Technology Assessment Need: **Review on Attractiveness and Competitiveness**

Siti Salwa Sait, Farrah Merlinda Muharam, Thoo Ai Chin and Zuraidah Sulaiman

Faculty of Management, Universiti Teknologi Malaysia, Skudai Johor, Malaysia

Email: merlinda@utm.my

**Abstract.** Technology assessment is crucial in managing technology for the purpose of technology exploitation. With business environment continuously changing, firms have to address this issue critically as technology is considered one of the important elements to evaluate performance and gain competitive advantage. Missteps in deciding the best technology to be developed, employed or maintained would cost the firm overall value. To fulfill the need of finding the appropriate scale to assess suitable technology, this paper summarizes that technology assessment should cover two main aspects, namely technology attractiveness and competitiveness. These components are seen capable to link the scale suggested towards evaluation of financial and non-financial performance towards competitive advantage.

Keywords: technology assessment, technology attractiveness, technology competitiveness, firms’ performance, competitive advantage.

**1. 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 in 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, problem occurs when managers failed to assess the implementation of technology that eventually will be affected 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 performance.

The problem above struck debate on what is the effective measurement for organizational to decide on the technology exploitation\(^{(4)}\). Most measurement circulated on financial indicator yet non-financial indicators also important because it lead to be more action and future oriented in order to improve organization’s technology capabilities in terms of planning and strategy implementation\(^{(5)}\).
The purpose of this review is to identify and propose a suitable measurement of technology that able to access the relevancy of technology towards financial and non-financial performance towards creation of competitive advantage. It is essential as this field is newly emerging discipline that gained focus recently [6]. Besides giving insights to technology based firms on the measurement criteria of technology, the review aims to provide framework for researchers to handle the issue of TA towards firms’ performance and gaining competitive advantage.

2. Technology assessment towards firms’ performance and competitive advantage

2.1. 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 [7]. The indicators assist organization’s objectives in finding 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 strong 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 SMEs [8,9,10]. 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 [11,12]. As growth covers market-share growth, assets growth, net revenue growth, net income growth and number of employee growth [4], it has great influence on profitability ratios.

Another financial indicator is 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 positive image in the society.

2.2. 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 [13] 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 [14,15,16] is 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. As to date, his works are cited by numerous researchers who have the same interest and philosophy as his. Some of them are Padovani & Carvalho (2016), Nagano, Stefanovits & Guimaraes (2014, 2016), Dutra, Ribeiro & Carvalho (2016) and Shin, Coh & Lee (2013).

Jolly [16] 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 behaviour and it is within firm’s control\textsuperscript{[16]}. Based on the author’s early publication\textsuperscript{[14]}, 16 indicators are used for depicting technological competitiveness and another 16 are being used for describing technological attractiveness.

2.2.1. Technology Attractiveness
Technology attractiveness depends more on the firms external features\textsuperscript{[16]}. The 16 indicators are being divided into four elements which are market potential, competitive situation, and technical potential and socio-political situation\textsuperscript{[14]}.

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\textsuperscript{[17]}. Thus, choosing an appropriate of technology is the most important part 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\textsuperscript{[16]}. 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\textsuperscript{[16]} in order to invent an initiative to enhance value creation\textsuperscript{[19]}. There are six criteria need to be adopted for assessing competitiveness: number of competition, 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 competitive technologies, the threat of substitute technologies, and the potential for unit-to-unit transfer.

Finally, the scale provided by Jolly\textsuperscript{[16]} 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 able to gain public support in term of financial\textsuperscript{[20]}. Based on these, the research will adopt attractiveness scale of technology by Jolly\textsuperscript{[16]} as summarized in the Table 1 below.

| Environmental factors over which the company has a weak control |
|---------------------------------------------------------------|
| **Market potential**                                           |
| Market Volume opened by technology                             |
| Span of applications opened by technology                      |
| Market sensitivity to technical factors                        |
| **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                                 |
2.2.2. Technology Competitiveness

Technology competitiveness evaluate internal features of a firm through 16 indicators which are grouped into value of technological resources and value of complementary resources\cite{14,16}.

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\cite{16}.

The second criterion includes 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 \cite{21}, applying appropriate technology to the core business is really important since it will directly give 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.

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

The fourth criterion 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 \cite{22}. Firms are considered to gain competitive advantage since their invention on 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. Mulero Mendigorri, García Valderrama and Rodríguez Cornejo \cite{23} 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 highlight about the selection either applied research or fundamental research that will be more expensive to develop a technology \cite{24,16} while the eighth criterion which is the development of team competencies. This is considered as most crucial part since it will show the successful of a technology\cite{16}.

Lastly is diffusion of technological knowledge in the firm. A firm must have a knowledge and capacity on handling technology. Lin and Tang \cite{25} supported that knowledge is very important to improve intellectual capital to gain effectiveness in organizational performance.

Meanwhile, complementary resources are similarly important as technology resources. There are seven criteria embedded under this factor. The first criterion is the capability to keep up with fundamental science and technique (S&T). 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\cite{26}.

The second criterion is capacity of a firm to finance technology development. In this notion, R&D manager should be able to convince the financial manager that certain technology is able to attract and develop financing capability\cite{16}.

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 need. Pérez-Luño & Cambra \cite{27} found the company that constantly adopt an incremental innovation would be able to connect with the requirement of customer yet it will create competitive advantages which lead to the fourth criterion.

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 \cite{16}. The fifth criteria of complementary resources is 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
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\cite{16}.

The final criteria are more prone to timing factor. According to Khalil and Shankar\cite{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 attractiveness is presented in the following table.

Table 2: Two elements of technology competitiveness (Adapted from Jolly\cite{16})

| Internal factors over which the company can exert a strong control |
|---------------------------------------------------------------|
| **Technological resources** | Origin of assets |
|                               | Relatedness to the core business |
|                               | Experience accumulated in the field |
|                               | Registered patents |
|                               | Value of laboratories and equipment |
|                               | Fundamental research term competencies |
|                               | Applied research term competencies |
|                               | Development team competencies |
|                               | Diffusion in the enterprise |
| **Complementary resources** | Capability to keep up with fundamental S&T knowledge |
|                               | Financing capacity |
|                               | Quality of relationship between R&D & Production |
|                               | Quality of relationship between R&D & Marketing |
|                               | Capacity to protect against imitation |
|                               | Market reaction to the company’s design |
|                               | Timetable relative to competition |

3. Conclusion

The review above highlights the importance of understanding how certain criteria are really important in TA. The scale developed by Jolly\cite{14,15,16} is seen as the most appropriate scale that relates TA towards evaluating firms’ performance towards competitive advantage. Taking consideration of technology life cycle (S-curve), this scale is seen capable in addressing continuous TA needs at any stage of the life with specific proposed relationship of both elements of scale towards financial and non-financial performance.

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