TECHNOLOGICAL CAPABILITY ASSESSMENT PROCESS: A PERSPECTIVE

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ABSTRACT

Technological capability comprises of the soft aspect (intangible), which is the skills, knowledge and experience, the hard aspect, which refers to systems, machines and equipments (tangible) and also the organizational alignment that provide the basis for competitive advantage by enabling organizations to reshape their skills and structures. Literally, technological capability is the ability of firms to undertake a set range of productive tasks aimed at improving their ability to operate specific functions and compete in specific markets and industries. Despite the importance of technological capability, there is still a scarcity of research on the integration of technological capability into the performance measurement system in order to quantify the causal impact of technological capability on the business performance. Existing methodologies, concepts, models, tools and techniques do not provide rigorous tools to allow managers to make investment decisions to enhance their technological capabilities whilst maximising its impact on business performance. This paper describes the development of an assessment model for assessing the impact of technological capability on the performance of a firm. The assessment model has two related objectives, which are: to lead the technological capability improvements and technological determination on the processes and to map the as is and should be of technological capability in relation to the performance of the firm.

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1. INTRODUCTION

In a modern world, organizations rely on using their performance measurement systems to excel in managing the performance of their business. Performance measurement systems need to be holistic and be able to measure what is managed. Moreover, in order for organizations to maintain and improve their competitive advantages, performance measures are widely used to evaluate, control and improve business processes (Ghalayani and Noble, 1996). However, recent studies indicate that traditional financial performance measures. Ghalayani and Noble (1996) identified, eight general limitations of traditional measures which are, they are based on a traditional cost management system, use lagging metrics, are not incorporated into strategy, are difficult to implement in practice and tend to be inflexible and fragmented, contradict accepted continuous improvement thinking and neglect customers requirements (Ghalayani and Noble, 1996).

As a result, various integrated and multidimensional performance measurement systems have been developed. The new performance measurement systems are those that emphasize self-assessment and those designed to help manager's measure and improve business processes. A common theme in the newer integrated performance models has been a determined attempt to tie performance metrics more closely to a firm's strategy and long-term vision (Wongrassamee et. el., 2003). It strives to align the organizational process with corporate strategy using both performance drivers and outcomes measures (Bremser et. al., 2004). Inappropriate measures lead to actions incongruent with strategies, however well formulated and communicated. Appropriate measures should provide and strengthen this link and both lead to attainment of strategic goals and impact on the goals and strategies needed to achieve them (Amaratunga et. al., 2001).

According to the balanced scorecard model, (Kaplan and Norton, 1996), by learning and innovation, organization will improve its abilities that will facilitate a better performance in internal processes, increasing the efficiency and effectiveness and productivity. As a result, it will fulfil customers' requirements and enhance customers' satisfaction and will result a better financial performance. One of the approaches of achieving it is by the technological approach. As agreed by various authors, technological capability enhancement is a learning process (Okejiri 2000, Figueiredo 2002, Costa, Queiroz, 2002, Archibugi, Coco 2004). Furthermore innovation is part of technological capability (Figueiredo 2002). Kaplan and Norton (1996) also note that the measures for the learning and growth is less developed compare to the financial measures, customers satisfaction measures and also in internal business processes measures (Kaplan and Norton, 1996). Thus, developing the measures for learning and growth is essential.

At the early stage of this research, numerous methodologies, frameworks, models have been proposed in recent years, to assess performance, which based on their own views of organizational performance, particularly in the literature of performance measurement, management of technology, knowledge management, and strategic management. All of them are adding value in their own right. Indeed, there has been much effort among scholars and practitioners to understanding technological capabilities, but very little progress has been paid on integrating technological capabilities into performance management system. Moreover, we still know very little about deployment of technological capabilities on the business processes and the causal effect on performance. The lack of such information represents a gap in our knowledge of technological capability. As continuing the study in technological capability, *this paper attempts to develop an assessment methodology of technological capability in operate processes to lead the technological capability improvements and technological determination on the processes and to map the as is and should be of technological capability in relation to the performance of the firm.*

2. BACKGROUND

2.1 Technological capability: Towards a definition

There has been a gradual increase in technological capabilities researches, which are complimenting to each other. A wide range of issues has been investigated including the definitions of technological capability, classifications of technological capability, assessment models on technological capability and also the determinants of technological

capability.

