

Determining Technological Innovation and Competitiveness: A Cross Organizational Analysis of the Malaysian Manufacturing Industry

Amlus Ibrahim^{*}, Ezanee Mohamed Elias, Abd.Rahim Saad and T.Ramayah
Faculty of Technology Management, Universiti Utara Malaysia ; Sirim Malaysia Berhad;
University Sains Malaysia

ABSTRACT

This study analyzed the determinants of technological innovation in the Malaysian manufacturing industry. Its main purpose is to identify a set of management- related variables characterizing Malaysian innovative firms. Moreover, the study aimed to test whether the set of determinant differs for firms with different technological trajectories. A sample of 204 Malaysian firms was used for the investigation, with one respondent from each firm. The questionnaire measured the technological innovation, as well as 5 main potential determinants of innovation adopted from literature. Statistical analysis used, including bivariate correlation and multivariate regression, in identifying association between the technological innovation and the determining variables. The results of the analysis lead the researcher to the model of 5 important determining factors of technological innovation. The important factors were intensity of R&D, technological trajectories, intensity of marketing, engineers, scientist and managers with experience locally and technical competency of personnel,. The analysis of technological trajectories confirmed the hypotheses that set of important determinants of innovation as well as the extent of technological innovation differs for firms in different innovation processes.

Keywords: Technologies trajectories, technological innovation, intensity of R&D.

Technology and the Technological Development Process in Newly Industrialized Country

The term technology can be defined through a variety of approaches. It is derived from the Greek words “techne” meaning an art or a skill and “logia” meaning a science or study. In dictionaries, this term was described as the science or study of the practical or

industrial arts, applied sciences and the science of the application of knowledge to practical purposes in a particular field (Nejad, 1997). Depending on the nature, role and impact of technology there were several major perspectives on technology. The first perspective, technology was defined as any tool or technique, any product or process, any physical equipment or method of doing or making by which human capabilities are extended. The second focuses on technology as the system by which a society satisfies its

^{*} Corresponding author. Email: amlus@uum.edu.my

needs and desires. In this case, when technology is applied to an individual enterprise, it means the capability that an enterprise needs to provide its customers with the goods and services which it proposes to offer, present and in the future. The third perspective highlights the importance of “know-why”; the factual knowledge embodied in proven scientific theories and “know-how”; the knowledge of empirical evidence and that of experiences through the application of know-why in practical situations which concentrates on the role that skills play in gathering, using and updating knowledge.

The fourth perspective refers to technology as an integration of hardware and software. It describes technology including the interrelated components; humanware, technoware, inforeware, and organoware. Humanware as people-embodied technology involves experiences, skills, knowledge, wisdom and creativity. Technoware is object-embodied technology and consists of tools, components; equipment, machines, vehicles and physical facilities. Inforeware is document-embodied technology comprising all kinds of documentation pertaining to process specialization, procedures, theories and observations. Organoware is institution-embodied technology including the managerial skill and organizational structure which is essential to facilitate the effective integration of humanware, technoware and inforeware (Rasiah, 1994). For technological development purposes of a country, it is crucial to develop these four inter-related components at the same time and in parallel.

Utterback (1999), in his study on the dynamic nature of technological innovation suggested there are two distinctive development processes for products and processes based on the different ages of firms. Furthermore, economists have increasingly appreciated that the rate of technical advancement depends not only upon the level of innovative effort, but also upon the composition of that effort. In this respect,

research on technological innovation as a new pattern of the technology development process should be able to discover the most influential ingredients of intra-and extra-firm behavior and those environmental factors which exhibit the greatest impact on technological innovation in developing countries or newly industrialized countries.

United Nation (2002) reported over the last 20 years, with the advent of the advanced technologies, the pattern and pace of technical change has altered sharply. Although most developing countries have been placed in economic trouble, nevertheless a rise of newly industrializing countries with basic infrastructure to accelerate their pace of growth can provide the opportunities, even for the others to improve their conditions if properly mobilized. In the past, developing countries have concentrated most of their science and technology efforts in establishing research institutes without higher investment commitment in the development, pre-investment studies, prototype production and market analyses that were really needed. An even larger effort is required to test and re-test products, to design the manufacturing facilities, to attract major capital, to acquire the operational expertise and eventually to reach profitable commercialization.

It is clear from Cooper (1994) that technological innovation studies can help to clarify the process of accumulation of technological capabilities for developing countries moving towards newly industrialized countries. Their strength is that they are firmly based, on clear ideas about institutions, whether these are the firms which do the innovation or the network of public and private agencies to which these firms relate. This perspective has often been lacking in the discussion of developing indigenous technological capability for developing countries or newly industrialized country.

An Overview on Technological Innovation

Definitions of terms and concepts concerning technological innovation

This study adopted the OECD definitions of technology and technological innovation (Oslo Manual, 1992) as the following:

1. *Innovation* is defined as the adoption of an internally generated or externally acquired product of manufacturing process perceived to be new by the firm (Oslo Manual, p.47).
2. *Technology* can be interpreted broadly as the whole complex of knowledge, skills, routines, competence, equipment and engineering practice which are necessary to produce a product or service (Oslo Manual, p.47).
3. *Technological product and process innovations* comprise implemented technologically new products and processes and significant technological improvements in products and processes (Oslo Manual, p.47). In this definition products included both goods and services.
4. A *technologically new or radically innovative product* is a product whose technological characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge (Oslo Manual, p.48).
5. A *technologically improved or incrementally innovative product* is an existing product whose performance has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher performance

components or materials, or a complex product which consists of a number of integrated technical subsystems may be improved by partial changes to one of the subsystems (Oslo Manual, p.49).

6. *Technological process innovation* is the adoption of technologically new or significantly improved production methods, including methods of product delivery. These methods may involve changes in equipment, or production organization, or a combination of these changes, and may be derived from the use of new knowledge. The methods may be intended to produce or deliver technologically new or improved products, which cannot be produced or delivered using conventional production methods, or essentially to increase the production or delivery efficiency of existing products (Oslo Manual, p.49).
7. Technological innovation occurs when a new or changed product is introduced to the market, or when a new or changed process is used in commercial production. The innovation process is the combination of activities - such as design, research, market investigation, tooling up and management - which are necessary to develop an innovative product or production process (Gaynor, 2002; Greene & Harich, 2000; OECD, 1992).

