

# TECHNOLOGY STRATEGY FORMULATION: AIDS, METHODOLOGY AND FRAMEWORK OF ANALYSIS

Rogério H. Quintella\*  
Camila Carneiro Dias\*\*  
Brenner Vasconcelos\*\*\*

**T**his paper is intended to identify the relationship between the concepts of “strategy” and “technology” at the different corporate levels and, mainly, to present a framework of analysis of technology strategies. The importance of the linkage between technology and business strategy was well exemplified by Szakonyi (1990), where he states that the absence of R&D leverage was responsible for the lack of competitiveness of American companies in comparison to Japanese up to the beginning of this decade. He observed that the main reason for all these problems was poor coordination between R&D and business planning.

## Introduction

Authors such as Ansoff (1976, 1984) and Porter (1980, 1985), among many others related to the business administration area, adopt the vision of different levels of strategies:

- Corporate Strategy: it is the most comprising strategic level. It searches for a proper balance between mature and emergent businesses and technologies within corporation’s portfolio. Something that makes a corporation more than the sum of its individual businesses can, in some way, be linked to corporate strategy.

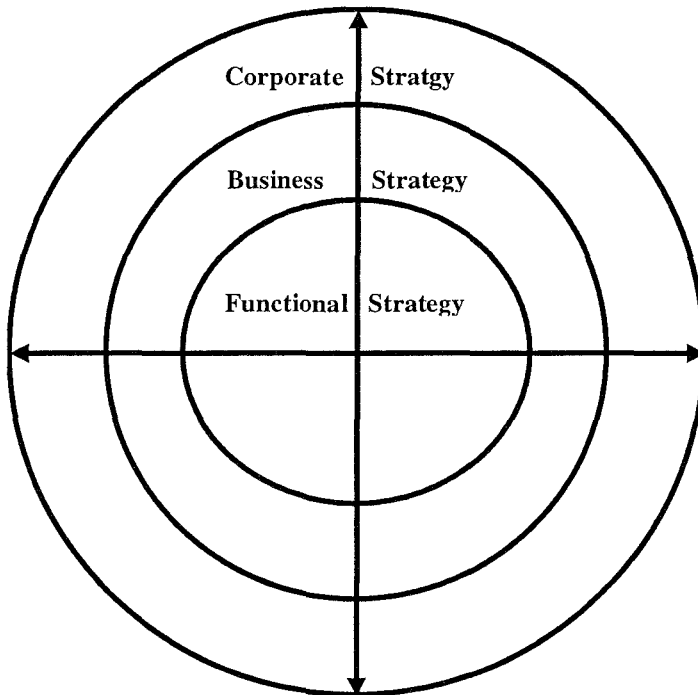
\* Ph.D., NACIT/NPGA - EAUFBA

\*\* Mestranda, NPGA - EAUFBA

\*\*\* Bolsista de I.C. - EAUFBA

- Business Strategy: it can be described as patterns of resources and competencies deployed to achieve a specific business goal or objective, which involves interactions with business' economic environment.

- Functional Strategy: it can be considered as unfolding consequences of business strategies at operational levels. According to Hoffer and Schendel (1978), at the functional level, the principal focus of strategy is on the maximisation of resource's productivity.



**Figure 1.** The strategic view trough different levels.

Corporate strategy is managed mainly trough the business portfolio and has two main issues: the first is the exploration of synergy among the different businesses (which should make the corporation more attractive to its shareholders than a group of individual companies). The second is the management of the portfolio in such a way that it optimises the probability of companies' long-term survival.

To understand the importance of technology upon corporate strategies, Fusfeld (1978) introduces the concept of “technology elasticity”. Technology elasticity allows the application of one technology to different markets and its segments. In his view, elasticity is missing from most research and development plans and could effectively help in a strategic use of technology in corporate planning. The concept of technology elasticity exemplifies what can be achieved through the exploration of technology as a source of synergy at corporate level.

