中國與亞太區域科技創新與工業發展邁向廿一世紀國際研討會

International Conference on Technology Innovation & Industrial Development in China and Asia Pacific Towards the 21st Century

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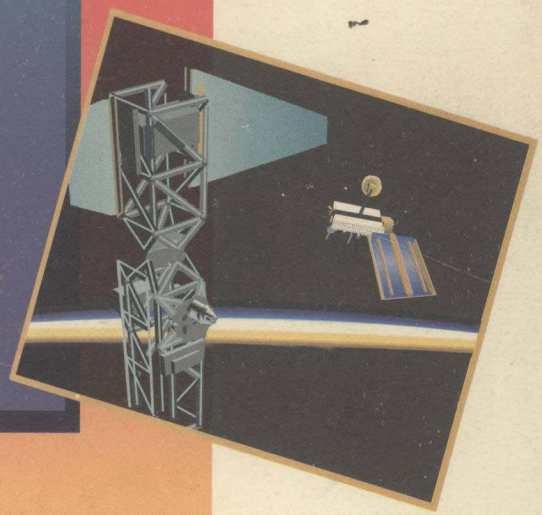

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Co-organisers : The Hong Kong Polytechnic University
National Natural Science Foundation of China
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Supporting Organisations : Institute of Industrial Engineers (Hong Kong)
Society of Manufacturing Engineers, Hong Kong Chapter

中國與亞太區域科技創新與工業發展邁向廿一世紀國際研討會

International Conference on Technology Innovation & Industrial Development in China and Asia Pacific Towards the 21st Century

Sponsoring Organisations : Advanced Chemicals Technology & Equipment Ltd.
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Message from the President of the HKAAST

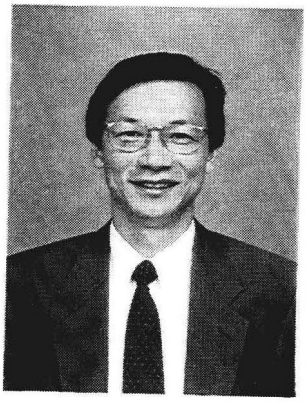
Ten years ago the Hong Kong Association for the Advancement of Science and Technology was founded. Now ten years later we are proud to look back and say to ourselves that we have done a good job.

The Association is, like Hong Kong, short of resources. Our task is not to explore the unknown world of science and technology, not to the push back the frontiers of knowledge. We opt to arouse the awareness of science and technology among the common people. We choose to foster the cross flow of data and information over boundaries, man-made or otherwise. On this premise we organise this Conference as the highlight of events to celebrate our tenth anniversary.

We are most honoured to have Professor Zhu Guang-Ya's personal consent to officiate this Conference. Compounding on our good fortune, Dr Raymond Ch'ien kindly agreed to co-officiate the opening. Doubtless these are great encouragements to us.

The Association is pleased to have the supports of the Hong Kong Polytechnic University, the Beijing-Hong Kong Academic Exchange Centre, the National Natural Science foundation of China and the Xi'an Jiaotong University, without which this event would not be a success. We are also pleased to receive the large number of papers submitted for publication in the conference proceedings. Due to the limitation in space we only manage to print a few on a selective basis.

There is no formula to success in technology innovation and industrial development. It is hoped that the Conference may accumulate and consolidate the views of the many experts of different background and shed lights on the paths for application in different economies.



Wong Ho-ching
President
The Hong Kong Association for
the Advancement of Science & Technology

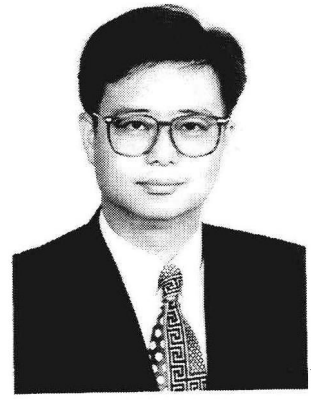
Message from the Conference Chairman

We have witnessed in the last few decades enormous changes in the industrial development of Hong Kong, China and the Asian countries. Many of the industries in Hong Kong have moved North, industries in China were booming, new markets and economy in the third world countries surfaced. No doubt, as many economists analyzed and predicted, that Asia will be the world's focal point in the 21st Century - economically and market-wise. It will be important that Asian countries establish a mutual understanding and an aligned approach in industrial development so that maximum benefits can be achieved.

