TECHNOLOGY STRATEGY IN

INDUSTRIAL AUTOMATION INDUSTRY

By

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ABSTRAK

Pelan Induk Perindustrian Kedua (IMP2) telah mengenal pasti automasi perindustrian sebagai salah satu kumpulan industri penting untuk mentransformasikan sektor perkilangan Malaysia ke sektor yang berdaya saing di peringkat antarabangsa. Penggunaan automasi meningkatkan daya bersaing para pekilang dari aspek kualiti dan kos operasi. Ini akan mengalih seluruh rantaian nilai ke tahap yang lebih tinggi, terutamanya menerusi peningkatan produktiviti. Dalam pada itu, IMP2 telah menekankan Pembangunan Perindustrian Berdasarkan Kelompok untuk memfokuskan pembangunan kelompok industri melalui integrasi dalam industri utama termasuk industri sokongan. Kejayaan industri sokongan ini, termasuk automasi perindustrian, akan menghasilkan rantaian ke depan dan ke belakang yang akhirnya akan memperkuatkan daya bersaing sektor perkilangan dan gugusan industri. Sayangnya, tidak banyak kajian empirik dibuat ke atas faktor pengaruh kejayaan syarikat automasi. Kajian ini bertujuan untuk menentukan kesan strategi teknologi dan pengagihan sumber terhadap prestasi syarikat automasi dalam aspek peningkatan pendapatan. Keputusan empirik ini berdasarkan 61 buah syarikat automasi tempatan. Kesan strategi teknologi, dalam aspek pemilihan teknologi, kecekapan teknologi, dan corak teknologi, terhadap peningkatan pendapatan dikaji dengan teliti. Pemilihan teknologi didapati adalah penentu positif terhadap peningkatan pendapatan pada aras keertian 5%. Kecekapan teknologi didapati adalah penentu positif terhadap peningkatan pendapatan pada aras keertian 10%. Tetapi corak teknologi didapati adalah penentu negatif terhadap peningkatan pendapatan pada aras keertian 5%. Pengagihan sumber mungkin menyederhanakan hubungan ini. Hanya pengagihan sumber kewangan didapati menyederhanakan kesan pemilihan teknologi dan corak teknologi ke atas peningkatan pendapatan pada aras keertan 5%.

ABSTRACT

The Second Industrial Master Plan (IMP2) had identified industrial automation as one of the key industry group to transform Malaysia's manufacturing sector into an internationally competitive sector. The utilization of automation helps to improve manufacturers' competitiveness in terms of quality and operating costs, thus shifting the whole value chain to a higher level especially through productivity growth. In addition, IMP2 has emphasized the Cluster-based Industrial Development that focuses on the development of competitive industry clusters through integration of key industries including those supporting industries. The success of these supporting industries, as well as industrial automation, will generate effective and efficient backward and forward linkages that ultimately will help in enhancing the competitiveness of the manufacturing sectors and the industry clusters. Unfortunately, there is lack of empirical studies on the factors that affect the success of an automation firm. This research was undertaken to study the firm performance, in terms of revenue growth, in this industry in relations to technology strategy and resource deployment. The empirical result is based on 61 Malaysian automation firms. Impact of technology strategy in terms of technology selection, technology competence, and technology posture on revenue growth were diligently studied. Technology selection is identified to be a positive predictor towards revenue growth at 5% significance level. Technology competence is only a predictor at 10% significance level. However, technology posture is found to be a negative predictor towards revenue growth. Resource deployment is thought to moderate the relationships. Only financial resources deployment was identified to moderate on technology selection and technology posture with respect to revenue growth at 5% significance level.

Chapter 1

INTRODUCTION

1.1 Industrial Automation

In primitive societies, production was achieved by manual labor and the economy was agriculture. The Industrial Revolution and the introduction of steam power in the 1800s created a major transformation in the way people live and do business. The factory system was born and mass production become dominant. Workers now no longer worked individually in small shops but assembled in one place to develop products. Besides, great strides were made in the development of mechanization, which served as a technology preceding industrial automation (Dorf & Bishop, 1995).