## **Technology strategy general approaches and its different levels**

It is generally accepted that there are two types of approaches regarding to the technology strategy:

- **Traditional:** where companies look for technologies that can help to maintain or “attack” a specific market;

- **Competence-based:** where the analysis is inverted whereby from its existing competencies a company looks for new applications and markets.

In terms of long-term survival there are two important technological aspects to be considered. First, is a proper balance between mature and emergent technologies within the firm’s portfolio. Second is the potential effect of radical innovations upon industries’ structures.

It is quite obvious the exploitation of technology as a source of competitive advantage. According to Porter (1985), even if technology does not yield competitive advantage to any one firm, it may affect the profit potential of all firms. Conversely, technological change that improves a firm’s competitive advantage may worsen structure as it is imitated. The potential effect of technological change upon industrial structure means that firms cannot set technology strategy without considering its structural impacts.

Technology has the capacity of integrating company’s strategic business units (SBUs) in a coherent way, contributing for the success in the implementation of corporate strategies. On the other hand, business strategies suffer the influence of technological innovations, once they can determine the appearance of new products, services and processes. In addition, it is obvious the impact of new technologies upon company’s

functional areas (marketing, production, finances etc.) in order to optimise the allocation of resources and the gains of productivity.

Porter (1985) analyses the importance of technology in a firm's strategy from two broad points of view:

1 - The Competitive Advantage. In order to affect the competitive position of a firm, technology should play a significant role in determining the cost or differentiation uniqueness of products or services.

2 - Industry Structure. In analysing the importance of technological change in the industry, Porter (1985) considers the relationship with suppliers, buyers, new entrants and substitutes.

The importance of technological issues to business-level strategy appears to be more readily acceptable than would seem to be the case with corporate strategy. Cookson (1991) says that traditionally the amount of money invested by "science-based multinationals" in corporate projects is just around 10 per cent of the whole R&D budget. It means that the other 90 per cent are allocated speedily in research projects within SBUs (strategic business units).

In spite of these strong indications of a disseminated "business orientation" on industrial research and development, Szakonyi (1990), in surveying more than 170 American Companies, concluded that less than 10 per cent of them had effective coordination between R&D and business planning.

Another important interface is that one regarded to the functional strategy. Many authors recognise the idea of strategies at functional level such as: a financial strategy, a marketing strategy and a research and development strategy. Others authors used to call the same concepts "functional tactics"<sup>1</sup>. Anyway, as it is stated before, the main focus of a functional strategy must be on the maximisation of resources productivity.

While each of these different types of strategies are distinct, they should form a coherent and consistent whole for any particular organisation, if the organisation is to be successful over the long run.

Porter (1987), defines "technology strategy" as a firm's approach to the development and use of technology. In his view it must address three broad issues:

1 - What technologies to develop. To choose the "technology to be developed" Porter suggests, as a first point, the need to consider companies'

generic strategies (cost-leadership, differentiation or focus). In doing so, a firm should concentrate on those technologies that have the greatest sustainable impact on cost or product differentiation.

2 - The role of technology licensing. Porter's analysis covers only the view of the licensor. Nevertheless, the licensee can also have a broad technology strategy, of which buying a license may be only one issue.

3 - Whether to seek technological leadership. In relation to the "technological leadership", Porter classified technology strategies as "leader", "followers" and "disregards". On the other hand, Freeman (1982), while recognising that any classification of strategies by type necessarily involves some arbitrary decisions, observed and described six types of strategy: offensive, defensive, imitative, dependent, traditional and opportunist<sup>2</sup>. Other interesting typology is shown in Weinsfeld-Schenk (1994).

Weil and Cangemi (1983) demonstrated that the main problems observed in the linkage of long-term range R&D and strategic planning are: the mismatch of horizons between business planners and researchers; the lack of knowledge about corporate goals by researchers and the difficulty in making long-range forecasts of markets and technologies. An important contribution to this discussion can be seen in Berry and Taggart (1994).

