market potential, competitive situation, technical potential and socio-political situation [13]. Market potential stressed that market, demand and customers are very important in decision making regarding the technological aspect. However, in the commercialization of new technology is quite challenging and face a lot of uncertainties [16]. Thus, choosing an appropriate of technology are most important parts that a manager needs to pay attention. This is because using an appropriate technology will directly link it to gain technology competence, yet will sustain its position in the market [17]. Three criteria developed under market potential which are market volume, the span of application and market sensitivity to the technical factors.

Next, competition situation allows firms to understand the concept of competition intensity [15] in order to invent an initiative to enhance value creation [18]. There are six criteria need to be adopted for assessing competitiveness: number of competitions, competitors' level of involvement, intensity of competitiveness, impact of technology on competitive issues, barrier to copy, and potential to develop the dominant design. In addition, technical potential assessed five (5) criteria covering the element of the technology position in own lifecycle (the S-curve), the potential for progress, the gap with competing technologies, the threat of substitute technologies, and the potential for unit-to-unit transfer. Finally, the scale provided by Jolly assessed how social-political affects technology implementation which consider societal stake and public support for technology development. This is important as technology will become more attractive if it is able to gain public support in term of financial [19]. Based on these, the research will adopt the attractiveness scale of technology by Jolly [15] as summarized in the Table 1.

TABLE 1. The four elements of technology attractiveness

Environmental factors over which the company has a weak control

Technology attractiveness	Dimensions
Market potential	Market volume opened by technology Span of application opened by technology Market sensitivity to technical factor
Competitive situation	Number of competitors Competitors' level of involvement Competitive intensity Impact of technology on competitive issues Barrier to copy or imitation Dominant design
Technical potential	Position of technology in its own life-cycle Potential for progress Performance gap vis-à-vis alternative technologies Threat of substitution technologies Potential for unit-to-unit transfers
Socio-political situation	Societal stakes Public support for development

(Adapted from Jolly, 2003, 2008, 2012)

Technology Competitiveness

Technology competitiveness evaluates internal features of a firm through 16 indicators which are grouped into value of technological resources and value of complementary resources [13] [15]. Competitiveness of technological resources covers nine (9) aspects including tangible assets, intangible asset, and human resources. The first criterion is the origin of the assets, whether it is dependent or independent in its development process. Dependent means that firm totally depends on the external third party asset while independent means that firm has their own asset to develop its technology and both of this method has its own pros and cons [15].

A second criterion is relatedness to core business which is defined by the relationship between the contributions of technologies implementation toward the company's core business. According to Zhang and Liu [20], applying appropriate technology to the core business is really important since it will directly give a high impact on the production efficiency, improve the stability of production, raise the equipment operation rate, reduce consumption of products, and improve the utilization of waste materials.

The third criteria under technological resources also include the experience accumulated by a firm in the certain technological field. When a firm has an experience and broad knowledge in the specific field is considered as an important aspect in order to handle the technology because it will directly reflect the level efficiency of using the technological resources.

The fourth criteria is about the pattern owned by the firm. A firm that patented their new technology is considered as a stronger firm as they can put obstacles toward others firm from access the resource for producing the technology [21]. Firms are considered to gain competitive advantage since their invention in new technology has been patented.

The fifth criterion of technological resource is the value of laboratories and equipment owned by a firm that emphasize about the expertise of R&D staff and its effectiveness in doing research. Mendigorri, Valderrama, and Cornejo [22] stress that having and R&D staff that has large expertise and know-how on certain aspect would lead to having a valuable outcome.

The sixth and seventh criteria are highlighted about the selection either applied research or fundamental research that will be more expensive to develop a technology [15] [23] while the eight criteria which are the development of team competencies. This is considered as the most crucial part since it will show the success of a technology [15]. Lastly is the diffusion of technological knowledge in the firm. A firm must have a knowledge and capacity of handling technology. Lin and Tang [24] supported that knowledge is very important to improve intellectual capital to gain effectiveness in organizational performance. Complementary resources are similarly important as technology resources. There are seven criteria embedded under this factor. A first criterion is the capability to keep up with fundamental science and technology (S&T). The firm will be able to be successful if they could keep up-to-date with the latest fundamental knowledge in S&T. The knowledge gap between science and technology in a firm will appear due to lack of application of scientific knowledge [25].