Since the Industrial Revolution, many production technologies had been introduced and evolved to improve the production efficiency, thus reducing the production costs. In the late 1800s, Frederick Taylor introduced the concept of standard time with the scientific approach to raise productivity (Barnes, 1967). Frank and Lillian Gilbreth introduced motion study in the early 1900s (Gilbreth, 1911; Niebel 1988). They advocated reducing redundant movements and finding the best way to do a job. Henry Ford introduced the assembly line and specialization of workers in the early 1900s to increase production efficiency. The concepts of the assembly line and economies of scale were thus born, and are still in use in modern industry until today with advances in technology and in the marketplace (Khalil, 2000).

Industrialization had created wealth and improved the quality of life in industrialized countries. These resulted in rising wages and inflationary costs. Thus, the concept of industrial automation and automatic machines had been introduced in

1960s (Turner, Mize, Case & Nazmetz, 1993) to increase the production of a plant per worker in order to offset the rising costs.

The term automation first became popular in the automobile industry. Transfer lines were coupled with automatic machine tools to create long machinery lines that could produce engine parts virtually without operator intervention (Dorf & Bishop, 1995). The concept of industrial automation is now widely extended to other manufacturing industries, such as electronic and electrical products, chemicals and steel industries, for a better plant efficiency or a lower unit cost of production. This has helped firms compete with a low cost leadership strategy (Porter, 1980).

In addition, high-precision automatic machines are able to produce high quality products, which help to further improve the competitiveness of the products. Nowadays with the demand for flexible and quick change-over production emerging in the 1990s, industrial automation has moved towards flexible automation and robotics. These helped a firm improve its performance through four distinct competitive priorities – cost, quality, flexibility, and delivery (Skinner, 1978; Hayes & Wheelwright, 1979; Buffa, 1984; and Wheelwright, 1984).

Meyer et al. (1989) surveyed the literature on the production strategies pursued by the industrial organizations in the USA, Europe and Japan. They found that these countries adopted automation strategy to improve their competitiveness, which has been widely supported by literatures (Hayes & Jaykumar, 1988; Goldhar & Jelinek, 1985; Parthasarthy & Sethi, 1992). These needs are supported by industrial automation in various production lines. These firms are based in Europe, Japan and US, which have long experience and the necessary technical competence in their respective fields.

1.2 Industrial Automation in Malaysia

Since independence in 1957, Malaysia has aggressively promoted industrial development to diversify its economy which was formerly focus on agriculture. Foreign direct investment (FDI) has been the main source of technologies necessary to expedite the process through the inflow of technology, capital and expertise (Ali, 1992). From the 1980s the FDI started to increase considerably in the manufacturing sector. Looking at the important role of the manufacturing sector in boosting the economy, Malaysia introduced the Industrial Master Plan (1986-1995) in the mid-1980s to further diversify her manufacturing base (Wan Abdullah, 1994). These included giving tax incentives, building supporting infrastructures and pro-FDI government policies.

The government's efforts had generated fruitful results. The sector has experienced significant growth, which averages at more than 13% from 1987 to 1994. According to the recent introductory report of the Eighth Malaysia Plan (2001-2005), the sector grew rapidly at an average rate of 14.1% during 1996-1997 before contracting by 13.4% in 1998 due to the Asian Crisis. With the rebound in external as well as domestic demand, the sector staged a turnaround and grew by 17.2% per annum during 1999-2000 periods. As per year 2000, the manufacturing sector generated 33.4% of Malaysia Gross Domestic Product (GDP).

In view of success of the first Industrial Master Plan, the Malaysian government continued with the second Industrial Master Plan (IMP2) for 1996-2005 period. The plan charted the policies and strategies in order to transform the manufacturing sector into a resilient, broad-based and internationally competitive sector. One of the new strategies introduced, named as Manufacturing Plus-plus

Strategy, was aimed at shifting the whole value chain to a higher level through productivity growth.

The strategy clearly specified the utilization of automation/robotization as well as increasing Total Factor Productivity (TFP) with emphasis upon knowledge and capital and knowledge intensive manufacturing, the application of new technology, innovation, best management practices and a more efficient utilization of resources. Besides, machinery and equipment (industrial automation) industry has been identified in IMP2 as one of the important Eight Industry Groups. Industry Task Force has been set up to promote the further development of the industry. These indicated the government's recognition of the importance and the contribution of industrial automation in enhancing the manufacturer's competitiveness in global market.

