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# TECHNOLOGIES AND MARKETS

J J Verschuur

Peter Peregrinus Ltd on behalf of the Institution of Electrical Engineers

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# TECHNOLOGIES AND MARKETS

# Preface

Industrial and economic growth are generally accepted to be major factors in improving living standards in the free world. It is in this world that industrial firms, in free competition with each other, create useful products. The profits obtained from these operations may be used by the firm to expand and thus to make yet more products; this, in turn, will satisfy the users of such products. Sustained growth is a goal for which nations and industries strive, despite the current stagnation in the economy. All are agreed on this aim, but how to achieve it is the subject of much debate.

The role of technology as a motor that drives industrial growth yet serves society has been discussed widely in many books and articles. Technology flows continuously from its sources and stocks, and the management of these so that they meet market requirements is thus of prime importance.

The current debates about the role of technology seem to show that there is a need for a book such as this. It deals with the subject of product creation as a result of the interactions between science and technology on the one hand, and society and the market on the other. Products are created as the result of R&D projects, and the book also deals with the generation, evaluation and selection of such projects. They should enable industry to market their products at the right time so as to safeguard their competitive position.

It was at the instigation of my friend Alan Montgomerie that I wrote this book; we were colleagues in various working groups of the European Industrial Research Management Association (EIRMA), Paris. The book is based on personal experience in industry and on the views and experiences of EIRMA colleagues as published in several EIRMA working group reports.

The book was written, as Alan Montgomerie suggested, 'for those who come after us in industry'. Thus it is meant for management students in general as well as for young technology and R&D managers and their staff. They are the entrepreneurs of the future, needed to achieve a healthy industry that works for mankind and industry's own welfare.

I want to thank my friend John Michiels, director of research (rtd), Ateliers de Constructions Électriques de Charleroi, Belgium, my predecessor as chairman of the

EIRMA working group on R&D project evaluation and selection, for the stimulating discussions we had both in EIRMA and privately. In addition I recall, with gratitude, various discussions with my colleagues in EIRMA.

I must also acknowledge my debt to my ex-colleagues at N.V. Philips Gloeilampenfabrieken at Eindhoven, the Netherlands, who read parts of the book. They are D. J. Grootjans, of the Technical Efficiency and Organisation Department, and H. J. Vink, senior managing director of research (rtd). I also remember with gratitude the many discussions with my former associates at Philips, especially with my friend Aldert Potjer, which have contributed to the ideas in this book.

Another colleague and friend who helped me by reading parts of my book is Jan van Rees, formerly of Philips, professor extraordinary of marketing management at the Industrial Engineering and Management Sciences Department of Eindhoven Institute of Technology, the Netherlands, and I thank him for his pertinent and useful comments.

I am also indebted to my former students and colleagues at the Graduate School of Management at Delft, the Netherlands, for the many lively discussions which have also influenced my thinking, and for persuading me that there was a need for this book.

Finally, my deepest gratitude is to Lida, my wife, who cheered me up at times when I felt discouraged; to Paul, my son, who corrected my English and also made many useful comments on the contents of the book; and to Ietje Dunlop, who cheerfully and competently completed the typescript in time and became a family friend in the process.

January 1983

Jan J. Verschuur

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I have been unable to trace Maurice E. Esch, the copyright holder of 'Planning assistance through technical evaluation of relevance numbers', paper presented to the second annual technology management conference on technological forecasting and planning, Lake Placid Club, Essex County, NY, 1968, and would appreciate receiving any information that would enable me to acknowledge his source material.

# Introduction

In the free world, unfettered industrial enterprise has led to ever-increasing prosperity for the population. If this is to continue, industry must be able to satisfy its customers with useful products. Industrial firms seek market opportunities for their products, and in order for them to increase the affluence of society they must obtain a net income; in other words, they must make a profit. Profit makes it possible to invest capital in operations aimed at producing improved and innovatory goods, systems, processes and services that are based on existing and new technology and which, in turn, satisfy customer demand.