The second criterion is the capacity of a firm to finance technology development. In this notion, R&D manager should be able to convince the financial manager that a certain technology is able to attract and develop financing capability [15]. The third criteria stressed that the technology can be developed through the strong relationship between R&D department and marketing department yet it requires smooth communication between them in order to produce a better technology that could fit customer's needs. Pérez-Luño and Cambra [26] found the company that constantly adopts an incremental innovation would be able to connect with the requirement of customer yet it will create competitive advantage which leads to the fourth criteria.

Technology also can be developed through the quality relationship between R&D with production department. Manager should control the transfer of knowledge in order to smooth the production [15]. The fifth criteria of

complementary resources is the capacity of the firm to protect their technology from being imitated by other by acquiring intellectual property protection of its invention via internal development effort or through external licensing to ensure the possibility of downstream technology [27] as R&D function cannot disconnect its relationship with the market in producing their own design. Sixth criteria suggest that a firm is stronger when they are able to reach the stage where they could produce a product that become most preferable in design and dominant to the customers [15]. The final criteria are more prone to timing factor. According to Khalil [1], action to develop, to industrialize and commercialize must be taken at the right time if a firm wants to succeed in a competitive marketplace. The summary of these two aspects of technology competitiveness is presented in the Table 2.

TABLE 2. Two elements of technology competitiveness
Internal factor over which the company can exert a strong control

Technology attractiveness	Dimensions
Technological resources	Origin of assets Relatedness to the core business Experience accumulated in the field Registered patent Value of laboratories and equipment Fundamental research team competencies Applied research team competencies Development team competencies Diffusion in the enterprise
Complementary resources	Capability to keep up with fundamental S&T knowledge Financing capabilities Quality relationship between R&D & production Quality relationship between R&D & marketing Capacity to protect against imitation Market reaction to company's design Timetable relative to competition

(Adapted from Jolly, 2003, 2008, 2012)

METHODOLOGY

The list of spin off companies that gathered from ICC UTM was compiled and filtered to select companies under Faculty of Chemical and Energy Engineering that undergo research and development at IBD UTM. The method used to choose the sample is purposive sampling in which the companies that deal with high technology and only two out of six companies have been chosen to be respondents. Bio Pro Resource Sdn. Bhd. and Phyto Biznet Sdn. Bhd. were selected and they are producing bio-products through R&D such as skin care and wellness. Hence the interview session completed from the entire targeted respondent, the data was analysed and a conclusion was made.

The interview was conducted in Malay. The recording of interview session has been transcribed first which then will be translated into English. Several key words were used to group and classify interview findings in order to address research objective. The frequency of the selected keyword being recorded and researcher calculate the average by using a simple mathematical calculation. The interview procedure is shown in Figure 1.