Technological capability has been defined in numerous and varying approaches. It comprises:

The ability to make effective use of technological knowledge (Kim, 1999).

The knowledge and skills required to identify, appraise, utilise and develop technologies and techniques (Arca, 2000).

The skills, technical knowledge and organizational coherence required to utilise a given technology efficiency, and accomplish any process of technological change (Lall, 1992).

The skills, knowledge and experience required for a firm to achieve technological change at different levels (Costa, Queiroz, 2002).

The knowledge and skills required for firm to choose, install, operate, maintain, adapt, improve and develop technologies (Madanmohan et. al., 2003).

The skills, knowledge and organization needed to absorb, reproduce, adapt and improve new technologies (Caniels and Romijn, 2003).

A set of functional abilities, reflected in the firm's performance through various technological activities and whose ultimate purpose is firm level value management by developing difficult to copy organizational abilities (Panda and Ramanathan, 1995).

The ability of a firm to transform inputs into outputs (Fransman, 1984).

The operational of the transformation process by regarding technological capability as the ability of a firm to use the resources to combine/recombine components, linkages between components, methods, processes and techniques and underpinning core concepts to offer products (Afuah, 2002).

The ability of firm to undertake a set range of productive tasks aims improving their ability to operate specific functions and compete in specific markets and industries (Lynskey, 1999).

The specific capacity of the research and development (R&D) related resources to create performance (Praest, 1998).

After reviewing the definitions, it became apparent that, having high technology solely does not guarantee profitability. The increase in hardware capacity must go hand in hand with the development of local skills and knowledge to effectively assimilate technology, adapt, improve and ultimately create new technology locally. Further more, management's ability to engage and operationalise these two aspects and create an environment to maximise the utilisation of the soft and hard aspects are nevertheless important. Therefore, we define technological capability as the soft (comprises the skills, knowledge and experience), hard (machines, equipments, systems, procedure) and also the organizational alignment that define a firm's ability to effectively and efficiently leverage its technological resources to create competitive advantage. Figure 1. explains our definition of technological capability.

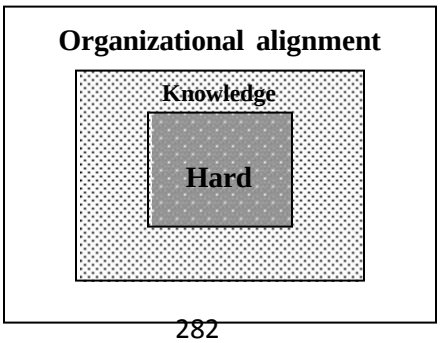

Figure 1. Definitions of technological capability: hard, soft aspect and organizational alignment

When reviewing the definitions of technological capability, it became apparent that technological capability is intangible. In fact some of the authors use proxies to measure technological capability development (Acha, 2000). It also involves the organizational learning aspect. Organizational learning is concerned with improving the behaviour and capability of individuals so that the organization can more effectively respond to the environment. One major question then arises, *would there be any causal connections between technological capability and performance of a firm?*

The measurement system should make the relationships (hypotheses) among objectives (and measures) in the various perspectives explicit so that they can be managed and validated (Kaplan and Norton, 1996). We choose the balanced scorecard model to explain the cause and effect of technological capability to performance. The selection is based on the definitions of technological capabilities that best fit in the learning and growth perspectives.