General perspective on technological innovation

An overview of the process of technological innovation research shows that this subject is multi-disciplinary and interdisciplinary involving several disciplines, starting from economics, sociology, political science, design, manufacturing, industrial marketing, macro-organization behavior and the management of technology (Becker & Stafford 2001; Hislop, 2003; Nejad, 1997). As a result there are many perspectives about

technological innovation. Some see innovation as a creative act, as an invention, as its originality, and its newness. Others see innovation as a thing, a piece of hardware and some see it as an idea and a design. Others emphasize its applicability, its use in the market and production process and some focus on its marketing features. In this study, the word innovation refers to technological innovation as opposed to any other form of innovation.

In an economic perspective, technological innovation is seen as the first commercial transaction involving the invention (Sorge, 1991; Hislop, 2003; Martin & Terblanche, 2003). It is argued that all inventions do not necessarily lead to technological innovations and in fact the majority does not, since they must fulfill the condition of being accepted by the market before they can be classified as innovations (Gupta & Singhal, 1995). Economists, generally, consider innovation as a more or less linear process of three stages such as invention, commercial innovation (prototypes into production) and the diffusion of innovations (Martin & Terblanche, 2003).

According to Zaltman, Duncan and Holbek (1973), Dougherty and Hardy (1996), and Gupta and Thomas (2001) there are three inter-related perspectives on innovation which are referred to as the process of developing the new item by the developer; the process of adopting the new item by the adopter and the new item itself as an integrative function of both. The developer and the adopter can be an organization, such as a business firm, a social group or an individual. The first perspective, referring to the creative or development process, starts with the recognition of a potential demand for an item, its related technological feasibility, and ends with its widespread utilization. Innovation, here, is depicted as the creative process that results in something new. The second perspective views innovation as the process whereby a new item is adopted and thus implemented by an adopter. Gupta, Iyer, and Aronson (2000) stated that the adoption of a change which is

new to an organization and to the relevant environment is an innovation. The third perspective focuses on the invention and newness of items.

Rogers (1983), defined innovation as an idea, practice or object that is perceived as new by an individual or other unit of adoption. Furthermore, according to Rogers and Shoemaker (1991), and Fleming and Sorenson (2003) it matters little, as far as human behavior is concerned, whether or not an idea is “objectively” new as measured by the lapse of time since its first use or discovery, if the idea seems new and different to the unit of adoption, it is an innovation. This means that the same idea, product, process and system can be considered an innovation if it is employed by different companies in different markets at different times.

The concepts and meanings of technological innovation

Innovation has a number of related meanings. It is derived from the Latin word *novus*, meaning new. Also the term is alternatively defined by dictionaries as “the introduction of something new”, or “a new idea, method or device” (Nejad, 1997). Kristensen (1993) examined the definitions of “innovation” and concluded that many investigators fail to provide an explicit picture of this term; the employed definitions can be divided into a number of categories; and the aspects emphasized by the definitions change over time. Among the variety of definitions regarding technological innovation at the firm level, the following ones reflect the essence of it. Shane (1994) stated that when an organization learns to do something which it did not know how to do it before and then proceeds to do it in a sustained way, a process of innovation has occurred. Martin (1997) suggested that “an innovation” is the basic unit of technological change. This definition of innovation was based on the works of Schoemaker and Amit (1995) who believed

that when an enterprise produces a good or service or uses a method or input that is new to its environment it makes a technical change, its action is innovative.

According to Cooper (1984) innovation can be referred to as a wide spectrum of activities from relatively low-cost search to high-cost R&D, the selection and creation of new production techniques, minor and major adaptation of production processes and subsequent investments in innovation as a part of diffusion. OECD (1992) identified that innovation can take many forms such as a familiar product manufactured from new materials; a different combination of existing products to give improved performance; adaptation of an existing product to meet new demands; a new product utilized to perform a new function; and a new process either to make an existing, modified or new product, or to reduce its costs. Dougherty and Hardy (1996) and Robert (1998) stated that innovation can be regarded as a comprehensive process which starts with the generation of an idea leads to the production and commercialization. It means innovation is invention along with exploitation, which covers all efforts of creation of new ideas and getting them to work (invention) and also includes the process of commercial development including the focusing of ideas or inventions toward specific objectives, evaluating these objectives, transfer of R&D results and the eventual broad-based utilization, dissemination and diffusion of the technology-based outcomes (exploitation).

Dosi, Freeman, Nelson, Silverberg and Soete (1988) and Greene and Harich (2000) argued although R&D is essential for innovation, it is more accurate to describe innovation as the result of a succession of improvements attributable to “design, learning-by-doing and learning-by-using”. Technological innovation is the result of a cumulative learning process and is generated by the interactive process of various actors in multi-layer social networks (Gupta & Thomas,

2001). In a systemic approach, Parker (2002) stated that innovation is any change in the socio-technical systems of design, manufacture, distribution and/ or use which improves the performance of the entire system with regard to cost and quality of product or of service to users and / or employees.

United Nations (2002) in the definition of innovation pointed out the importance of social and economic innovation as the accelerators of technological innovation and referred to incremental nature of innovation often through adaptation, always by diffusion of a better product, process or service. Rothwell (1992) introduced the innovation process at the firm level as a logically sequential, though not necessarily a continuous process, that can be subdivided into a series of functionally separate but interacting and interdependent stages. The overall pattern of innovation can be thought of as a complex network of communication paths, both intra-organizational and extra-organizational, linking together the various in-house functions and connecting the firm to the broader scientific and technological community and to the marketplace. In other words, the process of innovation represents the confluence of technological capabilities and market needs within the framework of the innovating firm. There are clearly a number of well-developed ideas concerning these reviewed pictures of innovation. Their concepts overlap to some extent with each other, yet each of them provides some unique insights to understand the nature of organizations.