This International Conference on "Technology Innovation and Industrial Development in China and the Asia Pacific toward the 21st Century" organized by the Hong Kong Association for the Advancement of Science and Technology promises to provide a good forum for the exchange of experience and information among participants and explore various collaboration opportunities.

I wish every delegate a fruitful participation in the Conference and like to also take this opportunity to thank the co-organizers, supporting and sponsoring organizations for making this Conference a success.

Daniel M. Cheng
Conference Chairman



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Session II: Technology transfer and industrial development in the industrializing economies in the region

Session IV: Energy Conservation and Environmental Protection

Technological Innovation Strategies and the Choice of Hong Kong Firms

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Abstract Rapid technical change poses a major challenge to the survive and development of firms. Facing this changing environments of technology, any firm must take some measures and actions to adapt itself to the change circumstances. Behind these behaviours is the innovation strategies of firms, they play a critical role in helping firms to achieve competitive advantages. In this paper, a concept of strategy momentum of innovation (SMI) useful to evaluate the conditions for the choice of innovation strategies is put forward. Then the typology of innovation strategies and features of various innovation strategies are discussed and compared, and a map to illustrate the relation of SMI and the choice of innovation strategies is presented. Finally, the innovation strategies of Hong Kong firms are evaluated by using the concept and analytical model previously developed. Several case studies are also presented at the end of this paper. Their successful experiences in the choice and transformation of innovation strategies provide important implications for the future development of Hong Kong firm.

Introduction

Any firm operates with the permission of markets and technologies. In the traditional economic theories, market was regarded as the external environments of firms while the importance and complexity of technological change were largely neglected. But in most industries and in most countries of modern society, technological change becomes the most important aspect of external environment of firms.

Being Faced with this changing environments of technology, any firm, whether initiative or passive, has to take some kinds of action so as to adapt itself to the changing environments. Firms who do ignore the changing environments of technology very possibly would be superseded by technological competition. The behaviours of a firm to adapt to or to affect the technological environments are determined by certain guiding principals, which here are referred to as the innovation strategy of the firm.

The choice of innovation strategy by a firm is by no means arbitrary. In fact, it is affected by many factors such as firm's technological capability, operating conditions as well as external economic and technological factors. Innovation strategy is also not the recent strategic behaviours of firms, the history of firms in technological innovation already presents some regular patterns in the selection of innovation strategies. In this paper, an concept of strategy momentum of innovation (SMI) useful for the choice of innovation strategy is put forward, then the typology of

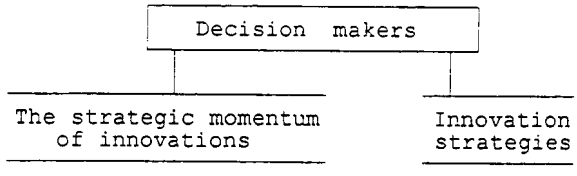
innovation strategy and features of each kind of innovation strategy are discussed. Then, a map representing the relations of SMI and innovation strategies can be drawn based on previous studies and by inference. Lastly, the innovation strategies of Hong Kong firms and some case studies are discussed and presented.

Concept and its Compositions of SMI

Strategy may be defined in various ways, so is the innovation strategy. But the initiation of innovation strategy is specially due to changes of technology and demand pattern. In confronting the rapid change of technology, firms must take some measures or actions so as to survive and to develop. A simply definition of innovation strategy would be the attitude and guiding principals behind these measures and actions.

According to above definition, the formation of innovation strategy are both objective and subjective. On the one hand, the internal capabilities and operating conditions as well as external environments are decisive and objective factors to the choice of innovation strategy, they provide possibilities, limitations for the alternatives of innovation strategy. Here we refer them to as SMI. The rational choice of innovation strategy should be matched with the SMI. On the other hand, the choice of innovation strategy is also subjective, it is subject to the understanding and evaluation of SMI, the attitude of decision makers toward risk, and the weight lesser or greater they give to short-term or long-term considerations. Therefore, the innovation strategy of a firm is in essence a reflection of SMI by decision makers (see Figure 1).