Geographically, the manufacturing activities are mostly concentrated in a few states such as Selangor, Penang, Negeri Sembilan, Melacca and Johore. The industries range from a diversified electronics industry and supporting industries in engineering, metal, plastics and packaging for the electronic/electrical industry, to textiles/apparel industry.

In supporting the industrial automation activities of these factories, there have been a number of design firms being set-up to provide the engineering solutions. To these automation firms, technologies are their products and are sold in the form of standard machines or customized machines. Therefore, technology is always viewed as critical strategic weapon to compete with other rivals. In other words, their technology strategy is their product strategy, which greatly affects their competitiveness and firm performance.

Most of these automation solution providers are foreign companies that are well established and are highly experienced in their respective fields. However, there

are numbers of Malaysian-owned automation firms that compete intensively with both local and foreign rivals. Not all these firms are doing well in this industry. Unfortunately, the technology management in industrial automation industry is one of the fields that lack research attention both in Malaysia or abroad. Therefore, there is a need to have a more comprehensive understanding on factors that influencing the performance of an automation firm.

1.3 Technology Strategy and Resource-based Theory

Industrial automation is a technology-driven industry. There have been literatures that study factors that affect firm performance of technology-intensive companies. Researchers and academicians have generally focused on the structure-conduct-performance theory. These researches have emphasized greatly on external factors such as market conditions and competition (Porter, 1980, 1985) to link strategies to firm performance. Porter (1980) postulates that a firm may pursue superior performance by employing five market forces (threat of new entrants, rivalry within the industry, buyer power, supplier power, and threat of substitution) to select an attractive industry, or by selecting a strong competitive position within an industry; that is, become a cost leader, a differentiator, or become focused.

Technology has been viewed as the main strategic weapon to gain technological competitive advantages especially in technology-intensive industries. However, many organizations still seem to underestimate the importance of technology. Ford (1988) cited a Booz, Allen and Hamilton survey of 800 executives and found that two-thirds of them thought that their companies were doing a poor job in harnessing technology to their corporate strategies. Failure to develop and integrate technology strategy and business strategy is a major contributing factor to the decline

of a firm's competitiveness. Literatures indicated that technology strategy played an important role in determining firm performance in technology-driven industries (Cooper, 2000; Schilling & Hill, 1998; Herman 1998; Ford, 1988).

Barney (1991) perceived Porter's view of strategy to be very externally (market) oriented, dealing primarily with the opportunities and threats with which a firm must contend with. He contrasts this with an internally (resource) oriented approach to strategy. This resource-based view is termed as the Resource-Based Theory (Barney, 1991; Rumelt, Schendel, & Teece; 1991; Mahoney & Pandian, 1992) and is getting more and more popular among academic researchers and consultant companies nowadays.

The Resource-Based Theory of the firm proposes that firm's resources or capabilities serve as a competitive advantage to be utilized by the firm to pursue superior firm performance (Rumelt, Schendel, & Teece, 1991). The resource-based view holds the promise to explain intra-industry variability in performance (Wernerflet, 1984).

There has been significant conceptual development of the resource-based view but limited empirical validity. Thus, there are researches that studied the joint effect of the strategy view and resource-based view. Chen (1996) found that the effect of the firm characteristics on technology strategy is moderated by the resource capability. Cooper (2000) found three cornerstones of high performing business to be (i) having a successful roadmap, (ii) allocation of right and sufficient resources, and (iii) having a new product and technology strategy.

This research is exploring the strategic view and the resource-based view on the performance of an automation firm. Although most of the literatures that studied the relationship between technology strategy and firm performance were largely in

new electronic-product development, there should be some degree of similarities between electronic product industry and industrial automation industry as both of the industries are highly technology-driven and are selling technologies as their products.

1.4 Research Problem

Industrial automation is one of the widely used strategies by the manufacturers to improve their competitiveness, in terms of quality and operating cost. The utilization of automation shifts the whole value chain to a higher level especially through productivity growth. The Second Industrial Master Plan (IMP2) had also identified industrial automation as one of the key industry group to transform the manufacturing sector into a resilient, broad-based and internationally competitive sector. The significant role of the industrial automation thus cannot be disregarded.

