Chapter 1
INTRODUCTION

1.1 THE PROBLEM CONTEXT

Today, an increasing amount of managerial attention around the world deals with the problem of increasingly technology based international competition. Four inter-related phenomena are of particular relevance in this context:

(a) technological levelling among a growing group of actors (nations, companies) on the international scene;
(b) increasing international technology flows and technology sharing;
(c) rising research and development (R&D) costs, increasing R&D times, and often technological substitution at an accelerating rate;
(d) a slow-down of economic growth and an increasing struggle for market shares.

The tendency to opt for high technology and innovation might very well lead to decreasing industry-average returns on investments in new technology, at least for some time to come. On the other hand, waves of investment opportunities in some particular new technologies may increasingly differentiate profits and growth arising from investments in R&D. The pressures are mounting on nations and companies to be not only innovative but efficiently so but there is a dilemma. Large corporations constitute the backbone in the economy of many nations. At the same time it is said that large corporations tend to stifle parts of the innovation process.

Large corporations in a small nation such as Sweden often depend heavily on foreign output markets and a foreign supply of technology. Such corporations have been inclined to develop an international organization and maintain a specialized technological leadership based on the absorption of foreign technology in combination with internal R&D. Large corporations in a large nation such as the United States are accustomed to large domestic output markets and a large domestic supply of technology. Such corporations may find it increasingly necessary to have a more internationally oriented outlook on technology and markets.

1.2 PURPOSE AND METHOD

The management of R&D and innovation processes in a large corporation requires a great deal of insight into the nature of these processes whether one is a policymaker, a general manager, a functional manager or a project manager. The principal purpose of this book is to explore the processes of R&D and innovation

systematically and to provide empirical insight into the management and organization of these processes in large corporations.

An attempt has been made to integrate technological, economic and behavioural perspectives. Corporate behaviour in relation to R&D and innovation is viewed from the inside out, based on in-depth studies of a medium-sized sample of corporations. In this way it is hoped the work will in some small respects be complementary to works on micro- and macro-levels of economic theory and organization theory.

The data have been collected through documents and several hundred interviews with people in R&D, marketing, and top management positions in eight large multinational corporations. A small number of supplementary interviews have been made, covering half a dozen other companies, three co-operative or collective research institutes and three universities.

The study has mainly been explorative and a wide variety of aspects of the history, strategy, structure, and behaviour of these corporations have been covered. Four criteria governed the design of the sample of eight corporations studied:

(a) the corporations should be large, industrial corporations;
(b) the corporations should represent different technologies and sectors of industry;
(c) if possible, not all of the corporations should be Swedish;
(d) the sample should be medium-sized and permit both case studies and some aggregate statistical analysis.

The largest Swedish corporations in the main industrial sectors were then approached. However, the largest corporation in the electrical engineering field and the largest one in the pulp and paper industry declined to participate in the study. The largest foreign-owned subsidiary in Sweden, Philips-Sweden, a subsidiary of Philips in Holland, which is in the electronics industry, and another large corporation in the pulp and paper industry, Iggesund, were then chosen, and these corporations agreed to participate in the study.

Naturally, one has to be cautious in generalizing from an explorative study of such a small sample drawn in this way from various industries. However, the high degree of concentration of industry and industrial R&D in Sweden means that the sample accounts for a substantial amount of the total industrial production and R&D in Sweden. Around 30 per cent of the total industrial R&D in Sweden was performed by the corporations in the sample.

The sample was not designed to contrast successes and failures, which makes it difficult to formulate firm implications for management. On the other hand, the corporations in the sample have survived a long time in international competition, and, for example, Volvo and SKF have successfully met competition from Japan, although through different strategies.

Empirical observations are presented in Chapters 2 to 11. Each of these chapters, which have the same structure, treats different aspects in a self-contained way. Thus, the chapters may be read independently, although some cross references exist. The book is organized in the same way as Chapters 2 to 11

