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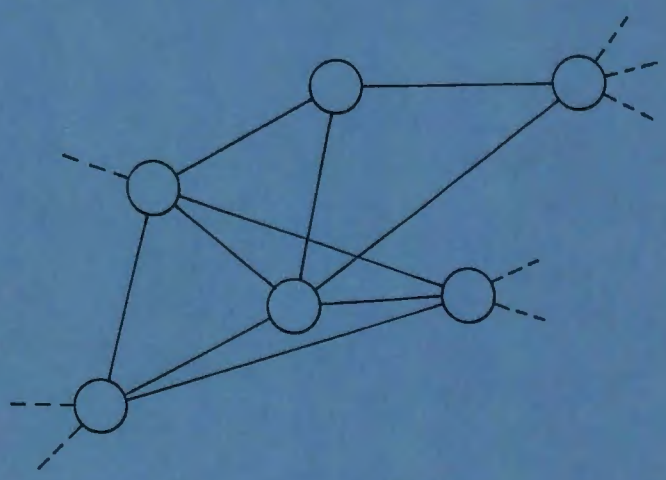
DEVELOPING INNOVATIONS WITHIN NETWORKS

With an application to the Dutch medical equipment industry



Wim G. Biemans

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PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de
Technische Universiteit Eindhoven, op gezag
van de rector magnificus, Prof.Ir. M. Tels,
voor een commissie aangewezen door het
College van Dekanen in het openbaar te verdedigen
op dinsdag 12 december 1989 te 16.00 uur door

WILHELMUS GERARDUS BIEMANS

geboren te Slagharen

Dit proefschrift is goedgekeurd door de promotoren:

Prof.Dr. H.W.C. van der Hart
Prof.Dr. R.S. Reneman

Cover design: Maryse J. Brand

PREFACE

In 1985, together with a colleague, I started an investigation into the development of complex innovations for industrial markets. The study resulted in a considerable number of publications and papers presented at national and international congresses and eventually this book. While the author is being credited for all these efforts, this is perhaps the right place to point out that many other people contributed in various ways. Thanking them all individually would go far beyond the scope of this preface, but some must be singled out.

First I would like to thank my first promotor, Prof.dr. H.W.C. van der Hart, for giving me the opportunity to conduct the investigation the way I wanted to. His criticism of initial drafts led to frequent improvements in their structure and content. My second promotor, Prof.dr. R.S. Reneman, provided motivating guidance during the follow-up investigation in the field of medical technology. His comments, criticism and contacts were invaluable. In addition, both Prof.Ir. C.H. Botter and Prof.Drs.Ir.Ing. B.J.G. van der Kooy provided constructive criticism on previous drafts.

I wish to express my gratitude to Rolf de Vries, with whom the preliminary investigation was conducted. His practical approach to theoretical issues provided the perfect complement to my own theoretical ideas and suggestions. Because of our converging views, our cooperation proved to be both fruitful and companionable. Many were the hours we spent "on the road" together (thank you for never arriving on time, Rolf!).

It goes without saying that the investigation could never have been conducted without the willing cooperation of all the managers at the firms that took part in the study. Their enthusiasm constantly fuelled the fire of motivation, which sometimes threatened to turn into dying embers. I would like to thank them all for allowing me to take a look in their kitchen and never complaining when I phoned them with yet another set of questions. The members of the study group 'Commercialization of Industrial Innovations' deserve special thanks, since most of them not only took part in the investigation, but also contributed

their views at meetings and criticized first drafts of papers and presentations.

I am indebted to Tonny Brouwers of the Eindhoven University of Technology Centre of Biomedical and Health Care Technology who, in showing me around in the Dutch medical equipment industry, introducing me to various people, listening to my ideas and convincing people everywhere of the great things I was going to accomplish, did me an invaluable service.

My ex-colleagues at Eindhoven University of Technology provided me with a stimulating environment for conducting the investigation. All of them are thanked for showing interest in my research, convinced as they were that I was engaged in something useful and mistaking enthusiasm for progress. To Kees Kokke, in particular, go my thanks for always listening to my problems, motivating me in my efforts and letting me win at squash just that one time. I want to express special gratitude to Lian Krijger, who showed herself to be a very good friend as well as a critical colleague. I shall not forget the long walks we used to have during lunch break, while her comments on initial drafts removed many inconsistencies as well as much interesting, but irrelevant material.

My brand-new colleagues at the University of Groningen have earned my thanks as well. Bart Nooteboom allowed me to finish my book without being disturbed too much, while all other colleagues refrained from complaining about my socially unacceptable behaviour.

I am indebted to Mr. Smith-Hardy for reading the final draft and making sure the language employed would be English.

Finally, I would like to thank you, Maryse, for acting as a constant discussion partner and contributing substantially, not only to the content of the book, but not least to my general well-being and sense of accomplishment. During the final stages you made sure that not even illness would prevent me from making the deadline.

Wim G. Biemans

Groningen,
October 1989.

CONTENTS

CHAPTER 1. INTRODUCTION

> Business has only two basic functions -
> marketing and innovation.
>
> (Peter Drucker)

Thomas Alva Edison is generally considered one of the most famous innovators of all time. He patented more than a thousand inventions, including major innovations like the phonograph, the incandescent electric lamp and the microphone. Although a technical genius, he failed time and again in his real ambition: the successful commercialization of his inventions. He had to be removed from all the businesses he started in order to save them.

More than 150 years later, innovating has undergone change. Although innovations are still being developed by archetypical individuals like Edison (e.g. Jobs and Wozniak, the founders of Apple, who built their first personal computer in a garage), a large number of innovations are now being developed by teamwork within the context of organizations. This does not mean that individuals cannot perform a crucial role in these situations (see e.g. Thomas, 1980). Nevertheless, the same problem still holds: the commercialization of innovations leaves much to be desired. The high-tech industry, in particular, abounds with examples of promising young firms that captured the imagination of the public with an innovative product, but failed to capture a significant part of the market and thus turn their promise into profit.

An empirical study has been undertaken to address the problems related to commercializing innovations for industrial markets. This first chapter describes the motivation underlying the research and presents a general problem formulation. The research project will be positioned with respect to studies conducted by other researchers, and case research presented as the preferred research method and elaborated upon. The chapter concludes with a survey of the contents of the book.

1.1 MOTIVATION FOR THE STUDY

This work reports on a study on the commercialization of technically complex innovations for industrial markets. While there are several reasons for a study of this kind, they can be broadly categorized into two groups, social and scientific motivation.

1.1.1 SOCIAL MOTIVATION

Innovations and the innovation process have been discussed extensively in both scientific and popular publications. Although practical interest in innovations dates back a long way, explicit attention from theorists started with scientists like Schumpeter (1939), who was one of the first economists to focus on the innovation process, the number of publications has grown dramatically during the past decade (and is still growing!). In recent years, the popular press started a veritable flood of publications about innovations as well. One obvious reason for all this attention is that innovations readily capture the imagination and have a certain romantic flavour. A more rational reason is the growing realization that innovations are of major importance to society. Innovations are expected to stimulate economic growth and promote employment, and thus change the quality of life, which has led to the recommendation to national governments to set up stimulation programs (Industrial Research Institute, 1980). At a micro level, individual firms regard innovations as the key to productivity. Avard, Catto and Davidson (1982, p. 40) cite a study which demonstrates that 40 percent of America's growth in productivity over the years 1929-1978 must be attributed to technological innovations. The importance of new products to the bottom line of a firm was also made clear by the result of a survey among 700 U.S. manufacturers that "the portion of total company profits generated by new products is expected to increase by 40 percent over the next five years" (Booz, Allen & Hamilton, 1982, p. 11).

Although the importance of innovations to the continuity of the firm is generally agreed upon, firms encounter problems when it comes to developing and commercializing them. Abernathy (1982, p. 38) commented that "the problem of deficient competitive performance really

originates as a 'management of innovation' problem". Extensive research conducted among 103 Canadian firms showed that, on the average, 19 percent of new industrial products failed after being introduced into the market, while another 22 percent of the projects were killed before launch (Cooper, 1982, p. 218). Thus, large amounts of money are spent on unsuccessful projects. According to Booz et al. (1982, p. 14), in general almost 50 percent of new-product expenditure goes on projects that do not succeed.

Our study is meant to contribute to the knowledge necessary to reduce both the percentage of unsuccessful products and that of new-product expenditure on unsuccessful innovation projects. The research will not only be of interest to firms introducing industrial innovations, but has relevance for their customers as well. Although the customers can improve their internal efficiency through adopting innovations, a certain level of risk is always present because

- the firm is unfamiliar with the innovation,
- is not sure of its functioning,
- may be confronted with start-up problems during implementation,
- the consequences of adoption are not clear and
- references in the market are scarce.

The results of our study can be used by the adopting firms to handle and reduce such risks and uncertainties.

Apart from manufacturers and buyers of innovations, this study is of interest to governments and other policy makers, intermediaries (like distributors, consultants, knowledge brokers, etcetera) and the growing number of scientific researchers studying the innovation process.

1.1.2 SCIENTIFIC MOTIVATION

The scientific motivation is based on the fact that many aspects have not received the attention they deserve in existing literature.

Although much has been written about developing and launching new products, these publications generally refer to consumer products. Some influential books on introducing new products for industrial markets have been published, but are very superficial and more than 15 years old (e.g. Gisser (1972), Skinner (1972)). It is only in recent years

that this situation has started to change, the most notable example being the extensive research conducted by Cooper (the results are summarized in Cooper (1980)). Although Cooper stresses the importance of a market-oriented product development process, he only provides very sketchy guidelines to indicate how to accomplish it.

The process of adopting industrial products has been widely studied as well, but

- the research generally relates to only one specific detail of the adoption process and is thus very fragmented,
- a large part of the available research does not concern the adoption of technically complex innovations (but, for example, relates to buying existing materials instead) and
- in most cases regards the adoption process as being separate from the product development process.

This last point takes us to the importance of studying product development and adoption as two interactive processes. The users who play a major role during product development (e.g. through involvement in the development or testing of a prototype) are usually the first buyers of the innovation as well. The necessary interactive approach to the study of the process of product development began to develop at the end of the 1970s (e.g. Von Hippel, 1978; Hakansson, 1982; Hakansson, 1987a; see also Chapter 4). However, the existing literature has thus far been largely descriptive and hardly offers any normative guidelines to management.

1.2 PROBLEM FORMULATION

Innovations are being considered more and more as crucial to the long-term survival of the firm. Nevertheless, many firms experience problems in commercializing their innovations. The reasons for failure on the market can be broadly classified in five groups, i.e. factors related to

1. marketing (e.g. insufficient market research, lack of effective marketing inputs),

2. management (e.g. insufficient contacts with research institutions, bad planning, wrong timing, insufficient internal and external communication),
3. technology (e.g. product problems, defects, technical production problems),
4. financial resources (e.g. insufficient funds) and
5. external events (e.g. changes in customer needs, changes in exchange rates, expiration of patents).

Most studies on failure rates merely discuss percentages, while few delve into the causes of failure. Of the possible causes mentioned above, marketing-related factors are clearly considered the most important. After comparing eight studies, Crawford (1977, p. 52) concluded that "all studies point to lack of meaningfully superior product uniqueness as the predominant reason for failure". This lack of superior product uniqueness could have been avoided by making sure that the marketing dimension is sufficiently integrated in the product development process; i.e. by taking the right marketing decisions during the product development process. In other words, it appears that the most important factor causing failure is controllable by the firm.

A number of studies has been conducted with the aim of improving the marketing decisions made during the process of product development. Beginning around the middle of the 1970s, these studies tended to stress the importance of the interaction between manufacturer and user. In the United States, Von Hippel (1976, 1977a) pointed out that potential users can play a crucial role during product development in some specific sectors of industry. Around the same time, an International Marketing and Purchasing Project Group was founded in Europe, consisting of industrial marketing researchers from France, Italy, Sweden, West Germany and Great Britain. This international collaboration resulted in a book presenting the results of the study, which was based on a theoretical interaction model (Hakansson, 1982). This study, however, focussed on the role of supplier-customer relationships in industrial marketing and purchasing in general, without emphasis on the development of innovations.

The role of interaction during the process of developing industrial innovations was studied by a group of Swedish researchers who expanded the interaction approach into a network approach (Hakansson, 1987a). The research no longer focusses on the interaction between two individ-

ual firms. Instead, firms are considered to be structurally connected through relationships with a number of organizations, such as suppliers, customers, research institutes, governmental agencies, consultants, competitors and producers of complementary products. Such a structure of connected exchange relations is termed a network. With respect to product development, it is no longer just the supplier-customer relationship that is important; instead, product development is considered as taking place within networks.

The importance of relationships between companies in developing innovations for industrial markets implies that a firm can no longer be considered as a separate, independent unit. This perspective led the Swedish researchers to focus on the total network instead of the individual firm. Thus, their studies tend to be more descriptive (describing the characteristics and functioning of networks) than normative (offering specific guidelines for individual firms).

Considering these comments, the objective of our research can be stated as follows:

> Describing how, in practice, potential users and third parties are involved in developing innovations for industrial markets, and thus generating implementable guidelines to assist industrial firms in achieving successful product innovations through cooperation in networks during product development.

Let us take a closer look at the different elements of the problem formulation.

1. The research will concentrate on relationships between manufacturers on the one hand and potential users and third parties on the other. From this it becomes clear that the network approach is adopted with emphasis on the perspective of the marketing management of the manufacturing firm. Although the study focusses on the manufacturer-user relationship, relationships with third parties (especially research institutions and governmental agencies) and indirect relationships (e.g. between the customer and his customers) are not neglected.
2. The study will describe involvement in developing innovations. The term 'involvement' is chosen to cover the many possible degrees of intensity of the relationship. Near one end of the continuum, user

involvement can mean no more than providing the new product idea, while close to the other end, cooperation may take the form of an extensive joint development program characterized by intensive interaction between the parties involved over an extended period.

3. The study is limited to innovations for industrial markets. This means that the users who adopt the innovations are themselves organizations, instead of individual consumers. In the rest of this book, the terms 'innovations for industrial markets' and 'industrial innovations' will be used interchangeably. Because the study involves innovations for industrial markets, the presented guidelines are meant to assist industrial marketers. Although the results of the study will be of interest mainly to the marketing managements of industrial manufacturers and their customers, governmental agencies and students of innovations in general will be interested as well.
4. The emphasis of the study will be on generating implementable guidelines. Apart from describing the process of developing innovations from a network perspective, the results will focus on implementable guidelines, that is normative prescriptions to assist individual firms in their decision making. For example, in the case of the manufacturer, these guidelines will be related to aspects like (1) the product development stages during which potential users should be involved, (2) the criteria to be used in selecting suitable users, (3) the desired intensity and form of manufacturer-user cooperation, (4) the problems that are likely to arise and (5) ways to avoid them.
5. Implementation of the guidelines may be helpful in achieving successful product innovations. Although the study is largely descriptive, successful and unsuccessful innovation practice will be compared so as to obtain normative guidelines for management.
6. The scope of the guidelines is restricted to cooperation in networks during product development. Other relevant factors that influence the eventual success of an innovation, for example the R&D-marketing interface, R&D expenditures, product-organization fit, etcetera, are not taken into account explicitly.

1.3 POSITIONING OUR RESEARCH

Our research was a logical consequence of research into industrial purchasing processes conducted previously by investigators at the Eindhoven University of Technology in the Netherlands (Van der Hart and Van Weele, 1982; Van Weele, 1984).

The position of our research, relative to other studies of innovations, is illustrated by Figure 1.1. First of all, innovations can be studied at three different levels. At a macro level the influence of innovations on national economic growth and employment is studied (IRI, 1980; Rothwell and Zegveld, 1981; Smith, 1982), while studies at a meso level relate to the effects of innovations on specific industries (Abernathy, 1982; Wagner, 1981). Our own research considers innovations at micro level, that is from the perspective of individual firms. While many studies of innovations at micro level concern consumer products (Gruenwald, 1985; Scheuing, 1974; Urban, Hauser and Dholakia, 1987), our research focusses on products for industrial markets. In studying these industrial innovations, many researchers have concentrated on either the manufacturer's perspective (that is, focussed on the process of product development; Booz et al. (1982), Cooper (1980), Crawford (1983), Van der Kooy (1983), Schon (1967), Twiss (1986)) or the customer's perspective (that is, the process of adoption/diffusion; Cohn (1981), Hayward (1978), Johne (1984), Nabseth and Ray (1974), Rogers (1983), Webster (1969, 1971)). Only limited attention has been paid to an integration of both perspectives (Foxall and Tierney, 1984; Von Hippel, 1976, 1977a; Hakansson, 1987a; Shaw, 1985).

To further illustrate the position of our research, we will compare it with two relevant 'directions of research': the studies conducted by Cooper cum suis (because of their subject matter and research methodology) and the studies by Von Hippel and a group of Swedish researchers (because of the topic they have been dealing with).

First of all, our research may be compared to the studies, known as Project NewProd, conducted in Canada by Robert Cooper (as well as the many studies undertaken afterwards by other researchers and largely based on Cooper's research). Many differences between his research and ours can be identified.

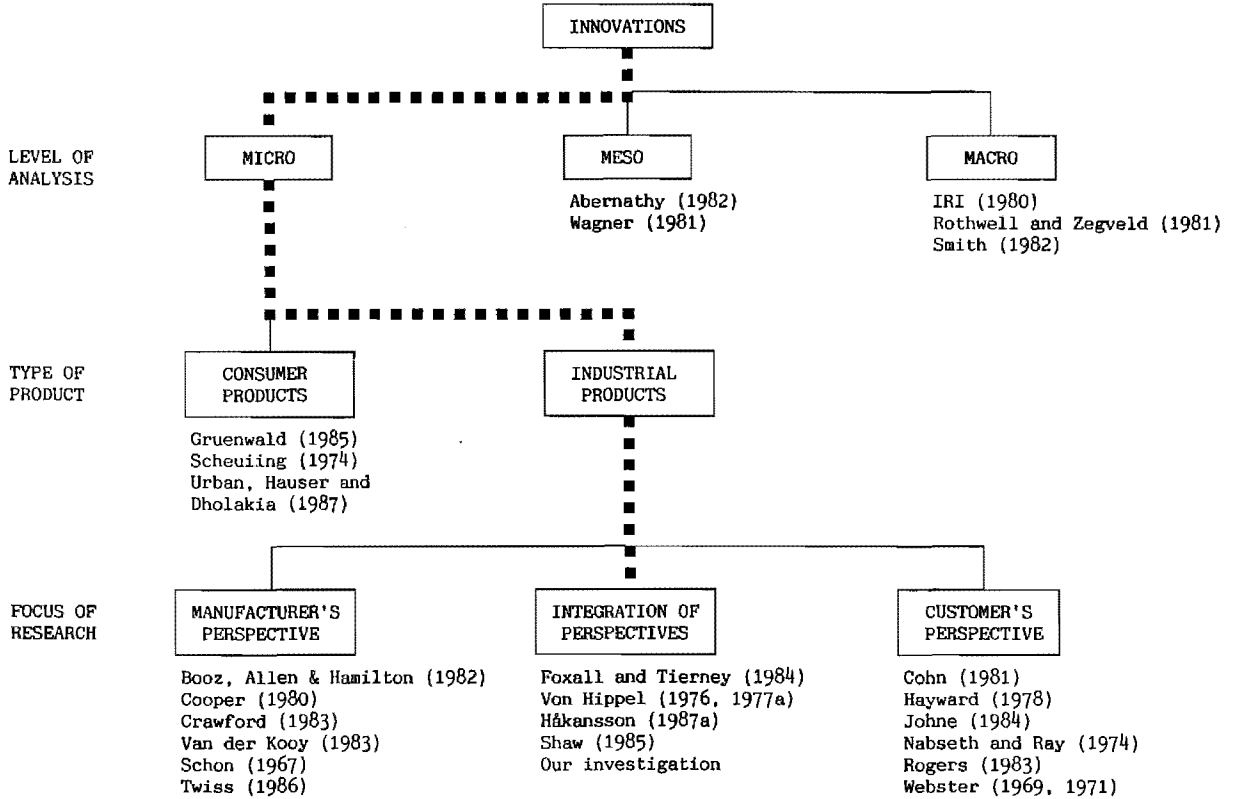


Figure 1.1 The position of our investigation.

The main objective of the studies conducted by Cooper was to identify the factors explaining the eventual success of new industrial products. A large number of possible factors were taken into account without emphasis on one specific factor. Cooper concluded that the success of new product strategies depends on not just marketing-related elements, but also on other factors like the organization of product development, technical/production synergy, source of the idea, newness to the firm, top management support and planning of the process. Although we acknowledge the relevance of all these factors, our research will focus explicitly on the commercialization of innovations and concentrate on the involvement of external parties in the process of product development in order to arrive at innovations that more successfully meet market requirements.

Another main difference is that, although Cooper concludes that "a strong market orientation makes all the difference when it comes to separating successful vs unsuccessful industrial new products" (Cooper, 1979b, p. 135), he formulates only very sketchy guidelines to assist management in achieving market-oriented product development. Our investigation aims to remedy this situation.

The research methodology used constitutes a third important difference. Cooper's results are based on a comprehensive survey conducted among more than 100 industrial firms in Canada known to be active in product development. Extensively pretested mailed questionnaires were used containing a large number of questions, and the resulting comprehensive database has been analysed from different perspectives using techniques like factor analysis, analysis of variance and correlation analysis (Cooper, 1979b). Thus, the research methodology can be described as highly structured, using a large number of responding firms, and yielding quantitative information. Our own research, on the other hand, is based on the construction of case studies which delve deeply into the subject. Case research (see the next paragraph) can be characterized as being less structured and explorative, using a limited number of responding firms, relying heavily on repeated extensive personal interviews, and thus yielding largely qualitative data to be used in generating theoretical concepts and managerial guidelines.

While the respondents in Cooper's research are industrial suppliers, our own research also includes industrial customers, governmental agencies, research institutes, consultants and other third

parties, and pays explicit attention to the relationships between all the organizations involved in developing innovations.

Finally, a minor aspect of interest is the fact that while Cooper's research is conducted among Canadian firms in Ontario and Quebec, our own study focusses on Dutch firms.

The importance of relationships and networks is also recognized by a group of industrial marketing researchers in Sweden (Hakansson, 1987a), and this brings us to the second direction of research in positioning our project. While the starting point of our own research is also based on the recognized importance of relationships in developing innovations for industrial markets, there is nevertheless an important difference between our research and the studies conducted thus far by the Swedish researchers. The Swedish studies focus mainly on the network as a whole. They address matters like the structure and durability of the network, the existence and importance of individual relations, the members of the network, the activities performed within the network and the transactions that occur. Although these studies are of importance and eventually yield a compact body of theory, our research does not consider the network as an end in itself, but as an instrument that can be used to the individual firm's advantage. This implies that, from our perspective, networks will be studied to obtain implementable guidelines that can be used by firms operating within these networks. With the adjective 'implementable', we stress the fact that the guidelines should not be of a theoretical and purely descriptive nature, but instead address matters that are of direct relevance to industrial marketers.

1.4 RESEARCH METHODOLOGY

A large number of different research methods can be used in addressing a specific research question. The research methodology selected has important consequences for the interpretation of the results obtained, while the choice of the research methodology depends largely on the characteristics of the problem to be investigated. In this section we will first discuss a number of possible research methodologies and show that there is no ideal research method. Next we will consider the

factors influencing the choice of a research method. The decision to use case research in our study will be motivated and the advantages and limitations discussed. Finally, the implemented research methodology will be described as a process consisting of six stages.

1.4.1 DIFFERENT RESEARCH METHODS

Research methods are generally divided into quantitative and qualitative methods, the latter being "an umbrella term covering an array of interpretive techniques which seek to describe, decode, translate, and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world" (Van Maanen, 1979, p. 520). Several organization theorists have started to question the use of quantitative techniques. The obsession with methodologies involving large samples and comprehensive questionnaires led Mintzberg to exclaim: "Too many of the results have been significant only in the statistical sense of the word ... What, for example, is wrong with samples of one? Why should researchers have to apologize for them? ... Measuring in real organizational terms means first of all getting out into the field, into real organizations. Questionnaires often won't do" (Mintzberg, 1979, pp. 583, 586).

In a fairly recent article, Bonoma (1985, p. 199) argued for more applications of qualitative research methods in marketing science, and specifically advocated the use of case research to marketers. Case research is defined by Bonoma as "the qualitative and field-based construction of case studies". A case study has been defined by Yin (1984, p. 23) as "an empirical inquiry that

- investigates a contemporary phenomenon within its real-life context, when
- the boundaries between phenomenon and context are not clearly evident, and in which
- multiple sources of evidence are used".

To make his point, Bonoma compared many different research methods and positioned them within a triangle (see Figure 1.2).

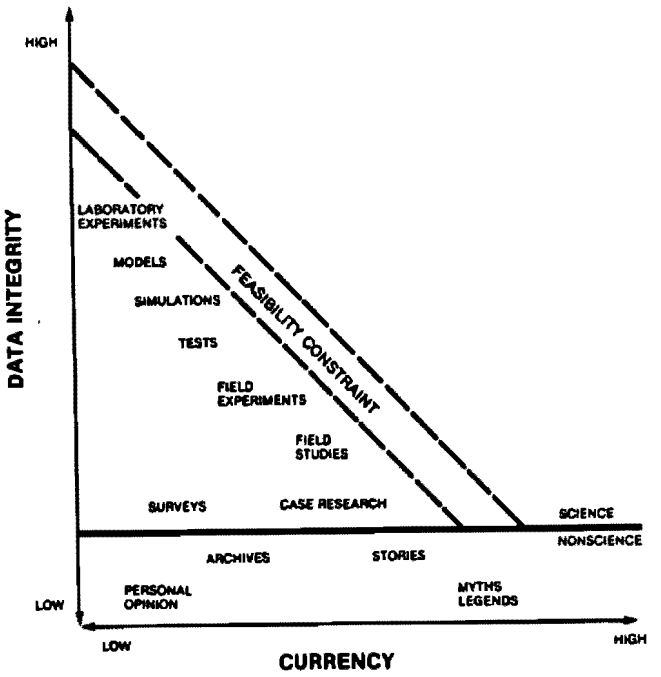


Figure 1.2 A knowledge-accrual triangle.

Source: T.V. Bonoma, 'Case Research in Marketing: Opportunities, Problems and a Process', Journal of Marketing Research, May 1985, p. 200.

The main objectives of research are represented by the two axes. The horizontal axis, labeled 'currency', refers to the generalizability of the results. It is a measure of the extent to which the results are valid in different situations (external validity). The vertical axis, labeled 'data integrity', pertains to the extent to which the results are error-free and without bias (internal validity). Ideally, researchers would like to attain maximum levels of both data integrity and results currency. In practice, however, this is not possible; in choosing a research method the researcher is forced by feasibility constraints to make a trade off between both objectives. The third side of the triangle is thus explained.

There simply is no research method that optimizes both data integrity and currency. Take, for example, the laboratory experiment; it enables the researcher to use a relatively large sample size, generate quantitative data that can statistically be tested and exercise control over variables in order to avoid contamination. Although the

data integrity will be high, the currency of the results will be relatively low. When, on the other hand, a researcher seeks high currency he is typically confronted with variables that are operationally less defined, observations within natural settings with a lot of outside influence, qualitative data that have to be subjectively analysed and a minimal level of control over variables. Methods like case research can be used in such situations. Although it is theoretically possible to achieve both high data integrity and high currency of the results by using different methods within a research project in order to corroborate the findings, such multimethod approaches are seldomly used owing to the costs involved (some examples have been given by Jick (1979)). Despite this, results can be corroborated by other researchers using other research methods in pursuing the same topic. If, for example, a given result is confirmed by experiments and simulations and case research, this type of cross-method cross-project validation lends high credibility to the result, even though case research may be troubled by data integrity problems and the experiments are low in currency.