To summarize, generally the above arguments highlighted the similarities in concepts and definitions of technological innovation. In this study technological innovation is considered as a multi-dimensional process which is science, technology and system based, and people related in nature. This process includes several factors affecting and affected by the firm’s internal capabilities, its networking and its technological learning ability, and influenced

by its environmental factors. It would mobilize all existing potential resources to augment the firm's innovation capacities, ending with the introduction of a new or better product, material and / or production process.

The core concentration in this study, however, is not necessarily upon everything that is new in the world or time and place. Rather, the emphasis is placed on those changes that involve human activities and artifacts which would be new for the innovation process in innovator or its economy, whether produced before elsewhere or not.

Research Frame framework

In order to answer the research questions, the researcher reviewed the literature, searching for potential determinants or firm competencies (independent variables) associated with technological innovation. The firm's competencies were classified into sixteen variables as presented in the following Table 1 and covered the following: intensity of R&D, technical competencies, intensity of marketing,

Table 1. Technological trajectories of the respondent firms

Trajectory	Frequency in the sample	Percentage of the sample
Supplier dominated	74	36.3
Scale intensive	20	9.8
Specialized supplier	39	19.1
Science based	71	34.8
Total	204	100.0

The researcher adapted the framework of strategic influences and firm-specific competencies determining innovation of Souitaris (2001,2002) and made the necessary adjustment to fulfill the requirements of this study. Both empirical studies were carried out in Greece. However, Greece and Malaysia were categorized as the newly industrialized country (NIC). The researcher positioned the technological trajectories as moderators of firm-level determinants of innovation. The decision to position the technological trajectories as the moderators was influenced by the empirical confirmation by Souitaris (2003) that firms in different trajectories of Pavitt's taxonomy had differences in the technological innovation.

1. Intensity of R&D

Not surprisingly, industrial R&D was one of the first business practices positively associated with innovation (Souitaris, 2002). Duchesneau et al., (1979); Etlie et al., (1984); Globerman (1975), Kim, Kwangsun and Jinjoo (1993) and Romeo (1975) provided strong statistical evidence of the positive relationship between number of employees and financial resources allocated for R&D activities and adoption of innovations. Therefore the following hypothesis was formulated:

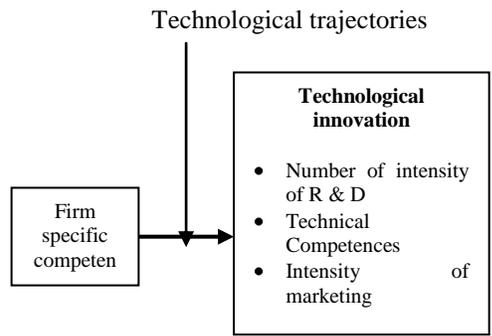


Figure 1. The Study's Framework.

H1 : The extent of technological innovation of Malaysian firms is positively correlated with the intensity of R&D.

2. Technical Competencies

Quality management was a major issue in the business literature in the 1990s and 2000s. Rothwell (1992) and Zairi (1996) associated positively the implementation of quality control procedures which included human resources with innovation. Chiesa et al. (1996), suggested and positively proved that the innovative firms integrate better process improvement with effective quality and human resource management system.

Research had proved the importance of skill and experience of human resources in adopting technological change (Kim et al., 1993). Li (1999) empirically established that the decision of innovation adoption very much and positively influenced by human resource competencies, organizational factors, environmental factors and tendency for technological improvement. Hence, the following hypothesis was proposed:

H2: The extent of technological innovation of Malaysian firms is positively correlated with the extent of technical competencies of human resources.

Intensity of Marketing

Cooper (1984), Maidique and Zinger (1984) and Vazquez (2001) positively associated innovation with an effective marketing programme and a broad distribution system, which can access distant markets. Rothwell (1992) and Vazquez (2001) suggested that a strong market orientation is

directly and significantly related to innovation. Hence, the researcher hypothesized that:

H3: The extent of technological innovation of Malaysian firms is positively correlated with the intensity of marketing.

Technological Trajectories Moderating Firm-Level Determinants of Innovation

Pavitt (1984) identified different patterns of technological change (technological trajectories) in four sectoral classes of industrial firms. An empirical test in a sample of Greek manufacturing companies showed that firms in different trajectories of Pavitt's taxonomy (1984) had differences in the rate of technological innovation. Specialized suppliers and science based firms were found to have higher rates of innovation than supplier dominated and scale intensive one. Most importantly different variables proved to be significantly associated with innovation for each category of firms (Souitaris, 2002).

The process of classifying the sample of Malaysian companies into technological trajectories was related to the study's which involved the following:

1. to test whether technological innovation differs for the different trajectories
2. to test whether the determining factors of technological innovation differs for each trajectory.

Hence, the following research hypotheses were developed:

H4: Firm's technological innovation differs for the different of technological trajectories.

H5: Determining factors of innovation differ for firms in different technological trajectories.

Methodology

To carry out this study 204 Malaysian manufacturing firms of this study were categorized according to these four technological trajectories . Obviously, the classification is somewhat subjective and arbitrary, as the criteria are qualitative in nature.

Profile of Respondent Firms

It is obvious from the table, that the percentage of very small and small firms is considerably lower in the sample compared with those in the total population. Consequently, the percentages of medium and large firms are higher in the sample. In other words, larger firms are over represented in the sample, a fact that was expected from the way it was designed

Table 2. Size comparison of respondent firms and the total population

Size	Frequency in the sample	Percentage of the sample	Frequency in the population	Percentage of the population
Very small	0	0	0	0
Small	53	26.0	850	28.3
Medium	119	58.3	1700	56.7
Large	32	15.7	450	15.0
Total	204	100	3000	100

Table 3. Sectoral comparison of respondent firms

Industry	Frequency in the sample	Percentage of the sample
Automotive assembly	7	3.4
Automotive parts and components	7	1.5
Food and beverages	20	.5
Building materials	6	2.9
Chemical and fertilizer	16	5.9
Concrete and structure	1	.5
Electrical and electronic	35	5.4
Telecommunication	3	1.5
Food packaging	6	1.0
Furniture	2	1.0