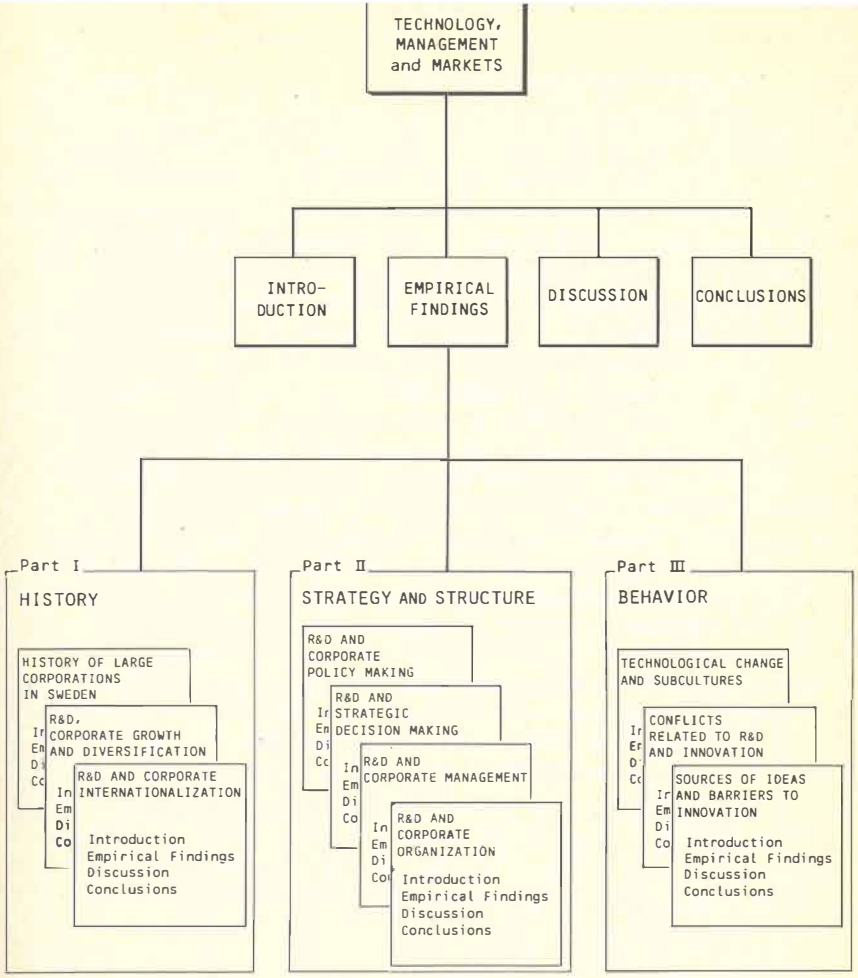

Figure 1.1 Organizational structure of the book

and constitutes a presentation of the results of the entire study. This structure is similar to a multidivisional structure in a corporation, as shown in Figure 1.1.

The introduction to each chapter defines the central concepts used in this study. The sections on empirical findings and the discussion sections constitute the body of the study. In Chapter 12 a further analysis and synthesis are presented and these are the overall contribution of the study at a higher level of aggregation. Finally, some managerial implications have been developed.

1.3.1 A note on concept formation

Penetrating studies and insights into a field are required for the formulation of useful definitions. Some problems in concept formation will be illustrated below.

There are many advocates of the view that technological innovations constitute 'the prime mover' in an economy. An extreme view is that these innovations emanate solely from scientific research. For the authors who simply define technology as applied science this is true by definition. On the other hand, several empirical studies, which do not use such a definition, claim that technology is not based solely on science. Some authors even claim that science owes more to technology than technology owes to science, that is to say, that technology applied in science characterizes the relation between science and technology rather than the reverse. Thus, the use of a conceptual connection between science and technology influences the discovery of an empirical connection and vice versa.

In definitions of both research and innovation, a basic requirement is that something new should be produced. But this is not what the linguistic construction of the terms suggests. The prefix 're-' means 'again'. Thus research has an original connotation 'to search for again'. ('Search', in turn, derives from 'circus', meaning circle, which suggests a further element of repetition.) 'Innovate' has as an original connotation 'to renew'. Thus, the etymological evolution of a concept may reveal very little about its preferred contemporary connotations.

This has been said in order to emphasize the importance of concept formation in the following descriptions and discussions. It is also a reminder that discussion of this field has to allow for a flexibility in the interpretation of many basic terms. To quote Jewkes, Sawers and Stillerman (1969, p. 25):

> There can be no doubt that an over-rigid insistence upon definition would immediately bring all discussion of invention, and of the part it plays in changes in ways of living, to a dead stop. The choice must be between discussing these matters with concepts that are necessarily somewhat vague and not discussing them at all.

1.3.2 Concepts

(a) Science, technology, research, development and related concepts

'Technology' usually stands for a branch of knowledge that deals with industrial arts, applied science, engineering etc. A common distinction is made between techniques and technology and in the language of Freeman, technology 'is simply a body of knowledge about techniques' (Freeman, 1974, p. 18). The word 'technique' here refers to arts, skills, methods, procedures and so on and derives from the Greek *téchné* meaning art, skill. Besides, the distinction between technology and techniques is related to the distinction between the 'soft' and 'hard' side of technology. The phrase 'technological knowledge', which is actually tautological, is used to emphasize the fact that physical manifestations are not referred to.