Coombs (1990) in analysing some highly professionalized R&D departments of large industrial companies observed that the need for managers to identify technologies and products separately and give strategic action to both portfolios appears to be an increasing one. Thus, it can be argued that the rate of increase of technological diversity at firm level appears to be greater than the rate of increase in product diversity. Coombs emphasises that the R&D effort unrelated to corporate goals and objectives is a waste of time and money.

A direct link between R&D and business, disregarding the different (although complementary) natures of technologies and products, can be associated with the traditional approach described above. The exploitation of those differences, on the other hand, makes easier the development of new products or markets to explore the firm's competence and, consequently, to follow the second type of technology strategy generic approach.

At the level of corporate strategies, it can be seen that the perception of technology as a strategic factor has increased. It can also be concluded that one of the main issues from this strategic view of technology is the concept of synergy, corroborating the dissemination of the competence-based approach. The concept of technology strategy will be used in this paper in accordance with the following definition:

A pattern of technico-scientific resources and competencies deployed to achieve a technological goal or objective defined from the analysis of the business' competitive forces.

## **Framework of analysis**

As the relationship between the concepts of strategy and technology was analysed at the previous sections, the present one intends to spot some light on a technology strategy framework of analysis. The first step will be to divide this kind of study into three analytical areas, following the work of Mulder and Vergragt (1990).

### **Macro-Level**

The macro-level analysis takes in consideration only the broadest aspects of strategy formulation such as the technological trajectories, paradigms and dominant designs.

Nelson and Winter (1977) studied technological progress by introducing the concept of "technological regime". This concept deals with potential, constraints and unexploited opportunities. They state that: "...this sense focuses the attention of engineers on certain directions in which progress is possible...". The combination of these factors has a technological momentum that results in a "natural trajectory".

Dosi (1982) introduced the concept of "technological paradigm". The concept involves continuous and discontinuous processes of technological change. The continuous changes "are often related to progress along a 'technological trajectory' defined by a technological paradigm, while discontinuities are associated with the emergence of a new paradigm". He relates this concept to that of technological trajectory by suggesting that

these trajectories are a clustering of possible technological directions whose outer boundaries are defined by the nature of the paradigm itself.

Albernathy and Clark (1985) introduced the concept of “dominant design” and used it to describe four different types of innovations:

- **“Architectural Innovations”**: are the most radical ones. This type of innovation disrupts the existing competencies in the industry and even the existent linkages with markets. Such innovations sometimes create a completely new market and constitute a new dominant design.

- **“Regular Innovations”**: follow a dominant design. However, they can generate successive improvements, entrenching the existent competencies and the linkages between producers and markets.

- **“Niche-creation Innovations”**: reinforce existing competencies, but disrupt market linkages as they create specific niches for the innovator.

- **“Revolutionary Innovations”** : disrupt existing competencies; nevertheless, they do not change the existing linkages with markets.

The three works cited are complementary and comprehensive, providing a basis for an economic innovation theory.

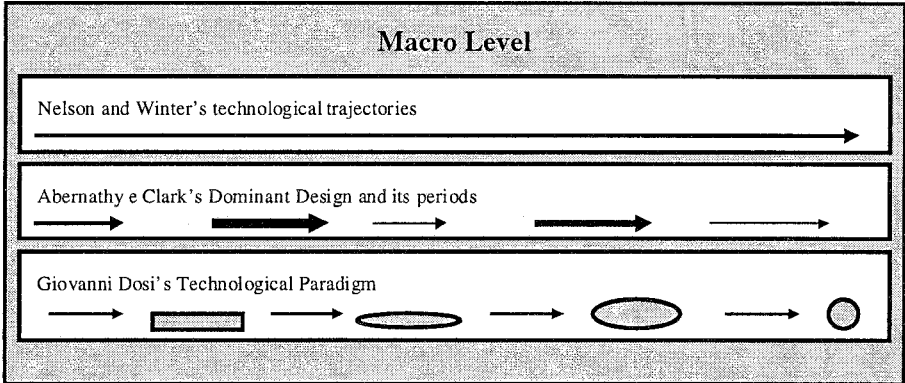


Figure 2. The Macro Level of Analysis

## Meso-Level

The second level of analysis is where the interactions and competition among different companies and their strategies occur. Here it is possible to analyse the opportunities provided by the interaction between the