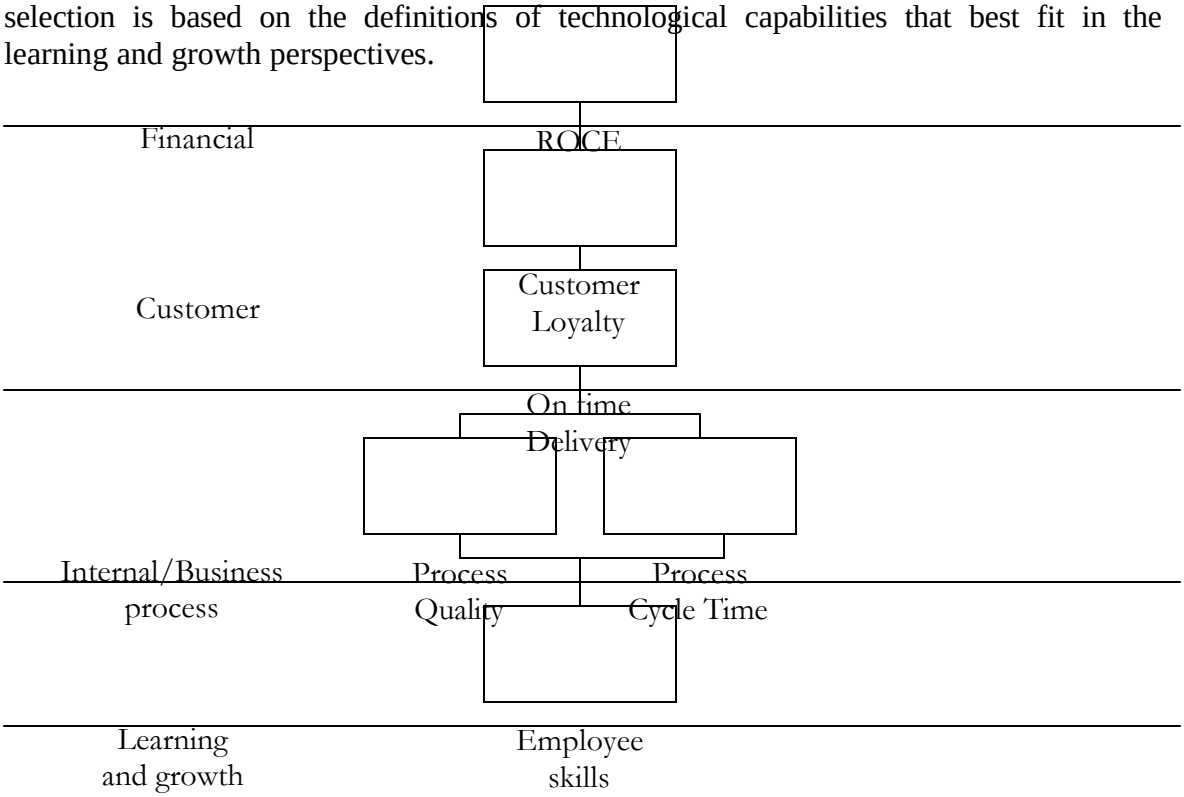

Figure 2. Strategy maps
Source: Kaplan and Norton, 1996

According to the balanced scorecard model (Kaplan and Norton, 1996), return on capital employed (ROCE) may be a scorecard measure in the financial perspective. Customer loyalty has a strong influence on ROCE and is achieved by the on time delivery (OTD). The process continues by asking what internal processes must the company excel at to achieve exceptional on time delivery. To achieve improve OTD the

business may need to achieve short cycle times in operating processes and high quality internal processes. And how do organizations improve the quality and reduce cycle times of their internal processes? Ultimately, the ability to meet the ambitious targets for

financial, customers and internal business process objectives depends on the organizational capabilities for learning and growth (Kaplan and Norton, 1996).

From the literature, we deduce the learning and growth perspective into seven generic drivers, which represent the definition of techno logical capability (TC) which are skill, experience, knowledge (soft), systems, procedures and machines (hard) and also the organizational alignment.