Figure 1. The formation process of innovation strategy



Any firm can be viewed as an innovation system. It may attempt to develop a variety of new products or processes, it can make modifications or improvements to existing products, it can also license innovations made elsewhere, all these changes in technology are new to the firm itself. The capability and characteristics of a firm as an innovation system are mainly represented by the following aspects:

1. Capabilities in applied research and experimental development. The technological and scientific information for an innovation will rarely come from one single source or be in a finished form, therefore, the ability in applied research and development play an important role in an innovating firm. Firms who only make imitations and modifications also need a certain extent of R&D capabilities.

2. The relationship with world science and technology society, or ability in fundamental research, or some combinations of these two advantages. Though industrial R&D in a firm centres on experimental work, many empirical researches demonstrated that inputs of new scientific knowledge, skill and expertise are very important to successful innovation.
3. Level of design, manufacturing and quality control. The abilities in design, manufacturing and quality control can either help market or product leaders in keeping their monopoly position, or help imitators or adopters of innovation to enter the market in competition with the established innovating firms.
4. Effective information system and training system. They are especially important to firms who want to keep pace with technological change. Firms who are left behind the tide of technological change may get information and train their own staff and customers by socialized information and education systems.
5. Others. Technical service, production planning, advertising and marketing are also important aspects of innovation system, but they are less important to the choice of innovation strategy compared with the above functions.

In addition to the capabilities and characteristics mentioned above, the SMI of a firm is also strongly affected by external factors as following:

1. Government technology policy and granting level to R&D and STS. These include the national essential infrastructure of science and technology, inputs level and directions of R&D as well as incentives to technical innovation and technology transfer by governments. The affects of these factors are clearly observable from comparative studies among different national systems of innovation (Freeman, 1987, Lundvall, 1988).
2. The extent of tariff protection and/or whether having "captive" market. Firms may enjoy some advantages of the special markets such as the protection of domestic "infant industry", geographical advantages or as a satellite company of large firms, all these can have important influence upon the choice of innovation strategy.
3. Natural resources and cost of labours. The abundance of natural resources, price level of materials, and the cost of labours also affect the choice of innovation strategy of a firm. If a firm can be in a dominant position by enjoying some advantages in material supply or labour cost, it may not necessarily take the risk of innovation.
4. Others. There are some other factors such as firm's size and "culture", and technological opportunities which also have great impact on the choice of innovation strategy, the extent of the impact varies with the particular circumstances of the firm, the industry and the country.

Innovation strategy of a firm is different from its business strategy. To innovate to some extent means to change the original business conditions so as to achieve initiatives in changing environments. Therefore, innovation strategy is the central and key part of the whole business strategy while serving it.

Innovation strategy is also different from research and development strategy. The later concerns with the goal setting, budgeting and organizing of R&D activities as well as the allocations of R&D resources among different sections, while the former influences almost all activities from R&D, training, production and marketing. On the contrary, some authors also emphasize the reverse influence of R&D strategy and innovation strategy to the whole business strategy.

Classifications and Features of Innovation Strategies

Any classification of strategies by "types" may be somewhat arbitrary and does violence to the infinite variety of circumstances in the real world. However, just as other typologies, the classification of innovation strategy are very useful for purposes of conceptualization, description and study. The most useful and often quoted typology of innovation strategies is that of Freeman (1982). He summarized six alternatives of innovation strategy which are offensive, defensive, imitative, dependent, traditional and opportunist strategies, respectively.