1.4.2 CRITERIA IN CHOOSING A RESEARCH METHOD

According to Bonoma (1985, pp. 201-202) there are two important criteria to be taken into consideration when selecting a research method.

1. Purpose of the research

   Studies can be conducted with several purposes in mind. A well-known classification distinguishes between three different types: (1) exploratory studies to identify problems and formulate new alternative courses of action, (2) descriptive studies to describe a phenomenon and (3) causal studies to determine cause and effect between associated variables (Green, Tull and Albaum, 1988, p. 97). Although a number of other classifications have been proposed, they all show the same hierarchy, with the more complex/advanced studies presuming that the preceding types of studies have been undertaken. For example, a study conducted to determine cause and effect only makes sense if a preceding study has already established association between the variables involved. Thus, exploratory and descriptive studies are used for theory building, whereas causal studies are more often used for verifying a proposed theory.

Bonoma (1985, p. 201) states that "when the existing body of knowledge or theory is well developed, the use of methods oriented toward the lower-right apex (of Figure 1.2) may be inefficient .... However, when researchers' interests or phenomenon requirements dictate theory building rather than verification ... methods oriented toward the lower-right apex (of Figure 1.2) may be more efficient than others".

2. Phenomena of interest

With respect to the phenomena of interest, two aspects are relevant: (a) whether the phenomena can be studied outside their natural setting, and (b) whether the phenomena are amenable to quantification. Many marketing phenomena have to be studied within their natural setting, while at the same time many variables of interest to marketers are difficult to operationalize and quantify. According to Bonoma (1985, p. 202), "where respondents cannot verbalize the underlying causes of their behaviour reliably or where a phenomenon, because of its complexity or breadth, cannot be operationalized meaningfully in quantitative terms, clinical judgment based on qualitative data is required".

Similar criteria for choosing a research method are given by Yin (1984, p. 16):

- the type of research question posed,
- the extent of control an investigator has over actual behavioural events, and
- the degree of focus on contemporary as opposed to historical events.

The first aspect mentioned by Yin, the type of research question posed, is strongly related to the purpose of the research, Bonoma's first criterion: descriptive studies concern 'how' and 'why' questions, while causal studies relate to 'what' and 'how many' types of questions. Yin's second criterion is the same as the first aspect of Bonoma's second criterion. Combining all three aspects, Yin (1984, p. 20) comes to a similar conclusion as Bonoma, namely using case research as a research method is advisable when "a 'how' or 'why' question is being asked about a contemporary set of events, over which the investigator has little or no control".

1.4.3 CASE RESEARCH AS THE PREFERRED RESEARCH METHOD

After the exposition given above about research methodologies, it will be obvious that, for our study, case research is the preferred research method for the following reasons.

a. The main purpose of the research is to describe the process of developing industrial innovations within firms and to generate theory.
b. Apart from theory, the research aims at generating practical guidelines for management, based on detailed investigation of actual management situations.
c. The existing body of theory is fairly limited.
d. The research concerns 'how' and 'why' questions.
e. Processes are studied that take place within and between organizations; furthermore, the (relations between the) relevant variables are unknown beforehand. This means that the phenomena cannot be studied outside their natural setting. A flexible research method is called for to cope with all the relevant aspects of the widely different situations the researcher is likely to encounter.
f. The information sought is largely qualitative and not amenable to quantification (e.g. the atmosphere in which the relationship between manufacturer and user takes place).
g. The events studied are outside the control of the researcher.
h. As the study will focus on recent projects of innovation development, the emphasis lies on contemporary events.

Although the method of case research is the most suitable in our situation and has many advantages, there are also some inherent limitations that need to be mentioned here in order to better understand the quality of the results obtained.

a. The results obtained are largely dependent on the subjective interpretation of the individual researcher (Van Maanen, 1979, p. 520).
b. The construction of case studies is relatively expensive and time-consuming compared to other research methods. Many in-depth interviews with different people have to be conducted over an extended period of time, written notes have to be put into report form and reports have to be summarized into case descriptions (Miles, 1979, p. 590).

c. To obtain a complete case description and fully understand the interactive relationships involved, all the relevant parties have to be interviewed. This requires relatively much time and money. It also implies that the existing relationships between the parties involved must be handled with care; for instance it is advisable to contact initial customers only with explicit approval of (or through) the manufacturer.
d. It can be difficult to gain access to organizations. The difficulty can be caused by managers having just a limited amount of time available, being unwilling to cooperate, or being unable to be contacted because of existing sensitive relationships.
e. A central difficulty with case research, as with all qualitative techniques, is that methods of analysis are not well formulated (Miles, 1979, p. 590).

Although these limitations of case research are treated as separate factors, they are strongly interrelated. For example, when many parties have to be interviewed and the parties are difficult to reach, the costs and time needed to get complete case descriptions are relatively high.

1.4.4 RESEARCH METHOD: A PROCESS IN SIX STAGES

Our study can be described as consisting of six stages (the stages are somewhat analogous to the four stages presented by Bonoma (1985, p. 204)). The first three were undertaken in close collaboration with Rolf de Vries.

1. Demarcation
   The research started with an explorative stage, during which we aimed at getting acquainted with the relevant concepts, environment and jargon of the subject of research by scanning the relevant literature. Based on this preliminary exploration the problem definition was formulated and the contours of the research were drawn up.
2. Exploration
   During the second stage, a limited number of case studies was conducted to stimulate further thinking. Five were taken from various industries to achieve broad generalizations. The selected companies

were mostly medium-sized and known to be innovative. Medium-sized companies were selected because (1) in small companies the problems connected with commercializing innovations are largely intertwined with problems in other areas like finance, personnel and production, (2) it is too difficult and time-consuming to identify and reach the right persons within large organizations and (3) the medium-sized companies form a neglected sector (see Chapter 2). The case descriptions are based on semistructured in-depth personal interviews with the persons involved, documents, records, physical artefacts and direct observation. People from several departments (marketing, new business development, production, research and development, sales) and levels have been interviewed in order to cross-check the findings. Many of these people were interviewed more than once, and the results of the interviews were reviewed with them, thus inviting them to correct errors of fact and supply additional information. Subsequently, the potential users and third parties involved in the product development process, such as the customer's customers, the manufacturer's suppliers, consultants, government agencies, industry experts and research institutions were all interviewed. As regards these parties, one interview with the right person was usually sufficient to obtain the required information. The purpose of the interviews was to obtain additional information and cross-check that obtained from the manufacturer. Thus all the relevant parties have been accounted for.

3. Creation

Tentative explanations of the situations observed and some general principles were formulated during the creative stage. The basic subject of research was assessed and refined. This stage led to a number of conclusions, the most important being that having prototypes tested by potential users is a crucial stage of the product development process but not always performed with care by industrial marketers. A tentative framework to assist them in testing prototypes with industrial customers was drawn up.

4. Investigation

During the fourth stage, the generalizations obtained by comparing a limited number of case studies from various industries were tested, supplemented and refined by constructing a larger number of case studies from a different field. For many reasons (see Chapter 6), the area of medical technology seemed particularly suitable to our

purposes. Seventeen more cases were investigated along similar lines to those used during the second stage. The main difference was that these cases included some extremes like small firm/large firm and industry/university for reasons of comparison and testing the limits of the generalizations.

5. Derivation

   The investigation's main conclusions were formulated during the fifth stage.

6. Implication

   During the sixth and final stage the conclusion's managerial implications were derived and recommendations for future research formulated.

A survey of the research stages, the activities undertaken during each stage, and the corresponding chapters in the book is presented in Table 1.1.

RESEARCH STAGE	ACTIVITIES UNDERTAKEN	CHAPTERS
1. DEMARCATION	Review of literature, formulation of research subject and problem definition	2,3,4
2. EXPLORATION	Investigation of five cases from various industries	5
3. CREATION	Formulation of tentative explanations and generalizations of the findings	5
4. INVESTIGATION	Selection of the field of medical technology to test, supplement and refine the results; investigation of seventeen cases	6,7
5. DERIVATION	Formulation of the investigation's main conclusions	8
6. IMPLICATION	Formulation of the managerial implications and recommendations for future research	8

Table 1.1 The six stages of the research method.

1.5 CONTENTS OF THE BOOK

The concept of innovation will be described in Chapter 2. After presenting innovations from a number of different perspectives a general definition will be derived. Next, innovations will be presented according to a number of classification schemes. The chapter further focusses on innovation strategies and identifies medium-sized firms as a neglected sector. The chapter concludes with an analysis of the percentage of innovations that fail and the underlying causes of failure. Marketing-related factors are identified as the most important single cause for failure.

Chapter 3 describes the three central processes of product development, adoption and diffusion. A large number of existing models of the product development process is classified and a specific model chosen for our research. With respect to adoption and diffusion the chapter will only present the aspects relevant to our study. The three processes are shown to be closely interrelated.

Relationships are assumed to be of primary importance in developing innovations. The general concept of interaction is explored in Chapter 4. As a number of different organizations can be involved in developing innovations, product development is presented from a network perspective. A network can be described as a structure of connected relationships.

Chapter 5 presents five case studies taken from different areas of industry. Each case study is described extensively and some general conclusions are drawn from each case. Some generalizations are arrived at after comparison of the case studies with each other. Having a prototype tested by potential users is recognized as being one of the most crucial stages of the process, something which, however, is often performed inadequately. A tentative general framework for having a prototype tested by users is proposed.

The generalizations derived from the cases presented in Chapter 5 have been tested, supplemented and refined by looking at a number of new cases taken from the field of medical technology. In Chapter 6, medical technology is defined and the choice of this particular area is explained. After a description of the Dutch market for medical technology, the concepts of product development, adoption, diffusion, interaction and networks are related to the area of medical technology.

Chapter 7 presents the results of seventeen case studies from the field of medical technology. The cases are described briefly in Appendix C, while the chapter presents the main results.

Chapter 8 presents the most important conclusions from the whole investigation and discusses their managerial implications. The chapter also pays explicit attention to the value and pitfalls of conducting case research in marketing. The contribution of our study to the existing body of theoretical knowledge is indicated and directions for future research are proposed.

CHAPTER 2. INNOVATION

> A company must 'innovate or die'. The process of innovation is fundamental to a healthy and viable organization. Those who do not innovate ultimately fail.
>
> (J.A. Telfer, Maple Leaf Mills Ltd.)

Innovations are essential to the long-term wellbeing of the firm. Although most people readily agree with this assertion, the subject of innovation is the centre of controversy. For a large part this controversy can be traced back to the fact that every individual researcher uses his own specific definition of 'innovation'. Therefore, in order to clarify the subject, we feel compelled to start this chapter on innovation with a discussion of the different meanings of the term, and then present our own definition. After this, innovations will be grouped according to a number of classification schemes, followed by a presentation of innovation strategies. Next, the relationship between size and innovativeness of the firm is briefly discussed and medium-sized firms are identified as a relatively neglected sector in innovation research. Finally, the possible causes for the failure of innovations are analysed and marketing-related factors shown to be the most important single cause of failure.

2.1 DEFINING 'INNOVATION'

> The beginning of wisdom is the definition of terms.
>
> (Socrates, 470?-399 BC)

Although, or maybe we should rather say <u>because</u>, much has been written about innovations, a veritable Babel of tongues has arisen and definitions of the term 'innovation' have proliferated. Each writer presents a new definition, emphasizing the elements he or she deems relevant. Van der Kooy (1988) studied seventy-six definitions of 'innovation' and concluded that (a) many investigators fail to provide an explicit

definition of the term, (b) the definitions used can be divided into a number of categories and (c) the aspects emphasized by the definitions change over time. Considering the objective of our investigation another classification, that is the one discussed by Zaltman, Duncan and Holbeck (1973, pp. 7-9), is especially relevant. According to them, the term 'innovation' usually refers to one of three different concepts.

1. The process of developing the new item

   The first concept of innovation refers to the creative or development process, that is the process that starts with the recognition of a potential demand for, and the technological feasibility of, an item and ends with its widespread utilization. Innovation is depicted as the creative process that results in something new. Holt (1983, p. 13) uses this perspective when he defines innovation as "a process which covers the use of knowledge or relevant information for creation and introduction of something that is new and useful". The same view is adopted by Haeffner (1973, p. 20) in describing innovation as "an irrational process in which the invention idea appears first, and a completed product results after an often long and circuitous development route", and by Morton (1971, p. 4) when he defines technological innovation as "the process of perception or generation of relevant science and its transformation into new and improved products and services for which people are willing to pay". Most definitions of innovation belong to this category.

2. The process of adopting the new item

   A second perspective views innovation as the process whereby a new item is adopted, and thus implemented, by an adopter. An example is given by Knight (1967, p. 478), when he defines innovation as "the adoption of a change which is new to an organization and to the relevant environment".

3. The new item itself

   The third use of the term innovation refers to the item itself that has been invented and is regarded as new. The main difference from the first two views, describing innovation as a process, is that the third view defines innovation as the outcome of a process. Zaltman et al. (1973, p. 10) define an innovation as "any idea, practice or material artifact perceived to be new by the relevant unit of adoption". According to Rogers (1983, p. 11) an innovation is "an idea, practice, or object that is perceived as new by an individual or

other unit of adoption". It should be noted that in both cases an innovation is viewed from the perspective of the adopter.

It should be clear that the three views presented above are closely related to each other. The first view defines innovation from the perspective of the developing unit. It concerns the stages of the development process and the characteristics of the developing unit. The developing unit can be an organization (e.g. a business firm), a social group or an individual. The second view defines innovation from 'the other direction', i.e. the adopting firm, and relates to the stages of the adoption process and the characteristics of the adopting unit. The adopting unit can represent an individual, a business firm, or any other organization. It should be noted, however, that in specific instances the developing unit and the adopting unit can be one and the same (e.g. when a firm develops a production machine for internal use). Finally, the third view concentrates on the new item itself, although it usually defines the innovation as being new to the unit of adoption.

For the purpose of our study, we regard 'innovation' as the outcome of a development process, as something new that is being adopted by units of adoption. Nevertheless, we would like to deviate from a point of view widely adhered to by present-day researchers, that is that "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" (Rogers and Shoemaker, 1971, p. 19). This view has been attacked by Becker and Whisler (1967, p. 463) who, although defining innovation as a process, state that organizational innovation only occurs when the organization is among the first to adopt and incurs significant costs of search and risk. Later adopters undergo organizational change but not innovation. In other words, innovation processes do not occur during the later phases of the diffusion process. The same viewpoint is echoed by Knight's definition (given above) that ends with "new to the organization and to the relevant environment" (emphasis added). We endorse this view because it stresses important implications for the parties involved. Let us consider the example of a firm that has developed a new product for industrial markets. The first firms adopting the new product are confronted with an innovation. They are unfamiliar with the product, do

not know exactly how it functions and what it does, and cannot turn to other firms for advice because there are no references in the market yet. The manufacturer, on the other hand, is confronted with similar difficulties. The product has just been developed and is being introduced into the market. The manufacturer has no clear idea as to what firms can be considered as potential customers and cannot refer to firms already using the innovation. Furthermore, he has to solve initial implementation problems that occur at the early user sites. However, as time goes by

- the innovation is being adopted by more and more firms,
- the manufacturer is getting more and more experienced in marketing it,
- the innovation is modified and various versions are introduced and
- similar products are introduced by competitors.

In other words, the innovation loses its uniqueness and becomes just one of the many products offered by the manufacturer, and just one of the many options available to potential adopters.

Because of these considerations, we will define an innovation as any idea, practice, or material artefact that is perceived to be new by the early units of adoption within the relevant environment (thus belonging to the third view discussed above).

An innovation is not synonymous with an invention. In general, an invention refers to the direct result of research activities, while an innovation concerns a commercial product. Accordingly, an invention is assumed to precede an innovation. Martin (1984, p. 2) describes it as follows: "a scientific invention may be viewed as a new idea or concept generated by R&D, but this invention only becomes an innovation when it is transformed into a socially usable product". Or, as one other writer succinctly put it, "Innovation = invention + exploitation" (Roberts, 1988, p. 13). This distinction between invention and innovation is implicit in many definitions of innovation: for example, an innovation is an invention applied for the first time (Mansfield, 1968, p. 99), and "innovation is the process by which an invention is first transformed into a new commercial product, process or service" (Saren, 1984, pp. 11-12).

2.2 CLASSIFICATION OF INNOVATIONS

Many classification schemes have been proposed by different authors to define categories of innovations. According to Zaltman et al. (1973, pp. 17-32) three types of classification schemes can be discerned (the following discussion is based largely on their analysis of classification schemes).

1. State of the system

   Knight (1967, p.484) proposed to classify innovations as programmed and nonprogrammed innovations. Programmed innovations are scheduled in advance and their development follows defined routines and procedures. Nonprogrammed innovations, on the other hand, may be of two different types: (1) slack innovations, that are developed because the firm happens to have funds available (i.e. slack) and (2) distress innovations, that are developed as a reaction to the lack of success of the firm (Cyert and March, 1963, pp. 278-279).

2. Initial focus

   An obvious way to classify innovations is to define categories according to the initial focus of the innovation. Dalton (1968) mentioned three categories: (1) technological innovations, (2) value-centred innovations and (3) structural innovations. A more important classification is proposed by Knight (1967, p. 482), who distinguishes (1) product or service innovations, (2) production process innovations, (3) organizational-structure innovations and (4) people innovations. The importance of this scheme lies in the fact that it demonstrates clearly that an innovation is not by definition a new product. Instead, it can refer to a new production process, a new organizational structure or new relations between people, as is also made clear by the general formulation of our own definition of innovation.

   The distinction between product innovations and process innovations has also been stressed by Utterback and Abernathy (1975). Product innovations are concerned with products introduced commercially to meet a user or a market need, while process innovations involve the equipment, methods and systems employed to produce the products. Both concepts are integrated by Utterback and Abernathy into a dynamic model of process and product innovation. As the industry in which a firm is operating matures, the emphasis changes from product

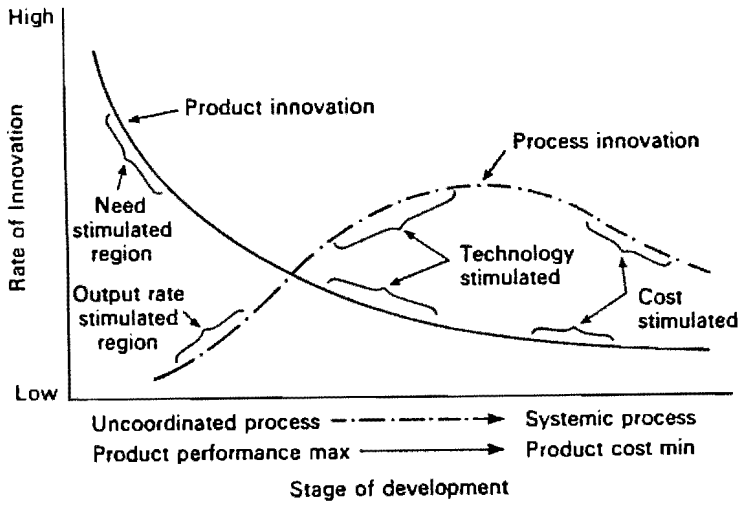


Figure 2.1 Innovations and stage of development.

Source: J.M. Utterback and W.J. Abernathy, 'A Dynamic Model of Process and Product Innovation', Omega, Vol. 3 (1975), No. 6, p. 645.

innovation to process innovation (Figure 2.1).

However, this seemingly clear-cut distinction between product and process innovations is in practice difficult to maintain. A Computer-Aided Design system that is thought of as a process innovation by the user, may be considered a product innovation by the manufacturer. It all depends on the perspective from which the innovation is viewed.

Product and process innovations together can be termed technical innovations, to distinguish them from the other two groups which make up the social innovations (Braun, 1980). Finally, Grossman (1970, p. 543) distinguished between instrumental innovations and ultimate innovations. The latter are ends in themselves, while the former are aimed at specific changes intended to make possible or facilitate the introduction of ultimate innovations at a later time.

3. Outcome or effect

A third way to classify innovations is to view them in terms of their outcome or effect. Many authors have proposed classifications of this type, all of them describing two extremes: radical and routine innovations. The central variable is the radicalness of an innovation. The more it differs from existing alternatives, the higher is its degree of radicalness. The degree of radicalness can

be viewed either from the perspective of the adopter of the innovation or that of its developer, or both perspectives can be integrated.

a. The perspective of the adopter. Harvey and Mills (1970, p. 189) distinguished between routine and innovative changes. In a study of the diffusion of innovations in the flour milling industry, Hayward, Allen and Masterson (1977, p. 306) discovered that they fell into two distinct categories: traditional and nontraditional innovations.

b. The perspective of the developer. Inspirated by Kuhn's theory of paradigms, Martin (1984, pp. 29-31) differentiated between normal and revolutionary innovations. Normann (1971, p. 205) separated product variations (minor changes) from reorientations (major changes), dividing the latter into three different types.

c. The perspectives of adopter and developer integrated. An example of an integration of both perspectives is provided by Gobeli and Brown (1987, pp. 25-27). Using the two dimensions, they arrive at four types of innovations, incremental innovations and radical innovations again being the two extremes (Figure 2.2).

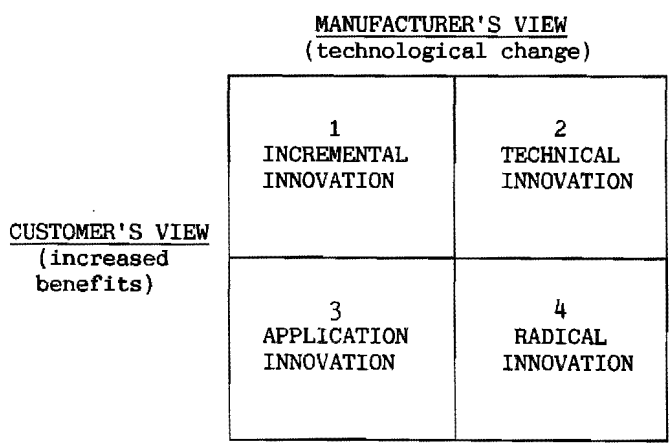


Figure 2.2 A product innovation matrix.

Source: D.H. Gobeli and D.J. Brown, 'Analyzing Product Innovations', Research Management, July-August 1987, p. 26.

When we characterize the complex innovations for industrial markets, the subject of our investigation, by the dimensions described above, they can be said to be (1) either programmed or nonprogrammed innovations, (2) technological innovations, (3) product or process innovations (i.e. technical innovations), (4) ultimate innovations and (5) positioned near the 'radical' end of the continuum.

Figure 2.3 summarizes the various classification schemes discussed above.

I. TYPES OF INNOVATIONS IN TERMS OF THE STATE OF THE SYSTEM

1. Programmed innovations
2. Nonprogrammed innovations
   a. Slack innovations — Cyert and March (1963)
   b. Distress innovations — Cyert and March (1963)

Knight (1967)

II. TYPES OF INNOVATIONS IN TERMS OF THEIR INITIAL FOCUS

1. Technological innovations
2. Value-centred innovations
3. Structural innovations

Dalton (1968)

1. Product or service innovations
2. Production process innovations

Utterback and Abernathy (1975)

3. Organizational-structure innovations
4. People innovations

Knight (1967):
1. Technical innovations
2. Social innovations

Braun (1980):
1. Ultimate innovations
2. Instrumental innovations

Grossman (1970)

III. TYPES OF INNOVATIONS IN TERMS OF THEIR OUTCOME OR EFFECT

A. PERSPECTIVE OF THE ADOPTER:

1. Routine changes — Harvey and Mills (1970)
2. Innovative changes — Harvey and Mills (1970)

1. Traditional innovations — Hayward et al. (1977)
2. Nontraditional innovations — Hayward et al. (1977)

B. PERSPECTIVE OF THE DEVELOPER:

1. Normal innovations — Martin (1984)
2. Revolutionary innovations — Martin (1984)

1. Variations
2. Reorientations
   a. systematic
   b. idiosyncratic
   c. marginal

Normann (1971)

C. BOTH PERSPECTIVES INTEGRATED:

1. Incremental innovations
2. Technical innovations
3. Application innovations
4. Radical innovations

Gobeli and Brown (1987)

Figure 2.3 Various schemes for classifying innovations.

2.3 INNOVATION STRATEGIES

In earlier days product development projects were typically initiated in the absence of a formal strategic plan. The resulting informal planning styles, however, were not always able to cope with the multi-functional intricacies of the product development process. Thus, it is not surprising that in more recent years the importance of an explicit product development strategy has gained wider recognition (this is illustrated by Ramanujam and Mensch (1984) who present a model to improve the strategy-innovation link). Business strategies in general serve the purposes of providing synergy and coordination, aiding organization, allocating resources, motivating personnel and permitting evaluation (Crawford, 1983, pp. 70-72). Although these general purposes of strategy also apply to new product stategies, the last-named offer two specialized values. They limit the many new product opportunities that face a firm (restricted diversion) and direct the different stages of the product development process (see also Chapter 3).

Crawford's study of the new product strategies of 125 American firms uncovered that these strategies are nowadays much more comprehensive than in earlier years. Deliberately avoiding terms like 'policy' or 'program', Crawford (1980, p. 4) introduces the term product innovation charter to "emphasize that the PIC carries a directional and activity mandate". The study demonstrated that the product innovation charter consists of

a. the target business arenas that product innovations are to take the firm into or keep it in,
b. the goals or objectives of product innovation activities and
c. the program of activities chosen to achieve the defined goals.

In a recent study of new product strategy practices of industrial marketers, Moore (1987, p. 12) found that "the existence of a formal new product strategy or innovation charter was mentioned by only one-third of the participants". The resulting informal approach, however, did not appear to be a handicap. Although not formally put down in writing, the elements of a product innovation charter were in place.

While, during the 1970s, product development was mainly regarded as a marketing problem, the 1980s have witnessed an upsurge of interest in the technology dimension (Kantrow, 1980; Pappas, 1984; Martin, 1984;

Nyström, 1985; Capon and Glazer, 1987; Willyard and McClees, 1987). Recently, this growing emphasis on the strategic implications of technology led Brownlie (1987, p. 56) to warn that it "must be tempered by a healthy consideration of the market and user needs", thus arguing for a balance between marketing and technology. According to Petroni (1985), the direction of emphasis depends on the type of industry.

Every organization is confronted with a range of strategic opportunities and has to select a strategy based on the specific circumstances and established goals. According to Urban, Hauser and Dholakia (1987, p. 15) one of the first basic strategic decisions a firm has to make is whether to be reactive or proactive. A reactive product strategy deals with the initiating pressures as they occur (e.g. waiting until the competition introduces a product and copying if it is successful). A proactive strategy explicitly allocates resources to identify and seize opportunities and to preempt possible adverse events (for instance, outsmart the competition by being first on the market with a product that competitors find difficult to match). Urban et al. (1987) distinguish four reactive and four proactive product strategies (Table 2.1).

Cooper (1984) studied the reported new product strategies of 122 industrial product firms in Canada and characterized every strategy on each of 66 strategy elements, which were subsequently reduced to 19 strategy dimensions. Clustering of the data resulted in a classification of five new product strategies:

a. technologically driven,
b. balanced,
c. technologically deficient,
d. low budget, conservative and
e. high budget, diverse.