A sequence of these events is only possible if sufficient capital for investment continues to be available, and if customers' incomes enable them to purchase the goods they require. The relationship between technology and the market is mutual. More investment capital enables industry to expand the sources and stocks of technology, and these, in turn, may supply more goods for the marketplace. This, again, may result in higher investments. History has shown that these relationships have caused increases in the standard of living, and modern free society must regard R&D as a basic factor in the growth of prosperity; the alternative is low or zero growth of the economy and a reduced standard of living.

Yet technological and economic developments may be slow – for instance, when existing technology is used for rather marginal product improvements and no entirely new technology is yet in sight. When such new technology does come to the fore, a wealth of new applications may be created and give rise to rapid economic growth. The applications of the electronic 'microchip' may serve as an example.

In addition to such waves of technological and economic growth there is continuous technological progress in a wide variety of fields, which results in a stream of improved and innovatory products. Provided that these can be sold at a profit, the economy and people's prosperity may, even after the stagnation of the 1980s, pick up again.

It is therefore important to stimulate technological growth and industrial activity; these, as is now generally realised, create prosperity in developing countries and safeguard it in the highly developed ones.

Technology has at least two roles. It can create products and it can increase production efficiency. Its role in creating products has been subjected to criticism and even abuse by groups in the population which fear its uncontrolled growth and its unwanted or even dangerous side effects.

The role of technology in increasing production efficiency has led to more automation and, as a result, to rising unemployment, although this may be offset to some extent by the fact that new products are created and produced all the time. Nevertheless there is sincere concern about this effect of technological progress, and it should be dealt with seriously.

Thus, the management of technology sources and stocks, and of the use of technology, is an important but complex subject which is the responsibility of society itself. As de Bono has remarked,

> For society to quarrel with technology is like a man quarreling with his legs. Legs are the means by which we get about the material environment of life. They can be used for walking, for running, for sport, for dancing, or for destructively kicking at things. No one would willingly hand over the management of his legs to someone else.

In the past, science and technology used to go their own ways with often little mutual influence. Sometimes science came up with results which were then put to technological use; there may have been a considerable time lag. The basic principles of stereophonic sound reproduction were discovered before the Second World War, well in advance of their use in equipment. On the other hand, the steam engine was invented before even the elementary principles of thermodynamic science had been formulated.

Now the interrelationship between science and technology has strengthened, and it is seen that major technological innovations have their roots in science. The time lag between scientific findings and their applications now also tends to be shortened. Science will continue to play a crucial role in contributing to our general welfare, such as in health, food supply, better transportation and the like, and such possible contributions should not be left to linger but should be exploited as soon as possible. The time element is becoming increasingly important.

Timely product creation and maximum production efficiency are not only in the interest of the customer but also prerequisites for the industrial firm's competitiveness. A sound competitive position in the market is based on low product cost which, in turn, is associated with large production volume. Early market entry in a growing market may be crucial in establishing the company as the market leader. Thus in both the present and the future there is a call for closer coordination and timing of the main industrial activities in creating products and enhancing productivity.

In this book we shall deal with the complex problem of technology management as it operates in a free market to produce useful goods, systems, processes and services. We shall investigate the general interactions between science and society as a framework from which more particular interrelations between technology and the

marketplace will emerge. Within this general framework a model has been developed which is based on three distinct phases in both scientific research and research into society's needs. The results of these two types of research are used as inputs to the process of product creation, in which three phases, partially overlapping, can again be discerned.

Scientific research includes basic or undirected research, applied or directed research, and technical development. Similarly, research into society's needs passes from undirected research, through directed societal or market research, to market analysis.

The three steps in product creation can be described as discovery/invention, orientation/substantiation, and product design/development.

Undirected scientific and societal research will usually only lead to rather weak spurs to new discovery and invention, both of possible products and of technologies. The next phase, in which both scientific and societal research become more directed and their interactions clearer, may result in clearer descriptions of products and of market requirements. Finally, in the third phase of product creation, technical development/design work and market analysis will determine which product will be prepared for subsequent production and marketing by the company.