In addition, IMP2 has emphasized the Cluster-based Industrial Development that focuses on the development of competitive industry clusters through integration of key industries including those supporting industries. The success of these supporting industries such as industrial automation will generate effective and efficient backward and forward linkages that ultimately will help in enhancing the competitiveness of the manufacturing sectors and the industry clusters.

Unfortunately, there is lack of empirical studies on the factors that affect the success of an automation firm. This research intends to assess the firm performance in this industry in relations to technology strategy and resources view.

1.5 Research Objectives

The objective of this research is to identify ways of strategic management (external strategic factors- technology strategy - and internal resources) that an automation firm

can formulate and implement in order to be successful in industrial automation industry. This research seeks to achieve the following objectives:

- Assess the prevalent technology strategies being employed by local automation firms
- Assess the effect of technology strategy on the success of a local automation firm, and
- Assess the moderating effect of the resource deployment in determining the success of a local automation firm.

1.6 Research Questions

Guided by the above objectives, the research seeks to answer the following questions:

(i) What are the prevalent technology strategies being employed by local automation firms?

(ii) Is technology strategy important in determining the success of a local automation firm?

(iii) Does resource deployment moderate the impact of technology strategy on the success of a local automation firm?

1.7 Scope of Research

The firms in this research will only cover the industrial automation firms that are owned by Malaysian. The unit of analysis for this research will be each individual Malaysian-owned automation firm.

There are numbers of factors that determine the success of an automation firm. They are external environmental factors (social, economic, political and technological), strategies (corporate, business and functional), organizational factors

(culture, values or norms), and resource factors. Since the unit of analysis is from the same industry, the respondents are exposed to the same technology factors. Besides, their businesses are primarily operating in the same geographical areas, that is, West Coast of Peninsular Malaysia. Therefore, they are subject to the same political and social conditions. Lastly, the main customers of these automation firms are primarily electrical and electronic factories located in free industrial zones and industrial parks. Thus, their business performance is subject to similar economic factors.

Due to these similarities, this research does not study the external environmental factors. The research strictly focuses on the perspective of technology strategy and resource deployment.

1.8 Significance of Research

Today, the International Institute for Management Development (IMD) based in Lausanne, Switzerland has ranked Malaysia at 29th in its world competitiveness scoreboard, as compared to 14th in 1997. Among the indices evaluated are trade indices and productivity indices. Therefore, the decline indicates that Malaysia has to improve its global competitiveness by further increasing its productivity and trade outputs.

As mentioned in section 1.4, IMP2 has identified the important role of industrial automation in enhancing the manufacturing competitiveness and shifting towards higher end of the value chain. This will not happened without strong and successful automation firms to support the activities. As this research focuses on the success factors of the industrial automation industry, it is useful to provide Malaysian automation firms a deeper insight towards how to achieve success.

While there are many factors that could affect firm performance, this research focuses on the technology strategy content and resources context as the variables for study. This research will show the relationships between these factors and firm performance. It is desired that the findings will assist top managers of the industry in formulating a technology strategy that is fit to his/her firm's position, with regards to the business focus and technological positions. Aligning to its technology strategy, the top managers should consider the tactical issues of resource deployment in embracing the strategy implementation. Information about key dimensions of these strategies and resource deployment will give the managers a more comprehensive understanding on importance of various aspects in leading his/her company towards long-term success.

Besides, this research will fill the gap in empirical support for the strategic management in industrial automation industry, both within Malaysia and abroad. As mentioned earlier, most of the literatures that studied the relationship between technology strategy and firm performance were largely in new electronic-product development. The factors that affect the performance of industry automation industry are unknown due to lack of empirical studies. This study will increase our understanding of the technology strategy-resource deployment-performance relationship in this industry and benchmark against findings of other technology-based industries.

1.9 Definitions of Terms

The following definitions are provided to clarify this study's use of key terms.

Industrial automation refers to the control of an industrial manufacturing process by automatic means, which consists of actuators, sensors and controlled

systems. It is a technique that can be used to reduce costs and/or to improve quality (Morriss, 1995).

Technology is the application of scientific and engineering knowledge to achieve a practical result (Roussel, Saad & Erickson, 1991). Khalil (2000) defined technology in a wider scope as all the knowledge, products, processes, tools, methods, and systems employed in the creation of goods or in providing services.