The main conclusion was that "The elite group of firms that adopted ... the balanced strategy ... achieved by far the best performance on virtually every performance criterion" (Cooper, 1984, p. 36). (The balanced strategy featured a balance between technological sophistication, orientation and innovativeness, and a strong market orientation. The program was highly focussed and new products were targeted at very attractive markets.) In fact, each of the five strategies was associated with a different performance level and type, thus establishing a

REACTIVE PRODUCT STRATEGIES	PROACTIVE PRODUCT STRATEGIES
DEFENSIVE: Modifying existing products as a reaction to successful new products from the competition. IMITATIVE: Copying the competition's new product before it is known whether or not the product is a success. SECOND-BUT-BETTER: Introducing a copy of the competition's new product that offers distinct advantages over the original. RESPONSIVE: Develop a new product as a reaction to customer's requirements.	RESEARCH AND DEVELOPMENT: Conducting future-oriented research and development activities in order to develop technically superior products MARKETING: Finding a customer need and developing a product to fill it. ENTREPRENEURIAL: A special person (the entrepreneur) has an idea and realizes it by generating enthusiasm and mobilizing resources. ACQUISITION: Purchasing other firms that have products new to the acquiring firm and perhaps the market.

Table 2.1 Product strategies.

Based on: G.L. Urban, J.R. Hauser and N. Dholakia, Essentials of New Product Management, Prentice-Hall, Englewood Cliffs, NJ., 1987, pp. 16-17.

strong link between the new product strategy a firm selects and the results it achieves.

2.4 INNOVATIVENESS AND FIRM SIZE

A much debated and researched issue in the literature about innovations is the link between firm size and innovativeness. Apart from a discussion of the relative importance of firm size, the question of causality has also been raised. Is firm size a determinant of innovativeness or is the size of the firm a result of the innovativeness of the firm?

Although most studies assume the former position, the matter is not clear-cut. As regards the relative importance of firm size, we are confronted with a similar ambiguous situation. While many researchers discovered that small firms are more innovative than large ones and that firm size is directly related to innovativeness, others have found that large organizations are more likely to be innovative. Rothwell and Zegveld (1982) remark that any discussion of the issue is bound to be sterile when it is not conducted on an industry by industry basis. Ettlie and Rubenstein (1987) have tried to resolve some of the apparent contradictions by focussing on the radicalness of the innovation as an important variable. Roberts (1989) arrives at the same conclusion when he draws attention to 'the stage of development and use of the technology' as a significant factor. "Much of the loose talk about small companies being more innovative than large ones should really be more precise statements that say small companies are likely to be the ones who are innovative at very early stages of new fields. Large companies as a group are more likely to be the primary innovation sources at later large-market stages of fields of technology" (Roberts, 1989, p. 38).

In discussing the relationship between innovativeness and firm size the discussion usually focusses on the two extremes: small and large firms. Also, when reviewing the existing literature on innovations, it becomes clear that by far the largest number of publications are written from the perspective of either the newly founded, small, emerging company that has started to make an impact on the market with an innovative product, or the established large company that has introduced another new product in order to obtain a larger share of the market. The group in between is usually lost sight of or neglected. This group consists of medium-sized companies that have been in existence for a number of years and persist in their striving to turn out innovative products.

The economic importance of the group of midsized companies is stressed by several authors. In his treatise 'Innovation and Entrepreneurship', Peter Drucker (1985, p. 2) points out that in the United States the Fortune 500 companies have been losing jobs steadily since around 1970, slowly at first, but at a much faster rate since 1977/1978. All in all, by 1984, the jobs permanently lost by these companies were estimated to be at least 4 to 6 million. During this period, employment by government, universities and hospitals declined

as well. Nevertheless, during this period more than 40 million new jobs were created. As Drucker (1985, p. 3) concludes, "And all these new jobs must have been created by small and medium-sized institutions, most of them small and medium-sized businesses, and a great many of them, if not the majority, new businesses that did not even exist twenty years ago". Clifford and Cavanagh (1985, pp. 2-3) estimated that less than 1 percent of all businesses in America are independent, medium-sized companies (defined as having sales between $25 million and $1 billion), and concluded that, despite their small number they "are responsible for about a quarter of all sales and account for a fifth of all private-sector employment". Furthermore, this segment is a mirror-image of the U.S. economy in general in terms of industry composition, geography, and overall business and financial performance. These were the major reasons for their study of the winning performers in this 'neglected sector'.

Myers and Sweezy (1978) analysed the reasons for failure of 200 innovations and related them to firm size. With respect to medium-sized companies they found that they encounter a disproportionate share of management problems. "Apparently, these companies are too big for innovations to command the individual attention of top management, but too small to hire the kind of specialized management that innovation needs". Marketing and technology were also considered to be obstacles.

In Europe, some researchers have started to shift their attention away from large to small and medium-sized firms (e.g. OECD, 1982; Steinhöfler, 1986; Corsten and Lang, 1988). In the Netherlands as well, small and medium-sized firms are usually grouped together. Poutsma et al. (1987) mention a considerable decline in the number of large firms in the Netherlands during the years 1970-1982, while at the same time the number of small and medium-sized firms grew dramatically (in 1986 almost 80% of all firms in the Netherlands belonged to this category). In spite of this, research into innovation processes in small and medium-sized firms is strongly biased in favour of small firms (e.g. Nijverheidsorganisatie TNO, 1974; Buijs, 1984; During, 1984; Kok, Offerman and Pellenbarg, 1985).

For the reasons outlined above, ((1) midsized companies have been largely neglected by researchers both abroad and in the Netherlands, (2) midsized companies are of significant economic importance and (3)

in midsized companies failure of innovations is predominantly caused by management-related factors) our own research aims at taking this segment of midsized companies in the Netherlands out of its relative anonymity. For our research we will measure firm size by the number of employees (small: 50 employees or less; medium: between 50 and 500 employees; large: 500 employees or more).

2.5 INNOVATION: FAILURE VERSUS SUCCESS

We all agree that innovation
Will benefit both world and nation
The question we must answer later
Is, will it help the innovator?
(Kenneth Boulding)

For industrial marketers it is of prime importance to know which factors determine the success of an innovation. This knowledge can be of assistance in setting up a product development program and taking the right decisions during the different stages of the process. In this section we will therefore discuss the different factors influencing the eventual success of an innovation and stress the importance of marketing-related factors. First, however, we will try to answer the question of how large a percentage of innovations actually fails.

2.5.1 NEW PRODUCT FAILURE RATES

Practitioners and academics alike, usually agree that many newly developed products do not become a success and that the failure rate is too high. Notwithstanding this agreement, the exact percentage of new products that fail has been subject of discussion for many years. A variety of studies has been conducted, but the results vary widely. The fact that percentages mentioned by authors as private opinions have been cited by others as facts, only added to the confusion. According to Crawford (1979a, pp. 10-11), the differences between the percentages mentioned are mainly due to different research methods and definitions of key concepts.

1. The research method used

The results of any kind of research are obviously very dependent on the research method used. With respect to research into the failure rate of innovations, Crawford (1979b, p. 10) mentions four different research methods.

a. One of the most common is to investigate success/failure pairs. Similar new products, one a success and the other a failure, are paired and compared. The factors influencing success can be determined by making statistical analyses of large samples. This method has been used in the widely published SAPPHO-studies (Robertson, Achilladelis and Jervis, 1972; Szakasits, 1974), but was also used by Cooper (1979a) and Maidique and Zirger (1984).

b. A second method is to analyse executive opinion. The persons involved in the development of specific new products are asked what, in their opinion, were the most important reasons for success or failure. A disadvantage is that, except for large samples, the information obtained is often anecdotal and subjective. The most famous example of a study using this method, is the one by Peters and Waterman (1982). Other examples are a study into innovation processes in Dutch industry (Nijverheidsorganisatie TNO, 1974) and the recent study conducted by Link (1987).

c. When the persons interviewed are experts on industry, instead of the people directly involved, the research method is called third-party assessment. This method is obviously very subjective and only useful when the experts are very familiar with the industry in question.

d. When a generalized survey is used, experienced marketers are asked for their experience with failed products (as a group instead of individual cases). An example is given by Hopkins and Bailey (1971).

2. Key definitional decisions

The results of individual studies are also strongly influenced by the way certain key terms have been defined. Especially important are the following questions. What is a new product? When does the new product come into existence? What is success? How long should a product have to achieve success? What types of firms or products should be studied? To illustrate the complexity of all these definitional decisions we will take a closer look at the central question 'what is success?'. Should just financial criteria be used

in determining the eventual success of an innovation, or should they be combined with nonfinancial goals? As Maidique and Zirger (1985) pointed out: "while financial return is one of the most easily quantifiable industrial parameters, it is far from the only important one". This observation and the results of an empirical investigation led Cooper and Kleinschmidt (1987a, p. 216) to define three dimensions that characterize new product performance: (1) the overall financial performance, (2) the degree to which the product opens new opportunities and (3) the impact of the product in the market.

In an attempt to determine the new product failure rate in America by evaluating the most reliable and most recent studies, Crawford (1979a) compared thirty-two sources which actually were reporting on a study or which were cited as doing so. Initially he discovered that the cited failure rates varied between 15 percent and 99 percent, but closer investigation led him to drop 25 of these sources for varying reasons. Based on analysis of the remaining seven studies he came to the conclusion that "the best estimate from available studies is that around 35% of new products fail" (Crawford, 1979a, p. 12). Eight years later he updated the study by reviewing another seven studies published after 1979, which resulted in a confirmation of the results obtained earlier (although the failure rate for industrial products seemed to be somewhat lower than the rate for consumer products).

2.5.2 FACTORS CAUSING FAILURE

After having determined the percentage of innovations that fails, it is time to discuss the underlying causes of failure. Or, to put it differently, what factors determine the eventual success of an innovation?

As early as 1964, the National Industrial Conference Board published the results of a study of the factors causing the failure of new products. The most important causes of failure were (in order of importance):

1. inadequate market analysis,
2. product defects,
3. higher costs than anticipated,
4. poor timing,

5. competitive reaction,
6. insufficient marketing effort,
7. inadequate sales effort and
8. inadequate distribution.

Eight years later, Foster (1972) presents a long list of causes of product failure. However, the reasons are very similar to those cited in the NICB study and can be reduced to two main factors: (1) inadequate knowledge of market conditions and (2) managerial incompetence. Both studies mention inadequate analysis of the market as a very important factor, which fact has also been stressed by Marquis (1969), Webster (1969), Gisser (1973) and Brisco (1973). Crawford (1977) compared eight studies of new product success rates and listed the most important reasons cited for new product failure (Table 2.2). All studies point to lack of meaningfully superior product uniqueness as the predominant reason for failure. This could have been avoided by conducting better marketing research. Crawford offers nine hypotheses to explain the failure of marketing research to stem or stop the flow of new product failures.

Although every researcher uses a different list of criteria, the factors influencing the success of innovations can be grouped in five broad categories, i.e. factors related to

1. marketing: uniqueness of the product, benefit offered to the user, the structure/size/growth of the market, efficiency of the marketing communications, launch effort, distribution channel choice, targeting and pricing strategies, synergy with existing marketing skills, involvement of users, quality of market research, education of users, training of the sales force, etc.;
2. management: top management support, contacts with research institutions, planning, timing, efficiency of the development activities, internal communications, quality of management, management style, inadequate project evaluation or control, integration of the innovation project with corporate strategy, existence of a protocol, etc.;
3. technology: in-house expertise, contact between R&D and the production and marketing functions, practicality of the design, product defects, production problems, technical and production synergy, availability of outside technology, etc.;

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	TOTAL
1. LACKED MEANINGFUL PRODUCT UNIQUENESS (a)	X	X	X	X	X	X	X	X	8
2. POOR PLANNING (b)	X	X		X	X	X	X		6
3. WRONG TIMING	X	X	X	X		X			5
4. ENTHUSIASM CROWDED ON FACTS				X	X	X	X	X	5
5. PRODUCT FAILED	X	X				X			3
6. PRODUCT LACKED A CHAMPION					X				1
7. COMPANY POLITICS					X				1
8. UNEXPECTED HIGH PRODUCT COSTS						X			1

(1) G.J. Abrams, 'Why New Products Fail', Advertising Age, April 22, 1974, pp. 51-52.
(2) T.L. Angelus, 'Why Do Most New Products Fail?', Advertising Age, March 24, 1969, pp. 85-86.
(3) Booz, Allen & Hamilton, Management of New Products, Chicago, Il., 1968, especially pp. 11-12.
(4) W.J. Constandse, 'Why New Product Management Fails', Business Management, June 1971, pp. 163-165.
(5) R.W. Diehl, 'Achieving Successful Innovation', Michigan Business Review, March 1972, pp. 6-10.
(6) D.S. Hopkins and E.L. Bailey, 'New Product Pressures', The Conference Board Research, 8 (June 1971), pp. 16-24.
(7) M.B. MacDonald, Jr., Appraising the Market for Industrial Products, National Industrial Conference Board, New York.
(8) V. Miles, 'Avoid these Errors in New Product Design', Advertising Age, July 15, 1974, pp. 26-ff.

(a) In some cases there was, in fact, no difference, but in most cases there was some difference, whose value was overestimated by the marketers to potential buyers.
(b) Includes poor positioning, poor segmentation, underbudgeting, poor overall themes, over pricing, and all other facets of a plan.

Table 2.2 The most important reasons for new product failure.

Source: C.M. Crawford, 'Marketing Research and the New Product Failure Rate', Journal of Marketing, April 1977, pp. 51-61.

4. financial resources: financial resources devoted to the project, etc.;
5. external events: reaction of key competitors, changes in user needs, changes in exchange rates, expiration of patents, government regulations, etc..

Failure cannot be attributed to one single factor, but is generally brought about by a complex set of interacting factors. Nevertheless, it may be clear by now that the first group of factors is the most important in determining the eventual success of product innovations. In recent years, this conclusion has been underscored by Banting (1978), Cooper (1979a), Rothwell (1979), Hopkins (1981), Peters and Waterman (1982), Maidique and Zirger (1984), Voss (1985b), Twiss (1986) and Link (1987). Cooper (1976) and New and Schlacter (1979) stress the need for involvement of marketing in the development process at an early stage (indeed at every stage!), while Wilson and Ghingold (1987) offer a framework to link the R&D activities to market needs.

The above discussion implies another observation of importance to industrial marketers: viz. the most important causes of failure can be controlled. In their recent study, Cooper and Kleinschmidt (1987b, p. 182) concluded that "Controllable variables, rather than situational or environment variables, are the dominant factors in success ... [This] means that the way the new product process is managed and executed ... largely decide project outcomes". Despite all these observations, empirical studies that offer industrial marketers practical guidelines to incorporate marketing during all the stages of the product development process are scarce and usually fail to reach industrial marketers. (A recent study by Barclay and Benson (1987) showed that a very small minority of managers has even heard of well-publicized studies into the success and failure of new products, while only 10% of them had actually taken steps to apply the results!) Marketing-related factors, with emphasis on the role of market research, are mentioned as being of crucial importance. But at the same time, many critics maintain that traditional approaches to market research are inappropriate for innovative products (Tauber, 1974; Cowell and Blois, 1977; Crawford, 1977; Littler and Sweeting, 1985). Before discussing how market research can be conducted for innovations for industrial markets, and thus describing how marketing can be integrated with the development

project, in the next chapter we will present the processes of product development, adoption and diffusion.

CHAPTER 3. PRODUCT DEVELOPMENT, ADOPTION AND DIFFUSION

Before an innovation becomes a product widely accepted by the market it has passed through a number of stages. Even before the actual development of the new product is started, a product innovation strategy must be set out. According to a study conducted by Booz, Allen & Hamilton (1982), companies that have successfully launched new products are more likely to have had a formal new product process, as well as a strategic plan, in place for a longer period of time. The new product strategy (1) links new products to company objectives, (2) aids in the search for new products (i.e. suggests what markets and/or technologies should be investigated), (3) identifies the strategic roles to be played by new products (e.g. defending a market-share position or maintaining the firm's position as a product innovator) and (4) provides general screening criteria (Booz et al., 1982, p. 11; see also Chapter 2).

Typically, after the new product has been developed, it is adopted by innovative customers and a gradual diffusion into the market follows. This chapter describes the central processes of product development, adoption and diffusion. Several types of models of the product development process are discussed and eventually one specific model is selected for our investigation. The sections on the adoption and diffusion processes only discuss the aspects essential to our research, like the buying centre, the role of the purchasing agent, the speed of diffusion, adopter categories and opinion leadership. For a more extensive review of the literature on the adoption and diffusion of new industrial products, the interested reader is referred to Kennedy (1983). At the end of this chapter the three processes are shown to be closely interrelated.

3.1 THE PRODUCT DEVELOPMENT PROCESS

The literature on the subject of new product development abounds with models that try to capture the essence of a complex process in a relatively simple structure. When studying innovation, a general model is

needed as a conceptualization of the product development process. However, Cooper (1983) studied the product development processes of fifty-eight new products in thirty firms and concluded that there is no 'typical process model'. Instead he found seven models, each with its own distinct set of activities and emphases (see Figure 3.1). Nevertheless, it should be borne in mind that these models were based on descriptions of real situations and included processes that led to poor or just average performance. The fact that in actual situations several distinct models can be distinguished should not preclude the construction of a generalized normative model, which can be used to guide management in developing new products. Many studies of innovation assume such a general model.

In this paragraph, a number of existing models are discussed and classified according to the taxonomy proposed by Saren (1984, p. 11):

a. departmental-stage models,
b. activity-stage models,
c. decision-stage models,
d. conversion process models and
e. response models.

Within each category the models are mostly arranged in order of growing complexity. However, not all existing models neatly fall into one of the categories mentioned above. In the following survey these models are grouped according to their most outstanding characteristic. The advantages and disadvantages of each type of model are summarized.

However, before we continue the discussion of various product development models, we would like to comment on the function of models in general (cf. Botter, 1985, p. 53). In the literature on scientific methodology, models are frequently described as

(a) being a simplification of reality, which implies that they must reflect reality, and/or
(b) possessing instrumental value, which means that a model does not necessarily reflect reality but can be used, for example, to predict real-life phenomena (an example is provided by models of atoms employed in natural science).

This goes to show that the structure and content of a model strongly depends on the objective of the designer of the model. For our purposes, that is in order to have both scientific and practical value, a

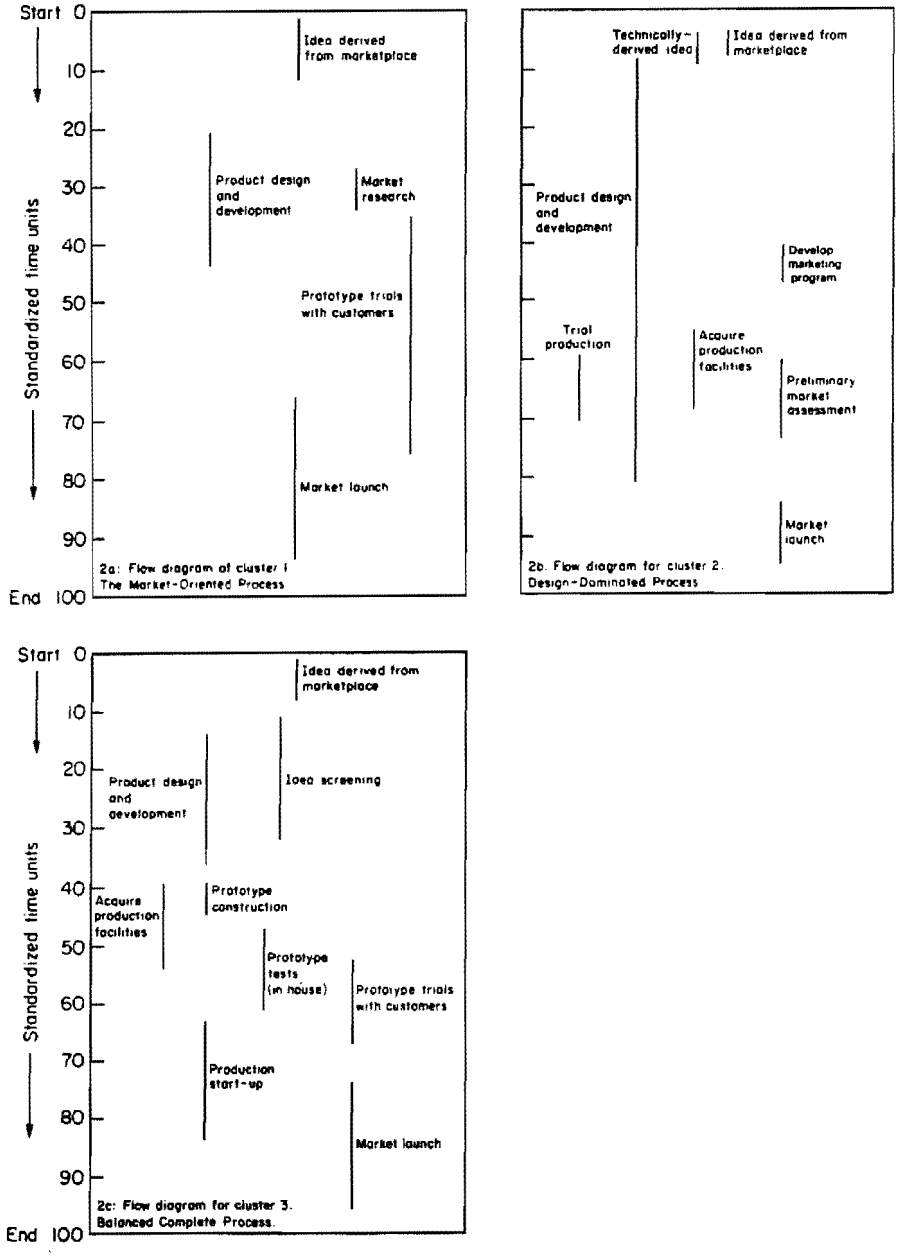


Figure 3.1 Seven different flow diagrams of the product development process.

Source: R.G. Cooper, 'The New Product Process: An Empirically-Based Classification Scheme', R&D Management, Vol. 13 (1983), No. 1, pp. 8-9.

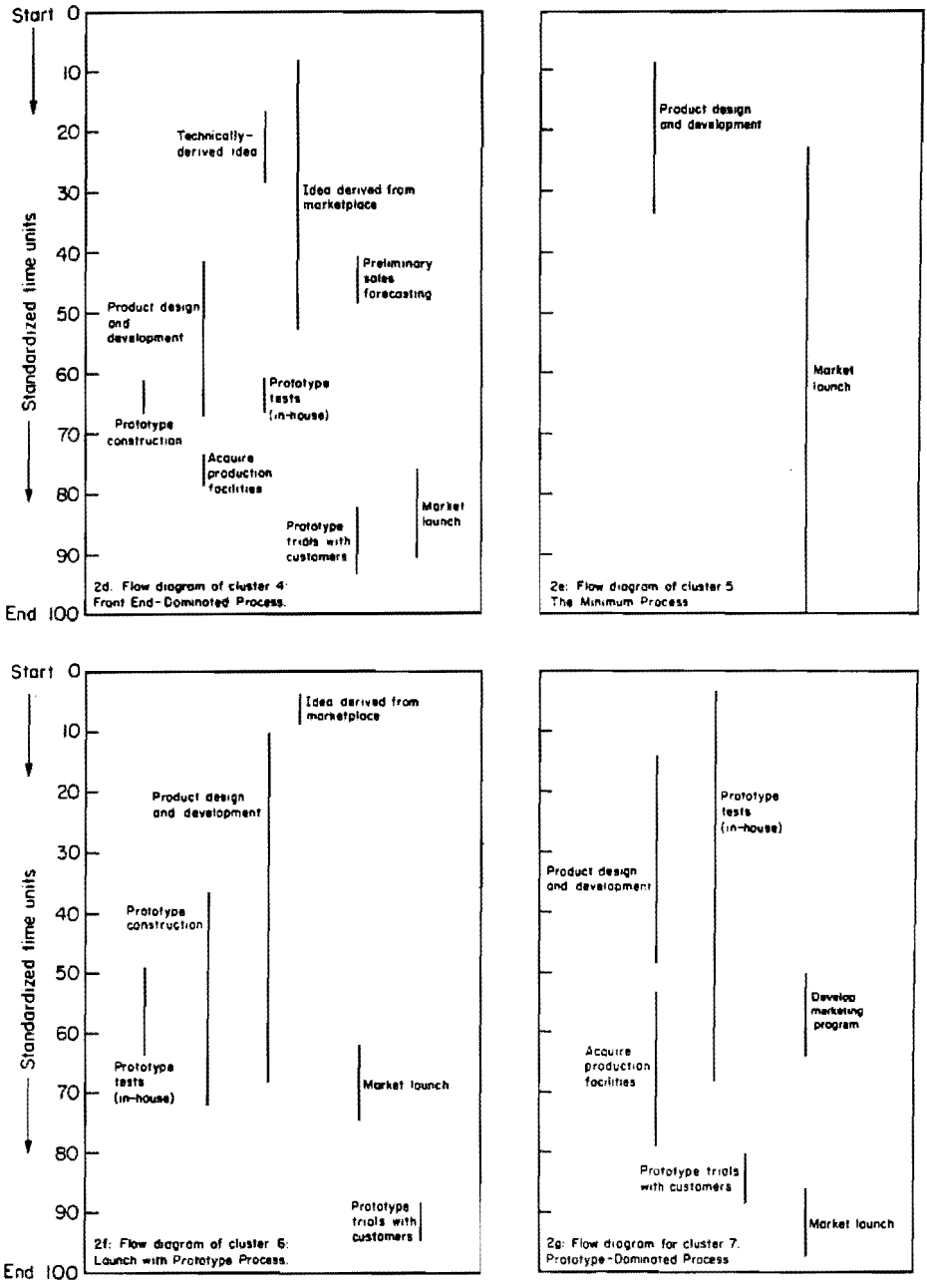


Figure 3.1 (continued).

model of industrial product development should possess both characteristics at the same time. The model should be sufficiently realistic to reflect the intricacies involved in developing industrial innovations. At the same time, it must be simple enough to enable management to make real-life decisions. This dual objective was borne in mind in discussing the advantages and disadvantages of the models presented below. Based on both this discussion and our objectives, as stated in Chapter 1, a model has been selected as the basis of our research.

3.1.1 MODELS OF THE PRODUCT DEVELOPMENT PROCESS

3.1.1.1 Departmental-stage models

The simplest model represents the product development process by a series of stages referring to the departments within the firm that are involved in the process. An example is given in Figure 3.2 (Saren, 1984). According to this model an innovation enters the R&D department as an idea, moves sequentially through several other departments and eventually reaches the marketplace as a new product.

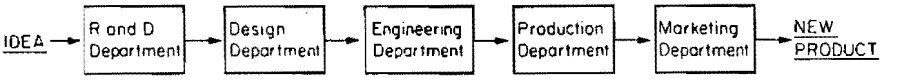


Figure 3.2 An example of a departmental-stage model.

Source: M.A. Saren, 'A Classification and Review of Models of the Intra-Firm Innovation Process, R&D Management, Vol. 14 (1984), No. 1, p. 13.

A more advanced model presented by Robertson (1974) shows an innovation as progressing from the R&D department through Design, Production and Marketing to emerge in the market as a new product (see Figure 3.3). Apart from progress through these departments, it also shows the influence of technological knowledge and market needs. The origin of an innovation is shown to be the result of a synthesis of knowledge-push and market-pull elements.