Industry	Frequency in the sample	Percentage of the sample
Gas (LPG)	3	1.5
Hospital products	1	.5
Leather and leather products	3	.5
Machine tools and assembly	2	.5
Marine products and food processing	3	.5
Medical products	3	1.5
Cosmetics	1	.5
Metal based furniture	1	.5
Metal stamping and fabrication	12	2.5
Palm Oil	10	4.9
Paper	5	1.5
Plastic and petrochemicals	15	3.4
Power generation	5	2.5
Precision engineering	3	.5
Rubber and rubber products	11	1.0
Semiconductor	4	2.0
Steel	6	2.9
Textile and garment	6	.5
Tobacco	1	.5
Wood product and furniture	4	.5
Total	204	100.0

Conclusions

A generalization of the findings of the Malaysian case leads to the hypothesis that the most important determinants of innovation in newly-industrialized countries are those that are generally missing in the country-specific institutional context. In other words, the most innovative companies are the ones that manage to overcome the traditional rigidities of the institutional context and incorporate uncommon attitudes and practices for the local business environment (Souitaris, 2001). This hypothesis has to be tested by future innovation research. In general, the researcher supports the call for more empirical research on the international differences in innovation management (see for example Patel & Pavitt, 1994; Moenaert et al., 1994). We need more robust evidence to understand and support theoretical claims about the influence of the

complex, multi-dimensional and difficult to define national 'institutional context' on the factors and best practice that lead to innovation. This study was an initial step towards this direction.

The study's compact set of important strategic determining factors can have immediate practical application in Malaysia and other newly industrialized countries with similar environments. Several types of users could benefit from the results, including industrial managers in search of innovation and growth and venture capitalists trying to identify potential innovative companies and also the national technology policy maker. The findings demonstrated to the practicing managers the importance incorporating R&D, marketing activities, strategic business planning, favorable organization structure, education and training, interdisciplinary

teamwork, internal communication, and utilization of professional staff and shop floor employees as sources of innovative ideas.

Also, the finding that innovation is driven by owner-managers with a perception of intense competition and changing customer needs could be a hint for policy-makers to support entrepreneurship, deregulate the economy and encourage competition.

Policy makers too have something to learn from the study. For them there is a message to encourage and possibly increase the funding for industrial research and help small firms with training. Also, the public education system has to be assessed and modernized in order to help the industry to recruit key personnel with relevant qualifications. Moreover, the importance of previous work experience in other companies and countries calls for the encouragement of knowledge transfer through human-resource mobility and the provision of incentives towards a more open labor market.

In relation to the technological trajectories in moderating firm-level determinants of innovation, this study indicated that firms in different trajectories of Pavitt's taxonomy had differences in performance and determinants of innovation. Hence, the main theoretical contribution of this study is the positioning of Pavitt's taxonomy as an integrative tool, bridging two distinct literature streams-the economic and management studies on technological innovation.

The empirical results in the Malaysian context supported that the important determinants of innovation differ in the four classes of Pavitt's taxonomy. Therefore, the study contributed to the economic and management perspective as well as methodology in identifying the distinguishing characteristics of innovative firms in the future.

References

- Aiken, M. and Hage, J. (1971). The organic organization and innovation. *Sociology*, Vol. 5 No.1, pp. 63-82.
- Anuwar, A. (1992). *Malaysian industrialization: the quest for technology*. Singapore: Oxford University Press.
- Ansoff, I. (1965). The firm of the future. *Harvard Business Review*, Vol. 43 No. 5, pp. 162-178.
- Archibugi, D., Cesaratto, S. and Sirilli, G. (1991). Sources of innovative activities and industrial organization in Italy. *Research Policy*, Vol. 20, No. 6, pp. 299-313.
- Archibugi, D., Cohendet, P., Kristensen, A. and Schaffer, K.A. (1994). *Evaluation of the community innovation survey (CIS)*. European Commission DG XIII D, EIMS project No. 93140.
- Archibugi, D., Evangelista, R. and Simonetti, R. (1995). Concentration, firm size and innovation: evidence from innovation costs. *Technovation*, Vol. 15 No. 3, pp. 153-163.
- Ayers, D.J., Gordon, G.L. and Schoenbachler, D.D. (2000). Integration and new product development success: The role of formal and informal control. *The Journal of Applied Business Research*, Vol. 17 No. 2, pp. 133-148.
- Ball, D.F. (1992). R&D Conference: External Acquisition of Technological Knowledge, Conference Report. *R&D Management*, Vol. 22 No. 1, pp. 89-94.
- Becker, S.W. and Stafford, F.W. (2001). Some determinants of organizational success. *Journal of Business*, 40, pp. 511-518.
- Bell, M., Hobday, M., Abdullah, S., Ariffin, N. and Malik, J. (1995). *Aiming for 2020: A demand driven perspective on industrial technology policy in Malaysia*. Final report for