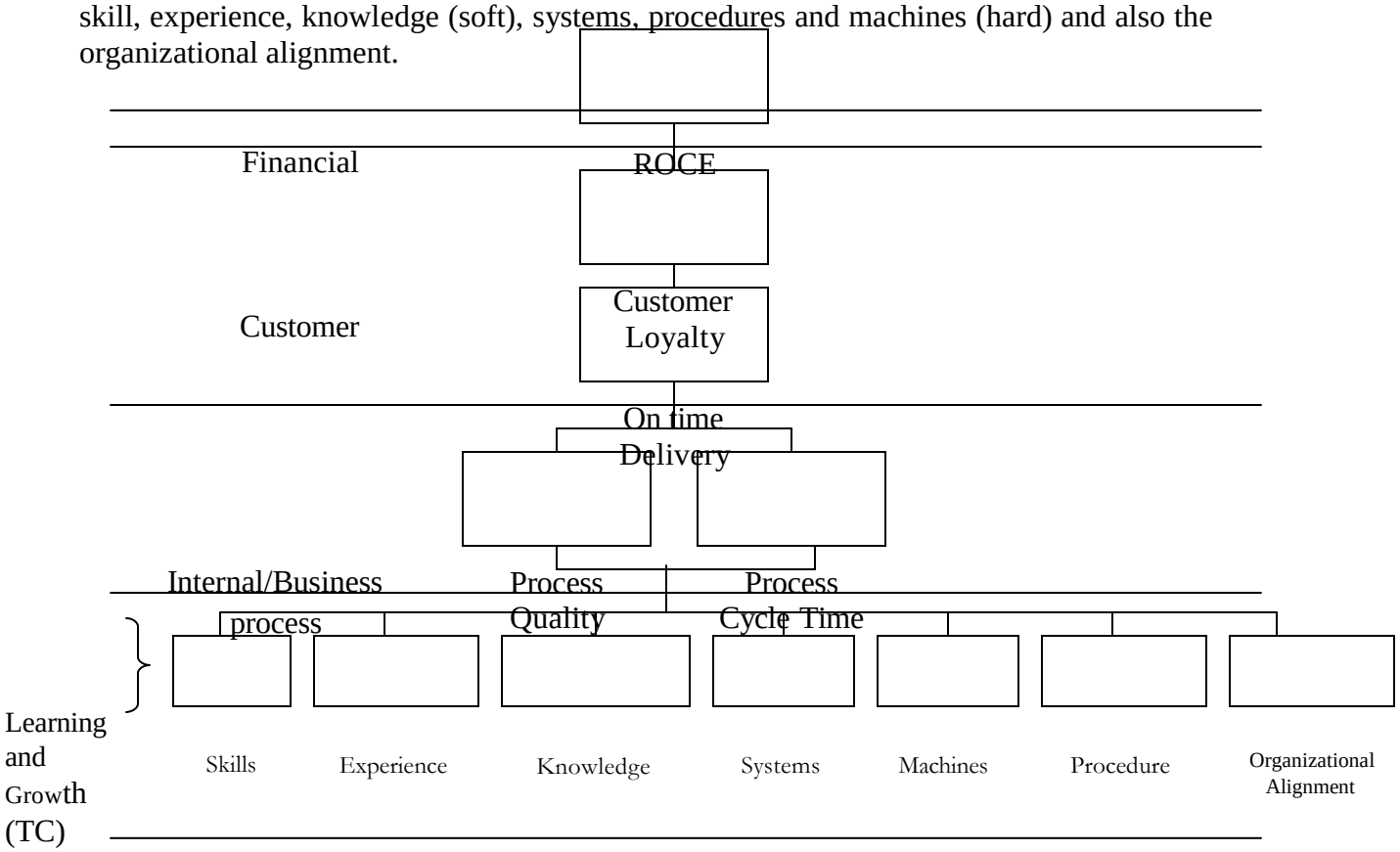

Figure 3. Cause and effects of technological capability in the strategy maps

2.2 Classifications of technological capability

Earlier works have also contributed to the classification of technological capability as follows:

Investment capability (identify, prepare, obtain technology for design, construct, equip, staff and commission a new facility), production capability (quality control, operation, and maintenance to more advanced ones such as adaptation and linkage capabilities (skills and technology to and receive them from, component or raw materials suppliers, subcontractors, consultants, service firms, and technology institutions) (Lall, 1992).

Experience capability, budget capability, equipment capability, output capability, information capability and management capability (Lin, 1997).

Functional capabilities, which facilitate activities in the productive level, There are three kinds of functional technological capability:

- *Operational* related to an efficient performance of productive activities; they encompass skills, knowledge and experience to search, acquire,

assimilate, use, master and make minor adaptation of important product and process technologies;

- *Improvement* capabilities are skills and knowledge associated with major creative imitation of technologies adopted, that is the firm's ability to improve upon technologies developed by external agents;
- *Generative* capabilities are characterized by technological creative skills and knowledge.

Meta technological capability, which facilitate the dynamic of the knowledge accumulation itself. There are two meta technological capability which are::

- *Learning*- knowledge in managing the learning process, there fore it is required through the learning process itself, *interacting*- is associated with abilities to interact and exchange knowledge with external agents and so it is accumulated through the interaction itself.
- *Monitoring*- the skills and knowledge required to identify, localize and keep abreast of relevant knowledge in the technological fields related to a firm's activities. (Costa, Queiroz, 1999).