Although many more examples of departmental-stage models can be given, they all exhibit the same basic structure by showing the various departments through which an innovation moves on its way to the

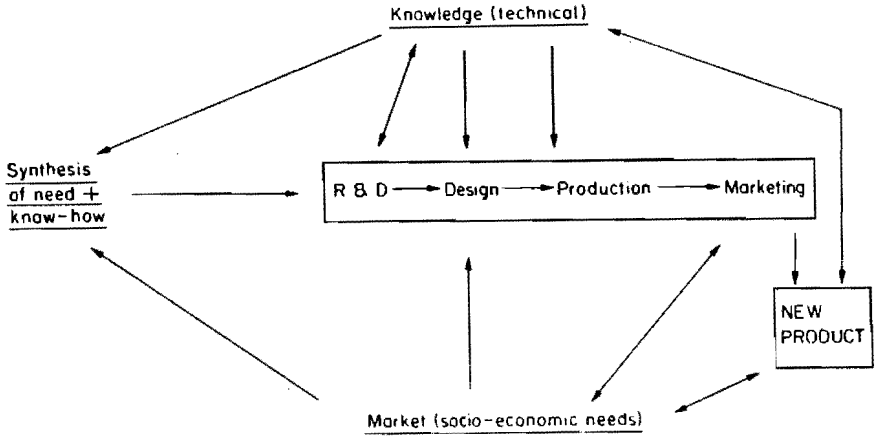


Figure 3.3 A departmental-stage model.

Source: A. Robertson, Innovation Management, Management Decision Monograph, Vol. 12 (1974), No. 6.

marketplace. Differences between individual models are due to the degree of specification. As regards these models, criticism is not levelled against the number and kind of departments involved, but rather addresses the fact that they do not offer much insight into the process of product development.

a. The models only list the various departments involved and do not show the activities carried out in the course of the process.
b. This type of model shows that the innovation starts as an idea and emerges as a new product, but does not show the intermediate forms.
c. Departmental-stage models assume a sequential movement through the various departments involved. Possible overlaps between departments like R&D and Production as well as feedback are ignored.
d. The models lack a general character in the way that individual models are hard to compare with each other. Different organizations use different terminology in naming their departments.

Although in some cases a department-stage model is all that is needed, another type of model is required to provide a more realistic representation of the product development process.

3.1.1.2 Activity-stage models

A common approach to a more realistic description is to represent the product development process by a sequence of activities. An example is given by Utterback (1974) who divides the process into three distinct stages, that is

1. idea generation,
2. problem solving or idea development and
3. implementation (bringing the product to the marketplace).

During (1986) presents a model, based on a model of the psychologist Kolb for individual learning, that breaks the process down into four phases that are very similar to the three stages from Utterback's model:

1. creative phase,
2. selection phase,
3. design phase and
4. application phase.

The main difference is that, whereas Utterback presented the process as a linear series of steps, During depicts a cyclical process (see Figure 3.4).

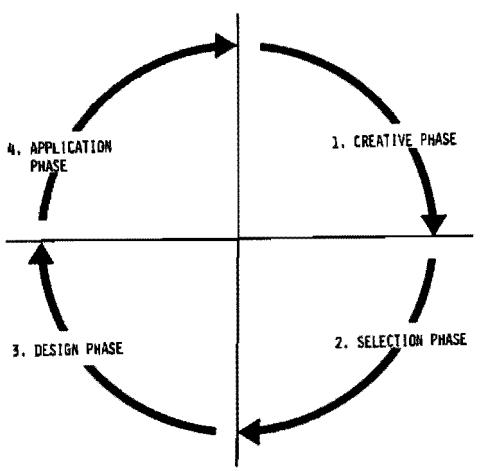


Figure 3.4 Product development as a cyclical process.

Source: W.E. During, 'Project Management and Management of Innovation in Small Industrial Firms', Technovation, Vol. 4 (1986), p. 271.

The best known activity-stage model, however, is the one developed by Booz, Allen & Hamilton (1968, p. 8). It depicts the innovation as moving through six sequential stages, that are presented in a logical order and are interdependent. The explicit activity stages allow us to follow the intermediate forms of an innovation as it moves through the process. In the first stage, a number of ideas are generated that are screened in the second stage according to a number of criteria (technical feasibility, organizational fit, product mix, financial requirements, etc.). Stage three entails a commercial evaluation, that is, the innovation's future sales and costs are estimated. A prototype of the new product is developed in stage four and subsequently tested in stage five. The process concludes with the commercialization of the new product.

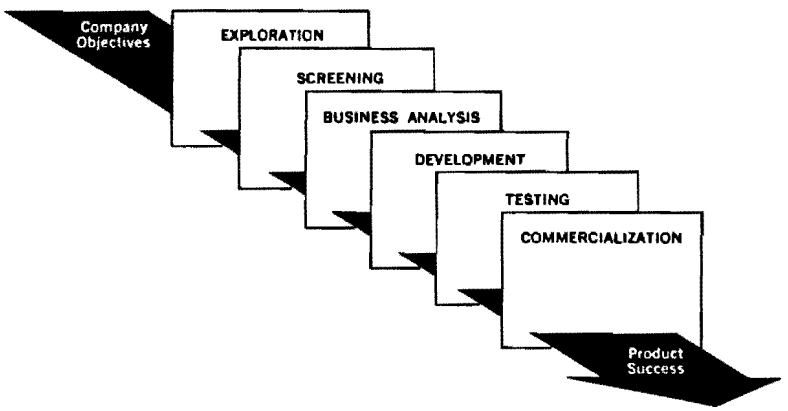


Figure 3.5 The process of product development depicted as a series of activities.

Source: Booz, Allen & Hamilton, Management of New Products, Booz, Allen & Hamilton Inc., New York, 1968, p. 8.

As a result of subsequent research, the original model (illustrated in Figure 3.5) was modified to include the stage 'new product strategy development' at the start of the process. In this way, the original model became linked to the strategic objectives of the firm (Booz, Allen & Hamilton, 1982, p. 12). The Booz, Allen & Hamilton model has formed the basis for a large number of similar models (see, for example, Haeffner (1973, p. 21) and Samli, Palda and Barker (1987, p. 49)).

These traditional sequential models have been criticized by Moore (1984, p. 11) for two reasons:

a. their inability to illustrate the interactions between the various stages of the new product development process and
b. the assumption that each stage is completed before the next one starts.

To overcome these shortcomings, he developed a tentative model in which some of the stages occur in parallel with each other (Figure 3.6). The stages themselves, however, are essentially the same as the ones from the original Booz, Allen & Hamilton model.

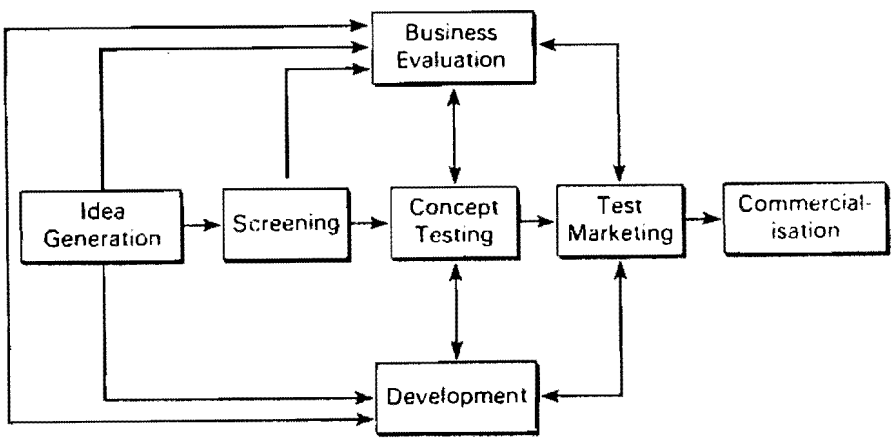


Figure 3.6 A new product development process with parallel activities.

Source: R.A. Moore, 'Control of New Product Development in UK Companies', European Journal of Marketing, Vol. 18 (1984), No. 6/7, p. 11.

Miaoulis and LaPlaca (1982) depicted the process as consisting of three broad activity stages: assessment, development and execution. As can be seen in Figure 3.7, each of these stages is made up of a large number of activities that must be undertaken. The various activities are no longer depicted as being on one level but are related to three different dimensions: market, product and technology. The product dimension shows the progress of the innovation during the product development process. By linking the last activities of the execution phase to the first activities of the assessment phase the cyclical character of the process is acknowledged. Finally, the model allows for

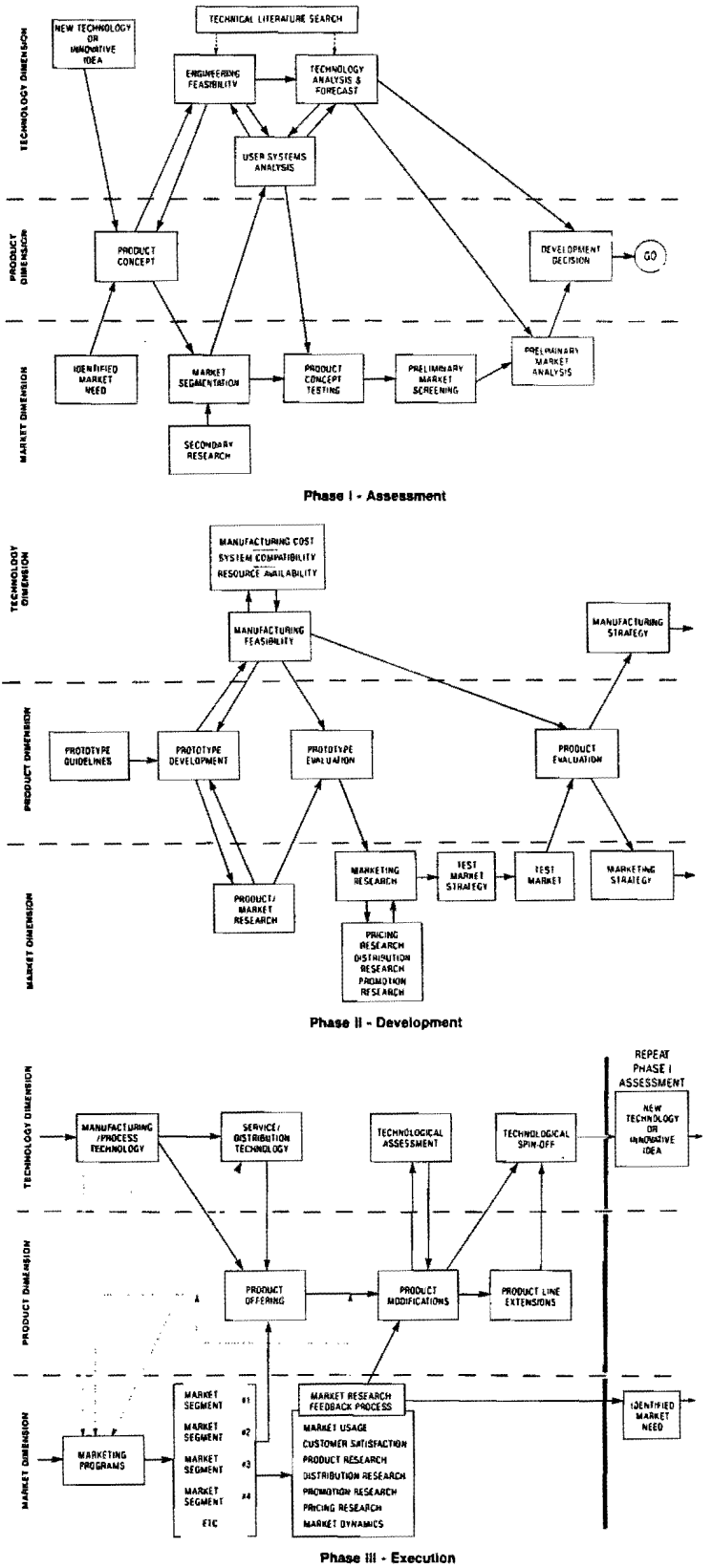


Figure 3.7 A model distinguishing between three broad activity stages related to three different dimensions.

Source: G. Miaoulis and P.J. LaPlaca, 'A Systems Approach for Developing High Technology Products', Industrial Marketing Management, Vol. 11 (1982), pp. 255, 256, 258.

feedback loops as well; a phenomenon largely overlooked by the models previously discussed.

Kline (1985, p. 38) drew attention to three different types of feedback links. Sometimes work is passed from one group to another as the innovation moves to another stage. The first type of feedback is important at these interfaces. The second type of feedback relates to the fact that sometimes it is necessary to go back to previous stages of the process to correct certain aspects of the product. A third type of feedback link is distinguished because, after market introduction, the competitive position of the product should be investigated and the results used as input for the development and design of later products. So, again the cyclical character of the process is recognized.

The seven models distinguished by Cooper (1983) (see Figure 3.1) are also activity-stage models. Although the seven models differ in the types of activities and the time spent on them, they all depict the development process as a series of activities. Like Moore (see Figure 3.6), Cooper recognizes that activities can be undertaken in parallel.

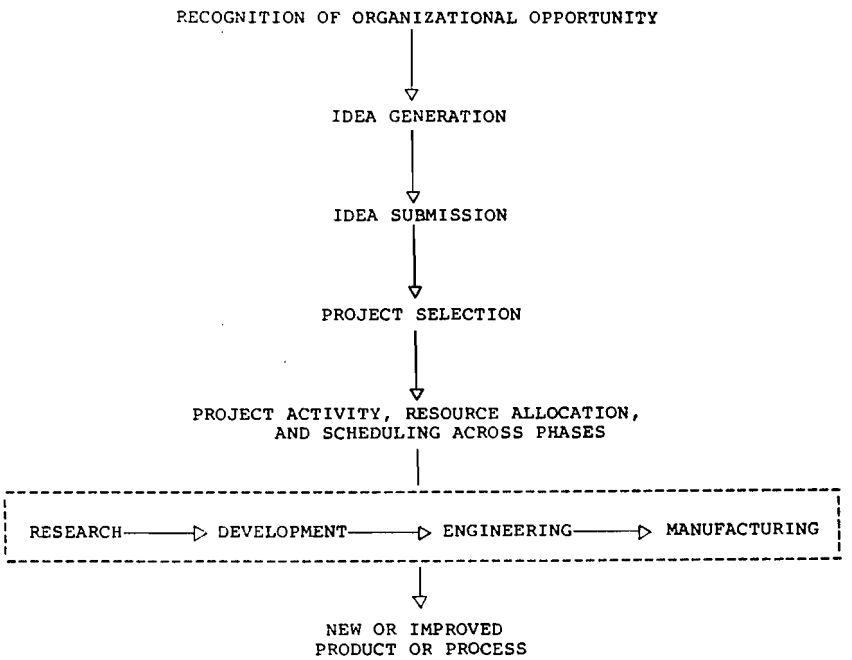


Figure 3.8 A model combining activities with the departments involved.

Source: P. Kelly and M. Kranzberg (eds.), Technological Innovation: A Critical Review of Current Knowledge, Georgia Institute of Technology, San Francisco Press, San Francisco, 1978.

More sophisticated models can be obtained through combining the two different types of models by linking the various activities with the departments involved (although the problem that different organizations use different terminology in naming their departments still remains). An example is given by Kelly and Kranzberg (1978) who relate a series of activities to a number of departments (Figure 3.8). However, the model is only of limited use since it does not show what departments are involved in what activities.

A much better example is presented by Grandstrand and Fernlund (1978). As Figure 3.9 illustrates, the activities identified in this model are similar to those of the original Booz, Allen & Hamilton model.

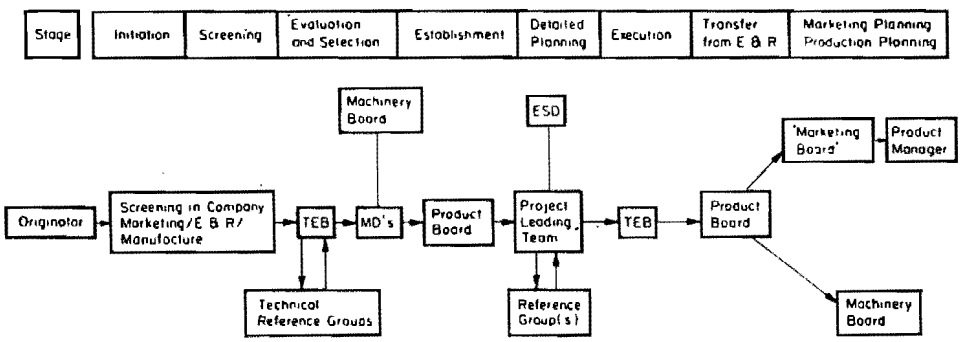


Figure 3.9 A more advanced example of combining activity stages with the departments involved.

Source: O. Grandstrand and I. Fernlund, 'Co-ordination of Multinational R and D: A Swedish Case Study', R&D Management, Vol. 9 (1978), No. 1.

Another model that combines the activity breakdown with the departmental-stage approach has been described by Twiss (1986). Apart from showing how an innovation moves from idea to product, it also mentions the intermediate forms of the innovation. Scientific knowledge and market needs are identified as external influences on the process, with the R&D and marketing departments functioning as intermediaries (Figure 3.10).

Activity-stage models obviously improve on the departmental-stage models because

a. they clearly show the tasks carried out during each stage,
b. they show the intermediate forms of development as the innovation progresses through the process,

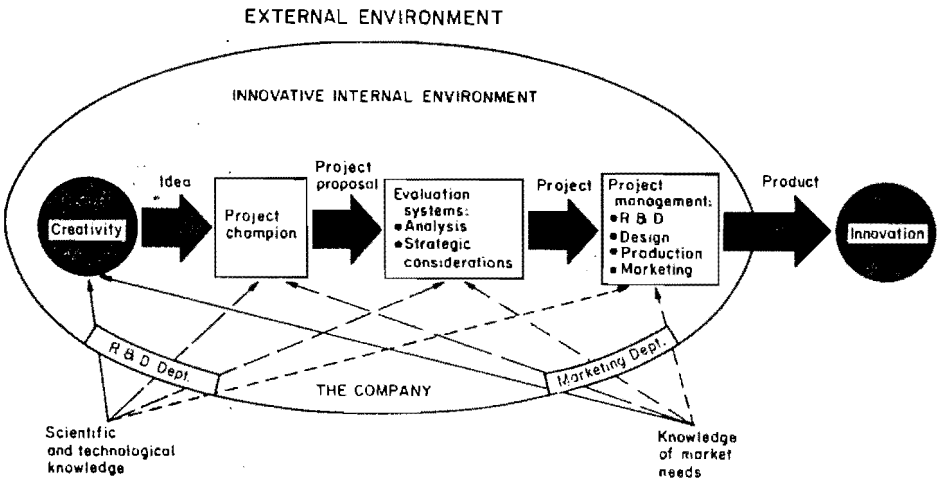


Figure 3.10 A model of the product development process that combines activities with departments and clearly shows the innovation's intermediate forms.

Source: B.C. Twiss, Managing Technological Innovation, 3rd. ed., Pitman Publishing, London, 1986, p. 18.

c. the various stages are more clearly separated (although several of the models show that some overlap still exists) and
d. by breaking the process down into general activities, instead of departments, the resulting model is more generally applicable.

The weak point of this approach, however, is that it implies an ordered sequence by which the innovation moves through the process. Generally, there is no other alternative than to move from one stage to the next. However, some activity-stage models have incorporated feedback loops and thus implicitly acknowledge the need for evaluative decisions. The existence of different alternatives and the decisions necessary to choose among them are explicitly recognized by the decision-stage models.

3.1.1.3 Decision-stage models

Decision-stage models rest on the premise that the product development process can be broken down into a number of decisions, which are based on the information available. The process is divided into several

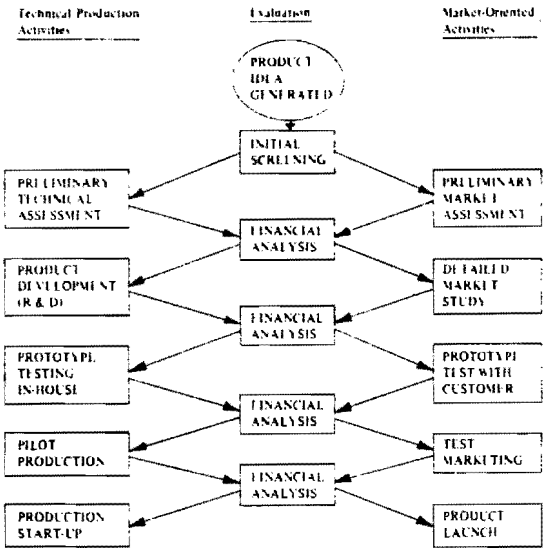


Figure 3.11 An example of a decision-stage model.

Source: R.G. Cooper, 'Why New Industrial Products Fail', Industrial Marketing Management, Vol. 4 (1975), p. 317.

stages, separated by evaluation points. At every evaluation point, two types of decisions must be made. The first one is referred to as the GO/NO GO decision (should the process be continued or stopped?). Balachandra (1984, p. 96) identified some of the more important criteria to be used in GO/NO GO decisions. He divided these criteria into two categories: the absolutely critical ones (RED LIGHT variables) and the cautionary ones (YELLOW LIGHT variables). Regular and careful monitoring of these variables leads to a better insight into the likelihood of successfully completing the project. If it is decided to continue the process, a second decision concerns the next stage to be undertaken. This can be the next stage in the process, but one may also skip one or more stages or go back to an earlier stage (feedback loops). This results in a much more flexible approach as compared with activity-stage models, which generally imply that all stages are carried out in a prescribed sequence. (Therefore many firms control complex development projects by using 'systems management', which is based on scheduled review sessions. In these sessions, all the people involved collectively make the decisions on the basis of so-called base-line documents (see Halbmeijer and Botter, 1986)). Another

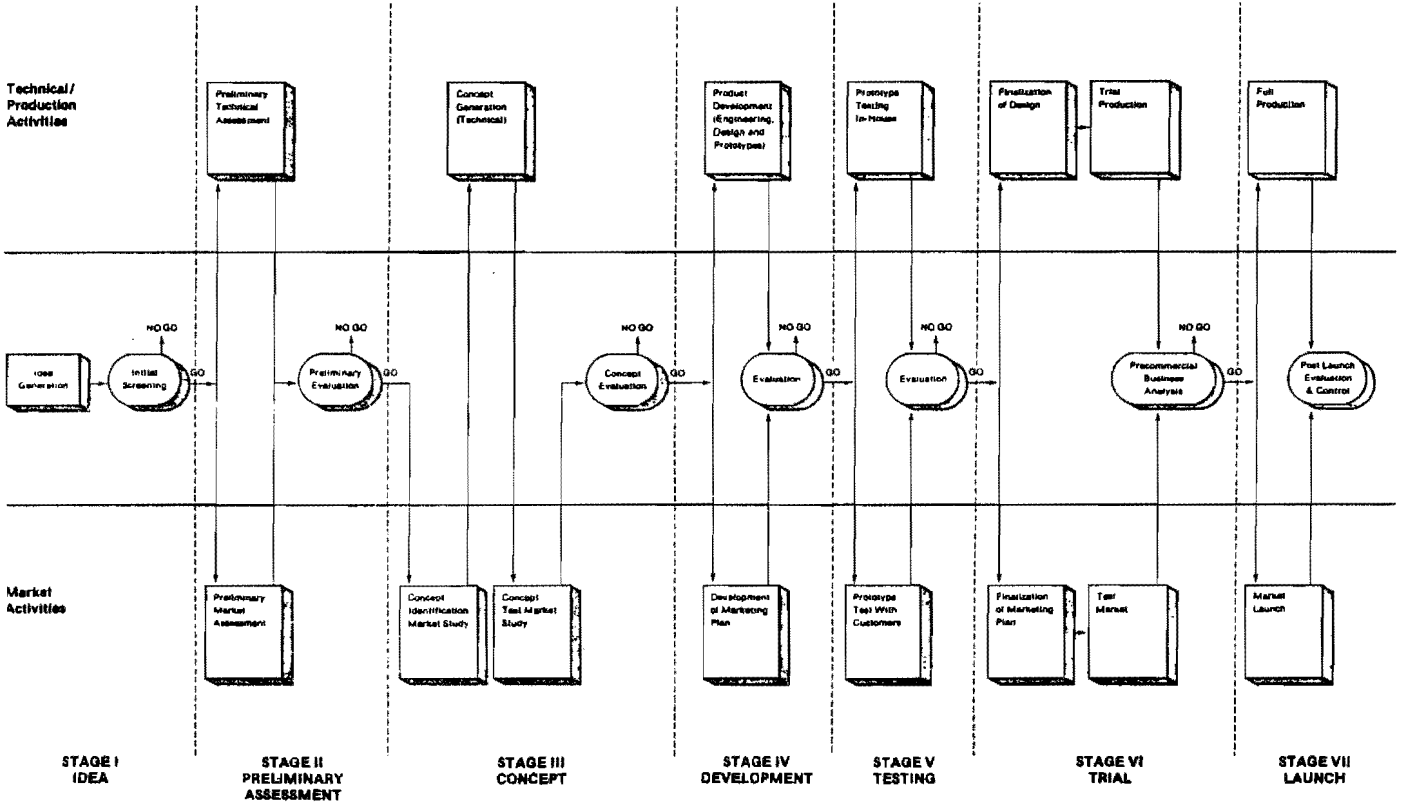


Figure 3.12 An example of an elaborate decision-stage model.

Source: R.G. Cooper, A Process Model for Industrial New Product Development, McGill University, Faculty of Management, Montreal, 1981, p. 14a.

advantage of decision-stage models is that they are easily constructed by taking the stages of an activity-stage model and linking them by evaluation points. An example is given by Cooper (1975) in Figure 3.11. Six years later Cooper presented a more elaborate example, based on an extensive review of both existing theoretical models and actual case histories (Figure 3.12). Both models distinguish between technical/production activities and market-oriented activities.

Ronkainen (1985) presented a model consisting of five broad phases (concept, feasibility, product and process development, scale-up and standardization), with each phase broken down into several activities (Figure 3.13). The model not only incorporates many evaluation points, but also shows the consequences of every GO/NO GO decision. Thus many potential feedback loops, as well as the input necessary for each evaluation, are identified. Ronkainen emphasized that decision makers use three basic groups of criteria, that is product, market(ing) and financial criteria. The importance of the criteria varies from one phase to another. At the outset of the process, decisions are mostly based on market criteria. During the next few phases product-related criteria start to dominate while, during the last phases, financial criteria are the most important.

Van der Kooy (1983, p. 53) suggested a model consisting of three stages, that is definition, design and preparation, which are separated by evaluation points. Each stage is subsequently split up into three substages: becoming aware of the situation, searching for alternatives and selecting an alternative. These substages are separated by interim evaluation points. The decision points are thus not only situated between the stages, but within the stages (i.e. between the substages) as well. A similar breakdown is given by Cooper and More (1979), who split up each stage into four activities:

1. information gathering to reduce uncertainties,
2. evaluation of information,
3. decision-making and
4. identification of remaining key uncertainties.