Some authors broaden the concept of technology and go beyond knowledge pertaining to the natural sciences, engineering and traditional inventiveness and include, for instance, the social sciences. According to Jantsch (1967, p. 15):

> Technology denotes the broad area of purposeful application of the contents of the physical, life, and behavioral sciences. It comprises the entire notion of technics as well as the medical, agricultural, management, and other fields with their total hardware and software contents.

Usually 'technology' is not used in such a broad sense but rather in accordance with Freeman's definition above. Technology then refers to knowledge about industrial products and processes and include knowledge from, for example, medical or agricultural fields but not knowledge about management.

'Science' and 'technology' often appear together, in some texts abbreviated as S&T. 'Science' has a similar connotation of knowledge as 'technology' but not specifically referring to industrial products and processes.

Another pair of basic terms that is frequently used is 'research' and 'development', often appearing as 'R&D'. These terms have diverse interpretations. A simple view is to look upon science and technology as a state of knowledge, research (basic and applied) as a systematic and methodical search for knowledge, and development as the application of knowledge and ideas to new industrial products and processes. This view underlies many official definitions of R&D. However, R&D also have many additional meanings. These are often more important in meaning than formal definitions and are therefore discussed below.

First, the concept of research and development often corresponds to the abbreviation R&D itself in the sense that 'R' always appears together with 'D' and moreover precedes 'D'. That is to say that development, according to this view, is always based on research. The connotation of R&D then is coloured by the connotation of 'R', sometimes to the extent that much inventive engineering work is not included in R&D at all. A similar view exists concerning science and technology (S&T) that is a link from 'S' to 'T' is assumed. Strong opposition against these views has been articulated, especially by Price (1973). On the other hand, there are definitions of technology as the application of science, which render truth to a linkage from 'S' to 'T'. Some authors also emphasize the conceptual continuum between 'R' and 'D'. Doubts about the usefulness of distinguishing between basic 'R' and applied 'R' exist as well.

Secondly, the rationalistic notion that R&D activities have to be systematic would—in the minds of many people—exclude much work behind innovations or technological advances because of the way this work is actually carried out. The notion of a beginning and an end of such work may sometimes be a useful simplification, but the notion of an ordered process in between is misleading.

Thirdly, 'R&D', and especially the 'R'-part, connotes together with 'science' a great deal of goodwill to some people. This connotation has to do with notions that R&D is performed by highly competent professionals, using their abilities of intelligence and creativity in solving problems requiring advanced solutions, which—correctly used—will be of benefit. Admittedly, there are vital elements of this sort in R&D, but there is also a tendency to take advantage of such notions and use the label 'R&D' generously. However, 'everything that is done by people

in white coats is not research' to quote an R&D-manager. Conversely, R&D may very well be performed in a non-prestigious setting.

The need to operationalize the concept of R&D, if for nothing else than budgeting and accounting purposes, leads to the fourth point. In some cases R&D is highly integrated with other types of activities; in other cases it is not. If an organization creates departments or hires individuals to do R&D, as in large corporations or in universities, R&D will be recognized, and the idea of R&D will be influenced accordingly. When this is not the case, for example, in certain parts of industry or among independently working individuals, R&D tends to gain less attention as a concept and to be underestimated, both as a resource sink and as a source of innovations.

R&D should be viewed in a broad sense and ought to include inventive work not necessarily based on research or on scientific results or methods. As far as industrial R&D is concerned, the abbreviation is misleading in still another respect because industrial R&D is mostly 'D.' (In this case R&D ought to be written r&D instead.) Furthermore, R&D may include non-routine design, engineering, trouble-shooting and similar activities contributing to technological advances although distinguished from direct technical assistance to production or marketing. One may also draw attention to the fact that 'research' and 'development' literally refer both to activities or stages in a process and to the outcome, result or 'product' of this process.

(b) Management, entrepreneur and related concepts

Linguistically the word 'management' derives from the Latin word for hand, *manus*. 'Management' also has a connotation of doing, or influencing others to do. A typical textbook definition would include a list of so-called managerial functions such as planning, decision making, directing, organizing, co-ordinating, controlling, staffing, motivating, evaluating, communicating, goal-setting, initiating. These functions (or activities, provided these are functional) are moulded in a managerial process for purpose-oriented transformation of material and human resources. This process is considered to be carried out mostly by certain specialized individuals, although any individual can perform acts of management. The term 'management' is often associated with business and sometimes also with the business leaders as a class, although managerial processes are just as prevalent, for example, in government, universities, the church, banks, the army or labour unions.