technological trajectories and the cultural, economic and competitive environment in which a company is inserted. Mulder and Vergragt found that this trajectory provides some opportunities, which are circumstantial to the companies, their markets and socio-political environments. They emphasised that at this level of analysis, it would be possible to formulate questions such as: “why do some firms enter a new trajectory?” and “how they react to the choices other companies made?”

It is in this meso-level of analysis that works such as those of Porter and other authors pertaining to the so-called “managerial school” of the strategic thinking can be inserted. Porter (1980) provided a useful model for the analysis of business strategies. Based upon his work and the work of Wilkinson (1987), it is suggested a systematic approach for using business strategies as a source of ideas for research and development projects, as it is shown bellow in figure 3 and 4 (adapted from Quintella, 1993).

In analysing the industrial competitors, Wilkinson considers three main aspects: the maturity of technology, the portfolio of activities and the breadth of activities, as shown pictorially in figure 5. Wilkinson states that R&D has a clear role to play in seeking to introduce product differentiation (to a whole industry or to a particular sector), or in giving the company a cost advantage in process know-how.

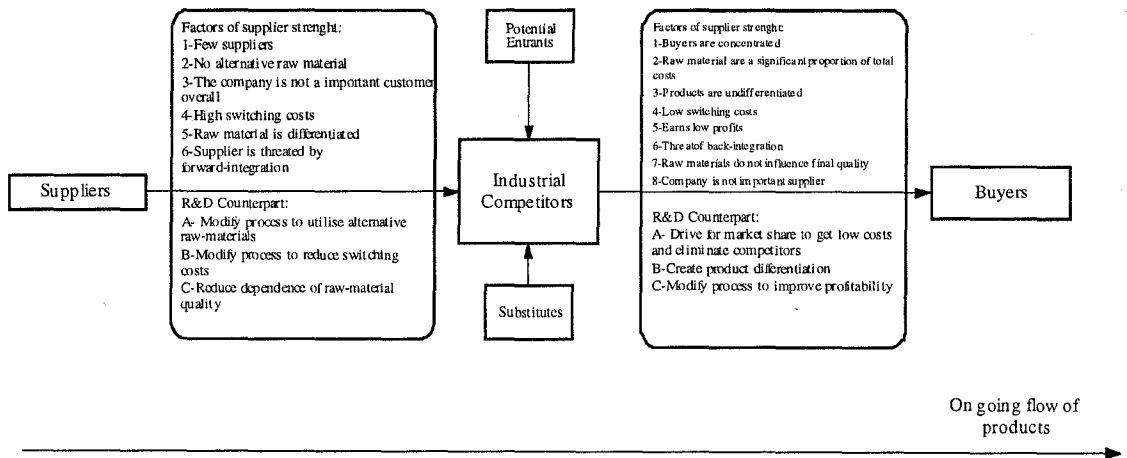


Figure 3. R&D project generation from threats from “on-going flow of products dimension”.



In considering the portfolio of activities, Wilkinson considers the use of some “technological matrixes”, such as McKinsey’s and Booz Allen’s technical matrices. The use of this type of tool may lead, however, to a potential mismatch between the maturity of technologies and that of products/markets, requiring some care in their use and interpretation. Care should also be applied to the third aspect considered by Wilkinson: the maturity of the technology. This aspect was analysed by Wilkinson (1983) and is also summarised within Figure 5, where a straight connection between investment in R&D and maturity of technology is indicated. This link can be compared with that made by Porter (1985), where he states that only certain combinations of sub-technologies can be considered mature and not a specific technology as a whole.