- the World Bank and the Ministry of Science, Technology and the Environment, Malaysia, SPRU, October.
- Bossink, B.A.G. (2002). The strategic function of quality in the management of innovation. *Total Quality Management*, Vol. 13, No. 2, pp. 195-205.
- Burns, T. and Stalker, M. (1999). *The Management of Innovation*. London: Tavistock.
- Calvert, J., Ibarra, C., Patel, P. and Pavitt, K. (1996). Innovation outputs in European Industry. *The EU conference Innovation measurement and policies*, Luxembourg.
- Carrol, J. (1997). A note on departmental autonomy and innovation in medical schools. *Journal of Business*, Vol. 40, No. 4, pp. 531-534.
- Carper, W.B. and Snizek, W.E. (1980). The nature and types of organizational taxonomies: An overview. *Academy of Management Review*, Vol. 5 No. 1, pp. 65-75.
- Carrier, C. (1994). Intrapreneurship in large firms and SMEs: A comparative study. *International Small Business Journal*, Vol. 12 No. 3, pp. 54-60.
- Carter, C.F. and Williams, B.R. (1997), *Industry and technical progress: Factors governing the speed of application in science*. London: Oxford University Press.
- Chiesa, V., Coughlan, P. and Voss, C.A. (1996). Development of a technical innovation audit. *Journal of Product Innovation Management*, Vol. 13 No. 5, pp. 105-135.
- Cohn, S.F. and Turyn, R.M. (1984). Organisational structure, decision making procedures and the adoption of innovations. *IEEE Transactions of Engineering Management*, Vol. 31 No. 4, pp. 154-161.
- Clark K.B. and Fujimoto, T. (1991). *Product Development Performance*. Boston: HBS Press.
- Cooper, R.G. (1979). The dimensions of industrial new product success and failure. *Journal of marketing*, Vol. 43, pp. 93-103.
- Cooper, R.G. (1984). The strategy-performance link in product innovation. *R&D Management*, Vol. 14, No. 4, pp. 247-259.
- Cooper, R.G. (1990). New products: what distinguishes the winners? *Research and Technology Management*, Vol. 33, No. 6, pp. 27-31.
- Cooper, R.G. (1994). Third-generation new product processes. *Journal of Product Innovation Management*, Vol. 11 No. 1, pp. 3-14.
- Danneels, E. (2002). The dynamics of product innovation and firm competences. *Strategic Management Journal*, Vol. 23 No. 12, pp. 1095-1115.
- Damanpour, F. (1984). *The adoption of technological, administrative and service innovations: Impact of organizational factors*. Working Paper, LaSalle University.
- Damanpour, F. (1991). Organizational innovation: a meta-analysis of effects of influences and moderators. *Academy of Management Journal*, Vol. 34, No. 3, pp. 555-590.
- De Bresson, C. (1986). *Conceptual notes on the measurement of innovation*. OECD, Paris.
- Dewar, R. and Dutton, J.E. (1986). The adoption of radical and incremental innovations: An empirical analysis. *Management Science*, Vol. 32 No. 11, pp. 1422-1433.
- Dosi, G.W. and Mohr, L.B. (1976). Conceptual issues in the study of innovations.

- Administrative Science Quarterly*, Vol. 21, No. 4, pp. 700-714.
- Dosi, G. (1982). Technological paradigms and technological trajectories. *Research Policy*, Vol. 11, No. 3, pp. 147-162.
- Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. (1988), *Technical change and economic theory*. London: Pinter.
- Dougherty, D. and Hardy, C. (1996). Sustained product innovation in large mature organization: Overcoming innovation-to-organization problems. *Academy of Management Journal*, Vol. 39 No. 5, pp. 1120-1154.
- Downs, G.W. and Mohr, L.B. (1976), Conceptual issues in the study of innovation. *Administrative Science Quarterly*, Vol. 21 No. 4, pp. 700-714.
- Drucker, P.F. (1999). *The Practice Of Management*. Oxford: Butterworth-Hienemann.
- DTI (Department of Trade and Industry) (1996). *A Pocket Guide To The Innovation Unit*. London.
- Duchesneau, D., Cohn, S.F. and Dutton, J.E. (1979). *A Study Of Innovation In Manufacturing: Determinants, Processes And Methodological Issues*. Social Science Research Foundation, University of Maine, Orono.
- Ettlie, J. (1986), *Implementing Manufacturing Technologies: Learning From Experiences In Technological Innovation*. San Francisco: Jossey-Bass.
- Ettlie, J., Bridges, W.P. and O'Keefe, R.D. (1984). Organization strategy and structural differences for radical versus incremental innovation. *Management Science*, Vol. 30, No. 6, pp. 682-695.
- EUROSTAT (1996). *Innovation in European Union*. Statistics in Focus, Research and Development, 2.
- Felberg, J.D. and DeMarco, D.E. (1992). New Idea Enhancement at Amoco Chemical: An early report from a new system. *Journal of Product Innovation Management*, Vol. 9, No. 4, pp. 278-286.
- Fleming, L. and Sorenson, O. (2003). Navigating the technology landscape of innovation. *MIT Sloan Management Review*, Vol. 44 No.2, pp. 15-23.
- Flor, P. and Oltra, D. (2004). Impact of innovation on Norway manufacturing competitiveness. *European Innovation Management Journal*, Vol. 2 No. 5, pp. 76-90.
- Freeman, C. (1982). *The economics of industrial innovation*. 2nd edition. London: Pinter.
- Frosch, L.M. (2000). Succeeding in technological innovation. *Research Technology Management*, Vol. 43 No. 3, pp. 24-39.
- Gaynor, G.H. (2002). *Innovation by design*. New York: American Management Association.
- Gibb, A.A. and Scott, M. (1985). Strategic awareness, personal commitment and the process of planning in the small business. *Journal of Management Studies*, Vol. 22 No. 6, pp. 135- 148.
- Globerman, S. (1995). Technological diffusion in the Canadian tool and die industry. *The Review of Economics and Statistics*, Vol. 57, No. 4, pp. 428-434.
- Gupta, A.K. and Singhal, A. (1995). Managing human resources for innovation and creativity. *Research Technology Management*, Vol 36 No. 3, pp. 41-48.