Decision-stage models are basically an extension of the activity-stage models, and thus enjoy all the advantages of these models (already mentioned above). An additional advantage is that, since they incorporate evaluation points, it becomes possible to apply decision theory, probability analysis and computer simulation. Each decision point is

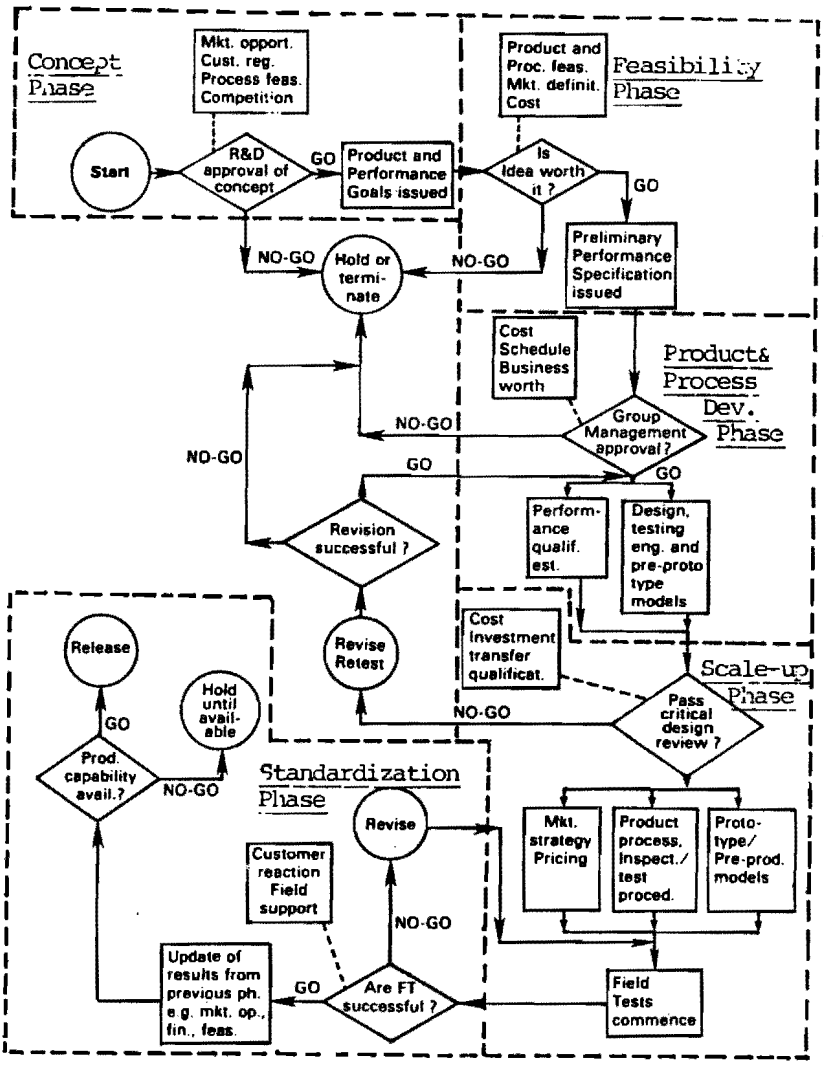


Figure 3.13 A model of the product development process that shows both evaluation points and the consequences of every GO/NO GO decision.

Source: I.A. Ronkainen, 'Criteria Changes Across Product Development Stages', Industrial Marketing Management, Vol. 14 (1985), p. 173.

viewed as a small process with information as input and the decision(s) as output. In the same way, the next type of model views the total development process in terms of inputs and outputs.

3.1.1.4 Conversion process models

The main criticism directed against all three types of 'stage' models is that they depict the process of product development as an orderly and logical sequence. This enables one to analyse innovations as progressing through a series of stages in a rational manner. In practice, however, there is substantial evidence that this view is a simplification of reality. The innovation process is usually not quite so rational and ordered. In an article with the revealing title 'Managing innovation: controlled chaos', Quinn (1985, p. 83) concluded that

> "Innovation tends to be individually motivated, opportunistic, customer responsive, tumultuous, nonlinear, and interactive in its development. Managers can plan overall directions and goals, but surprises are likely to abound."

This consideration leads to viewing the innovation process as a system with specified inputs and outputs.

An example of this approach, given by Cooper (1982), views the product development process as using R&D spending and the firm's resources and skills as inputs to achieve new products in the marketplace as outputs, while being influenced by firm characteristics (Figure 3.14).

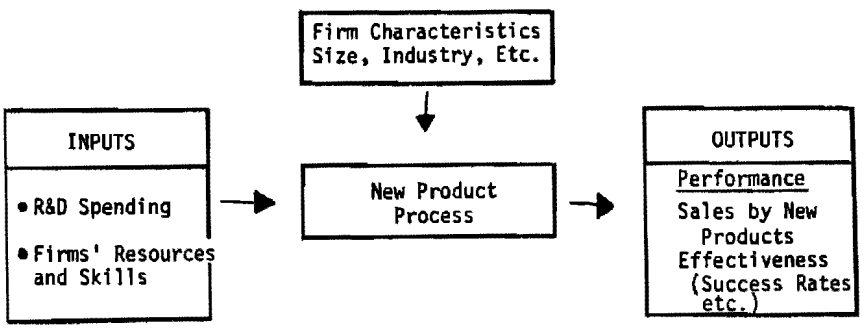
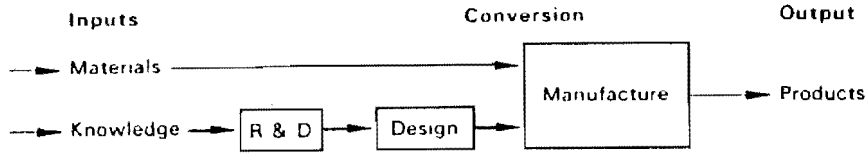


Figure 3.14 Product development viewed as a conversion process.

Source: R.G. Cooper, 'New Product Success in Industrial Firms', Industrial Marketing Management, Vol. 11 (1982), p. 216.

Twiss (1986) viewed technological innovation as a 'conversion process'. Inputs, such as raw materials and scientific knowledge, are transformed into outputs, i.e. new products. As can be seen in Figures 3.15a and 3.15b, he made a further distinction between product-oriented and market-oriented firms. The main difference being that, in the latter type of firm, 'customer needs' is seen as an additional input. In both cases, however, product development is represented as a conversion process, with the process itself largely remaining a black box. The inputs may take the form of activities (e.g. design), information (e.g. scientific knowledge and customer needs) and departments (e.g. R&D) and are used by the firm. The order in which they are used, however, remains unspecified.

(a) Product orientation:



(b) Marketing orientation:

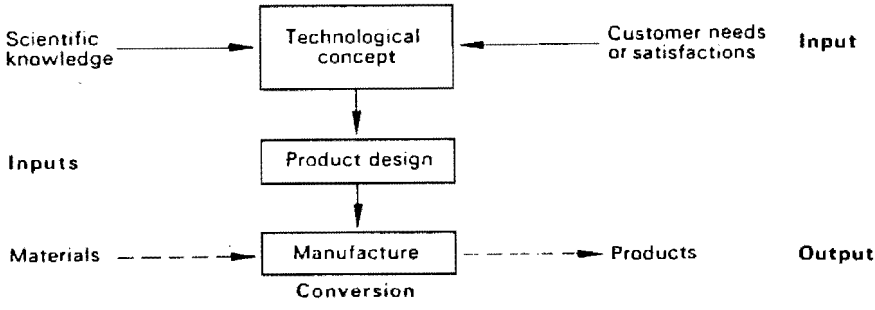


Figure 3.15 Another view of product development as a conversion process.

Source: B.C. Twiss, Managing Technological Innovation, 3rd. ed., Pitman Publishing, London, 1986, p. 4.

Schon (1967, pp. 19-20) also attacked what he calls 'the rational view of innovation':

> "According to this view, innovation is essentially similar to other major functions of a firm. It can be managed. It must be analyzed into its component parts and made subject to rational control. It

is a series of orderly steps ... intelligently directed toward an objective spelled out in advance. ... The rational view of innovation ignores or violates actual corporate experience."

Schon distinguished between uncertainty, which he considers incalculable, and risk, which he characterizes as quantifiable. Firms are unable to operate in uncertainty, but are beautifully equipped to handle risk. This led him to conclude that "the innovative work of a corporation consists in converting uncertainty to risk" (Schon, 1967, p. 25) by both using the existing body of knowledge and adding to it when necessary. This last aspect is illustrated by Figure 3.16 where the line at L represents the current state of the art of knowledge; while at point A in the development process the existing body of knowledge is still sufficient, at point B it becomes necessary to surpass it.

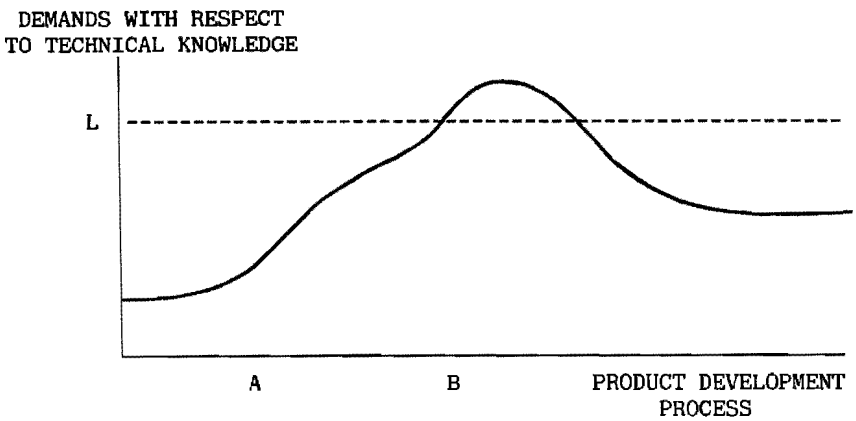


Figure 3.16 An abstract view at the product development process.

Source: D.A. Schon, Technology and Change, Delacorte Press, New York, p. 25.

Schon's model is clearly more abstract than the preceding models of Cooper and Twiss, but all these models are based on the same conception of the product development process: a conversion of inputs into outputs. Because the conversion process is presented as a black box, it fails to offer any insights into the activities undertaken or the stages that must be gone through. These models can be used, however, for 'externally oriented' studies of innovations, for instance studies concerning the effects or diffusion of innovations.

E. Response models

Innovations involve changes to which people react. This reaction can be described by a series of stages. At the outset the individual must perceive the change, he or she then searches for information about its effects and evaluates the results. Finally, he or she reacts to the change. This type of description has been termed a stimulus-response model. The individual reacts (the response) in a certain way to a change (the stimulus).

Not only individuals, but organizations as well, react to a change. Becker and Whisler (1967) compared a number of studies and concluded that most investigators agree that the process of innovation consists of the following four stages:

1. stimulus, that leads an individual within the organization to conceive a new idea,
2. conception of the idea for an innovation,
3. proposal of the innovation project by the individual (or others) and
4. adoption/rejection of the innovation.

Response models present an innovation as a reaction of the firm to a stimulus. They are radically different from the other models presented in this chapter. The product development process that is broken down into activities or stages by other models is located implicitly between the third and fourth step in response models. These models strongly concentrate on just one aspect of the innovation process, namely the early stage of inception.

3.1.2 SELECTION OF A MODEL OF THE PRODUCT DEVELOPMENT PROCESS

From the survey given above, we can conclude that there is a wide variety of models that try to describe the product development process. All these models were developed by the authors with a specific purpose in mind, for example to examine the factors influencing success or the role of product champions and top management, and were not meant as an accurate general description of the process. The aspects studied by the authors determined the format of the model. In the same way, the purpose of our investigation largely determines the choice of the research model.

When evaluating the five broad categories, we can conclude that conversion process models do not describe the actual development process, while response models concentrate on just one stage of the process. Departmental-stage models focus on the departments involved rather than the activities, which precludes the formulation of generalizations concerning the actions to be taken during the process. Since our investigation primarily aims at offering managers practical guidelines regarding the actions to be undertaken during the process of product development, both the activity-stage models and decision-stage models appear to be suitable. Because (1) decision-stage models are in fact extensions of activity-stage models (making them more flexible and realistic) and (2) the decisions underlying the actions undertaken during the product development process are of primary importance, a decision-stage model is clearly to be preferred. Furthermore, decision-stage models can easily be adapted to account for involvement of users and third parties in product development.

The choice of a specific decision-stage model further depends on the degree of specification of the models available. The model presented by Cooper (1981) (Figure 3.12), based on recent research findings, an analysis of previous normative models and a review of 60 flow charts of case histories of new product projects, seems to offer a sufficiently detailed and realistic description of the product development process with respect to industrial products to act as an action guide to managers. The advantages of the model are manifold:

a. the process becomes more multidisciplinary by distinguishing between market and technological activities,
b. the process encourages interaction, since the many evaluation nodes demand diverse inputs from various groups in the company and one activity tends to feed on another (often in a different functional area within the firm),
c. the process exhibits incremental commitment and
d. it is decidedly market oriented, providing for ample market information and marketing planning throughout the entire process.

Nevertheless, some criticism can be raised against this model. Stage V of the model (testing) includes both in-house testing of the prototype and testing the prototype with customers, this being undertaken in parallel. In our opinion this seems highly improbable: a firm will perform the internal test (in-house) before performing the external

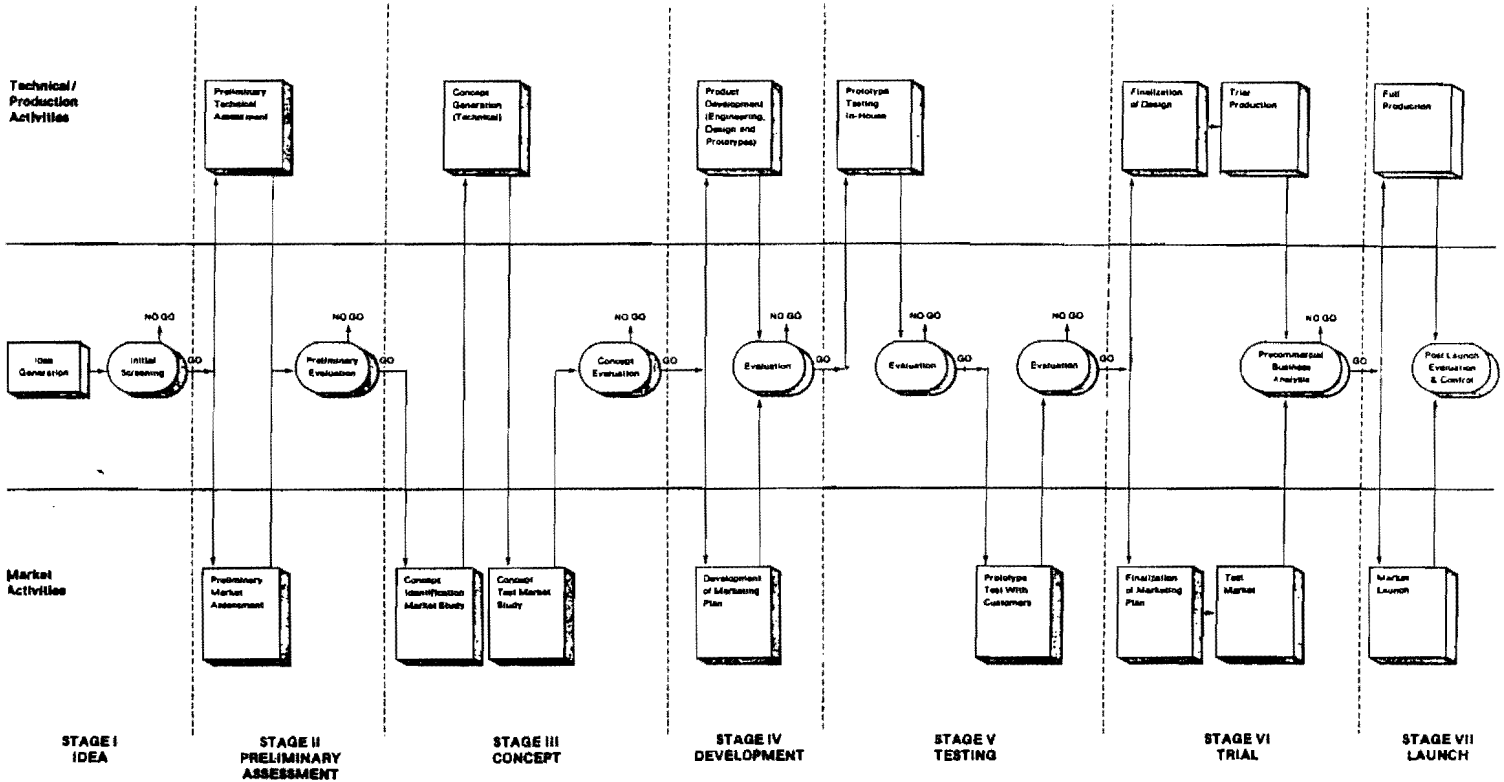


Figure 3.17 The model selected as the basis of our research.

Source: Based on R.G. Cooper, A Process Model for Industrial New Product Development, McGill University, Faculty of Management, Montreal, 1981, p. 14a.

test (with customers) because of the different objectives of both activities. The purpose of the in-house test is to test the technical functionality of the product, while testing with customers is done as a last check to see whether product characteristics meet customer requirements. As a result of the in-house test the prototype may be modified before being tested by customers. The modified model is presented in Figure 3.17 (a description of the individual stages can be found in Appendix A). It should be stressed here that, in practice, the various stages will not be as sequential and as neatly separated from each other as the model suggests. Overlapping stages and feedback loops will be the rule rather than the exception. As mentioned before, each GO decision may result in going back to a previously completed stage. However, for the sake of clarity, all these potential feedback loops have not been included in the figure.

3.2 THE ADOPTION PROCESS

> If anyone advances anything new, people resist with all their might; they act as if they neither heard nor could comprehend; they speak of the new view with contempt, as if it were not worth the trouble of even so much as an investigation or a regard; and thus a new truth may wait a long time before it can make its way.
>
> (Johann W. von Goethe, 1749-1832)

In the third edition of his classic work 'Diffusion of Innovations', Rogers (1983, p. 21) defined adoption as "the decision to make full use of an innovation as the best course of action available". The adoption process is the process that a potential customer goes through to reach the decision to adopt a new product. More (1984) proposed a comprehensive model of the industrial buying process which revolves around adoption-stage activities and outcomes. The process starts with recognition of a need and the eventual result is the adoption of an innovation. In addition to these adoption stages and outcomes the model incorporates buying-centre behaviour, the choice process, risk and

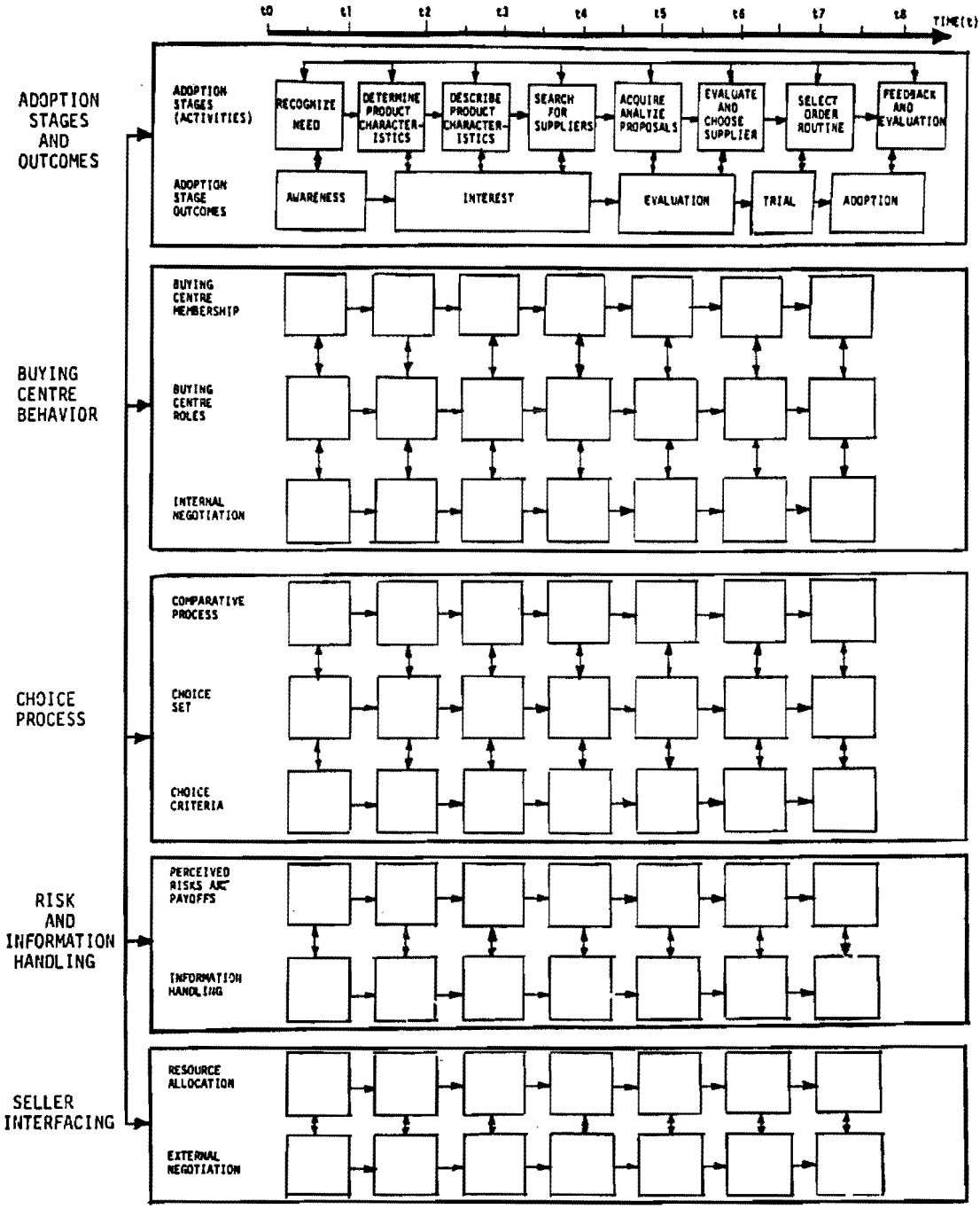


Figure 3.18 The organizational adoption process.

Source: R.A. More, 'Improving the Organizational Adoption Rate for High-Technology Industrial Products', Journal of Product Innovation Management, Vol. 1 (1984), p. 186.

information handling and finally, seller interfacing. The complete model is presented in Figure 3.18.

After having described the stages of the adoption process, the discussion will focus on the concept of the buying centre and the role of the purchasing agent in buying processes.

3.2.1 STAGES OF THE ADOPTION PROCESS

Rogers (1983) has presented the adoption process as a series of stages similar to the ones distinguished by More. Rogers, however, stresses the fact that rejection (i.e. the decision not to adopt an innovation) is also a conceivable outcome of the decision process. For this reason he prefers the more neutral term innovation-decision process. (The complementary process of product development he calls 'innovation-development process'.) Whatever the outcome of the decision process, it may be reversed afterwards. For example, 'discontinuance' is the decision to reject an innovation after it had previously been adopted. The innovation-decision process is described as a series of actions and choices over time through which an individual or organization evaluates a new idea and decides whether or not to incorporate the new idea into ongoing practice (Rogers, 1983, p. 163).

The adoption process consists of the following five stages (Rogers, 1983, p. 164; Figure 3.19).

1. Knowledge

   This stage starts when the decision-making unit is confronted with the innovation and gains some understanding of how it functions. The knowledge relates to the existence of the innovation, how it should be used and how it works.

2. Persuasion

   At the second stage the decision-making unit forms a favourable or unfavourable attitude toward the innovation, which is based on the information acquired. Matters such as the kind of information needed and where it can be found are important here, but the way information is interpreted (selective perception) plays a major role as well. The information sought at this stage of the process has a typical evaluative character and aims to reduce the uncertainty regarding the innovation's expected consequences.

3. Decision

At the decision stage the decision-making unit engages in activities that lead to the choice of adopting or rejecting an innovation. A small-scale trial of the innovation is quite often a major determinant of this decision (as is also illustrated by the case studies in Chapter 5). The trial can be performed by the decision-making unit itself or a third party (particularly if the third party is considered to be an opinion leader).

4. Implementation

Implementation is the actual use of the innovation by the decision-making unit. This stage follows the preceding one naturally, but has been rather neglected by researchers. As Wood and Elgie (1976, pp. 32-54) demonstrated, many start-up problems may occur at this important stage. Therefore, information necessary at this stage relates to the operation of the innovation, the problems that may occur and the ways to prevent or solve them. Training and assistance by the seller may be necessary where complex industrial innovations are concerned. During the implementation, the innovation may be changed or modified by the user (re-invention). This phenomenon has been neglected by researchers for many years (Agarwala-Rogers, 1978, pp. 138-141).

5. Confirmation

Although most investigators consider implementation to be the last stage of the process, Rogers distinguishes another stage: confirmation. At this final stage the decision-making unit seeks information to reinforce the decision made. However, the information may also lead to reversal of the decision. Discontinuance, the decision to reject an innovation after having previously adopted it, can be very difficult when considerable investments were involved in the decision to adopt it in the first place. This may lead the decision-making unit to seek only information that will support the original decision (selective exposure).

Following the descripton of the adoption process a few observations are in order. Firstly, the decision to reject an innovation is not limited to the decision stage. In fact, rejection may occur at any stage of the process. For example, if the knowledge gained at the first stage does not rouse any interest, the innovation can be rejected by just forgetting about it. As pointed out earlier, rejection may also

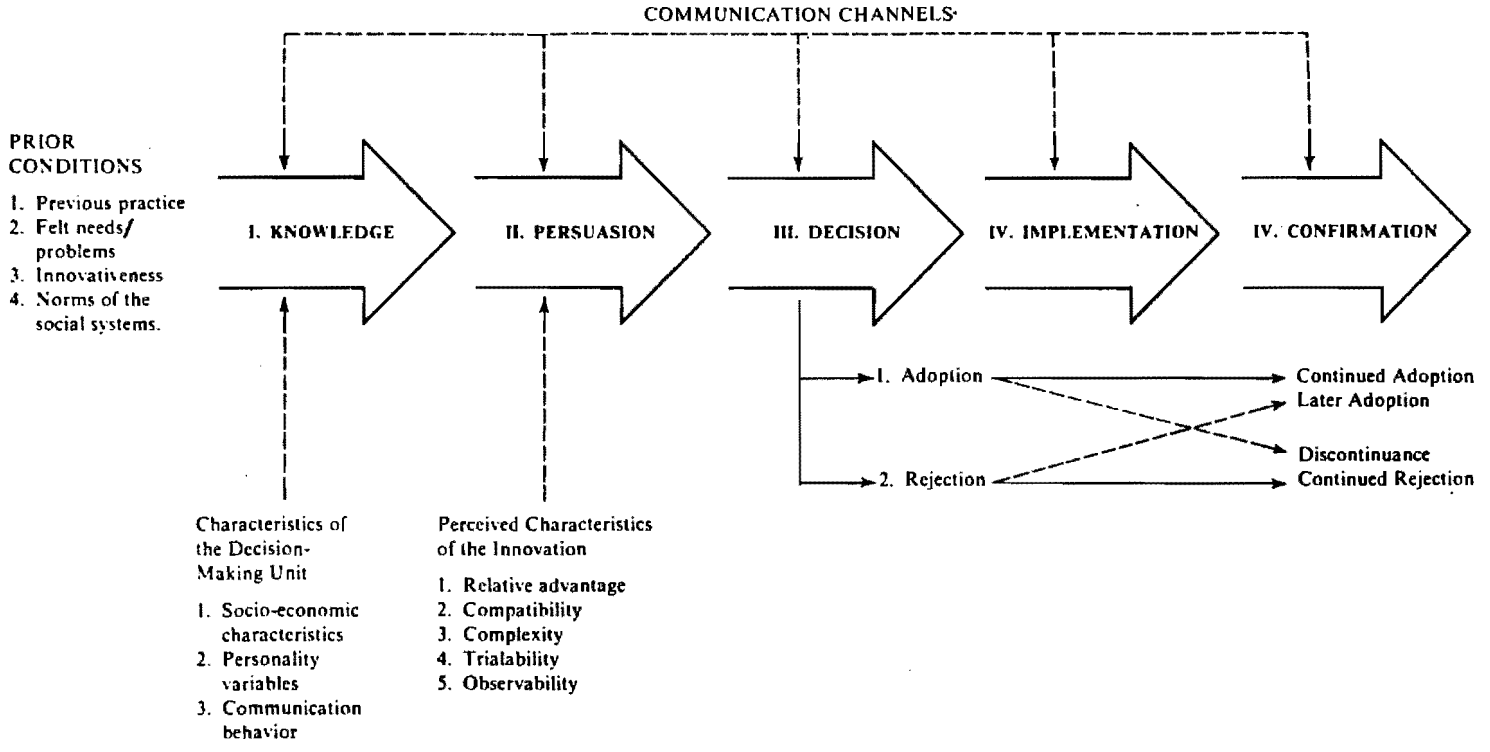


Figure 3.19 A model of stages in the adoption process.