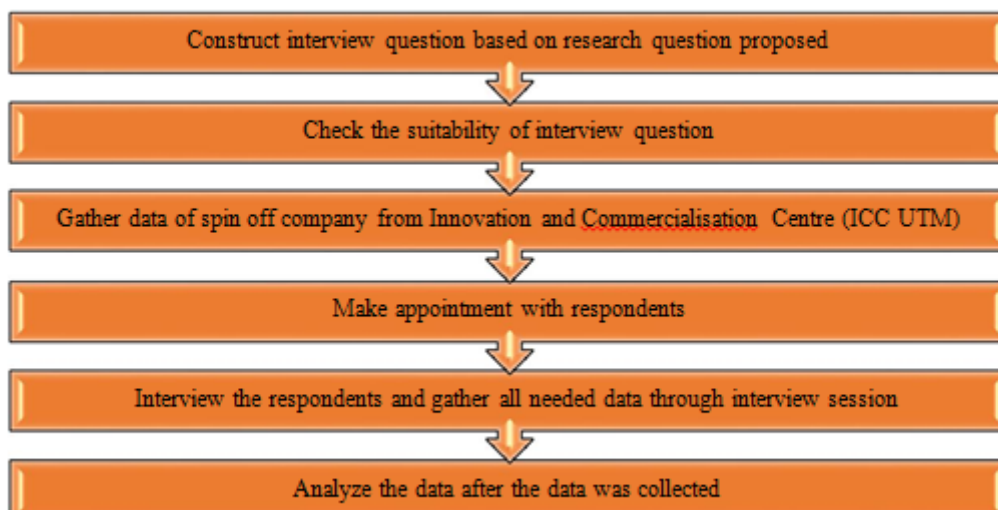


FIGURE 1. Interview Procedure

FINDINGS AND DISCUSSION

The result from this study then has been summarized in the Table A and Table B (see appendix). The aim of this study is to achieve the entire objective constructed at the beginning of the study. First objective was to analyse the impact of technology assessment towards firm's performance. Table 3 (a) shows impact of TA toward financial performance for both spin-off companies. TA would give impact on firm's performance either negative or positive. Currently, there was negative impact of TA towards financial performance in Bio Pro Resource Sdn.Bhd. While, Phyto Biznet Sdn.Bhd is only able to make return on their investment but still they cannot make any profit. This is because; both firms are involved to put investment on development of new products.

On the other sides which refer to the Table 3 (b) state that there was positive impact between TC towards competitive advantage. This shows that, companies were more focus on the utilization of the resources that could create competitive advantages for them. The companies tend to build competitiveness before then create attractiveness for their emerging technology to compete in the marketplace. The assessment is important for the companies in helping them for business strategy development. The theory of s-curve of TLC aim to highlight the important of technology assessment towards performance of a firm at every stages of life. A firm should consider conducting continuous assessment to ensure firm can cope to the changes and sustain its competitive advantage.

TABLE 3 (a). Impact of TA toward financial performance

	Factors	Total average	Performance indicator	Bio Pro Resource Sdn. Bhd.	Phyto Biznet Sdn. Bhd.
TA	Market Potential	4.65	EBITDA margin	Decrease	Decrease
	Competition Situation	3.92	ROI	Decrease	Increase
	Technical Potential	4.20	Profit margin	Decrease	Increase
	Socio-political situation	3.50			

Second objective of this study was to identify the most prevalence indicator that available for organization to measure their performance. Researcher found that the most effective factor for TA was market potential. The uses of technology are very important to the companies to help them produce high quality of products. Quality is been measured by the ability to produce the products that suit with customer's need and want. In the case of these two spin-off companies, it can be said that most customers were very satisfied when using products offered as they can see the positive effect. Not only that, this research also able to found the most important TC toward competitive advantage which is complementary resources. This resources explained strong relationship of R&D team with other team such as marketing, production and finance. The interaction between those four teams is very important since it can help companies to produce product that suit with market's need and want. Financial is considered as important complement resources. An effort for fund seeking should be done in order to continue to provide platform to support the development of new technologies. In order to make development, companies must has familiarities and able to ensure all team expert to handle the technology.

TABLE 3 (b). Impact of TC toward firm's competitive advantage

	Factors	Total average	Performance indicator	Bio Pro Resource Sdn. Bhd.	Phyto Biznet Sdn. Bhd.
TC	Technological resources	4.60	Number of employee	Same	Increase
	Complementary resources	4.65	Repeat customer	Increase	Same
			Green campaign supported	Increase	NA

Third objective is to identify the current assessment practices that create competitive advantage. From the study, current assessment practices in NTBFs are market potential and complementary resources. Market potential is more to

focus on the ability of firms to push their products to be in the marketplace while complementary resources is resources needed by the companies to help the effort of commercialize the product. By considering to TLC, these two companies are still in embryonic phase in which they are more focus on technology push that involve aggressively to do innovation.

CONCLUSION

From this study it can be conclude that there was negative relationship between TA towards firm's financial performance for both companies. The negative relationship is because companies tend to allocate investment for new product development. In other sides, researcher found that companies were able to gain positive relationship between TC towards firm's competitive advantage. Relying to gain effectiveness in resource utilization was the main interest for NTBFs as they want to maintain competitive advantage.