- Gupta, A.K. and Thomas, J. (2001). Sources of market pioneer advantages in consumer goods industries. *Journal of Marketing*, Vol. 22, No. 3, pp. 305-317.
- Gupta, A.K., Iyer, R. and Aronson, T. (2000). The business of innovation: an interview with Paul Cook. *Harvard Business Review*, Vol. 68, No. 2, pp. 97-117.
- Greene, R. and Harich, S. (2000). Technological innovation for market driven. *European Innovation Management Journal*, Vol. 4, No. 1, pp. 40- 56.
- Hage, J. and Aiken, M. (1990), *Social Change in Complex Organizations*. New York: Random House.
- Hage, J. and Aiken, M. (1997). Program Change and Organizational Properties: A comparative analysis. *American Journal of sociology*, Vol. 72, pp. 503-519.
- Hage, J. and Dewar, R. (1993). Elite versus organizational structure in predicting innovation, *Administrative Science Quarterly*, Vol. 18, No. 3, pp. 279-290.
- Hair, F.J. (1995), *Multivariate data analysis with readings*. London: Prentice- Hall.
- Hajihoseini, H. and de la Mare, R.F. (1995), The impact of indigenous technological capability on the technological development process in Iran. *The R&D Management conference: Knowledge, Technology and Innovative Organizations*, Piza (Italy).
- Hamzah, K. and Ismail, S. (2001). *Technological Dynamism Behind Malaysia's Successful Export Performance*. MOSTE, Kuala Lumpur.
- Hansen, J.A. (1985). *International Comparisons of Innovation Indicator Development*. U. S. National Science Foundation.
- Hansen, J.A. (1986). Innovation indicators: Summary of an international survey. *The Workshop of Innovation Statistics*. OECD.
- Hansen, J.A. (1992). *New Indicators of Industrial Innovation in Six Countries: A Comparative Analysis*. U.S. National Science Foundation, State University of New York, College of Fredonia, 1992.
- Hassan, S. (2000). The strategic direction of higher education in Malaysia. *International conference on policy Issues in Higher Education in New Millennium*. University Malaya, Kuala Lumpur.
- Hise, R.T., O'Neal, L., Parasuraman, A. and McNeal, J.U. (1990). Marketing/R&D interaction in new product development: implications for new product success rates. *Journal of Product Innovation Management*, Vol. 7, No. 2, pp. 142-155.
- Hislop, A.M. (2003). Synergistic of technological innovation. *Journal of Product Innovation Management*, Vol. 5, No. 2, pp. 42-55.
- Hobday, M. (1995). *Innovation in East Asia*. Aldershot: Edward Elgar.
- James, W.M. (2002). Best HR practices for today's innovation management. *Research Technology Management*, Vol. 45 No. 1, pp. 57-60.
- Janssens, M., Brett, J.M. and Smith, F.J. (1995). Confirmatory cross-cultural research: testing the viability. *Academy of Management Journal*, Vol. 38 No. 2, pp. 364-376.
- Johne, F.A. (1985). *Industrial Product Innovation, Organisation and Management*. Croom Helm.
- Johne, A. and Davies, R. (2000). Innovation in medium-sized insurance companies: How marketing adds value. *The International*

- Journal of Banking Marketing*, Vol. 18, No. 1, pp. 6-14.
- Kanji, G.K. (1996). Can total quality management help innovation? *Total Quality Management*, Vol. 7, No. 1, pp. 25-30.
- Kets De Vries, M.F.R. (1977). The entrepreneurial personality: A person at the crossroads. *Journal of Management Studies*, Vol. 14, pp. 34-57.
- Khan, A. (1986). Entrepreneur characteristics and the prediction of new venture success. *OMEGA*, Vol. 14 No. 5, pp. 365-372.
- Khan, A. (1990). Innovation in small manufacturing firms, in J. Allesch (ed.), *Consulting in Innovation*. Elsevier Science Publishers B.V.
- Khan, A. and Manopichetwattana, V. (1989a). Models for innovative and non innovative small firms. *Journal of Business Venturing*, Vol. 4, No. 3, pp. 187-196.
- Khan, A. and Manopichewattana, V. (1989b). Innovative and non innovative small firms: types and characteristics. *Management Science*, Vol. 35, No. 5, pp. 597-606.
- Kim, Y., Kwangsun, S. and Jinjoo, L. (1993). Determinants of technological innovation in the small firms of Korea. *R&D Management*, Vol. 23, No. 3, pp. 215-226.
- Kimberly, J.R. and Evanisko, M.J. (1998). Organizational innovation: The influence of individual, organisational and contextual factors on hospital adoption of technological and administrative innovations. *Academy of Management Journal*, Vol. 24, No. 4, pp. 689-713.
- Kristensen A. (1993). *Innovation structures and performance in Nordic industry*. European Commission (EIMS) Report.
- Lal, K. (1999). Determinants of the adoption of information technology: A case study of electrical and electronic goods manufacturing firms in India. *Research Policy*, Vol. 28 No. 7, pp. 667-680.
- Lall, S. (1994). *Malaysian export performance and its sustainability*. Oxford: International Development Centre, Queen Elizabeth House.
- Lefebvre, L.A., Mason, R. and Lefebvre, E. (1997). The influence prism in SMEs: the power of CEOs' perceptions on the technology policy and its organizational impacts. *Management Science*, Vol. 43, No. 6, pp. 856-878.
- Leonard-Barton, D. (1992). Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal*, Vol. 13, Special Issue, pp. 111-125.
- Li, T. (1999). The impact of the marketing-R&D interface on new product export performance: A contingency analysis. *Journal of International Marketing*, Vol. 7, No. 1, pp. 10-33
- Lundvall, B. (1998). Why study systems and national styles of innovation? *Technology Analysis and Strategic Management*, Vol. 10, No. 4, pp. 407-421.
- Maidique, M.A. and Zinger, B.J. (1984). A study of success and failure in product innovation: The case of the U.S. electronics industry. *IEEE Transactions in Engineering Management*, Vol. 31, No. 4, pp. 192-203.
- Martensen, A. and Dahlgaard, J.J. (1999). Strategy and planning for innovation management: A business excellence approach. *International Journal of Quality and Reliability Management*, Vol. 16 No. 8/9, pp. 734-756.
- Martin, R. (1997). *Some factors associated with the evaluation of ideas for production changes in small companies*. Unpublished