### Micro-Level

The micro-level is where the analyses of the genesis of each company strategy is conducted. It has its roots in business administration and in the sociology of science and technology. From the micro-level it is possible to analyse how strategy formulation and implementation within a firm takes place.

Within this third level of analysis some studies can be found in the literatures, aimed at developing procedures for developing strategies, such as the ones of Sethi *et al.* (1985) and Bemelmans (1979). Both of these are extremely complex and seem quite mechanistic in their conception. Some parts of these works are, however, often found in the literature such as:

- *Technological forecasting*; discussed by Twiss (1986), Harris *et al.* (1983), Szakonyi (1990) and others;

- *Technology audit*; discussed by Fusfeld (1987), Harris *et al.* (1983), Clarke *et al.* (1989), Twiss (1986), implicitly by Szakonyi (1990), Bitondo and Frohman (1981).

- *Project portfolio*; discussed by Harris *et al.* (1983), Coombs and Richards (1990), Twiss (1986), Wilkinson (1987), Szakonyi (1990), Bitondo and Frohman (1981) and others.

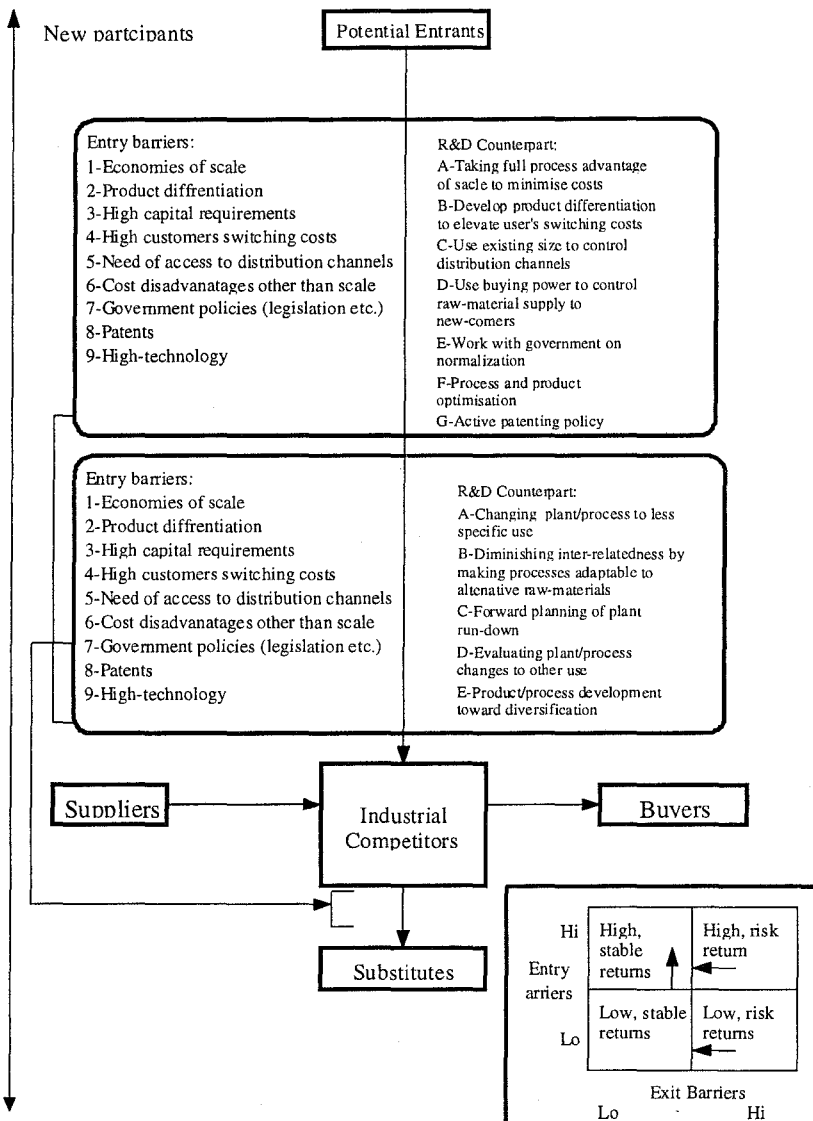


Figure 4. Project generation from threats from “new participants dimension”.