As Freeman he himself mentioned, the six alternatives of innovation strategy should be considered as a spectrum of possibilities, not as clearly definable pure forms. But

Table 1. The tactics and features of each type of innovation strategy

Types	Goal and tactics	Main features
Offensive	Achieving technical and market leadership generating information on its own, patent protection or using it to gain monopoly profit.	Initiative, research-intensive long-term planning planning, high risk
Defensive	Keeping pace with technical change, avoiding heavy risk, using product differentiation or technical service to rescue market share.	Initiative, long-term planning, generally research-intensive.
Imitative	Following way behind technological change, taking other advantages in competition.	Confirmative, short of R&D capability, simply copying of technology
Dependent	Meeting the requirements of its customers, usually acting as the sub-contractor of large firms.	Passive, relying on customer to provide technology
Traditional	Traditional and non-technical competition tactics.	Passive, often relatedto traditional product
Opportunist	Using imaginative entrepreneurship to find market vacancy	Initiative, not based on in-house R&D

each alternative of innovation strategy is not isolated, there must be some tactics and features to match with it, from which we can get better understanding of each alternative of innovation strategy. Table 1 lists out an over-simplified description of the main tactics and features of the six alternatives of innovation strategy.

The innovation strategies pursued by firms may not exactly "true to types", a firm may follow different strategies in different products or business sectors, or change from one strategy to another. In addition, the characteristics of industries (e.g., new emerging industries, traditional industries), stages of economy (e.g., developing, developed) and size of firms (the affect of firm's size to innovation is still the point at issue) are also highly relevant here. Firms who follow "offensive" or "defensive" strategies centre on research-intensive industries, while firms who follow "traditional" strategy are generally "traditional" firms providing "traditional" products. However, the typology of innovation strategies by Freeman provides an optimal spectrum of all alternatives of innovation strategies.

The Relation Map of Innovation Strategy and SMI

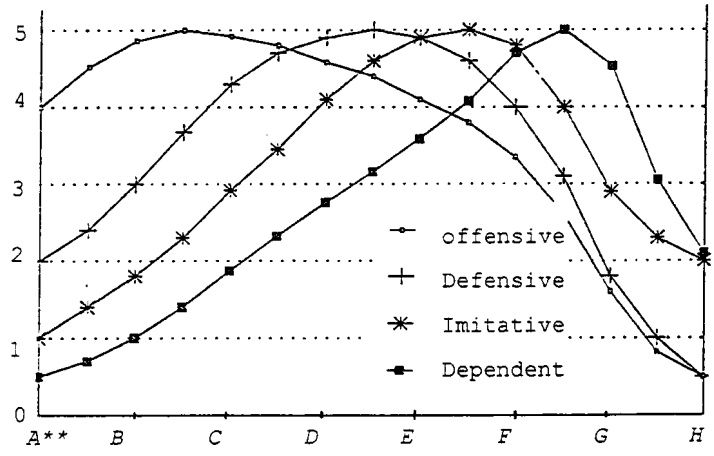
In the studies and classifications of business strategies, strategy is accorded two dimensions (Porter,1980). The first is "strategic advantages", sometimes referred to as "competitive weapons". The second is "scope", which may be broad or narrow. According to the definitions of innovation strategy and SMI in this paper, these two dimensions in essence can be applied to SMI or the contents of innovation strategy. By comparing the six alternatives of innovation strategy listed in Table 1, we can see that all strategies except "traditional', which most probably operates under conditions approximating to the "perfect competition" model of economists, are seeking or relying on one or more competitive advantages even if some of which are weak or passive. This is the first dimension of SMI. The second dimension is that firms may possess a wide or narrow range of comparative advantages. In other words, firms may be strong in more or fewer factors of SMI. It is obvious that the wider range of strategic advantages a firm possesses, the more alternatives it has.

On the prerequisite of rational knowledge of SMI, there exists regular relations between the optimal choice of firm's innovation strategy and its SMI. If we narrow the "scope" of strategic advantages and focus on the most powerful advantage in the SMI of a firm, there exists accordingly one optimal alternative of innovation strategy for the firm to choose. According to this principal as well as the compositions of SMI and the features of each type of innovation strategy discussed above, a map to represent the relations of the choice of innovation strategy and SMI can be drawn as Figure 2 (the SMI of "traditional" and "opportunist" innovation strategies are not shown in the map as they do not possess obvious comparative advantages).