Strategy is defined as the creation of a unique and valuable long term position involving a different set of activities. A company that is strategically positioned performs different activities from rivals or performs similar activities in different ways. Strategy is creating fit among a company's activities. If there is no fit among activities, there is no distinctive strategy and little sustainability (Porter, 1996). Similarly, Hofer and Schendel (1978) viewed strategy as the match an organization makes between its internal resources and skills and the opportunities and risks created by its external environment.

Technology strategy refers to the pattern of decisions, the position relative to competitors and the perspective from which management makes decisions regarding technological activities, equipment, materials and knowledge. It sets technological goals and means for achieving goals in the business strategy (Herman, 1998).

Resources are key input factors of production of goods and services. They can be classified as physical resources, financial resources, or human resources.

Resource deployment refers to allocation and utilization of resources available in technology research and development programs.

Malaysian-owned company is defined as company that is locally incorporated and has at least 51% Malaysian equity, in accordance to IMP2.

1.10 Outline of Report

Chapter 1, the current chapter introduces the problem of the research and discusses its context. Chapter 2 will touch on the related literature, in particular the technology strategy and the resource-based theory. This is followed by a discussion of the theoretical framework, design of the study and methodological procedures in Chapter 3. The research hypotheses will be tested and the findings of the study are presented in Chapter 4. Finally, the managerial implications and the conclusion of this research are drawn in Chapter 5.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

There are a lot of studies that addresses firm performance in relation to technology strategy or the resource-based theory. This chapter reviews the facts and findings from previous studies and reports deemed most relevant to the present study.

2.2 Technology

We begin our literature review with technology. Nandakumar (2000) defines technology as the application of scientific discoveries to the production of goods and services that improve the human environment. It includes the development of new materials, machinery, and processes that improve production and solve technical problems. Zeleny (1986) highlights that a technology consists of three interdependent, codetermining and equally important components: hardware, software, and brainware or know-why. He posits that there is a fourth element that must be considered independently, namely know-how, for it encompasses all levels of technological achievements.

Ford (1988) classifies technology into three types. The first is distinctive technologies, in which the company's standing gives it a distinctive competence, whereas, basic technologies are survival technologies on which the company's operations depend and without which it would be excluded from its markets. These technologies are necessary for a company to stay in business but do not differentiate or distinguish it from its competitors. Another type is external technologies, which are supplied by other companies. These types of technologies are usually available largely

to the market. Among these, distinctive technology is what gives an organization its unique competitive advantage in the marketplace.

The role of technology in determining firm performance is undeniable. The US National Science and Technology Council (1996) reports that the performance of individual companies is strongly linked to their use of technology. However, to use technology as a competitive weapon, managers must manage it as part of the business system. Firms that do not manage technology might eventually find their future managed by technology (Levine & Yalowitz, 1983).

In fact, technological force represents one of the major key forces in strategic management, especially in high-tech industries. Although some industries may appear to be relatively technology-insensitive in terms of products and market requirements, they are not immune from the impact of technology (Levine & Yalowitz, 1983). In many cases, technological changes within industries have brought new forms of product competition (e.g., micro technologies in electronics), new marketplace (such as e-business), or have led to different competitive advantages in production costs and product quality (such as using advanced manufacturing technology). To these technology consumers, technological forces represent major opportunities and threats that must be considered in formulating competitive strategies. In acquiring the advantages of these new technologies (basic and external), a firm might rely heavily on its suppliers of the technology.

In contrast, suppliers of technology such as industrial automation firms have to continually identify technological trends and constantly develop distinctive technologies for sustainable competitive advantage. Technology is their product. To them, having an effective technology strategy is a crucial step in achieving corporate success (Schilling & Hill, 1998).

2.3 Technology Strategy

A number of researchers (e.g. Maidique & Patch, 1978; Burgelman & Rosenbloom, 1989; Stacey & Ashton, 1990; Spital & Bickford, 1992; Herman, 1998; Cooper, 2000) have studied technology strategy. Herman (1998) defines technology strategy as the pattern of decisions, the position relative to competitors and the perspective from which management makes decisions regarding technological activities, equipment, materials and knowledge. Schilling and Hill (1998) note that the purpose of technology strategy is to identify, develop, and nurture those technologies that will be crucial for the long run competitive position of the company. Similarly, Khalil (2000) states that the purpose of technology strategy is to gain sustainable technological advantage that provides a competitive edge. Ford (1988) explains that technology strategy is concerned with exploiting, developing, and maintaining the sum total of the company's knowledge and abilities.