For the project portfolio, a frequently used tool of analysis (in the literature) is the so-called technology or technological matrix. Some of them are very well known, like Booz Allen and McKinsey’s matrixes cited above.

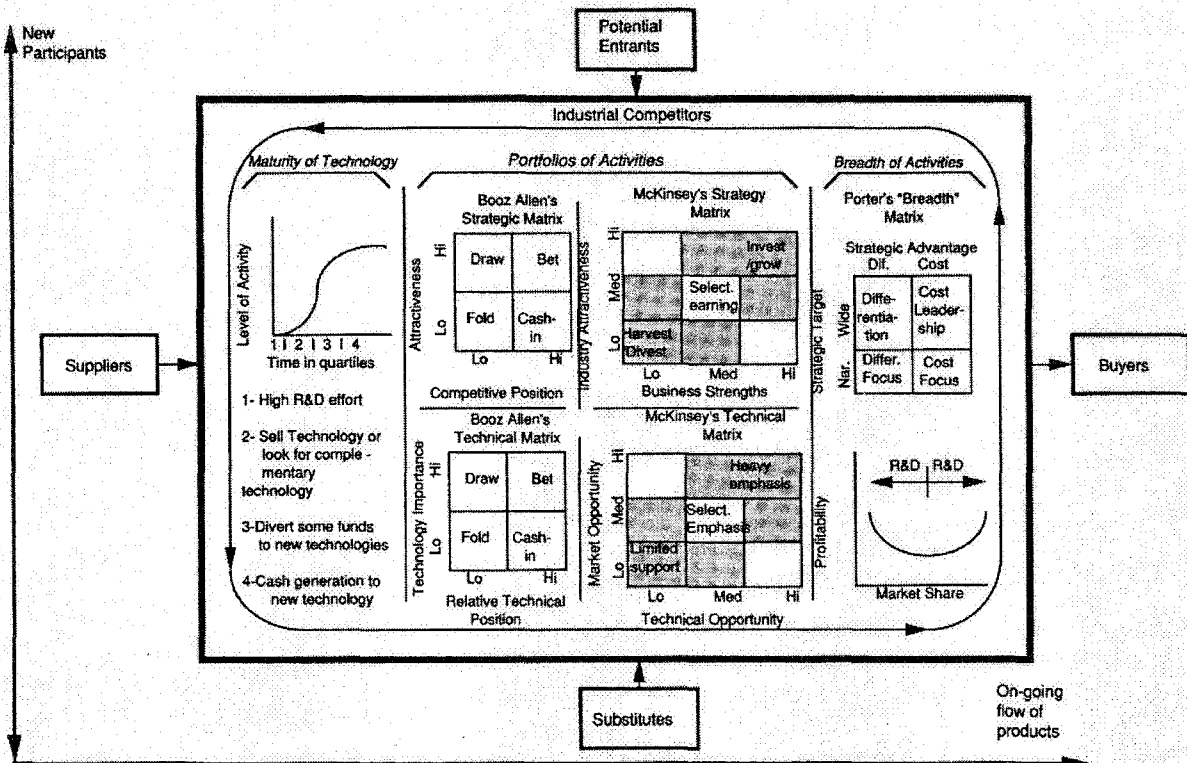


Figure 5. Pictorial view of Wilkinsons's technology strategy generation model on the "industrial competitors dimension"