Source: E.M. Rogers, Diffusion of Innovations, 3rd. ed., The Free Press, New York, 1983, p. 165.

occur after the decision to adopt the innovation has been made. Thus we would like to make a distinction between three different kinds of rejection (unlike Rogers (1983, p. 173), who lumps the second and third category together):

1. passive rejection (or nonadoption), which occurs when use of the innovation is never really considered,
2. a priori active rejection, which occurs when adoption of the innovation is considered but later decided against and
3. a posteriori active rejection (or discontinuance), which occurs when reconsideration of adoption of the innovation results in rejection.

Secondly, the adoption process, as described above, assumes a linear sequence of stages. In practice this is not always the case, as decision may precede persuasion. Think of the company that is 'forced' to follow the competition in adopting innovative production machinery. Finally, the description shows that the gathering of information is not limited to the knowledge stage but is at the centre of all stages of the process (see also More's model; Figure 3.18). Ozanne and Churchill (1968, p. 359) reported that personal sources (in particular personal selling) were more important at the early stages, while impersonal sources were paramount at the evaluation. Their research also showed that as the final decision approaches, the need for informational inputs increases. A study conducted by Chakrabarti, Feinman and Fuentevilla (1982, p. 203) demonstrated that the desired information depends on the function; managerial personnel demand evaluative information whereas technical personnel prefer problem-specific information. Differences regarding the way information is diffused inside the organization were also found: managers were mostly involved in downward communication, while design engineers showed more utilization of lateral communication channels. Because the technical personnel were found to be under time constraints, easy access is of prime importance regarding information targeted at this group.

3.2.2 THE BUYING CENTRE

In his writings about diffusion, Rogers uses the description "an individual or other unit of adoption". Since we are discussing the adoption of products for industrial markets, the unit of adoption is

the so-called buying centre. Some authors use the term 'Decision-Making Unit' (DMU) to refer to the same concept. However, we will consistently use the term 'buying centre' to differentiate it from 'Decision-Making Unit' which has more general connotations (Rogers, for example, refers to the decision-making unit when discussing the innovation-decision process to include the adoption of abstract ideas as well as the purchase of concrete products). The buying centre was originally defined as all the organizational members involved in the purchase decision for a particular product or service (Wind, 1967; Webster and Wind, 1972). Webster and Wind (1972) distinguished the following roles in a buying centre:

a. users, who will be using the innovation,
b. gatekeepers, who control the information to be received by other members of the DMU,
c. influencers, who affect the purchasing decision by supplying information for the evaluation of alternatives or by setting down buying specifications,
d. deciders, who actually make the buying decision, whether or not they have the formal authority to do so and
e. buyers, who have the formal authority for selecting a supplier and implementing all procedures connected with securing the product.

The initiator, who identifies a problem and starts the buying process, is a sixth role added to the list by Bonoma (1982, p. 113). Webster and Wind did not overlook this role, but incorporated it in the user as "in many cases the potential users are those who initiate the buying process" (Webster and Wind, 1972, p. 78).

Although different roles can be discerned within a buying centre, this does not imply that a buying centre always consists of more than one person. In specific instances the roles mentioned above may be incorporated in one person; at the other extreme lies the extensive buying committee consisting of several persons from several functional areas. Based on interviews with respondents in fifty-five industrial customers for reprographic equipment, Newall (1977, pp. 185-186) reported that "In the case of large companies, there is an element of constancy about the size of the buying group, where a number of roles are common ... In the case of smaller companies, the fact that a single member may fulfil

more than one buying role ... means that a smaller decision group emerges".

The existence of a multi-person buying centre has important consequences for research into organizational buying behaviour. After having studied the industrial adoption process, Ozanne and Churchill (1971, p. 327) remarked that "the use of a group as the typical unit of adoption complicated the analysis". Taking an individual as the unit of adoption, however, appears to be an unjustified simplification. Based on extensive literature research, Smith and Taylor (1985, p. 59) arrived at the conclusion that "the most that can be said about the composition of a buying centre is that it is typically made up of members drawn from between three and ten functional areas with almost 40 per cent of purchase decisions being influenced by at least three persons". When there is more than one person involved in the buying process, the interaction between the members becomes important. An early study that shows flow charts and interaction patterns is presented by Harding (1966). Johnston and Bonoma (1981) formulated five structural and interactive dimensions of the buying centre and demonstrated how they can be quantified.

The original definition of a buying centre leaves some room for discussion. For example, the definition of 'involvement' should not be formulated in such a way as to include only casual involvement as well. This would lead to the inclusion of a large number of people and thus to an impractical utilization of the concept. Only those individuals with direct major involvement in the given purchase decision should be included. A second matter of interest concerns the possible inclusion of outsiders. Most authors limit the membership of the centre to members of the buying organization, as implied by the original definition. Although Webster and Wind define the buying centre in their classic 'Organizational Buying Behavior' initially as "all those individuals and groups who participate in the purchasing decision-making process" (p. 6), further on they describe it as "members of the organization who interact during the buying decision process" (p. 77) (emphasis added). In a later publication, however, Wind (1978a, p. 69) argues that "... as long as the outsiders have a stake in the decision, there is no reason why they should be excluded". We endorse this reasoning because outsiders can indeed be significantly involved in the ultimate buying decision. Weigand (1968, p. 45) mentions as examples of outside

influencers "engineering consultants, insurance firms, testing laboratories, construction firms, governmental units, or simply respected firms in an industry who unwittingly perform part of the buying function for those who follow their lead". Zaltman and Bonoma (1977, p. 57) gave evidence of other firms in the role of influencers when they stated that "the importance of purchase-related word-of-mouth communication among buying firms is greatly underestimated".

A major determinant of the structure of the buying centre is the specific buying situation. Robinson, Faris and Wind (1967) in their BUYGRID model defined three principal buying situations, that is the new task, modified rebuy, and straight rebuy. As the buying situation becomes more complex and novel, there is a greater likelihood that a special buying centre will be established to carry out the purchasing decision (Wind, 1978a, p. 71), the average number of persons within the buying centre increases (Doyle, et al., 1979, p. 8; Crow and Linquist, 1985, p. 54), buyers are more actively searching for information (Grönhaug, 1975, p. 20) and other purchasing criteria are used (Krieger and Meredith, 1985, p. 279). Spekman and Stern (1979, p. 58) reported a strong correlation between environmental uncertainty and the participation of buying-group members in purchasing-related decisions. Finally, Johne (1984, pp. 191-193) drew attention to a possible link between the innovative behaviour of firms and the departments involved in buying decisions.

3.2.3 THE ROLE OF THE PURCHASING AGENT

Several studies have been conducted to determine the relative influence of members of the buying centre during the buying process. The buying decision is usually depicted as a process consisting of several stages. Ozanne and Churchill (1971) proposed five stages, while Wind (1978b) increased this number to twelve. Most researchers, however, postulate a model of the buying process based on BUYPHASE, the eight-step approach proposed by Robinson, Faris and Wind (1967):

1. anticipation or recognition of a problem and a general solution,
2. determination of characteristics and quality of a needed item,
3. description of characteristics and quantity of needed item,
4. search for and qualification of potential sources,

5. requisition and analysis of proposals,
6. evaluation of proposals and selection of supplier(s),
7. selection of an order routine and
8. performance feedback and evaluation.

Some studies have focussed explicitly on the relative influence of the purchasing agent on the buying decision. Bellizzi (1979) found that the purchase of expensive capital equipment appears to be dominated by top managers at most stages of the buying process. Purchasing agents were found not to exert great influence on most stages, but did rank quite high on some of the later stages of the process. For operating supplies and major materials, on the other hand, the influence of the purchasing agent was reported to be much more significant. Thus it seems that the product type is one of the major factors determining the purchasing agent's influence during the buying process. This conclusion is supported by Giunipero (1984, p. 247) when, in a study of computer buying, he points out significant differences in the perceived role activity between public and private purchasers and shows that these differences vary across product categories. Similar conclusions were arrived at by other researchers (e.g. Erickson and Gross, 1980). The influence of the purchasing agent also seems to depend on the buying situation. Doyle et al. (1979, p. 9) reported that the purchasing agent tended to be strongly involved in nearly all buying phases for straight rebuys, whereas his role in new-task buying situations had a more coordinating character. Mogee and Bean (1978, p. 136) remarked that if an innovative purchase becomes a routine one, primary responsibility is shifted to the purchasing department.

Considering the above, it seems that concerning complex, industrial innovations in particular, the purchasing agent only plays a minor role during the buying process. Bonoma and Zaltman (1978, p. 22) maintained that "As the rate of technical change increases, the importance of the purchasing manager in the organizational acquisition process decreases. At the same time, the importance of technical and engineering individuals making up the buying center increases rapidly, and they may well become the sole, or at least major, authorizers of purchases." Abratt (1986, p. 295) lends further support to this finding when, as the result of a study of buying behaviour of purchasers of high technology laboratory instrumentation, he concludes that "the involvement of the

buying department is mostly administrative and involves some information gathering."

Traditionally, the purchasing agent has been regarded as an 'order writer', one who only becomes significantly involved during the later stages of the buying process. This negative view has caused resentment among the members of the purchasing profession. Twenty-five years ago, Strauss (1964) already reported on the friction between purchasing agents and engineers. The conflict was primarily over the purchasing agent's attempts to gain more control over decisions on what to buy; he wanted more control over specifications. Purchasing agents also felt that top management pays too little attention to the purchasing function. A survey of 750 U.S. industrial managers conducted by Ammer (1974) disclosed negative perceptions of the purchasing function on the part of top management.

More than twenty years ago it was foreseen that "the trend of purchasing practice is likely to be towards greater centralisation, with larger and more responsible purchasing departments, increasingly embodying technical and specialist staffs and skills", thus enhancing the status and calibre of the purchasing department (Lister, 1967, p. 198) and resulting in greater professionalism (Strauss, 1964). In recent years, this view has been confirmed when authors pointed out that purchasing managers are upgrading their skills (Upah and Bird, 1980, p. 119) and a new class of professional buyer is coming into existence (Giunipero and Zenz, 1982, p. 21). The implications of these purchasing trends for industrial marketers were spelled out. However, no clear picture emerges. Barath and Hugstad (1977, p. 304), for example, warned that an increased professional status can restrict rather than expand the role of purchasing agents in the industrial buying process.

The theme of professionalizing purchasing agents has also been discussed extensively in the Dutch media (De Rijcke and Van Weele, 1980; De Rijcke and Faes, 1982), even as recent as 1987. As a result of a study of purchasing management in Dutch industry it was concluded that most industrial purchasers "function as order-takers for engineers in the production department. They are the ones that need materials, that formulate the technical requirements and very often even say where it should be bought. The role of the purchasers involved is reduced to negotiating about price". Upgrading of the purchasing function is

mentioned as a general remedy (FEM, 1987, p. 33). Another study (Van Weele and Van Hespen, 1987) arrives at similar, although somewhat less negative, conclusions: although the purchasing function was not found to be largely neglected, (1) the role during the buying decision is mostly restricted to administrative actions, (2) the involvement in buying innovative products is quite low and (3) professionalizing of the purchasing department is thought to be necessary.

Considering the above, the conclusion that purchasing agents only play a minor administrative role in the adoption of industrial innovations seems to be warranted. There is, however, another role traditionally attributed to the purchasing agent: the gatekeeper.

According to Mogee and Bean (1978, p. 135) "the purchasing agent plays an important gatekeeper role in industrial innovation but is not the principal decision maker". When the purchasing agent performs a gatekeeping function, the firm is better equipped to stay involved in technological innovations (Zaltman and Bonoma, 1977, p. 55). Situations of great environmental uncertainty in particular, offer the purchasing agent the opportunity to fulfil this central gatekeeping role (Spekman and Stern, 1979, p. 60), which makes the purchasing agent less of an order-taker than previously suggested (Spekman and Ford, 1977, p. 402). This unique gatekeeper position implies that the seller's representatives are generally required to go to the purchasing agent before contacting and influencing other parties in the buying organization (Mogee and Bean, 1978, p. 136; Berkowitz, 1986, p. 42; Bellizzi and Walter, 1980, p. 140). Nicosia and Wind (1977, p. 368) argue that, as the buying process grows more comprehensive and complex, the purchasing agent is the ideal person to plan and coordinate such a process. Basically, his task is to understand the different points of view and needs within the organization and to resolve conflicts.

3.3 THE DIFFUSION PROCESS

Diffusion is defined by Rogers (1983, p. 5), who conducted a comprehensive review of the literature on diffusion and summarized the findings into an integrated framework, as "the process by which an innovation is communicated through certain channels over time among the members of a

social system". Robertson (1971, p. 32) has expanded this definition to make it more applicable to the marketing of new products: "diffusion is the adoption of new products or services over time by consumers within social systems as encouraged by marketing activities". This definition illustrates the close link (and difference!) between adoption and diffusion: adoption is an individual decision-making process, while diffusion reflects a series of adoption decisions by individual units within the social system (see also the last section in this chapter). Although we will concentrate on the diffusion of new products in industrial markets, it must be kept in mind that, according to Rogers' more general definition, diffusion research may also relate to subjects like the dissemination of ideas within the firm (see e.g. Vandermerwe, 1987).

According to Rogers, research on diffusion of innovations originated independently within several distinct disciplines, such as sociology and anthropology. Although each discipline used its own approach, remarkably similar results were found. For example, that the diffusion of an innovation followed an S-shaped curve over time and that innovators had higher socioeconomic status than later adopters (Rogers, 1983, p. 38). Indeed, the lack of diffusion of diffusion research was mentioned by Rogers as one of the main reasons for writing the first edition of 'Diffusion of Innovations' (Rogers, 1962).

For a considerable time, the field of diffusion has been dominated by rural sociology. An early study that has had a major influence on (a) the methodology, theoretical constructs and interpretations of later students of diffusion in the rural sociology tradition, and (b) diffusion research in general, is the hybrid-seed-corn study conducted by Ryan and Gross (1943). One of the main findings was the important role of interpersonal networks in the diffusion process.

During the 1960s, diffusion research caught the attention of the marketing discipline as well. The large percentage of new consumer products that fail, prompted marketing managers to conduct diffusion studies. Despite its late start, diffusion research in the marketing field has really spread. According to Rogers "by 1981, there were 304 marketing (diffusion) publications, 10 percent of the total, and marketing ranked fourth in its contribution to diffusion research!" (Rogers, 1983, p. 74). A survey of innovation diffusion models in marketing is given by Mahajan and Muller (1979) and, more recently, Böckner and Gierl (1988). Although diffusion research seems to be well

established in marketing, little research has been conducted into the diffusion of industrial innovations. In 1966 the lack of research relating to adoption and diffusion of new industrial products was pointed out (King, 1966, p. 684). This conclusion was repeated by Ozanne and Churchill (1968, p. 352), Cook (1970), who mentioned that out of 708 publications on diffusion studies only five (!) were concerned with the industrial field, and later similar views were expressed by Abu-Ismail (1976, p. 2). Although the situation has clearly improved, there is still a strong bias in favour of consumer products.

3.3.1 ELEMENTS OF THE DIFFUSION PROCESS

After analysing the definitions of diffusion given by Robertson (1971, p. 32) and Rogers (1983, p. 5) we can distinguish the following six elements of the process of diffusion of industrial innovations.

a. Adoption

The adoption process has been discussed in the preceding section.

b. The innovation

The subject of innovations has been covered extensively in Chapter 2 and needs no further elaboration.

c. Time

Time is an important element of the diffusion process. It is used to separate early from late adopters of an innovation and to identify an innovation's speed of diffusion.

d. The units of adoption

As regards industrial innovations, the buyer is an organization instead of an individual. That means that one has to consider a group of people involved in the purchasing decision: the buying centre (see also the preceding section).

e. A social system

Diffusion of an innovation occurs within a social system, that is a set of interrelated units that are engaged in joint problem solving to accomplish a common goal (Rogers, 1983, p. 24). The social system constitutes the boundary within which the innovation diffuses, provides norms and values, defines roles, and evaluates the consequences of the diffusion.

f. The communication channels

Communication is the process by which participants create and share information with one another in order to reach a mutual understanding. Diffusion can be considered a special type of communication in which the information concerns new ideas. Communication channels are the means by which messages proceed from the sender to the receiver. When studying the diffusion of industrial innovations, two kinds of communication channels are important. First, channels whereby the industrial marketer sends information to potential buyers (marketing activities). Second, channels used for communication between potential buyers (word-of-mouth communication, opinion leadership). Another distinction is the one between mass media channels and interpersonal channels. The former are those that involve a mass medium, while the latter involve a face-to-face exchange. According to Rogers (1983, pp. 198-199) interpersonal channels play an important role at the persuasion stage. Ozanne and Churchill (1968, p. 359) found that personal sources (personal selling) were important at the earlier stages, while impersonal sources (tooling proposals and price quotations) dominated at the evaluation. Mass media were found to be of minor importance.

3.3.2 THE SPEED OF DIFFUSION

Many studies have been conducted to discover why some innovations gain acceptance faster than others, that is to determine the factors that influence the speed of diffusion. Rogers (1983, p. 23) terms it, somewhat confusingly, the rate of adoption and defines it as "the relative speed with which an innovation is adopted by members of the system". According to Rogers (1983, p. 233), there are five categories of variables that influence the speed of diffusion:

a. perceived attributes of the innovation,
b. type of innovation decision,
c. communication channels,
d. nature of the social system and
e. extent of the change agents' promotion efforts.

Here we will only describe briefly the first category, because it is by far the most important. Rogers (1983, p. 232) maintains that 49 to 87

percent of the variance in the speed of diffusion can be explained by the variables belonging to this category. The following five attributes of innovations are of importance.

1. Relative advantage

   The relative advantage of an innovation is the degree to which an innovation is perceived as being better than the idea it supersedes. This relative advantage can be expressed in many ways, such as cost savings or increased prestige. Hayward (1978, p. 195) drew attention to differences in perception of an innovation's characteristics between adopters and non-adopters. The substitution that is the result of the relative advantage of a new technology compared with the existing one, is explicitly incorporated in a diffusion model by Norton and Bass (1987).

2. Compatibility

   Compatibility is the extent to which an innovation is perceived as consistent with the sociocultural values and beliefs, past experiences (e.g. with previously introduced products), and needs of potential adopters. An innovation with a high degree of compatibility means less uncertainty to the potential adopter. Hayward et al. (1977, pp. 303-304) discovered that "the innovations which were adopted most rapidly were ... (those) innovations which are very similar to existing methods and practices" and called these 'traditional innovations'.

3. Complexity

   The complexity of an innovation refers to the degree to which it is perceived as relatively difficult to understand and use.

4. Trialability

   The speed of diffusion is influenced by the degree to which an innovation may be experimented with on a limited basis. More (1984, p. 195) studied the diffusion of a computer-assisted-learning system and concluded that a trial situation could involve the seller providing the buying centre with an available 'canned' teaching program at a modest price, which could allow the buying centre to simplify their comparison of alternatives and reduce many barriers.

5. Observability

   The last characteristic of an innovation to be mentioned is the degree to which the results of the innovation are visible and can be communicated.

The attributes of innovations mentioned above are to some extent interrelated. For example, new application software is an innovation with a low degree of observability. This is one reason for the conclusion of Voss (1985b, p. 127), that "the purchaser places a strong reliance on the information gained from seeing a demonstration of a working system" (i.e. a trial of the innovation on a small scale).

Apart from the five categories of variables enumerated by Rogers, numerous other variables that influence the speed of diffusion are mentioned by other researchers. Wood and Elgie (1976) stress the importance of the ease of start-up. Mansfield (1968, p. 120) drew attention to the adopter-industry competitive environment, while Robertson and Gatignon (1986) expanded this to include the supply-side competitive environment as well. Later they worked out these variables in more detail and empirically tested the competitive effects (Gatignon and Robertson, 1989). Johne (1984) focussed on one specific characteristic of the adopter industry, namely the innovative behaviour of firms, while Nooteboom (1988) stressed the importance of firm size. Both Cohn (1981) and Boorsma and Van Kooten (1989) named the attitudes of the decision makers towards change and risks as a relevant variable. Finally, the policies of labour unions and the size of the investment (Mansfield, 1968, pp. 120-123) as well as the role of third parties (Mantel and Rosegger, 1987) have been mentioned as factors that influence the speed of diffusion. In an international context, Nabseth and Ray (1974, pp. 311-315) enumerated a large number of factors that may explain differences between the speed of diffusion in different countries.

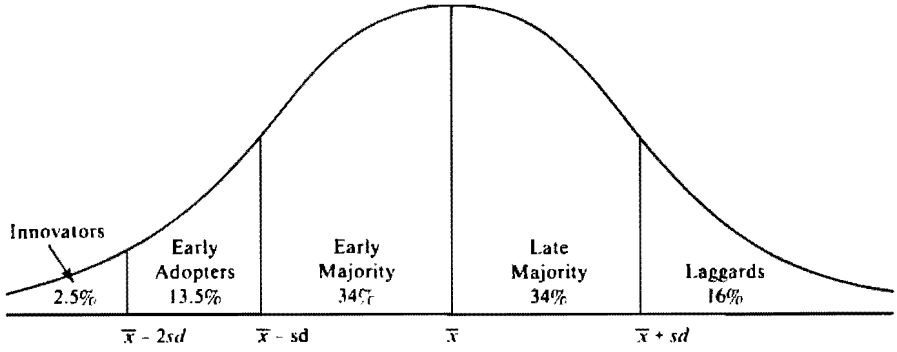
More (1984) has stated that a quick diffusion may not be realized because of several potential barriers to adoption. He mentioned thirteen different kinds of barriers (based on his model of the organizational adoption process, see Figure 3.18), and suggested how they can be overcome by improved interfacing with the potential buyer's adoption process (see also Rabino, 1983).

3.3.3 ADOPTER CATEGORIES

The time variable, which occupies such a central place in diffusion theory and research, can be used to make a distinction between adopters who adopt an innovation when it has just been introduced and adopters

who only adopt after the innovation has been around for a considerable time. In other words, adopters can be categorized according to their innovativeness (i.e. the degree to which an adopter is relatively earlier in adopting new ideas than other members of a system). Rogers (1983, p. 246) distinguished five adopter categories (Figure 3.20):

1. innovators,
2. early adopters,
3. early majority,
4. late majority and
5. laggards.



$\bar{x}$: mean value of x (variable measuring time)
sd : standard deviation

Figure 3.20 Adopter categorization on the basis of innovativeness.

Source: E.M. Rogers, Diffusion of Innovations, 3rd. ed., The Free Press, New York, 1983, p. 247.

A great deal of research has been conducted to determine the characteristics of adopter categories. Some generalizations are presented by Rogers and Shoemaker (1971, pp. 352-376), who analysed approximately 900 empirical publications, dealing with the diffusion of innovations, available in July 1968. Although many studies have been conducted since then, the general conclusions still seem to hold (Rogers, 1983, pp. 260-261).

Webster (1969, p. 39) argued "that those firms which are first to adopt an innovation are those

a. for whom the innovation offers the largest relative advantage ...,
b. that can best tolerate the risk involved in adoption ...,
c. that have the highest level of aspiration ..., (and)

d. for whom information relating to the innovation ... has the greatest value".

In a study of the diffusion of product and process innovations among 352 small and medium-sized manufacturing companies in the Netherlands, Docter and Stokman (1987) found that early adopters differed from late adopters with respect to the sector of industry, size of the firm, age of the firm, average level of educational qualification within the firm, long term orientation, market position, degree of exportation, characteristics of the market, cooperation with other firms, and search for and use of information.

The innovators and early adopters are extremely important in the diffusion process. They provide the supplier of the innovation with an initial level of penetration, can be used as references and, hence, influence other potential adopters (Robertson, 1971, p. 112; Foxall, 1984, p. 93; Webster, 1968). This influence can be exerted in three ways (Turnbull and Meenaghan, 1980, p. 10).

a. Social display

Potential adopters will be encouraged by conspicuous new products to interpersonal communication with the owner, thereby creating awareness and knowledge.

b. Legitimation

The fact that the innovator group has already purchased the innovation reduces the perceived risk with risk-averse potential adopters.

c. Encouragement

The first buyers of the innovation can in conversation urge other members of the social system to adopt it. Their motive may be the desire to reduce their cognitive dissonance following the purchase.

3.3.4 THE ROLE OF OPINION LEADERS

> It is not best that we should all think alike; it is difference of opinion which makes horse races.
>
> (Mark Twain, 1835-1910)

Closely related to the concept of adopter categories is the notion of opinion leadership, which we will define as the degree to which an

actor (be it an individual, group or organization) is able informally to influence other actors' attitudes or overt behaviour in a desired way with relative frequency (based on Rogers, 1983, p. 271). Robertson (1971, p. 35) writes about the same phenomenon when he states that "the interaction effect refers to a process of influence and imitation among consumers by which adopters of a new product lead others to purchase".

In a study of the U.S. Presidential Election in 1940, Lazarsfeld et al. (1948) discovered to their surprise that almost no voting choices were directly influenced by the mass media. Instead, people appeared to be much more influenced by face-to-face contact with other people. Thus, they formulated the two-step flow model of communication: the first step being from sources to opinion leaders (a transfer of information) and the second step from opinion leaders to their followers (information plus influence).

Many studies have been conducted to determine the characteristics of opinion leaders. In general, they are thought to have greater social participation and higher socioeconomic status, and to be more cosmopolite and innovative than their followers. Rogers (1983, p. 284), however, warns that opinion leaders are not necessarily innovators: "when a social system's norms favor change, opinion leaders are more innovative, but when the norms do not favor change, opinion leaders are not especially innovative" (see also Summers (1971) for an investigation into the relationship between innovativeness and opinion leadership).

Little work has been done on the question of opinion leadership in industrial markets compared to consumer markets (Lancaster and White, 1976, p. 288). Webster (1968, p. 458) commented that industrial marketers can use the concept of opinion leadership by giving widespread publicity to the first successful installations of their product. He also hypothesized that the opinion leaders would be expected to be the early adopters instead of the innovators (the very first adopters), which is supported by Rogers (1983, p. 259). He concluded, however, that in industrial markets word-of-mouth communication may be of less importance than in consumer markets. In a later publication he confirmed this conclusion when he stated that "informal patterns of communication relating to new products appear to be weak in the industrial market" (Webster, 1970, p. 189). Webster (1971, p. 187) warns that "such concepts as opinion leadership and word-of-mouth which implicitly

assume interpersonal interaction simply do not fit the industrial context very well without considerable reworking ... It is simple-minded to assume that interpersonal interaction is the only basis for influence among firms in an industry". Other forms of influence among firms are, for example, managers' professional associations, industry trade associations, technical seminars, trade journals, etcetera. In our opinion, however, Webster diminishes the significance of opinion leadership in industrial markets by equating it with interpersonal interaction and excluding from the concept other forms of interorganizational influence.