Stacey and Ashton (1990) state that technology strategy addressed the four main elements that support the firm's basic business strategy: customers, competitive approach, investments and organizational culture. It addresses the following major issues: (i) what technologies to develop?, (ii) the cost and suitability of existing technologies with the organization and unit goals, (iii) whether or not to seek technology leadership, and (iv) how to capture economic returns.

Cooper (2000) elaborates that technology strategy consists of five elements: goals of development efforts, roles of development tied into business's overall goals, arenas of strategic focus, resource deployment across these arenas, and plan of attack for each arena. He stresses that the concept of strategic arenas is the heart of strategy, clearly specifying the focus and the direction of the technology development effort.

Closely related to the literature on technology strategy is literature related to the dimensions of technology strategy. One of the earliest conceptions of technology strategy is provided by Maidique and Patch (1978). They conceptualize technology strategy as consisting of six dimensions: type of technology, level of competence, timing of technology introductions, level of investment, organization and policies, and source of technology. Type of technology or technology selection is associated to the distinctiveness and the value of technologies that the firm specializes at. Level of competence refers to how specialize the firm is in its technologies. Timing of technology introduction equates to introducing a technology ahead of competitors. Level of investment is related to financial resource allocations whereas organization and policies are associated with implementation of strategy (Spital & Bickford, 1992). Source of technology refers to mode of technology acquisition, whether it is internal R&D, external R&D or others. These are methods or ways to pursuing technology strategies. These last three dimensions (level of investment, organization and policies, and source of technology) are greatly allied to technology management processes, which are worthy to be distinguished from technology strategy content for further evaluation of their contribution as a source of competitive advantage (Herman, 1998).

Burgelman and Rosenbloom (1989) frame the substance of technology strategy around four dimensions: competitive positioning, technology and the value chain, scope of technology strategy, and depth of technology strategy. These dimensions are pretty similar to some conceptions proposed by Maidique and Patch (1978). Competitive positioning entails technological distinctiveness and technology leadership. Technology and the value chain encompass the sourcing of value-creating technologies. Scope of technology refers to the scope of technologies actively

attended to by the firm. Depth of technology strategy is the "depth of its prowess" within the set of technologies in its portfolio.

Thereafter, most researchers derive the dimensions of technology strategy with reference to Maidique and Patch (1978), and Burgelman and Rosenbloom (1989) (Spital & Bickford, 1992; Herman, 1998).

There are different levels of strategy that may exist in a firm: corporate strategy, business strategy, functional strategy, and operating-level strategy (Thompson & Strickland, 1992). Technology strategy may be viewed in both a tactical and strategic context. Technology consumers consider technology strategy as one of the functional strategies, for the purpose of implementing business level strategies more effectively (Thomas & McGee, 1989). On the other hand, technology intensive industries view technology strategy as a driving force behind business strategy, in which technology strategy is integrated in the overall corporate and business strategy (Roussel et al., 1991).

2.4 Technology Strategy and Firm Performance

There is substantial amount of research regarding the linkage between technology strategy and firm performance, and most of them focus on new product development. Cooper and Kleinschmidt (1996) have found high correlation between a defined new product or technology strategy and firm performance. This factor is ranked second, after high-quality new product/process, as key success factor in driving business performance. There are four main ingredients of a positive new product or technology strategy, which when taken together, add up to positive performance and success of business's new product efforts. They are: defined and clear goals or objectives of projects (e.g. what sales, profits, etc. the new products will contribute to the business),

clear and well-communicated role of new products in achieving business goals, clear and defined areas of strategic focus, and long-term view of the business's new product effort. The long-term thrust is the most important of the four strategy ingredients, and significantly linked to a number of specific performance metrics. Cooper and Kleinschmidt (1996) argued that new product or technology strategy must be firmly linked to business strategy. Consequently, a clearly defined new product or technology strategy provides focus and direction of resource deployment towards achievement of business goals.