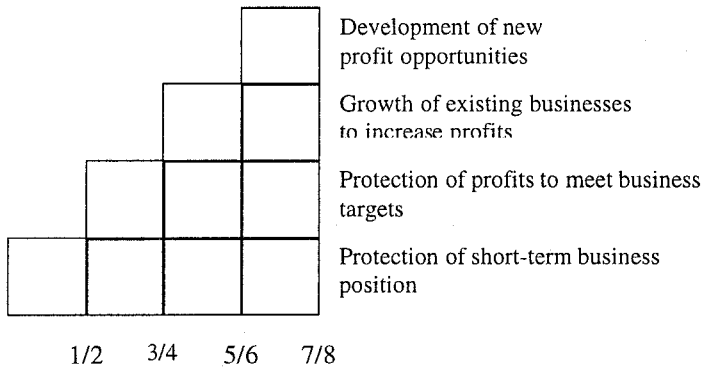
The matrixes described by Coombs and Richards (1989) in relation to the business portfolio and shown in Figure 6 bellow work as follows: “The Business Quality Matrix is used to differentiate into eight different business potential categories. Having differentiated all the business by this method, they are then mapped onto a standard 2x2 BCG matrix. The mapping is such that the place on the grid should take into account the dynamic nature of business, and that business can be located at any point in the space within the grid.” Each business differentiation category requires a different level of total R&T (research and technology) effort, which is built up from consideration of the business requirements and the R&T effort, but only the levels named “Strong Growth” and “New Business” require the development of a new category of R&T related to the “Profit Opportunities”. The level of each category is based upon a percentage of sales income and is generated from previous expenditure information. “The R&T effort is a cumulative total of the categories allocated to each business”.

	Below average	Average	Above average	
Business Competitive Position				Above average
				Average
				Below average
	Industry perspectives			

a) Business quality matrix

Ongoing/ cash	6-Maintain competitive position/ renew asset base	7-Strong business with good growth opportunities	Strong
	5-Optimise cash flow		
	4-Maintain operability minimum sustenance		
Problem	3-Recover	8-New products and businesses	New
	2-Divest		
	1-Rundown/ close		

b) Business differentiation matrix



c) Business differentiation category and R&T effort

Figure 6. Decision aids for technology-strategy generation (adapted from Coombs and Richards, 1990).

The work of Coombs and Richards is the culmination of comprehensive research on technology-strategy formulation. It clearly demonstrates the possibility of identifying technology strategy as something distinct from but related to business strategy. Coombs and Richards also make another important distinction between the strategic analysis of a product portfolio and the technology base in a business. Their deep probing provides an excellent source of information on technology strategy formulation (or Micro-level) analysis.

## Conclusion

The model proposed by Mulder and Vergragt, based upon three different levels of analysis (macro, meso and micro) has proved to be a very useful one in analysing the technological strategy of firms. Quintella (1993) uses this framework to describe the technology strategies of four european chemical companies. More specific models such as those of Nelson and Winter, Abernathy and Clark, Dosi, Porter and Wilkinson and several others reviewed throughout this paper, may be better used through this framework of strategic analysis.

It can be stated that some of the models cited above are used, at least as guidelines, for firm's technology strategies generation too. Many questions about them, however, are still to be answered, such as:

- Which gives better results?
- Are the use of these techniques associated with the cultural changes cited by Mulder and Vergragt?
- Are they in some way associated with a new techno-economic paradigm?
- Are there patterns of approaches to these questions?
- Do these patterns change only with the size of the businesses or also with their position within the supply-chain?
- Can stereotypes be observed?
- What is the proportion of managers who see technologies and products from different perspectives?
- In those companies that actually have a formal technology strategy, what is the process of strategy generation?

- Are tools such as technological forecasting, technology auditory and portfolio analysis in use? How often?

- Are there any others? What are their results?

These questions involve the state-of-the-art on strategic management of technology and can only be answered by continuous research on the subject.

## Notes

<sup>1</sup> According to Lamming and Bessant (1988), "tactics" can be described as patterns of operation deployed in the achievement of a strategic goal.

<sup>2</sup> Although it has been done before the works of Porter and Freeman, the study Bitondo and Frohman (1981) complement this researchers' view, describing what they call the technology strategy dimensions.