Each of the three successive phases in product creation is characterised by a number of factors. One is the duration of the work involved, which entails long-term, medium-term and short-term planning. These different types of planning correspond to company policy, strategic planning and tactical planning, respectively. The timing element becomes increasingly important, and is crucial in the final phase and in subsequent production.

Clarifying the general interactions between science and society through the three phases described is helped by the use of technology forecasts and market research. These approaches help to establish, at an early stage in the process of product creation, which of the potential products offered by technology may be actually or latently required by the market. In each phase of product creation the creativity of the workers involved should be enhanced as much as possible, and some suggestions are made as to how this can be done.

Products are created as a result of R&D projects. Creative people will usually propose more projects than the company is able or willing to finance, and projects should therefore be carefully evaluated and selected. Procedures for this again vary in the consecutive phases of R&D work. Basic research is difficult to evaluate whereas, at the other extreme, development work and subsequent production, involving large investments, should be evaluated as accurately as possible on the basis of a large number of factors. Views and experience in European industry on evaluation systems are reported. Although much of this work was carried out by EIRMA some six to ten years ago, it was reported at the EIRMA Annual Conference in Sweden in 1982 that the results have lost none of their topicality. This shows how long it may take for management concepts and methods to be diffused and made operational in industry.

Chapter 1 discusses some aspects of the world in which science and technology

are created and of the world in which they are used. Definitions of the three phases of scientific and societal research are given.

Chapter 2 explores the interrelations between science and society on the basis of a simplified three-step model consisting of the three main phases of scientific and societal research in relation to the three successive phases of product creation. The role of technology forecasting in structuring the interrelations is described, and a number of forecasting methods are briefly reviewed as an introduction to a fuller treatment in the literature.

Chapter 3 deals with the enhancement of researchers' creativity, the type of creativity needed, ways of ensuring that the company benefits from researchers' motivation, and a choice of aids to creative thinking, such as the use of technology forecasting methods.

Chapter 4 shows the importance of timing when a product is launched. Early market entry and profiting from experience obtained during the production process can put the company in a profitable position; late market entry leads to low or even negative profitability. An assessment is made of profitability potential and the amount of time required to obtain a profit upon late market entry, and a review is given of some methods for improving a company's chances when it is in such a position.

Chapter 5 analyses the interactions between basic scientific research and society, and indicates how the former can meet societal needs in terms of improving societal functions such as transportation and communication. Some examples are discussed. The evaluation of nonindustrial and industrial basic research is discussed, as is the role of the latter in shaping company policy.

Chapter 6 analyses the interrelations between applied scientific research and the market, which may result in improved or innovatory products that perform existing and latent product functions. Again, a few examples are discussed. The interrelations are of a strategic character. Company strategic planning and strategic research planning, including project generation, evaluation and selection, are described.

Chapter 7 deals in detail with the factors and criteria for the evaluation of development projects followed by production. Both product development and actual production involve considerable spending and must therefore be thoroughly evaluated. Evaluation systems, which include cash flow analyses and estimations of the credibility of project success, must be carefully designed and implemented, and it is shown how this can be done.

Chapter 8 pulls together the findings of the preceding chapters by describing several factors related to project management in an industrial laboratory in which work in all three phases of product creation is carried out. The factors related to project generation are reviewed, as are the increasingly possible and necessary ways of evaluating projects, the applicability of cash flow analyses, and methods for the estimation of success. The importance of the links between R&D and marketing departments is stressed, and an example shows how these can be structured. Some of the roles of an entrepreneur within the company in the timely creation of products are discussed.

Chapter 9 discusses the sources of resistance in society to new technology, and the growing importance of technology assessment, which may help to reduce such resistance. The degree of social desirability of technology has a bearing on project evaluation and selection, although the primary considerations here are of a financial nature.

Chapter 10 deals with organisational aspects of research laboratories, which are the driving force behind product creation. Characteristics of their management and staff are discussed, as are the tasks of and place in the organisation of technology forecasting and project evaluation and selection units. The place and tasks of strategic and policy planning in the company are discussed. The chapter ends with a plea for a coordinated industrial and government policy directed towards increasing economic growth, and shows how Japan has organised itself to obtain this goal.

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