Opinion leadership may be less common in industrial markets than in consumer markets for a number of reasons (Lancaster and White, 1976, p. 293; Webster, 1968; Webster, 1970).

a. The supplier provides more complete information.
b. The supplier is more likely to provide information about the product's limitations and negative consequences so as to avoid possible misuse of the product.
c. Consumer purchasing decisions often contain psychosocial problems which can be answered by peers; these problems are rare in industrial purchasing.
d. The motives and rewards for opinion leadership found in consumer markets would appear to be less relevant in industrial markets. Individuals in firms who may wish to volunteer information may be prevented from doing so as a result of company policy.
e. Consumers are closer in the spatial sense, which simplifies personal communication. For competitive reasons firms in the same industry are less likely to communicate directly.

However, there is also evidence in support of opinion leadership in industrial markets. Martilla (1971) investigated paper buying practices of 106 converting firms and emphasized opinion leadership within firms, an area which Webster ignored. His study led him to conclude that "contrary to Webster's findings, buying influentials in the converting markets also reported seeking information and opinions about paper from persons in competing firms, in much the same way as within the firm" (Martilla, 1971, p. 175). Similar results were found by Hayward (1978, p. 198) who, after having studied diffusion of innovations in the flour milling industry, stated that "purchasers and potential purchasers repeatedly stated that they gained information from colleagues after

having obtained initial details of new products from sales engineers, advertising leaflets and trade journals. Further study demonstrated that these people were visited time and time again ... These opinion leaders play a major role in the successful introduction of new products and highlight the importance of good communication". In studies of farmers' purchasing decisions, opinion leadership was found to be a relevant factor (Foxall, 1979, p. 305) and to be associated with innovativeness (Foxall, 1980, p. 80).

An investigation of the diffusion of a continuous-casting process in the steel industry led Czepiel (1974, p. 177) to conclude that early adopters exhibited greater opinion leadership. The study focussed on the social system and showed the existence of a functioning informal community linking the firms together. Consideration of his remarks about situational influences might offer an explanation for the seemingly inconsistent results found by other researchers with respect to opinion leadership in industrial markets (Foxall, 1984, p. 122).

3.4 INTERRELATED PROCESSES

In the first section of this chapter it was accentuated that there is (or at least should be) a close relationship between the product innovation strategy and the product development process. This link is also evident in the model of the product development process presented by Booz, Allen & Hamilton (1982, p. 13). The processes of product development, adoption and diffusion are closely interrelated as well. This is clearly demonstrated by the figure below.

The process of adoption can be regarded as complementary to the process of product development. The development and introduction of the innovation by the manufacturer are the logical counterparts of the purchasing and implementation of the innovation by the adopting firm. A detailed knowledge and understanding of the adoption process can assist the industrial marketer in introducing the innovation and overcoming barriers to adoption (Barnes and Ayars, 1977; More, 1984; Rabino, 1983). When we defined diffusion, we drew attention to the link between adoption and diffusion by mentioning that adoption is an individual decision-making process, while diffusion reflects a series of adoption

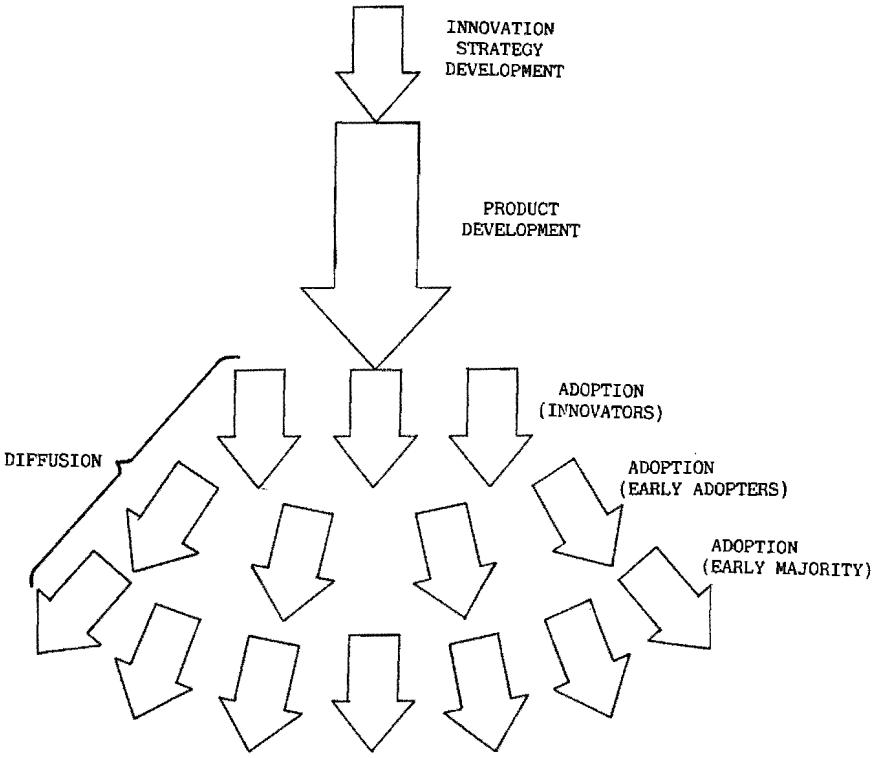


Figure 3.21 The relationship between product development, adoption and diffusion.

decisions by individual units within the social system. The close link between adoption and diffusion is also reflected in the terminology employed by different authors. Descriptions like 'speed of diffusion' and 'rate of adoption' are used interchangeably, while 'adopter categories' are generally employed to describe diffusion processes.

The close interrelationship between the product development process and the adoption process is reflected in the statement by Bonoma and Johnston (1978, p. 215) that industrial buying behaviour can not be studied in isolation from industrial marketing behaviour. Selling and buying are two closely related subjects and thus the industrial marketing researcher must use a dyadic approach, based upon relational variables (see also Wood and Elgie, 1976, p. 72). They conclude that industrial marketing must be viewed as the interaction between buyer and seller.

CHAPTER 4. INTERACTION AND NETWORKS

> Marketing can be seen as relationship management: creating, developing, and maintaining a network in which the firm thrives.
>
> (Evert Gummesson)

After having discussed several aspects of innovations in general terms, in Chapter 3 we discussed the process of product development. A large number of models were categorized and reviewed. Looking back on the models proposed by different authors, we note that most of them seem to presume that innovation is the sole province of the manufacturing firm. The models are conceptualized from the manufacturer's perspective.

a. Department-stage models: the development of an innovation is traced by enumerating the departments through which it passes within the manufacturing firm.
b. Conversion process models: the development process is depicted as a black box with several resources as inputs and the innovation as output of a conversion process within the firm.
c. Stimulus-response models: the process of developing an innovation is regarded as a process of change, whereby a firm responds to stimuli from its environment.

In practice, however, activities relating to the development of innovations are not always performed by the manufacturing firm only. In specific industries, users of the innovation may play an important role. This was already noted about 70 years ago by Alfred Marshall (1920, p. 280) when he observed that

> "(in industries that have) been long established on a large scale ... improvements in machinery are devised almost exclusively by machine makers ... But this is not the case in industries that are as yet in an early stage of development or are rapidly changing their form ... In all such trades, new machinery and new processes are for the greater part devised by manufacturers for their own use".

This observation has subsequently been ignored for many years. During the latter part of the 1970s seminal research in this area was conducted by Von Hippel. As a result of a number of empirical studies, he discovered that in some industries users play a dominant role in the innovation development process. This time, the notion was picked up by other researchers and elaborated upon.

When we argued that most models seem to be drawn up from the perspective of the manufacturing firm and neglect possible inputs from users, we left out the activity-stage and decision-stage models. Although these models are also formulated from a manufacturer's perspective, by describing the process as a series of subsequent general activities they can be easily modified to account for user involvement. Take, for example, the model we selected for our research. Even though specific reference to the user is only made in the step 'testing prototype with customers', the model can easily be adapted to account for more fundamental involvement of users in the process. If, for example, a manufacturer and a user jointly develop a prototype which is subsequently made into an industrial product by the manufacturer, who also produces and markets it, the model can still be used to describe the development process.

In this chapter we argue that product development in industrial markets needs to be looked at from a network perspective. In order to fully understand the essential elements of the network concept, we present a survey of various theories that clearly shows how the original concept of buyer-seller interaction evolved into the network approach. This survey starts with the studies of Von Hippel, that pointed out the dominant role of users with respect to idea generation in some industries (in Von Hippel (1988) the results of the studies are summarized and integrated). We go on to discuss some of the conceptual extensions and refinements of Von Hippel's theory proposed by other investigators. The main conclusion is that the process of developing innovations for industrial markets should generally be regarded as an interactive process in which both manufacturers and users may play a significant role. After having presented the central concept of interaction, we stress that parties other than manufacturers and users may also be involved in developing industrial innovations. All these parties are connected into networks by individual relationships. Thus, the process

of developing innovations for industrial markets is viewed from a network perspective.

4.1 THE STUDIES OF VON HIPPEL: MANUFACTURER-ACTIVE PARADIGM (MAP) VERSUS CUSTOMER-ACTIVE PARADIGM (CAP)

4.1.1 IDEA GENERATION: MAP OR CAP?

As we already noted in Chapter 2, market-related factors discriminate most strongly between successful industrial innovations and the ones that fail. Indeed, the most important single factor is a lack of accurate understanding of user needs. Furthermore, three out of four successful industrial innovations are developed in response to a perceived user need, rather than as the result of some new technological advances and opportunities (Utterback, 1974). Nevertheless, it is unclear how a manufacturer acquires the necessary 'accurate understanding of user needs'. How users can provide 'need input' to the innovation process is also unclear. Questions such as these were what led Von Hippel to study idea generation for innovations in several industries.

His first study concerned a sample of 111 successful innovations in scientific instruments, which were divided into three categories: basic innovations, major improvements and minor improvements (Von Hippel, 1976, p. 217). The innovations investigated all belonged to one of four narrowly defined classes of scientific instruments. Von Hippel's most

Innovation Significance	*% User Developed*	*Innovation Developed by*			
		User	*Manufacturer*	*NA*	*Total*
First-of-type	100%	4	0	0	4
Major improvement	82	36	8	0	44
Minor improvement	70	32	14	17	63
TOTAL	77	72	22	17	111

Table 4.1 Source of scientific instrument innovations by innovation significance.

Source: E. von Hippel, 'The Dominant Role of Users in he Scientific Instrument Innovation Process', Research Policy, Vol. 5 (1976), p. 222.

important conclusion was that the innovation process in scientific instruments is a user-dominated process: 77% of the innovations studied were developed by users (Table 4.1). In the large majority of cases it was the user, not the instrument manufacturer, who

1. perceived that an advance in instrumentation was required (i.e. recognized the need),
2. invented the instrument,
3. built a prototype,
4. proved the prototype's value by applying it, and
5. diffused detailed information on the value of his invention and how his prototype device may be replicated, via journals, symposia, informal visits, etcetera to both user colleagues and instrument manufacturers.

After a manufacturer got interested in the developed prototype, his contribution would be

1. to perform product-engineering work on the user's device to improve its reliability, convenience of operation, etcetera (that is, transform the user's device into a commercially viable product) and
2. to manufacture, market and sell the innovation.

Figure 4.1 shows graphically how the process of developing innovations in scientific instruments is dominated by the user instead of the instrument manufacturer. A second study arrived at similar results: 67% of the new process machines used by the semiconductor industry were developed by users (Von Hippel, 1977a, p. 67).

Both studies led Von Hippel to hypothesize that there are in fact two different paradigms describing the idea-generation stage of the product development process. The manufacturer-active paradigm (MAP) underlies idea generation for consumer products and is described by him as follows:

> "In the MAP, the role of the customer is essentially that of respondent, "speaking only when spoken to". It is the role of the manufacturer to select and survey a group of customers to obtain information on needs for new products or modification of existing products; analyze the data; develop a responsive product idea; and test the idea against customer perceptions and purchase decisions" (Von Hippel, 1978, p. 40).

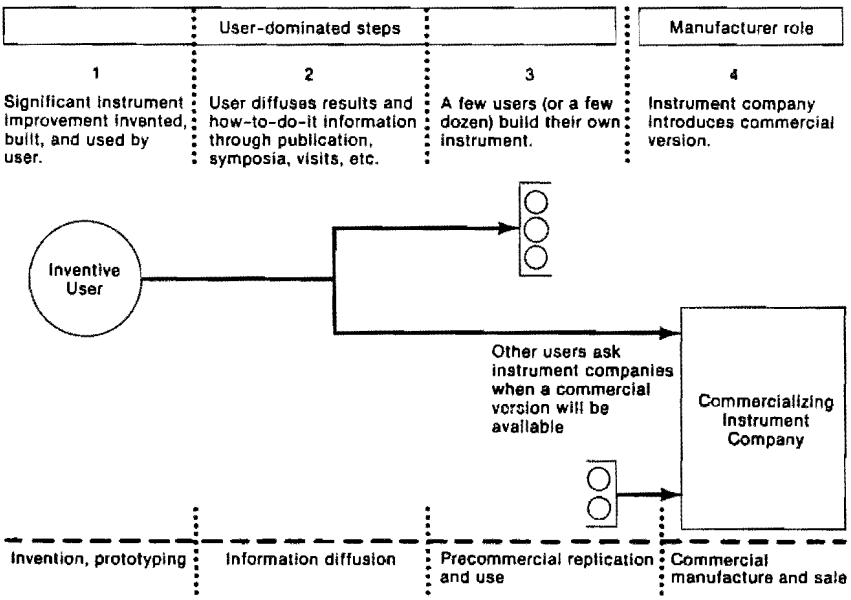


Figure 4.1 Typical steps in the development and diffusion of a scientific instrument innovation.

Source: E. von Hippel, 'The Dominant Role of Users in he Scientific Instrument Innovation Process', Research Policy, Vol. 5 (1976), p. 220.

This description is clearly relevant to product development processes in consumer goods markets, where there is a large number of potential users that can be identified relatively easily, where user requirements change but slowly and the manufacturer typically has a relatively long time span to develop and market his new products.

In industrial markets, however, the situation is quite different. The number of potential customers is relatively small, user requirements are changing quickly and new products need to be developed quickly in response to urgent problems. If no manufacturer can be found to meet these requirements, the user may be forced to develop the innovation in-house. Thus, based on his studies of idea generation for industrial innovations, Von Hippel hypothesized that a customer-active paradigm (CAP) provides a better fit with observed reality:

> "In the CAP, it is the role of the would-be customer to develop the idea for a new product; select a supplier capable of making the product; and take the initiative to send a request to the selected

supplier. The role of the manufacturer in this paradigm is: to wait for a potential customer to submit a request ...; to screen ideas (not needs) for new products; and to select those for development which seem to offer the most promise from the manufacturer's point of view" (Von Hippel, 1978, p. 40).

According to this paradigm, the user generally provides more than merely an idea for a new product. In specific instances, users may supply a manufacturer with

1. an identification of a problem or need,
2. a general type of solution,
3. product-functional specifications,
4. product design specifications or
5. a complete product design.

A number of studies by other investigators support these observations (Meadows, 1969; Peplow, 1960; Utterback, 1971; Robinson, Faris and Wind, 1967). Both paradigms are shown in Figure 4.2.

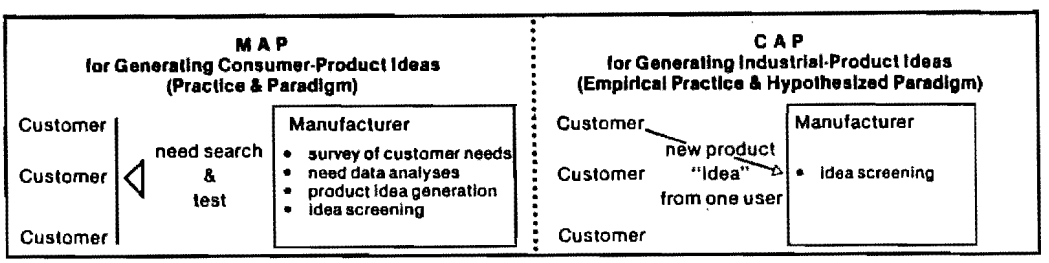


Figure 4.2 Manufacturer-Active Paradigm (MAP) vs. Customer-Active Paradigm (CAP).

Source: E. von Hippel, 'Successful Industrial Products from Customer Ideas', Journal of Marketing, January 1978, p. 40.

Although CAP seems to fit more closely to industrial product-idea generation practice than MAP, the issue is not so clear-cut. Von Hippel (1978, p. 44) argues that the answer to the question whether MAP or CAP is more appropriate in a given situation depends on the nature of the customer need and the accessibility of the new-product opportunity to manufacturer-managed action (Figure 4.3).

Nature of Customer Need	Accessibility of New Product Opportunity to Manufacturer-Managed Action: Low	Accessibility of New Product Opportunity to Manufacturer-Managed Action: High
Overt	Customer-Active Only	Customer- and/or Manufacturer-Active
Latent	Neither	Manufacturer-Active Only

Figure 4.3 Characteristics of new industrial product opportunity appropriate to CAP and/or MAP.

Source: E. von Hippel, 'Successful Industrial Products from Customer Ideas', Journal of Marketing, January 1978, p. 44.

In the article in which Von Hippel presented the MAP and CAP paradigms, he also reported on some anecdotal evidence of a third paradigm, "one in which "everyone knows" what the customer wants, but progress in technology is required before the desired product can be realized" (Von Hippel, 1978, p. 48). Despite his concluding remark that "further research into the matter should be of value" his subsequent studies have not elaborated this point.

4.1.2 IMPLICATIONS OF CAP FOR THE MANUFACTURER

The fact that CAP generally fits the circumstances in industrial markets better than MAP, holds two important implications for manufacturers of industrial innovations (Von Hippel, 1977b, pp. 20-21). First, manufacturers can suffice with primarily employing engineers skilled at product engineering instead of R&D. Second, market research strategies should focus on finding user solutions with attractive market potential rather than finding user 'needs'. However, a manufacturer following this strategy needs to keep in mind that (1) a large user population only develops a relatively small number of new products, of which but a fraction will be commercially promising, and (2) user-innovators often have no incentive to take their developed devices beyond their own company.

Von Hippel (1982, pp. 120-121) mentions two general strategies to find the innovating users. The first, the user-stimulus strategy,

consists of (1) defining the desired product as precisely as possible, (2) specify an appropriate award and (3) inform likely innovators only (these potential innovators are not restricted to the manufacturer's own customer base). The second, the user-analysis strategy, relies on analysing the self-screening and self-identification behaviour of users to identify the innovators. New-product ideas need to be analysed like any other internally generated idea; user-developed devices need to be evaluated like any other product prototype developed in the manufacturer's own laboratory. Based on this analysis, the manufacturer may decide to adopt the user-developed solution, adopt only certain aspects of it, or characterize the whole idea as commercially non-viable.

In recent publications (Von Hippel, 1985, 1986) the innovator users have been termed lead users and characterized as follows.

1. Lead users face needs that will be general in a marketplace, but do so months or years before the greater part of that marketplace encounters them, and
2. they are positioned to benefit significantly by obtaining a solution to those needs (Von Hippel, 1986, p. 796).

The concept of lead users provides a solution to the problem briefly mentioned in Chapter 2. How should marketing research be conducted for innovative products when traditional methods are inappropriate? In the words of Von Hippel, "average users have a poor ability to identify novel product attributes accurately because they do not have real-world experience with them. But lead users are well positioned by the very same reasoning: They have real-world experience with the needs that future profitable products must serve and with attributes they must contain. Clearly, therefore, systematic utilization of lead user data in marketing research will allow practitioners to identify profitable new product opportunities, attributes, and concepts that are invisible today" (Von Hippel, 1985, p. 317). Quinn (1985) observed that the potential of lead users is increasingly being recognized by both small and large companies. "Many experienced big companies are relying less on early market research and more on interactive development with lead customers. Hewlett-Packard, 3M, Sony and Raychem frequently introduce radically new products through small teams that work closely with lead customers. These teams learn from their customers' needs and innovations, and rapidly modify designs and entry strategies based on this information" (Quinn, 1985, p. 80). According to Von Hippel (1986, p.

797), lead users can be incorporated into marketing research by a four-step process:

1. identify an important market or technical trend,
2. identify lead users who lead that trend in terms of (a) experience and (b) intensity of need,
3. analyse lead-user-need data and
4. project lead-user data onto the general market of interest.

4.2 CAP: CRITICISM, REFINEMENTS AND CONCEPTUAL EXTENSIONS

After publication of Von Hippel's studies, a number of other researchers have demonstrated user involvement in innovation processes in areas as diverse as industrial machinery (Foxall and Tierney, 1984; Vanden Abeele and Christiaens, 1987), medical instruments (Shaw, 1985; Vanden Abeele and Christiaens, 1987), software (Voss, 1985a) and machine tools (Parkinson, 1982). However, in this section we will review some of the criticism and conceptual extensions to Von Hippel's customer-active paradigm made by researchers of innovation processes.

In order to test his new paradigm (i.e. CAP) Von Hippel investigated two necessary preconditions: (a) there is a customer request and (b) the request provides the 'idea' for the new product to the manufacturer. Vanden Abeele and Christiaens (1987, pp. 33-34) argued that these conditions need to be refined and put forward four necessary preconditions:

1. the customer must develop an innovative idea either for an existing or a new product,
2. transfer of the idea must occur (on the initiative of the customer, the manufacturer or even a third party),
3. the manufacturer must be receptive and
4. the compensation offered by the manufacturer to the customer for the innovation must be less than the price of proper technology transfer (if the customer has to be paid in full for the innovation it would not be different from the existing concept of 'technology transfer').

Foxall and Tierney (1984, p. 6) remarked that the customer-active paradigm, as hypothesized by Von Hippel, assumes that the eventual manufacturer benefits most from user-initiated innovations. Firstly, the manufacturer gains most significantly from the almost costless reduction in uncertainty which surrounds the earlier part of the new product development process. Secondly, during subsequent product development and commercialization, the manufacturer/marketer benefits from reductions in the costs of market research and R&D design which derive from their being targeted specifically towards the refinement of existing ideas or prototypes. Thirdly, the manufacturer/marketer benefits from the acceleration of the innovation diffusion process. Finally, by the time competitors are able to enter the market, the manufacturer will have gained the benefit of experience in production and distribution, which can result in his enjoying cost and margin advantages and which may forestall competitive entry.

A case study of a user-initiated innovation at British Aerospace questions the implicit assumption that the major benefits must inevitably accrue to the manufacturer/marketer. The case study describes how a division of British Aerospace plays the role of user-initiator but goes further than this by actively seeking out markets and marketing arrangements for its internally generated innovations. Thus, a second paradigm of customer activity, called CAP2, is proposed. "CAP2 describes a user-innovator, who also takes an active, entrepreneurial role in the successful commercialisation of the new item, while CAP1 (Von Hippel's Customer-Active Paradigm) actually describes customer-led invention/innovation but tends to ignore the possibility of customer-initiated entrepreneurship involving the alertness to

	MAP	CAP 1	CAP 2
Locus of invention	Manufacturer	Customer	Customer
Locus of innovation	Manufacturer	Customer/ Manufacturer	Customer
Locus of entrepreneurship*	Manufacturer	Manufacturer	Customer/ Manufacturer

*with respect to product innovation

Figure 4.4 Loci of invention, innovation and interpreneurship in MAP, CAP1 and CAP2.

Source: G.R. Foxall and J.D. Tierney, 'From CAP1 to CAP2: User-Initiated Innovation from the User's Point of View', Management Decision, Vol. 2 (1984), No. 5, p.14.

opportunities for product innovation" (Foxall and Tierney, 1984, p. 13). Foxall and Tierney suggest that CAP2 probably only applies to larger industrial companies. The differences between MAP, CAP1 and CAP2 are summarized in Figure 4.4. Foxall (1986, pp. 23-24) further suggests that user/manufacturer interactions in industrial new-product development should not be regarded as a simple MAP/CAP dichotomy. Instead, there is a continuum of possible interactions, in which both MAP and CAP1 would appear nearer the manufacturer-dominated extreme, while CAP2 approximates the other extreme.

Investigation of a number of case studies led Foxall and Johnston (1987) to further refine the continuum of scenarios for development of innovations for industrial markets (Table 4.2). They distinguish the following five categories.

1. Manufacturer-initiated innovation (MII): the manufacturer performs all the stages of the new-product development process. This is essentially the same as Von Hippel's MAP.
2. User-initiated innovation 1 (UII1): the user develops a new device for internal use.
3. User-initiated innovation 2 (UII2): the user-initiator of an internally implemented process innovation approaches a manufacturer with an idea, design or prototype and requests him to produce and deliver further supplies of the item.

	MII	UII1	UII2	UII3	UII4
Development of new product strategy	M	–	M	M/U	U
Idea generation	M	U	U	U	U
Idea screening	M	–	U	U/M	U
Business analysis	M	–	M	U/M	U
— concept testing	M	–	M	U/M	U
— financial appraisal	M	–	M	U/M	U
Development	M	U	M	M	U
Market testing	M	–	M	M	U
Test marketing	M	–	M	M	U
Commercialisation	M	–	M	M	U
Consumption	M	U	Users	Users	U + Users
Diffusion	M	–	M	M	U

M = the manufacturer; U = the user; Users = other customers who make use of the innovation as process or product.

Table 4.2 Locus of responsibility for creation and marketing of innovations.

Source: G.R. Foxall and B. Johnston, 'Strategies of User-Initiated Product Innovation', Technovation, Vol. 6 (1987), p. 96.

4. User-initiated innovation 3 (UII3): in addition to the steps from UII2, the user also acts entrepreneurially in the commercial exploitation of his process innovation. This situation corresponds with CAP2.
5. User-initiated innovation 4 (UII4): the user is responsible for all stages in the new product development process, including consumption.

In a quite recent publication, Foxall (1989, p. 95) groups UII3 and UII4 together under the heading of 'reverse innovation'.
Similar notions of a range of user-initiated innovations have been reported by Voss (1985a, pp. 114-115) and Shaw (1985, p. 288), although these researchers describe the development process from the manufacturer's (instead of the user's) point of view.

Reviewing the literature discussed above, we note that the initial concept of CAP has evolved into a broad spectrum of manufacturer-user interactions. The focus of research has shifted from identifying the innovation process as either manufacturer-active or customer-active, to determining the role of users during the process of product development. The involvement of users is no longer restricted to the idea-generation stage, but extended to all stages of the process. For example, Mantel and Meredith (1986, p. 34) discovered that an early customer sometimes even assists the manufacturer in marketing the innovation.

This interaction between manufacturer and users becomes especially important in the case of major innovations. As Gemünden (1985, p. 137) concluded, "a delegation-to-the-seller paradigm is efficient for a small innovative step, whereas for a big innovative step an intensive-interaction paradigm is needed". In the next section we will present the theoretical background of this central concept of interaction.