## References

- ABERNATHY, W.J., and Clark, K.B. (1985), **Innovation: Mapping the winds of crative desctruction**, *Research Policy*, **14**, 3-22.
- ANSOFF, I.H. (1976), **Corporate Strategy, an Analytic Approach to Business Policy for Growth and Expansion**, McGraw-Hill, New York.
- \_\_\_\_\_ (1984), **Implanting Strategic Management**, Prentice-Hall International, New York.
- BEMELMANS, T. (1979), **Strategic Planning for Research and Development**, *Long Range Planning*, **12**, April, 33-44.
- BERRY, M.M. and Taggart, J.H. (1994), **Managing technology and innovation: a review**, *R&D Management*, **24**, 4, 341-353.
- BESSANT, J. (1991), *Managing Advanced Manufacturing Technology*, Blackwell, Oxford.
- BITONDO, D. and Frohman, A. (1981), **Linking Technological and Business Planning**, *Research Management*, November, 19-23.
- CLARKE, K., Ford, D. and Saren, M. (1989), **Comapny Technology Strategy**, *R&D Management*, **19**, 3, 215-29
- COOKSON, C. (1991), **An experiment in chemical defence**, *Financial Times*, 20 June, 7.

- COOMBS, R. and Richards, A. (1990), **The Integration of R&D Strategy and Business Strategy**, *CRONTEC, Manchester School of Management*, March, Manchester.
- DOSI, G. (1982), **Technological Paradigms and Technological Trajectories**, *Research Policy*, **11**, 147-62.
- FREEMAN, C. (1982), *The Economics of Industrial Innovation*, Francis Pinter, London.
- FUSFELD, A.R. (1978), **How to Put Technology Into Corporate Planning**, *Technology Review*, May, 51-5.
- HARRIS, J.M., Shaw, R.W. and Sommers, W.P. (1983), **The Strategic Management of technology**, *Planning Review*, January, 29-35.
- HOFER, C.W. and Schendel, D. (1978), *Strategy Formulation: Analytical Concepts*, West Publishing Co, St Paul, Minnesota.
- LAMMING, R. and Bessant, J. (1988), *Macmillian Dictionary of Business and Management*, Macmillan, London.
- MULDER, K.F. and Vergragt, P.J. (1990), **Synthetic fibre technology and company strategy**, *R&D Management*, **20**, 3, 247-56.
- NELSON, R.R. and Winter, S.G. (1977), **In Search of a Useful Theory of Innovation**, *Research Policy*, **5**, 1, 37-76.
- PORTER, M.E. (1980), *Competitive Strategy*, The Free Press, London.
- \_\_\_\_\_ (1985), *Competitive Advantage*, The Free Press, London.
- \_\_\_\_\_ (1987), **The State of Strategic Thinking**, *The Economist*, 23 May.
- QUINTELLA, R.H. (1993), *The Strategic Management of Technology in the Chemical and Petrochemical Industries*, Pinter Publishers, London.
- SETHI, N.K., Movsesian, B. and Hickey, K.D. (1985), **Can Technology be Managed Strategically**, *Long Range Planning*, **18**, 4, 89-99.
- SZAKONYI, R. (1990), **Coordinating R&D and Business Planning**, *Technology Analysis & Strategic Management*, **2**, 4, 391-411.
- Twiss, B.C. (1986), *Managing Technological Innovation*, Longman, New York.
- WEIL, E.D. and Cangemi, R.R. (1983), **Linking Long-Range Research to Strategic Planning**, *Research Magazine*, May-June, 33-9.
- WEINSENFELD - Schenk, U. (1994), **Technology Strategies and The Miles & Snow Typology: A Study of the Biotechnology Industries**, *R&D Management*, **24**, 1, 57-64.
- Wilkinson, A. (1983), **Corporate strategy as a source of ideas**, *R&D Management*, **17**, 1, 51-61.
- \_\_\_\_\_ (1985), **Corporate Strategy and the Buying and Selling of Know-how**, *R&D Management*, **15**, 4, 261-69.