Similarly, Zahra and Covin (1993) studied the relationship between business-technology strategy and firm performance. They have found a clear correlation between business strategy-technology strategy fit and firm performance. This supports most research findings that organizations that know how to link their technology strategy with their business strategy will be more competitive in the global marketplace (Roberts, 2001; Mitchell, 1992; Frohman, 1982). In fact, there are many interdependencies between elements of business strategy and elements of technology strategy. Khalil (2000) states that the two strategies must be closely intertwined and highly integrated to focus on achieving its corporate goals and objectives, or in other words, to achieve high firm performance.

Spital and Bickford (1992) have also found that technology strategy does play an important role in determining success for firms operating in different levels of environmental dynamism. In industries with fast-changing technology, product innovation differentiation and depth of competence dominate the factors of success. They equate this to technology leadership that brings "first-to-market" advantages.

The technology strategy typology of "first-to-market" was first introduced by Ansoff and Stewart (1967). This is very similar to Porter's (1980) differentiation

strategies as differentiators can distinguish their goods from its competitors on the basis of either innovative products or advanced technology (Stacey & Ashton, 1990). Technology leaders are ahead of their key competitors in terms of technology. Since technology leader enters new product market before other competitors do, the leader has the advantage to capture a larger market share. Leaders can also protect their technology through patents and other means to prevent late entrants from competing, giving them better opportunities to fully exploit their technology. Since they establish a technology gap between their products and their customers or competitors, they are able to reap abnormal profits by charging a high price for their products (Khalil, 2000).

Herman (1998) also shows that significant relationships exist between technology strategy and technology policy and firm performance of publicly held US commercial electronics companies. One interesting finding is the interaction effect of company size. His study provides evidence that big companies that implement technology leadership strategy achieve better performance. However, on controlling for firm size, small firms perform better under low-cost technology strategy. This is because small firms do not have adequate resources, especially in terms of capital, to compete with technology leader. Thus, they can only compete by providing low cost solutions to price-sensitive customers (Porter, 1980).

Having an effective technology strategy, however, is not enough to achieve success if without proper allocation of resources. "Even the best game plan in the world comes to nothing if there aren't players on the field!" (Cooper & Kleinschmidt, 1996). Khalil (2000) stresses that the efficient deployment of technological resources is crucial in providing a competitive posture for techno-economic enterprises. The technological resources include instrument, equipment, tools, materials, methods,

software, skilled workers, information, intellectual assets, and financial resources. This leads us to another important arena – resource context – in determining firm performance.

2.5 Resource-based Theory

The advent of resource-based theory is to explain a few shortcomings of neoclassical theory of structure-conduct-performance (SCP) model (Bain, 1956). The neoclassical theory views resources as homogeneous and perfectly mobile, and firms are standardized production functions that combine these resources (i.e. land, labor, and capital). Sustainable and superior performance can only be achieved from industry factors, for example, collusion, market power (economies of scale and market imperfections), and barriers to entry, because these restrict the mobility of production factors.

Likewise, Porter (1980, 1985) points out that the firm's most important strategic decision is to select the industries in which to participate. Attractive industries are those that have high entry barriers, a low threat of substitutes, "good" competitors, and in which firms have high bargaining power over suppliers and customers. After selecting industries and/or, where possible, altering industry structure for competitive advantage, firms are advised to choose a generic strategy (differentiation or low cost) and concentrate on performing these activities well.

However, one of the shortcomings of the market forces approach is its lack of ability to explain intra-industry variability in performance even though they are competing within the same industry (Rumelt, 1991). Failures can be found in industries with protection and high entry barrier (Norton, 1998). Besides, firms that deploy the same generic strategy yield different level of performance (Spital &

Bickford, 1992). As yet, in industries where scale is considered to be very important, small-scale companies have completely opened up the competition (Baden-Fuller & Stopford, 1992). This lack of explanatory power of these theories can be explained by resource-based theory (Wernerflt, 1984; Lynch, 1998).