In contrast, Kumar et. al (1999) classify technological capability as investment capability, operational capabilities and dynamic learning capabilities involved in the technology transfer process.

Investment capabilities are the skills and information needed to identify feasible investment projects, locate and purchase suitable technologies, design and engineer the plant and manage the construction, commissioning and start up.

Operational capability generally consists of the skills and information needed to operate, maintain, repair and adapt the technology for increased production and efficiency.

Dynamic learning capability consists of the skills and information needed to generate dynamic technical and organizational changes and to manage the changes (Kumar et. al., 1999)

Panda and Ramanathan (1996 and 1997) classify technological capability into three major classifications, which are;

Strategic technological capabilities, comprises creation, design and engineering and construction capabilities,

Tactical technological capabilities, includes production, marketing and selling and servicing capabilities

Supplementary technological capabilities consist of acquiring and supportive capability (Panda and Ramanthan, 1996, 1997).

Having reviewed the classifications, the relevancy of the classifications are significant to business process which comprises of manage process, operate process and support process. Consequently, the capabilities are associated with the technologies used in different business. Figure 4. indicates the architecture of a business process.

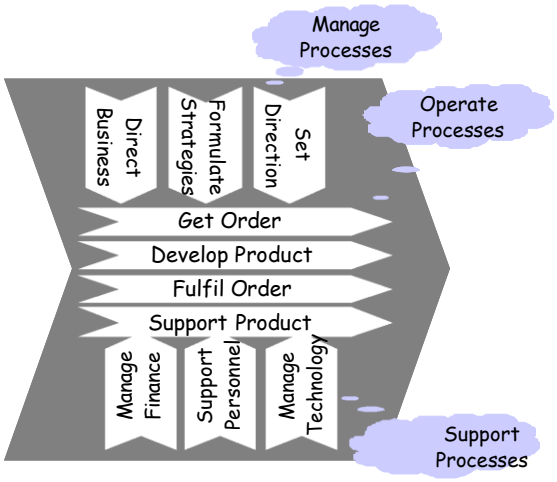

Figure 4. Architecture of a business process
Source : Bititci and Turner, 1999

According to this architecture, value is created through operate-processes, which are supported by support-processes and managed by manage-processes.

2.3 Determinants of technological capability

Researchers have also identified the factors, which influence the enhancing of technological capability of a firm. Those factors are R&D investment, planning and control, technical personnel, training programs, market orientation, government support, national technology infrastructure and mode of transfer (Madanmohan et. al., 2003), collaborations among firms (Lynskey, 1999), general education, formal education, working experience, internal efforts to assimilate and improve products, search for new technological information, external technical assistance and age of firm (Romijn, 1997).

2.4 Assessment of technological capability

There are several methods, frameworks, and models on assessing technological capability. Some of the examples are through benchmarking process (Panda and Ramanthan, 1996), using indirect measures (proxies) (Archa, 2000), technological capability indexes (Archibugi, Coco,2004, Haq, 1985) and also direct measures ((Panda and Ramanthan, 1996, Prencipe, 2000; Lin, 1997) . But, despite a volume of research undertaken, there is scarcity of research on impact on overall performance (Kuen, 2003).

Arguably, if firms do not know the impact of technological capabilities on performance, it is very difficult for them to align technological capabilities with their corporate and functional objectives. Thus, an assessment of technological capability is essential. Furthermore, the assessment output provides the effectiveness of using resources; ability to effectively import technology, enable products and processes to be changed in order to suit local and in the case of exports and external conditions (Fransman, 1984). It also assesses a firm's ability to:

Identify its technological needs and to select the technological needs and to select the technology to fulfil the need,

Operate, maintain, modify and improve the selected technology and
Promote technical learning (Kumar et. al.,1999).