Among those factors for technology assessment, there were some factors that able to support firm performance in term financial or competitive advantage which includes market potential and complementary resources. Market potential provides a set of guideline for strategy development to success in the marketplace. It highlights how the products are able to fulfil needs and solve the problem of society. This assessment tool needs to be supported by complementary resources. Any development of products needs resources that able to make them high quality and valuable in the market. This resources touch around human resources which highlight the close relationship between R&D teams with marketing, production, and finance yet will ensure that deliverable of needed information is happened smoothly.

This study aims to suggest the assessment tool that suit with NTBFs to maintain their performance. When applying the concept of TLC, it is can said that new technological product is still in embryonic phase. At this phase, companies need to rely on technology push where the effort of doing aggressive innovation in order to reserve places for their products to involve competing with others competitors in the market. The situation is reflected towards the assessment tools that will ensure them to have a proper planning which is market potential and complementary resources. These tools need to be pair together in order for companies to maintain its core competencies and thus create competitive advantages.

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REFERENCES

1. T. M. Khalil, *“Management of Technology: The Key to Competitiveness and Wealth Creation”*, (Boston: McGraw-Hill, 2000).
2. H. Stewart, “Center for Applied Research EDUCAUSE”, Research Bulletin, 21 (2002).
3. R. Phaal, C. Farrukh and D. Probert, “Technology management process assessment: A case study”, *International Journal of Operation and Production Management*, **21**, 8, 1116-1132 (2001).
4. J. B Santos and L. A Brito, “Toward a subjective measurement model for firm performance”, *Brazilian Administration Review*, **9**, 95-117 (2012).
5. L. Teeratansirikool, S. Siengthai, Y. Badir and C. Charoengam, “Competitive strategies and firm performance: The mediating role of performance measurement”, *International Journal of Productivity and Performance Management*, **62**, 2, 168-184 (2013).
6. M. R. Vilanova, P. M. Filho and J. A. Balesieri, “Performance measurement and indicators for water supply management: Review and international cases”, *Renewable and Sustainable Energy Reviews*, **43**, 1-12 (2015).
7. R. C. Moyer and R. C. Moyer, *“Contemporary financial management”*, (Mason, OH: South-Western, Cengage Learning, 2012).
8. D. Delen, C. Kuzey, and A. Uyar, “Measuring firm performance using financial ratios: A decision tree approach”, *Expert Systems with Applications*, **40**, 10, 3970-3983 (2013).
9. M. Madison, (n.d.). How to Evaluate a Company's Profitability. Retrieved August 30, 2016, from <http://smallbusiness.chron.com/evaluate-companys-profitability-10401.html>
10. G. Bottazzi, A. Secchi and F. Tamagni, “Productivity, profitability and financial performance”, *Industrial and Corporate Change*, **17**, 4, 711-751 (2008).
11. X. Hu and C. Liu, “Profitability performance assessment in the Australian construction industry: A global relational two-stage DEA method”, *Construction Management and Economics*, **34**, 3, 147-159 (2016).
12. J. Schot and A. Rip, “The past and future of constructive technology assessment”, *Technological Forecasting and Social Change*, **54**, 2-3, 251-268 (1997).
13. D. R. Jolly, “The issue of weightings in technology portfolio management”, *Technovation*, **23**, 5, 383-391 (2003).
14. D. R. Jolly, Chinese vs. European views regarding technology assessment: Convergent or divergent?, *Technovation*, **28**, 12, 818-830 (2008).