Although technological change and industrial management have existed for centuries, the nineteenth-century economists, with Marx as a notable exception, were remarkably ignorant of these factors. Joseph A. Schumpeter is the scholar to whom has been ascribed the first more extensively articulated emphasis on technological change through a distinctive function exercised by certain individuals. His emphasis is on the concepts of innovations and entrepreneurs. About the entrepreneur concept, Schumpeter simply states, 'For actions which consist in carrying out innovations we reserve the term Enterprise; the individuals who carry them out we call Entrepreneurs'. (Schumpeter, 1939, p. 102).

Moreover, Schumpeter distinguishes between entrepreneurial and managerial functions, the latter being connected to 'the mere head or manager of a firm who runs it on established lines . .'. These functions may be exercised by the same individual or by a collective of individuals, but it may be difficult to recognize an entrepreneur or entrepreneurial activities in a corporation or in a given situation. Although Schumpeter tries to distinguish the entrepreneurial functions from those of management or administration, he has no objection to equating 'entrepreneur' with 'business leader' or 'innovator' and writes that 'The essential thing is the recognition of the distinct agent we envisage and not the word' (Schumpeter, 1951, p. 254). However, he distinguishes between an entrepreneur and a capitalist. The latter bears a risk, while 'risk bearing is no part of the entrepreneurial function'. (Schumpeter, 1939, p. 254). An obstacle the entrepreneur has to overcome is raising the necessary capital for carrying out innovations, but his entrepreneurial function does not include risk bearing. Schumpeter consequently also distinguishes between leadership and ownership.

In this study 'management' will be used in a wide sense, including the role as an entrepreneur. For further discussion, see Chapter 7.

(c) Innovation and related concepts

'Innovation' typically denotes something new but also something renewed or altered according to the Latin origin of the term. Again, the term may refer to activities in a process as well as the outcome of that process. In an industrial or wider economic setting, the normal meaning of innovation has to include some element of introduction of something new on a market or in an application. In that respect, innovation has to be distinguished from invention as solely a creation of something new. Invention is also distinguished from discovery of something that already exists (in some sense) in the physical world. The parallel to innovation in the case of discovery of, for instance, an ore deposit would be the economic utilization of the deposit. As long as an invention or a discovery is not introduced into economic life, yielding transactions, its economic relevance is nil. Innovation is thus not merely change and, in particular, not merely technological change. An innovation must possess some degree of novelty and success in application. How much of each is often discussed in patent matters. All combinations of incremental/radical novelty with small/big success occur with relevance to both industrial products and processes. The degree of 'newness' or novelty of an innovation may be considered with respect to a certain context such as a firm, a market, or a nation. It must be emphasized that with a short-hand definition of 'innovation' as 'an invention introduced on a market' nothing is said about the profitability or economic feasibility of an innovation. Also, the distinction between major innovations usually refers to the 'size' of the change involved rather than the economic outcome over a period of time.

One may also talk about financial innovations, managerial innovations, innovations in art etc., as well as innovations in the form of new industrial products or processes, which are mostly then referred to as technological innovations.

A distinction between innovation and diffusion is common. Diffusion refers to the spread of an innovation after the first market introduction or the first adoption by a user in general. The future course of an innovation in economic life

may substantially involve new market introductions and alterations. Thus the processes of innovation and diffusion may be intertwined and there is seldom a simple process of first innovation and then diffusion.

The concept of diffusion is sometimes also used almost synonymously with transfer. In order for technology transfer to take place, some boundary line has to be crossed by a flow of technology. When such a crossing is connected to an economic and/or legal transaction, one may speak of technology trade, as in licensing. However, the majority of technology transfers take place without such transactions, for example, exchange or diffusion of technical information in general. The boundary line in technology transfer may pertain to structures of different kinds, such as internal departmental structures in a company, disciplinary structures in a university system, the phase structure of an innovation process, sector structures in industry, or the structure of different nations.

(d) Market and related concepts

The concept of a market is closely related to innovation. 'Market' originally meant a place for an exchange of products and economic transactions. In modern use the term has been abstracted and has several connotations. Thus, there are several ways to characterize and classify markets, for instance with respect to geography, demography, products, suppliers, customers, sectors of industry or regulations. In general, however, a market denotes a location or a group of sellers and/or buyers with actual or potential interest in making economic transactions in connection with an exchange of products, services, or knowledge.

(e) Corporation and related concepts

Such seemingly simple concepts as company, corporation, business firm, industrial organization, and enterprise may be subjected to thorough discussions in economic, legislative, sociological and political terms.

This concept will be discussed in different contexts, but for the present purpose it is enough to point out that the word 'corporation' will be used in this study to denote a company (or firm) in industry, sufficient in size and complexity to be considered (not necessarily legally) as a group of companies. A 'large corporation' generally means a corporation with 5000 or more employees. The corporations include their majority-owned companies.