- Ph.D. Dissertation, Northwestern University, Evanston Illinois.
- Martin, J. and Terblanche, J. (2003). Economic development in East Asia: Doing what comes naturally. In H.Hughes (eds), *Achieving Industrialization in East Asia*, Cambridge: University Cambridge Press.
- MASTIC (2002). *National Innovation Survey Report*. Ministry of Science, Technology and the Environment, Malaysia.
- Meyer-Krahmer, F. (1984). Recent results in measuring innovation output. *Research Policy*, Vol. 13, No. 3, pp. 175-182.
- Meyer-Krahmer, F. (1987). Evaluating innovation policies: The German experience. *Technovation*, Vol. 5 No.4, pp. 317-330.
- Meyer-Krahmer, F. (1983). Impacts of government incentives towards industrial innovation: An analysis of the federal program funding R&D personnel in the Federal Republic of Germany. *Research Policy*, Vol. 12, No. 3, pp. 153-169.
- Miller, D. (1983). The correlates of entrepreneurship in three types of firms. *Management Science*, Vol. 29 No. 7, pp. 770-791.
- Miller, D., and Friensen, P.H. (1978). Archetypes of strategy formulation. *Management Science*, Vol. 24 No. 9, pp. 921-933.
- Miller, D. and Friensen, P.H. (1984). *Organizations: A Quantum View*. New Jersey: Prentice - Hall.
- Miller, D., Kets de Vries, M.F.R. and Toulouse, J.M. (1982). Top executive locus of control and its relationship to strategy, environment and structure. *Academy of Management Journal*, Vol. 25 No. 2, pp. 237-253.
- Miller, D. and Toulouse, J.M. (1986). Chief Executive Personality and Corporate Strategy and structure in small firms. *Management Science*, Vol. 32, No. 11, pp. 1389-1409.
- Mintzberg, H. (1973). Strategy making in three modes. *California Management Review*, Vol. 16, No. 2, pp. 44-58.
- Mintzberg, H. (1987). Crafting strategy. *Harvard Business Review*, Vol. 65 No. 4 pp. 66-75.
- Mishra, S., Kim, D. and Dae Hoon, I. (1996). Factors affecting new product success: Cross country comparisons. *Journal of Product Innovation Management*, Vol. 13, No. 6, pp. 530-550.
- MITI (2002). *Malaysia: International Trade and Industry Report*. Kuala Lumpur: Ministry of International Trade and Industry, Malaysia.
- Mohr, L.B. (1999). Determinants of technological innovation in organizations. *American Political Science Review*, Vol. 63, No. 1, pp. 111-126.
- Moenaert, R.D., de Meyer, A. and Clarysse, B.J. (1994). Cultural differences in new technology management. In: Souder, W.M.E., Sherman, J.D. (Eds.), *Managing New Technology Development*. McGraw-Hill, New York.
- Mumford, M.D. (2000). Managing creative people: Strategies and tactics for innovation. *Human Resource Management Review*, Vol. 10 No. 3, pp. 313-351.
- Nabseth, L. and Ray, G.F. (1974). *The diffusion of new industrial processes: An international study*. Cambridge University Press.
- Nachimas, C. and Nachimas, D. (1990). *Research Methods for the Social Sciences. Alternative*. 2nd edition without statistics. Edward Arnold Publications.

- Nejad, J.B. (1997). *Technological innovation in developing countries: special reference to Iran*. PhD. Thesis, University of Bradford, UK.
- Nelson, R. and Winter, S. (1977). In search of useful theory of innovation. *Research Policy*, Vol. 6 No. 1, pp. 36-76.
- Niosi, J. (2000). Science-based industries: a new Schumpeterian taxonomy. *Technology in Society*, Vol. 22, No. 4, pp. 429-444.
- Norusis, M.J. (1994). *SPSS for Windows: Professional Statistics Release 6*. SPSS Inc.
- OECD (1992), *OECD Proposed Guidelines For Collecting Innovation Data*. Oslo Manual. OECD, Paris.
- Olsen, R.P. (1974). *Sources of Process Innovations in the Textile Industry*. Unpublished dissertation, Harvard Business School.
- Papadakis, V. and Bourantas, D. (1998). The chief executive officer as corporate champion of technological innovation: An empirical investigation. *Technology Analysis and Strategic Management*, Vol. 10, No. 1, pp. 89-109.
- Parker, A. (2002). Employee development in a changing organization. *CMA Management*, February, 12-15.
- Pavitt, K. (1984). Sectoral patterns of technical change: Towards taxonomy and a theory. *Research Policy*, Vol. 13, No. 6, pp. 343-373.
- Patel, P. and Pavitt, K. (1994). Is Western Europe losing the technological race? *Research Policy*, Vol. 16 No. 2-4, pp. 59-85.
- Pavitt, K., Robson, M. and Townsend, J. (1989). Technological accumulation, diversification and organization in UK companies: 1945-1983. *Management Science*, Vol. 35, No. 1, pp. 113-141.
- Pavitt, K. and Patel, P. (1998). The international distribution and determinants of technological activities. *Oxford Review of Economic Policy*, Vol. 4, No. 4., pp. 1-16.
- Philips, E.M. and Pugh, D.S. (1993). *How to get a Ph.D. A handbook for students and their supervisor*. 2nd Edition, Open University Press, Buckingham.
- Popper, K.R. (1961). *The logic of scientific discovery*. New York: Science Editions.
- Porter, M.E. (1985). *Competitive advantage*. New York: Free Press.
- Porter, M.E. (1990). *The competitive advantage of nations*. London: Free Press.
- Prahalad, C.K. and Hamel, G. (1990). The core competencies of the corporation. *Harvard Business Review*, Vol. 68, No. 3, pp. 79-91.
- Rasiah, R. (1994). Flexible production systems and local machine-tool subcontracting: electronics components transnational in Malaysia. *Cambridge Journal of Economics*, Vol. 18, pp. 278-298.
- Robert, E.B. (1998). Managing innovation and invention, *Research Technology Management*, January-February, pp. 11-29
- Rogers, E.M. and Shoemaker, F. (1991). *Communication of Innovations: A Cross-Cultural Approach*. New York: Free Press.
- Rogers, E.M. (1983). *Diffusion of innovations*. New York: The Free Press.
- Romeo, A.A. (1975). Interindustry and interfirm differences in the rate of diffusion of innovations. *The Review of Economics and Statistics*, Vol. 57, No. 3, pp. 311-319.
- Rosenbloom, R.S. and Cusamano, M.A. (1987). Technological pioneering and competitive advantage: The birth of the VCR