The resource-based theory of the firm proposes that firm resources (financial, physical and human resources) or capabilities serve as a competitive advantage to be utilized by the firm to pursue superior firm performance (Rumelt, Schendel, & Teece, 1991). The earliest champion of the theory is Penrose (1959). Penrose (1959) views that a firm is basically a collection of resources. In her theory of the growth of the firm, she recognizes the significance of heterogeneous and imperfectly mobile resources, which are led by resource's markets imperfection. An organization generates abnormal profit not only because it has better or more resources, but also because of its superior practice of allocating those resources appropriately to the various capabilities and competencies (Penrose, 1959). Wernerfelt (1984) argues that resources are tied semi-permanently to the firm (i.e. non-tradeable in factor markets), convey the potential for high returns, may manifest as entry barriers, and impel a firm's growth strategy.

Numerous literatures emphasize the important role of resources in determining performance of technology intensive industries. Cooper and Kleinschmidt (1996) found that adequate allocation of resources of people and money is one of the critical drivers of superior performance. They conclude that there are three main ingredients to success: (i) resource commitment by senior management, (ii) adequate technical budget, and (iii) the necessary people are in place with release time given. They argue that strategy must be properly backed up with people, time and money – and the commitments kept – else do not expect stellar performance. Based on earlier works,

Cooper (2000) further elaborates the point that having the right resources and sufficient resources in the right projects is one of the important cornerstones of high-performing businesses.

There also is support for the resource-based theory in the strategy paradigm. Hofer and Schendel (1978) propose that strategies at every organizational level, including technology strategy, have four components – scope, resource deployments, competitive advantage, and synergy. They argue that the deployment of firm-specific resources is central to strategy and performance. They observe that the principal focus of strategy at the tactical level is the maximization of resource productivity, which greatly relates to resource deployment. Norton (1998) argues that resource allocation should offer evidence of strategic significance. If a firm differentially commits resources, that commitment suggests a relative emphasis. That relative emphasis underlies the strategic significance.

Christman and Boulton (1992) propose a relationship between strategy and performance that is moderated by distinctive competencies. Their study found support for the proposition. Distinctive competencies may be defined as sets of differentiated skills, complementary assets, and routines that provide the basis for a firm's sustainable advantage (Leonard-Barton, 1992). Distinctive competencies arise from heterogeneous resources (Barney, 1991; Godfrey & Hill, 1995).

Barney (1991) proposes a framework that explicitly tests each resource to determine if it has the characteristics necessary to become a distinctive competence. The resources must possess four characteristics: it must be valuable, rare, imperfectly imitable, and non-substitutable. Valuable suggests that the resource conveys some strategic advantage to capitalize on an opportunity or neutralize a threat (Peteraf, 1993). Rare suggests that the resource may not be broadly distributed (i.e. imperfectly

mobile). It need not be unique to its possessors, but it may not be widely held (Barney, 1991). Imperfectly imitable suggests that competing firms are incapable of duplicating the resource (Barney, 1991). Non-substitutable refers to absence of a strategic equivalent that preserves the distinctive character of a resource, with its potential for contribution to sustainable competitive advantage (Barney, 1991).

Prahalad and Hamel (1990) also claim that the use of resources especially intangible resources is important in forming core competencies. The core competencies of a firm are major source of value-adding, hence rent-generating potential. They are by definition firm-specific, hard for others to emulate, hence they sustain the firm's competitive advantage. The intangible resources include the personal knowledge of individuals and collective knowledge lodged in the firm's architecture.

Recently, Miller and Shamsie (1996) comment that the resource-based view of the firm provides a useful complement to Porter's (1980) well-known structural perspective of strategy. They argue that the resource-based view shifts the emphasis from the competitive environment of firms to the resources that firms have developed to compete in that environment. As yet the resource-based theory is gaining more and more attention from researchers.

2.6 Summary

Technology is viewed as strategic weapons and drivers of business strategy, especially in technology intensive industries. To them, having an effective technology strategy is a crucial step in achieving corporate success.

There are a number of authors who have empirically shown the relationship between technology strategy and firm performance. However, the interest was largely

in US new electronic-product development. Few studies were done on industrial automation industry on the same topics. There should be some degrees of similarities as both of the industries are highly technology-driven. The literatures should be able to serve as good benchmarks for this research.

A good technology strategy will never achieve success without effective resource deployment in embracing the strategy. Numerous researches have explored the role of resources in performance of technology-based firms. As yet resources are viewed as an important driver that cannot be neglected.