Panda and Ramanthan (1996) suggest a five step approach in conducting technological capability assessment which are:

Identification of value addition stages

Identification of the technological capability needed to perform the necessary value addition

Development of a set of indicators for assessing each technological capability

Bench marking of technological capability of the firm for the state-of-the art company finding the existing level of technological capability

Determination of the gaps in technological capability (Panda and Ramanathan, 1996)

2.5 Technological capability vs. performance management

One of the important issues in any assessment is the measure used. Measures and measurement system should derive directly from the strategic planning and implementation process (Mc Adam R. and Bailie Brian, 2002). Despite the numbers of work that had been carried out in the area of technological capability, there is still a scarce incorporating activity between technological capability and the whole system of a business. *But how can it be done*?

Before that, we need to understand a few terminologies in the area of performance management. According to Bititci et. al., (1997), performance management process is the process by which a firm manages its performance in line with its corporate and functional strategies and objectives. The objective is to provide a proactive closed loop control system, where the corporate and functional strategies are deployed to all business processes, activities, tasks and personnel and feedback is obtained through performance measurement system to enable appropriate management decision (Bititci et. el, 1997).

Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of past action (Neely et.al., 2002). A performance measure is a parameter used to quantify the efficiency and/or effectiveness of past action (Neely et. al., 2002). A performance measurement system enables informed decisions to be made and actions to be taken because it quantifies the efficiency and effectiveness of past actions through the acquisition, collation, sorting, analysis and interpretation of appropriate data (Neely et. al. 2002).

Performance measurement system is vital in companies to:

Monitor performance

Identify areas that need attention

Enhance motivation

Improve communication and

Strengthening accountability (Waggoner et. al., 1999).

Bititci et. al., (1997) suggest two considerations to be taken into account in the structure of performance measurement system which are the integrity - the ability of performance measurement system to promote integration between various areas of business and the deployment – deployment of business objectives and policies throughout the hierarchical structure of the organization. Bititci, (2000), also suggests the need for

performance measurement system to be dynamic to reflect changes in the internal and external environments. There is a need for a dynamic approach to performance measurement and the use of varieties of short-term measures, proactively to change

system and behaviour rather than simply or minor or problem solving tools (Gregory 1993).

Consequently, Neely (1999) explains seven important reasons for lots amount of interest in performance measurement systems, namely the changing nature of work; increasing competition; specific improvement initiatives; national and international awards; changing organizational roles; changing external demands; and the power of information technology.

2.6 Conclusions

Based on the literature review, we can draw three important conclusions as follows:

i) Technological capability can be incorporated into the performance measurement system. Based on the definitions that we constructed, it fits most into the learning and growth perspectives in the balanced scorecard.

ii) The assessment of technological capability will be on operate processes where it involves most of the technologies and also it creates value for competitive advantage.

iii) The output of the assessment of technological capability is an input in strategic planning and enables appropriate decision making by providing a quantitative measures. Thus, a better approach in monitoring the enhancement of technological capability can be carried out.

3. ASSESSMENT METHODOLOGY OF TECHNOLOGICAL CAPABILITY

Taking into account the three conclusions and also the activities in the operate processes; some of the earlier suggestions of conducting an assessment of technological capability are adopted. We believe that, if technological capability assessment is carried out, technological capability improvements will be taken place. This leads to a better performance in the business processes. This leads to a better customer perspective and also better financial perspectives. Furthermore, the gaps of the target technological capability will be determined. This leads to an efficient improvements in technological capability and have a quantitative impact on business process performance. A conceptual framework of the assessment methodology has been developed as figure 5..