Figure 2 provides a direct perception about the spectrum of innovation strategies corresponding to SMI. It differs from Freeman's comparatively quantitative

evaluations of some internal functions of firms relating to their alternatives of innovation strategy in that, Freeman only discussed the in-house scientific and

Figure 2. The relation map of the strategic momentum of innovation and innovation strategies



* Range 0-5 indicates weak to very strong.
** *A.* Ability in fundamental research. *B.* Ability in allied research. *C.* Ability in experimental development. *D.* Level of design and engineering. *E.* The effectiveness of information and training systems. *F.* Level of manufacturing and quality control. *G.* The extent of market protection. *H.* The level of wages and the price of materials.

technical functions within the firm (1982), while the map here gives a pictorial illustration to the relations of innovation strategy and SMI, in which both internal and external factors affecting the choice of innovation strategy are included. Detailed analysis of Figure 2 can also reveal some meaningful results. The peaks of each curve in the map represent the "competitive advantages" of each innovation strategy, the widths of each curve above the middle level represent the "scope" of competitive advantages. From left to right of the innovation strategies, the map shows a continuous reduction in the competitive advantages, to some extent, this shift corresponds to the spectrum of innovation strategies from developed economies to developing economies or from research-intensive industries to traditional industries. From right to left is a transformation process of innovation strategies, Japanese experience from 1900 seems to fit this movement as it has an increasing proportion of firms shifting from traditional to imitative strategies, and then to defensive and offensive innovations.

The relation map of SMI and innovation strategy is somewhat subjective. But when considering that the majority of firms follow "imitative", "dependent" and "defensive" innovation strategies, and only a small minority of firms in any country are willing to follow an "offensive" strategy, the weighted sum of all curves in the map are identical to the curve of product life cycle by Utterback an Abernathy(1975) and the logistic diffusion model (Mansfield, 1969, Metcalfe, 1970), both curves are supported by many empirical studies. Therefore, the relation of strategic momentum and the

choice of innovation strategy represented by the map possesses certain generality and reasonableness.

Innovation Strategies of Hong Kong Manufacturing Firms

The innovation strategies of Hong Kong manufacturing firms as a whole possesses more characteristics of that in developing countries. In the past decades, Hong Kong firms have achieved remarkable success in world market, but now they are experiencing an increasing loss of competitiveness. Following nearly the same innovation strategies, why the manufacturing industries of Hong Kong could increase very fast in the past while cease to increase at present? In this and following parts of the paper, we use the concept and model previously developed and some case studies to give an explanation to this change.

Looking at the map of SMI, where are the manufacturing industries of Hong Kong located? The well-known fact is that the R&D capability and the scientific and technical infrastructure of Hong Kong are relatively weak compared with the other three of the "Four Little Dragons" and some developing economies. According to an evaluation made by Lall (1990), the NTC (national technology capabilities) of Hong Kong follows behind Korea, Taiwan, Brazil, Mexico, and India. There is almost no science and technology policy or planning by Hong Kong governments, the industrial R&D manpower and expenditure are also very low due to its light and supplier-dominated (Pavitt, 1984) industrial structure, small economic scale and firm's size. The majority of Hong Kong firms also lack long-term planning due to political and other reasons. Therefore, there are almost not any advantages in fundamental, applied research and experimental development in the SMI of Hong Kong firms, that is to say, they lack essential qualifications to pursue "offensive" and "defensive" innovation strategies in general.

However, Hong Kong firms in their specialisations do have some relative advantages in communication, design, manufacturing and quality control in comparing with newly industrializing economies and developing economies. These are part of reasons and part of results that most firms follow "imitative" and "dependent" strategies. Hong Kong firms received no tariff protection but they used to enjoy the advantage of low labour cost before the later 1970s, they also enjoy the reputation of legendary flexibility and quick response to changing circumstances. So the SMI of Hong Kong firms as a whole favours the options of "imitative", "dependent" and "opportunist" strategies.

Various studies can be used to support the conclusion that most Hong Kong firms follow "imitative", "dependent" and "opportunist" strategies. An empirical study made by Huang (1994) reveals that the main pathways of technical acquisition of firms are from customers, import of capital goods, FDI, imitation and technical licensing. Many studies have confirmed that in tradition the "competitive weapon" of Hong Kong firms is "cost-leadership", the export-oriented economic structure made