15. D. R. Jolly, "Development of a two-dimensional scale for evaluating technologies in high-tech companies: An empirical examination", *Journal of Engineering and Technology Management*, **29**, 2, 307-329 (2012).
16. H. Hellman and R. Vandenhoed, "Characterising fuel cell technology: Challenges of the commercialisation process", *International Journal of Hydrogen Energy*, **32**, 3, 305-315.
17. N. Acur, D. Kandemir, P. De Weerd-Nederhof and M. Song, "Exploring the Impact of Technological Competence Development on Speed and NPD Program Performance", *Journal of Product Innovation Management*, **27**, 6, 915-929 (2010).
18. M. K. Badawy, "Is open innovation a field of study or a communication barrier to theory development: A perspective", *Technovation*, **31**, 1, 65-67 (2011).
19. X. Dai and L. Cheng, "The effect of public subsidies on corporate R&D investment: An application of the generalized propensity score", *Technological Forecasting and Social Change*, **90**, 410-419 (2015).
20. R. Zhang and J. Liu, "On the Core Competence of Chinese Manufacturing Industry under the New Formats of "Internet Plus"—A Case Study on Furniture Industry," *Journal of Service Science and Management*, **8**, 6, 886-893 (2015).
21. L. J. Zane and D. M. DeCarolis, "Social networks and the acquisition of resources by technology-based new ventures," *Journal of Small Business and Entrepreneurship*, **28**, 3, 203-221 (2016).
22. E. M. Mendigorri, T. G. Valderrama and V. R. Cornejo, "Measuring the effectiveness of R & D activities", *Management Decision*, **54**, 2, 321-362 (2016).
23. Organisation for Economic Co-Operation and Development, (OECD in Figure: Statistics on the Member Countries, OECD Publishing, 2005).
24. X. Lin and H. Tang, "A Framework for Human Resource Configurations in Knowledge-intensive Organizations", *International Journal of Business Administration*, **7**, 1, (2016).
25. A. M. Subramanian and P. Soh, "An empirical examination of the science-technology relationship in the biotechnology industry", *Journal of Engineering and Technology Management*, **27**, 3-4, 160-171 (2010).
26. A. Pérez-Luño and J. Cambra, "Listen to the market: Do its complexity and signals make companies more innovative?", *Technovation*, **33**, 6-7, 180-192 (2013).
27. M. Allarakhia and S. Walsh, "Managing knowledge assets under conditions of radical change: The case of the pharmaceutical industry", *Technovation*, **31**, 2-3, 105-117 (2011).

APPENDIX

Table A: Technology Attractiveness

Item	Keyword	Bio Pro Resource Sdn. Bhd.		Phyto Biznet Sdn. Bhd.	
		Appearances	Rank	Appearances	Rank
Market potential	Essential/important/technology	10	5	35	5
	Product variety	48	5	74	4
	Customer satisfaction	2	5	2	4
TOTAL			15		13
AVERAGE			5		4.3
Competition situation	Competitors	3	1	3	3
	Competitor involve/compete	3	1	1	4
	Innovation	1	5	2	5
	Quality	10	5	7	5
	Barrier to copy	1	5	2	4
	Customer loyalty	3	5	6	4
TOTAL			22		25
AVERAGE			3.67		4.17
Technical potential	Novelty	7	5	7	5
	Potential	3	5	2	4
	Performance/improve	4	5	2	4
	Threat from competitor	6	5	2	4
	Technology transfer	1	1	2	4
TOTAL			21		21
AVERAGE			4.2		4.2
Socio-political situation	Technology acceptance/trust	5	4	1	4
	Difficult obtain/new technology	6	4	4	2
TOTAL			8		6
AVERAGE			4		3

Table B: Technology Competitiveness

Item	Keywords	Bio Pro Resource Sdn.Bhd.		Phyto Biznet Sdn.Bhd.	
		Appearances	Rank	Appearances	Rank
Technological resources	Development capability	4	5	15	4
	Enhance/operate better	14	5	5	5
	Experience	7	5	5	4
	Protection/ patent	7	5	2	4
	Expertise/ R&D	6	5	4	4
	Competencies fundamental research	4	5	9	4
	Competencies applied research	4	5	9	4
	Development of competent team	4	5	3	5
	Technological knowledge	12	5	2	4
TOTAL			45		38
AVERAGE			5		4.2
Complementary resources	Capability/ science and technology	5	5	5	5
	Financing	4	4	3	4
	Relationship R&D and production	6	5	8	5
	R&D and marketing	6	5	8	5
	Imitation/ protection	8	5	5	4
	Design/ acceptance/ quality	29	5	7	4
	Speed/ industrialize/ market	21	5	15	4
TOTAL			34		31
AVERAGE			4.86		4.43