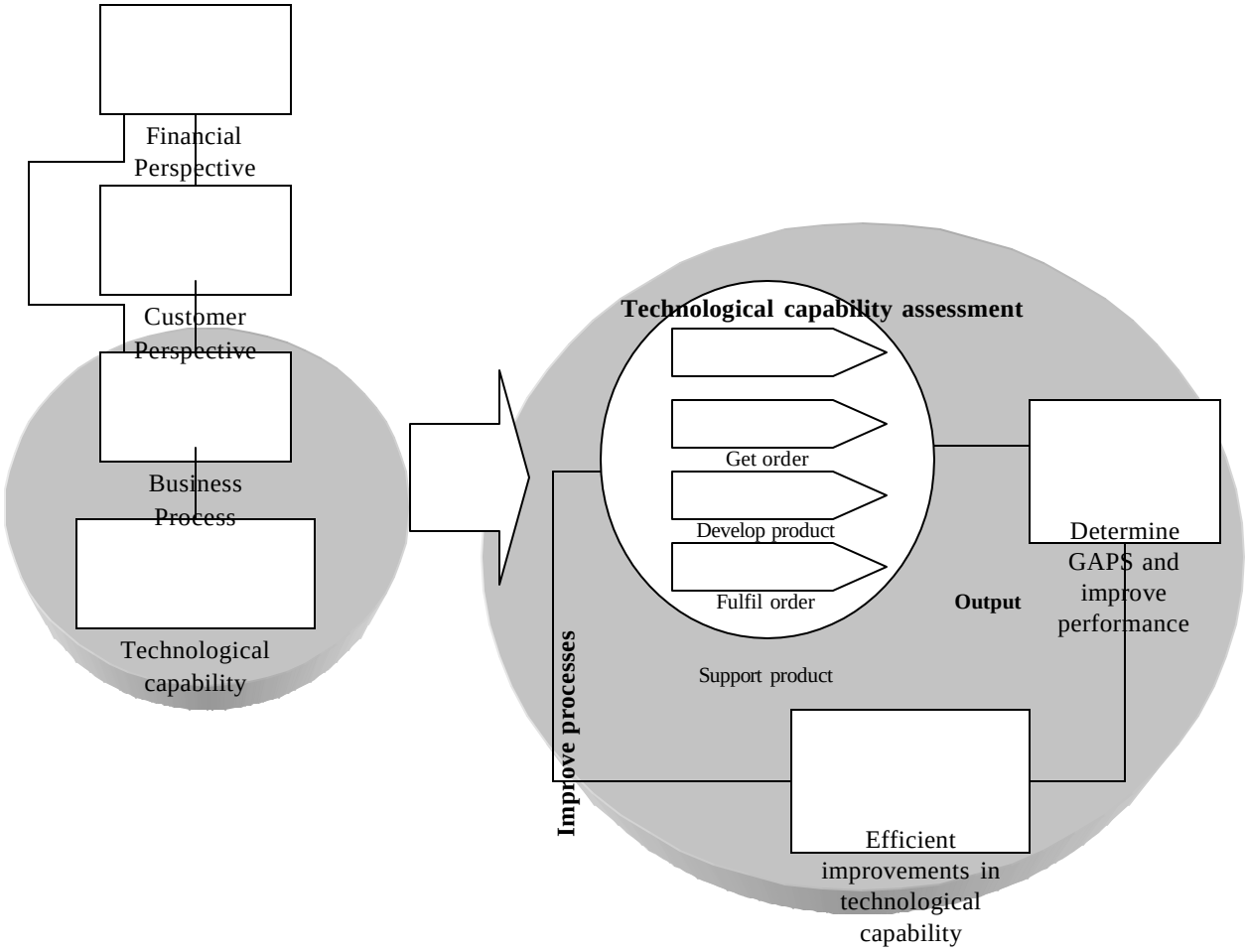

Figure 5.: The assessment methodology framework

The assessment methodology approach has six steps as follows:

- **Identify technology requirements**
  The technology requirements of a company are based on the classification of the company's operation. (Engineer to stock (ETO), Manufacture to stock (MTS) and manufacture to order (MTO). Score model will be used as a reference for each classification.
- **Priories the technology requirements**
  The technology requirements will be prioritised according to their needs which are: critical needs, importance and nice to have.
- **i) Assess Gap in technological capability for each technology for now**
  The gap for current technological capability will be assess to a 1-5 likert scale.
  ii) Assess Gap in technological capability for each technology for future
  The gap for future technological capability will be assess to a 1-5 likert scale.
- **Identify the reasons behind the gaps**
  Reasons for each of the gap will be established.

- **Establish current and future consequences for not fulfilling the gap on business performance**
  The consequences on the business performance will be illustrated using a strategy map.
- **Prioritise the GAPS**
  The technological capabilities gaps will be prioritise using the AHP technique.

4. CONCLUSION

The output of the assessment illustrates the causal connections between performance of a firm and it's technological capability. It leads to the technological capability improvements and technological determination on the processes and to map the as is and should be of technological capability in relation to the performance of the firm. As a result, it allows managers to make investment decisions to enhance their technological capabilities whilst maximising its impact on business performance.

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