- industry. *California Management Review*, Vol. 29, No. 4, pp. 51-76.
- Rothwell, R. (1974). SAPPHO updated: Project SAPPHO phase II. *Research Policy*, Vol. 3, No. 3, pp. 258-291.
- Rothwell, R. (1976). Small and medium sized manufacturing firms and technological innovation. *Management Decision*, Vol. 16, No. 6, pp. 362-370.
- Rothwell, R. (1977). The characteristics of successful innovators and technically progressive firms (with some comments on innovation research). *R&D Management*, Vol. 7, No. 3, pp. 191-206.
- Rothwell, R. (1992). Successful industrial innovation: critical factors for the 1990s. *R&D Management*, Vol. 22, No. 3, pp. 221-239.
- Rothwell, R. and Dogson, M. (1992). European technology policy evolution: Convergence towards SME's and regional technology transfer. *Technovation*, Vol. 12, No. 4, pp. 223-237.
- Rubenstein, A.H., Chakrabarti, R.D., O'Keefe, W.E., Souder, W.E. and Young, H.C. (1996). Factors influencing innovation success at the project level. *Research Management*, Vol. 19, No. 3, pp. 15-20.
- Sapolsky, H. (1967). Organizational structure and innovation. *Journal of Business*, Vol. 40, No. 4, pp. 497-510.
- Saviotti, P.P. and Metcalfe, J.S. (1984). A theoretical approach to the construction of technological output indicators. *Research Policy*, Vol. 13, No. 3, pp. 141- 151.
- Schoemaker, T.S. and Amit, S. (1995). Factors affecting a firm's commitment to innovation. *Harvard Business Review*, Vol. 72, No. 1, pp. 52-56.
- Schon, D.A. (1973). Champions for radical new inventions. *Harvard Business Review*, March/April.
- Sekaran, U. (1992). *Research methods for business: A skill building approach*. New York: J. Wiley & Sons.
- Shane, S. (1994). Championing innovation in the global corporation. *Research Technology Management*, July-August, Vol. 37, No. 4, pp. 29-35.
- Slappendel, C. (1996) Perspectives on innovation in organisations. *Organisation Studies*, Vol. 17, No. 1, pp.107-129.
- Smith, K. (1992). Technological innovation indicators: experience and prospects. *Science and Public Policy*, Vol. 19 No. 6, pp. 383-392.
- Sorge, A. (1991). Strategic fit and the social effect: interpreting cross-national comparisons of technology, organization and human resources. *Organizational Studies*, Vol. 12, No. 2, pp. 161-190.
- Souitaris, V. (1998). Determinants of technological innovation in the Greek manufacturing industry. *International Journal of Innovation Management*, Vol. 2, No. 3, pp. 78-96.
- Souitaris, V. (1999). Research on the determinants of technological innovation, a contingency approach. *International Journal of Innovation Management*, Vol. 3, No. 3, pp. 287-305.
- Souitaris, V. (2001). External communication determinants of innovation in the context of a newly industrialized country: a comparison of objective and perceptual results from Greece. *Technovation*, Vol. 21 No. 1, pp. 25-34.
- Souitaris, V. (2001). Strategic Influences of Technological Innovation in Greece. *British Journal of Management*, Vol. 12, No. 2, pp. 131-147.

- Souitaris, V. (2002). Firm specific competencies determining technological innovation: a survey in Greece. *R&D Management*, Vol. 32, No. 1, pp. 61-74.
- Souitaris, V. (2002). Technological trajectories as moderators of firm-level determinants of innovation. *Research Policy*, Vol. 31 No. 6, pp. 877-898.
- Souitaris, V. (2003). Determinants of technological innovation: current research trends and future prospects. In L. Shavinina (Ed.), *International Handbook on Innovation*. Oxford: Elsevier Science.
- Swan, J.A. and Newell, S. (1995). The role of professional associations in technology diffusion. *Organizational Studies*, Vol. 16 No. 5, pp. 846-873.
- Swan, J., Newell, S. and Robertson, M. (1999). Central agencies in the diffusion and design of technology: A comparison of the UK and Sweden. *Organization Studies*, Vol. 20, No. 6, pp. 905-932.
- Tidd, J., Driver, C. and Saunders, P. (1996), Linking technological market and financial indicators of innovation. *Economics of Innovation and New Technology*, Vol. 4, No. 3, pp. 155-172.
- Tidd, J., Bessant, J. and Pavitt, K. (1999), *Managing Innovation: Integrating Technological, Market and Organisational Change*. Wiley, Chichester.
- Tidd, J. (2000). *Measuring Strategic Competencies: Technological, Market and Organisational Indicators of Innovation*. London: Imperial College Press.
- Tidd, J. (2001). Innovation management in context: Environment, organization and performance. *International Journal of Management Review*, Vol. 3, No. 3, pp. 169-183.
- Teece, D. and Pisano, G. (1994). The dynamics capabilities of the firms: an introduction. *Industrial and Corporate Change*, Vol. 3, No. 3, pp. 537-556.
- Tornatzky, L.G. and Klien, K.J. (1998), Innovation characteristics and innovation adoption – implementation. *IEEE Transactions in Engineering Management*, Vol. 29, No. 1, 28-45.
- Tushman, M. and Scandal, T. (1981). Boundary spanning individuals : their role in information transfer and their antecedents. *Academy of Management Journal*, Vol. 24, No. 2, pp. 289-305.
- Twiss, B. (1998). *Managing technological innovation*. London: Pitman Publishing.
- United Nation (2002). *Report on technology advancement in Newly Industrialized Country*. London: Pitman Publishing.
- Utterback, J. (1999). The process of innovation in five industries in Europe and Japan. *IEEE Transactions in Engineering Management*, Vol. EM-23, No. 1, pp. 3-9.
- Vasquez, R., Santos, M., Alavarez, L. (2001), Market orientation, innovation and competitive strategies in industrial firms. *Journal of Strategic Marketing*, Vol. 9 No. 1, pp.69-90.
- Vernon, R. (1996). International Investment and International Trade in The Product Cycle. *Quarterly Journal of Economics*, Vol. 80, No. 2, pp. 190-207.
- Whetten, D.A. (1989). What constitutes a theoretical contribution? *Academy of Management Review*, Vol. 14, No. 4, pp. 490-495.
- White, M. (1988). *Small Firm's Innovation: Why Regions Differ*. London: Policy Study Institute.

Wilson, J.Q. (1999). Innovation in organization: Notes towards a theory. In J.D. Thompson, (ed), *Approaches to organizational design*, pp. 193-218. University of Pittsburgh Press, Pittsburgh.

Wolfe, R.A. (1994). Organisational innovation: review, critique and suggested research directions. *Journal of Management Studies*, Vol. 31 No. 3, pp. 405- 431.

Zairi, M. (1996). *Benchmarking for Best Practice*. London: Butterworth Heinemann.

Zaltman, G., Duncan, R. and Holbek, J. (1973). *Innovation and organizations*. New York: Wiley.