4.3 SUPPLIER-CUSTOMER INTERACTION IN INDUSTRIAL MARKETS

Industrial markets can be characterized by long-lasting relationships instead of short business transactions. This observation led to the establishment of the International Marketing and Purchasing Project

Group. Researchers from France, Italy, Sweden, West Germany and Great Britain initiated an international joint research project in order to study supplier-customer relationships in international industrial markets. Based on a theoretical interaction model, a number of case studies were conducted (Hakansson, 1982). The theoretical framework (illustrated in Figure 4.5) consists of four groups of variables that describe and influence the interaction between buying and selling companies, that is variables describing

a. the interaction process,
b. the participants in the interaction process,
c. the environment within which the interaction takes place and
d. the atmosphere affecting and affected by the interaction.

Instead of discussing the results of the study exhaustively, we will focus on the way supplier-customer relationships develop in industrial markets. Supplier-customer relationships do not come into existence overnight, but rather evolve over time. According to Ford (1980), the development of such relationships can be described by five stages. Differences between the stages can be characterized by the variables experience, uncertainty, distance, commitment and adaptations. The stages are summarized in Figure 4.6.

Stage 1: The pre-relationship stage

Obviously, the first stage is the pre-relationship stage. There are a number of reasons for a customer to look for a new source of supply, for instance dissatisfaction with an existing source or marketing efforts of a potential supplier. As regards the new supplier, there is no experience, no commitment, considerable uncertainty and at least some social distance (unfamiliarity with each other).

Stage 2: The early stage

At the early stage, the potential supplier is in contact with the customer to negotiate or develop the specifications for the purchase. Both parties have little experience of each other, there is considerable uncertainty and still the same distance, there is little or no evidence on which to evaluate the level of commitment, and adaptations relate to high investments of management time.

Stage 3: The development stage

The development stage starts after signing of the contract for the major capital purchase. It is characterized by increasing experience

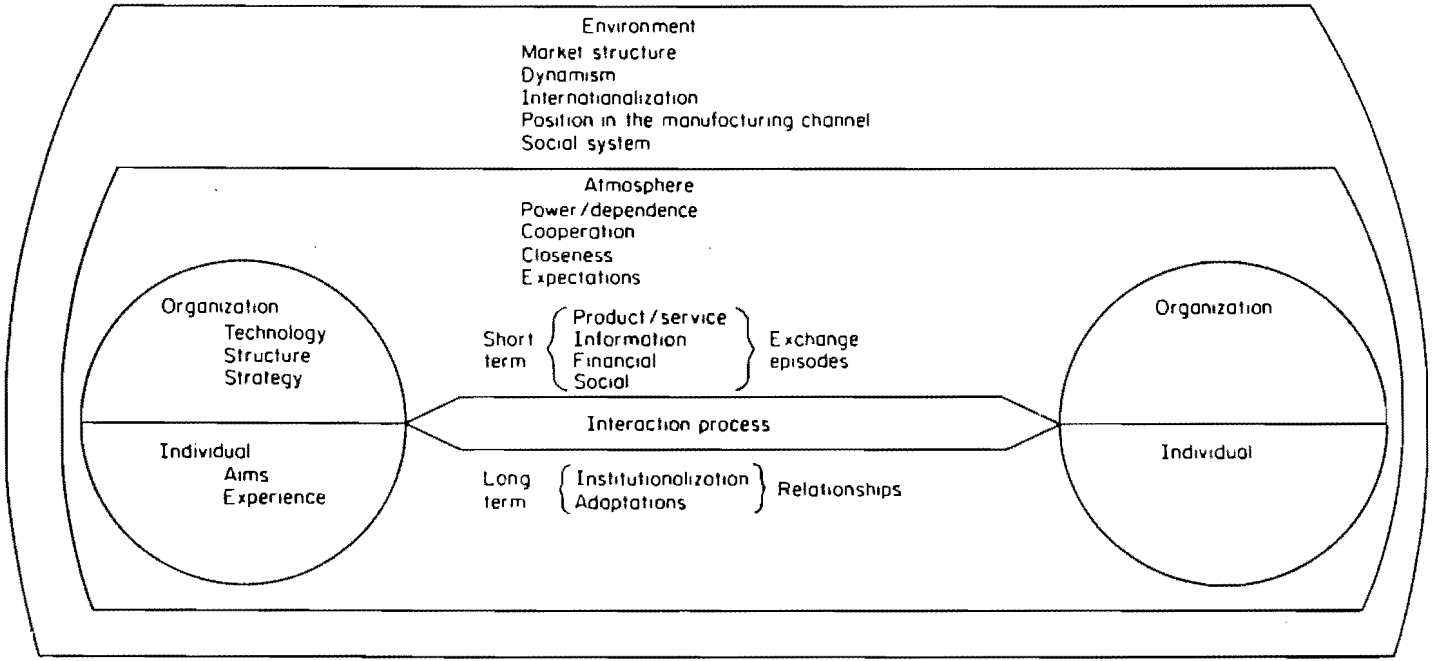


Figure 4.5 An illustration of the interaction model.

Source: H. Håkansson (ed.), International Marketing and Purchasing of Industrial Goods: An Interaction Approach, John Wiley and Sons, Chichester, 1982, p. 24.

1 The Pre-Relationship Stage	2 The Early Stage	3 The Development Stage	4 The Long-Term Stage	5 The Final Stage
Evaluation of new potential supplier	Negotiation of sample delivery	Contract signed or delivery build-up scale deliveries	After several major purchases or large	In long established stable markets
Evaluation initiated by: — particular episode in existing relationship — general evaluation of existing supplier performance — efforts of non-supplier — other information sources — overall policy decision	Experience — Low Uncertainty — High Distance — High	— Increased — Reduced — Reduced	— High — Minimum development of institutionalisation — Minimum	Extensive Institutionalisation
Evaluation conditioned by: — experienced with previous supplier — uncertainty about potential relationship — "Distance" from potential supplier	Commitment Actual - Low Perceived - Low Adaptation High Investment of Management time. Few cost-savings	Actual - Increased Perceived - Demonstrated by Informal Adaptations Increasing formal and informal adaptations. Cost savings increase	Actual - Maximum Perceived - Reduced Extensive adaptations. Cost savings reduced by institutionalisation	Business based on Industry Codes of Practice
Commitment —zero				

Figure 4.6 The development of buyer/seller relationships in industrial markets.

Source: D. Ford, 'The Development of Buyer-Seller Relationships in Industrial Markets', European Journal of Marketing, Vol. 14 (1980), No. 5/6, p. 342.

and therefore reduced uncertainty and distance. The firm's evaluation of its partner depends on the perceived commitment to the relationship. There is an increasing number of both formal and informal adaptations.

Stage 4: The long-term stage

The long-term stage is marked by the firms' importance to each other. There is considerable experience at this stage, while uncertainty and distance are reduced to a minimum. The level of commitment to the relationship is indicated by the extensive formal and informal adaptations which have occurred.

Stage 5: The final stage

The final stage can be reached in stable markets over long periods of time. It is characterized by an extension of the institutionalization process to a point where the conduct of business is based on industry codes of practice.

An alternative model for developing buyer-seller relationships that has received much attention was recently proposed by Dwyer, Schurr and Oh (1987). However, the stages they mention (awareness, exploration, expansion, commitment and dissolution) closely correspond to the stages of Ford's process. No matter which framework is adopted, supplier-customer relationships in industrial markets are invariably described as being long-term and based on cooperation, trust and loyalty. In other words, commitment is the key concept. A three-stage process model of the development of commitment has been presented by LaFief and O'Neal (1987).

When operating in international markets, one should keep in mind that there may be considerable differences between supplier-customer relationships in different countries (Campbell, 1985). A fairly recent IMP study demonstrated the importance of supplier-customer relationships by showing that "the ability of a company to ... establish close social and business relationships with clients is a major factor for success in international industrial marketing" (Ford, 1984, p. 109). Nevertheless, managing a portfolio of customer relationships involves specific problems and challenges (Campbell and Cunningham, 1985; Jackson, 1985).

4.4 NETWORKS

The International Marketing and Purchasing Group studied relationships between selling and purchasing firms in industrial markets in the broadest sense, that is the relationships were not studied within a more specific context. Although relationships are of importance to the marketing of industrial products, they are crucial in the context of innovations as well.

Consider, for example, the area of stimulating innovative activity. "Creating a dynamic high-tech region is not a matter of combining ingredients. It is one of building institutions and relationships - both locally and nationally - that support the development of innovative enterprises ... It is these relationships between the individuals, firms and instituations in the region that matter - not their simple presence" (Saxenian, 1988, pp. 74, 75). And, to return to the subject of our investigation, supplier-customer relationships may play a central role in developing innovations for industrial markets. Earlier in this chapter we presented a number of studies demonstrating the involvement of users in product development. Many industrial innovations were shown to be developed through interaction between the manufacturer and potential users. The Swedish branch of the IMP project group, however, has gone beyond simple manufacturer-user relationships and postulates that other parties may be involved as well. In these situations, the manufacturer operates within a network consisting of a number of organizations linked together by individual interactive relationships. We will present below some important theoretical studies with repect to networks and conclude by summarizing the relevance of the network concept to our investigation.

4.4.1 FROM SOLE FOCUS ON THE MANUFACTURER TO FUNCTIONING WITHIN NETWORKS

Thus far, we have seen that over the years, product development has been viewed from a number of different perspectives.

1. Product development initiated by the manufacturer

   The overwhelming majority of studies focusses on the manufacturer as the initiator of the product development process (see Chapter 3 for

examples). Much attention is paid to determining ways of increasing the rate of success of new products. The process of product development is usually divided into a series of subsequent stages and specific recommendations to the manufacturer are formulated. The manufacturer is considered the main actor who controls the process and influences the environment.

2. Product development initiated by the user
   Von Hippel focussed on the user as the initiator of the product development process and he developed a customer-active paradigm in contrast to a manufacturer-active paradigm (Von Hippel, 1978). The customer-active paradigm has been supported by many empirical studies.
3. Product development as an interaction process between user and manufacturer
   According to the first two views, the initiative for product development is located in one actor only. More recent research (Hakansson, 1982) has combined both views and proposed an interaction approach.

The three types of product development studies are complementary but to some extent also overlapping, as is shown in Figure 4.7 (Hakansson, 1987b, p. 86).

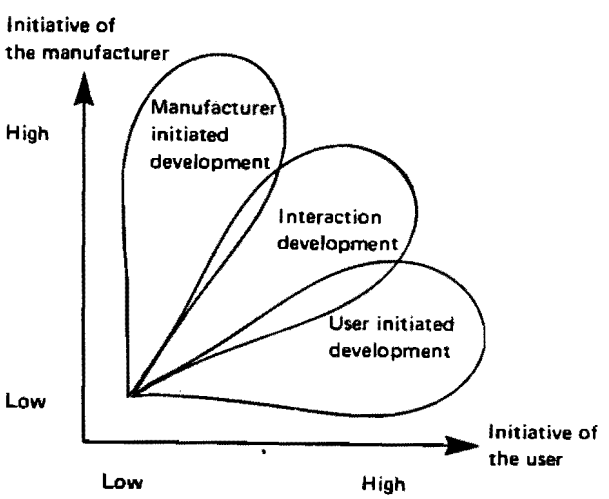


Figure 4.7 The initiator of product development.

Source: H. Håkansson, 'Product Development in Networks', in: Industrial Technological Development: A Network Approach, H. Håkansson (ed.), Croom Helm, London, 1987, p. 86.

The main criticism of the three perspectives outlined above is that each of them focusses on only one or a few actors. While the first two are oriented toward one specific type of actor, the third directs itself toward the interplay between two actors. Thus, all three viewpoints restrict themselves to a limited number of actors. These views are considered to be too narrow in their approach: product development should be regarded as the interplay between a number of actors, that is, as taking place within networks. New knowledge in terms of new product or process ideas often emerges at the interface between different knowledge areas. The specialized development resources of individual development units (such as firms and research institutes) need to be coordinated through a series of exchange relationships linking all these units together (Hakansson, 1987a, pp. 4-5). Shared values and unifying ideas are the most important elements holding the decentralized segments of a network together in a dynamic pattern of interaction (Lipnack and Stamps, 1987, p. 23). Although companies may consider technical cooperation as the only possible opportunity for developing new products, it is also stimulated by changes in the environment. "The significant change in the business environment due to economic conditions, high costs, the globalization of business and increasing political control has changed the focus of alliance strategies to the point where they are now becoming the rule rather than the exception" (James, 1985, p. 76).

Depending on the type of counterpart, interaction with the objective of cooperating in developing technological innovations can be grouped into three categories (cf. Hakansson, 1987a, pp. 6-8). Vertical interaction concerns all cooperation between partners belonging to the same production chain, e.g. manufacturer-customer relationships. There are often good reasons for manufacturers and customers to cooperate in developing an innovation. Through interaction with a major customer, a manufacturer can develop a product that fits the needs of the market segment better, develop technical ability, share the substantial development costs, gain access to the necessary application know-how and use the name and reputation of the customer as a reference when selling to other customers. The customer, on the other hand, acquires an advanced technology at an early stage, resulting in an improved competitive position, obtains a product better fitted to its market or production requirements and establishes or maintains an innovative reputation. Horizontal competitive interaction relates to cooperation

between companies which are basically competitors, e.g. Philips and Siemens who teamed up to develop the megachip. A more recent example involves Philips Medical Systems and Hitachi, who announced in October 1989 that they would cooperate in developing and producing computer tomography systems for the American market (and thus share the high costs involved). Through this type of interaction the manufacturers may gain access to specialized technological knowledge, reduce the costs of development and production, reduce the risks and increase market potential by making market agreements (for example, with respect to global standards) (cf. Frey, 1986, p. 295). However, if the parties involved should differ considerably in size or contribution to the project, the interaction may be detrimental to the weaker party. Finally, horizontal complementary interaction encompasses cases where manufacturers of complementary products cooperate. An example is presented by DSM and Peugeot who jointly started a project to develop new materials. Other examples can be found in systems selling or large turn-key projects. Elements of both horizontal competitive and horizontal complementary cooperation can be found in such large-scale cooperation programs as Eureka, which was initiated to integrate European industry and has brought together scientists and engineers from over 600 industrial companies and public research institutes in more than 165 R&D projects (Dickson, 1988, p. 27). For example, more than thirty European firms cooperated in developing a European High Definition Television system and, in April 1989 announced their intention to cooperate in the development of the corresponding television sets, videorecorders and studio equipment as well. Although this is an example of an extremely complex and comprehensive network, in developing innovations for industrial markets manufacturers typically deal with networks in one form or another.

4.4.2 THE NETWORK APPROACH

Interactive relationships connect individual companies into structures that can be analysed by means of network concepts. A network is described by Cook and Emerson (1978) as "sets of two or more connected exchange relations". However, we define a network so as to include the case of manufacturer-user interaction discussed previously, this being

a network in its most simple form. According to Hakansson (1987a, pp. 14-17), a network contains three basic elements (Figure 4.8).

a. Actors, defined as those who perform activities and/or control resources within a certain field. Actors can be individuals, a group of persons, a division within a company, a company, or a group of companies.

b. Activities, which are performed by actors. There are two main categories of activities: transformation activities (carried out within the control of one actor and characterized by one resource being improved by the use of other resources) and transaction activities (linking transformation activities and creating relationships with other actors).

c. Resources, which consist of physical assets (machinery, material etc.), financial and human assets (labour, knowledge and relationships).

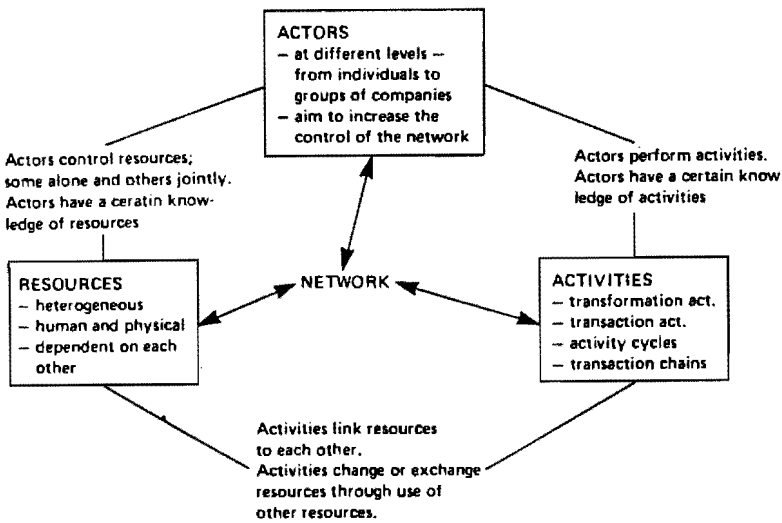


Figure 4.8 A network model.

Source: H. Håkansson (ed.), Industrial Technological Development: A Network Approach, Croom Helm, London, 1987, p. 17.

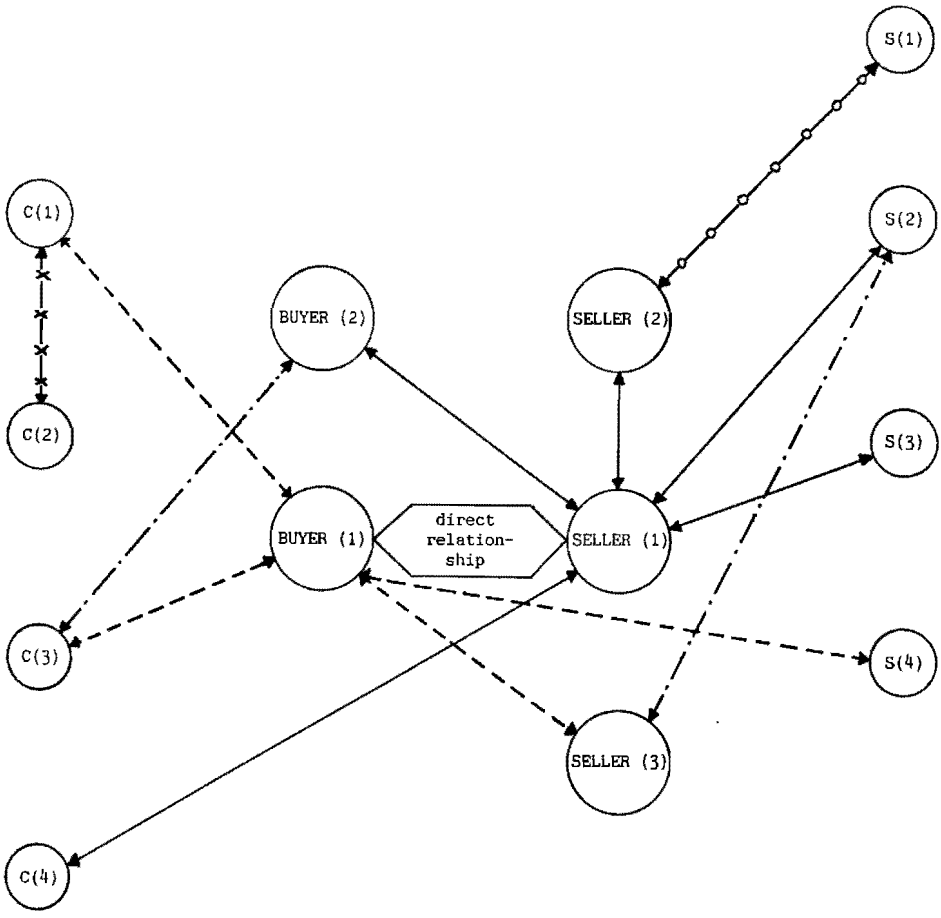
The network approach implies two important theoretical extensions of the original interaction concept.

First, the parties involved are no longer restricted to the buying and selling firms. Although the relationship between the manufacturer

and the user can still be of major importance in developing an innovation, many other parties can be involved as well. The government can stimulate innovation through subsidies, universities and other research institutes can carry out basic research that leads to new technologies, knowledge brokers and transfer centres can bring the relevant parties together and competitors can share the risks and costs of large development projects. Third parties may even be involved in the diffusion of innovations. Mantel and Rosegger (1987, pp. 124-128) presented a typology of third-party institutions that intervene, with varying intensity of influence, in the adoption decision of others. Through the network concept, the individual buyer-seller relationship is put into the context of other relationships. Although technological cooperation with local partners has obvious advantages, internationally operating firms often cooperate with foreign companies as well. Hakansson and Laage-Hellman (1984, pp. 228-232) discussed a continuum of cooperation strategies with respect to R&D.

The second conceptual extension relates to the kind of relationship. Apart from direct relationships, that is the straightforward relationship between the focal firm and its partner, one should distinguish indirect relationships. Mattsson (1987, p. 128) defines an indirect relationship "from a focal firm A's point of view to be a relationship between two firms of which A is not one of the counterparts". Thus, if the focal firm A has a direct relationship with B, while B has a direct relationship with C, B-C is an indirect relation for A; A has an indirect relation to C. The concept of indirect relationships can best be elucidated by an example. Suppose a manufacturer in the machine industry has developed a new process machine in close cooperation with one of its leading customers. In this case, the direct relationship is the one between the manufacturer and its leading customer. When implementation of the new process machine influences the quality of the end product produced with it, the leading customer will want to test the changed end product with its own customers. These relationships are termed indirect from the manufacturer's perspective. Similarly, considering the viewpoint of the leading customer, the relationships between the manufacturer and its suppliers are indirect relationships. Figure 4.9 depicts a hypothetical situation involving these and other indirect relationships.

Every firm has a certain position in a network that can be defined by (a) the functions performed by the firm for other firms, (b) the



C(i) : customer i
S(i) : supplier i
direct relationship for SELLER (1) / indirect relationship for BUYER (1)
indirect relationship for SELLER (1) / direct relationship for BUYER (1)
indirect relationship for SELLER (1) / indirect relationship for BUYER (1)
indirect relationship for SELLER (1)
indirect relationship for BUYER (1)

Figure 4.9 Direct and indirect relationships in a network.

relative importance of the firm in the network, (c) the strength of the relationships with other firms and (d) the identity of the firms with which the firm has direct relationships. The present network position can be regarded as the firm's 'strategic situation' (Mattsson, 1987, p. 128). Indirect relationships are of importance because,

a. given the strategic situation, they influence the direct relationship and
b. changes in the strategic situation can change the firm's position both with regard to the direct and indirect relationships (see also

the discussion on second order functions of relationships (Hakansson and Johanson, 1989, p. 220).

The relationships connecting companies into networks are among the most valuable resources a company posesses. As we have already seen, the relationships can be analysed according to the interaction model (Hakansson, 1982) and are of a long-term character. The development of relationships takes time and resources, involves commitments for the future and creates assets that can be used by the firm. Thus the development of relationships should be treated like any other investments made by a firm (Johanson and Mattsson, 1985). These investments in relationships are made to increase productivity or technical efficiency, to serve as information channels and to increase control (power). The relations between organizations can be regarded as bonds of different types and strength (Mattsson, 1985, p. 265):

- technical bonds: two companies have technical bonds when they have adjusted to each other in some technical sense;
- time-based bonds: there is a need for temporal coordination between sequential activities in a production process involving separate firms;
- knowledge-based bonds: through exchange of information over a period of time two organizations build up knowledge about each other;
- social bonds: to a great extent contacts between organizations take place on a person-to-person basis;
- economic bonds: companies can sometimes be united in more formal ways (investment, credit);
- legal bonds: common ownership and contracts of all kinds.

4.4.3 RESEARCH INTO NETWORKS

According to Fombrun (1982, p. 281) there are three approaches to the analysis of networks. The nodal strategy decomposes the original network into component nodes, where the focus is on the network as seen by the node occupant. The dyadic strategy leads to a decomposition of the network into nodal pairs, with a focus on the relationship among pairs. Finally, the triadic strategy results in an inventory of all possible triads in the network, with a focus on the composition of these triads in terms of the relationships linking the three nodes. Current research

into product development through networks mostly employs a dyadic strategy, although, by taking indirect relationships into account as well, some elements of a triadic strategy are present.

Despite all the opportunities offered by the analysis of networks, there are some inherent methodological problems, too (Kennedy, 1987, pp. 102-103; Mattsson, 1985, pp. 284-287).

a. Each study of networks is confronted with the issue of boundary specification, that is, where does one set the limits for collecting data when in reality a network may have no real limits? Each study of networks should explicitly state the way the boundaries of the network were set so that individual studies can be compared to each other.
b. When the total network is too large to study in its entirety, the investigator is confronted with the problem of sampling elements to estimate existing relationships.
c. A third issue relates to measurement. Networks can be investigated by using direct observation, analysis of archival records and survey data. Too many studies rely on survey data (in the form of personal interviews) only. Ideally, one should combine the different methods of data gathering to obtain a complete and realistic picture.

At the 5th IMP Conference, held from 5-7 September 1989 at Penn State University (Wilson, Han and Holler, 1989), a number of interesting conclusions and viewpoints with respect to the current state-of-the-art of interaction and network research were submitted (Biemans and Brand, 1989).

a. Increase in research into interaction and networks

The original IMP model of interaction has served as the basis of an increasing number of empirical studies into buyer-seller interaction. While at the 4th IMP Conference only about half of the 29 papers discussed interaction (Turnbull, Paliwoda, 1988), this share has increased to approximately two-thirds in 1989. Although, in recent years the network concept has become increasingly popular too, this increase is less marked while most of the research in this area is conducted by Swedish investigators. However, a second large-scale empirical study to be conducted by the IMP Group will investigate relationships in the context of networks and without a doubt be a stimulus for much subsequent research.

b. Research into interaction is no longer limited to Europe

Despite the fact that the original interaction model was developed by European investigators, research into this area has spread to other continents. In the United States, in particular, interaction has become the central theme of many congresses, seminars and workshops, and many publications on interaction have seen print by now. For a survey of these American publications the interested reader is referred to Wilson and Möller (1988).

c. Broader field of application

At present, research into interaction and networks is no longer exclusively applied to the buying and selling of industrial products. In addition, investigators applied the concepts to the study of services (agency-client relationships in advertising), distribution (buyer-supplier relationships in retailing) and international issues (East-West trade). Of particular interest was the announcement of a large-scale international investigation into the interfaces between various functions within organizations (Specht, 1989). (Krijger (1990) presents the results of an extensive study of the factors influencing the marketing-R&D interface in developing innovations.)

d. Time to strike a balance

After a decade of research, the time for striking a balance has arrived. A first attempt was made by Möller and Wilson (1988), but the recent review presented by Easton (1989) shows that much work still remains to be done. Problems arise because (a) many investigators define the same theoretical concepts in varying ways and (b) a significant part of the existing research is only available in a language that is not easily accessible (mainly Swedish).

e. Research into networks is only partly quantifiable

An important issue concerns the question whether research into networks can be quantified. To elucidate the matter the existing publications can be divided into two categories.

- A considerable number of the available publications is very general in nature and strongly oriented toward generating theoretical concepts. Most of them are based on a limited number of in-depth case studies or even lack any empirical basis at all. The purpose of these studies is to generate rather than quantify theoretical constructs (Mattsson, 1985, p. 286).

- Other publications do not address networks in their entirety, but instead concentrate on very limited and narrowly defined aspects of networks. Thanks to this narrow focus, quantification is possible (Gadde and Mattsson, 1987; Nelson, 1988; Wigand and Frankwick, 1989).

4.4.4 RELEVANCE OF THE NETWORK CONCEPT TO STUDYING THE DEVELOPMENT OF INDUSTRIAL INNOVATIONS

We will conclude this chapter on manufacturer-user interaction and networks by summarizing the relevance of the network concept to our investigation of the development of innovations for industrial markets. Nowadays, a number of trends can be observed in industrial markets.

a. Technological developments have accelerated to a level where product life cycles have shortened considerably. This implies that a manufacturer can no longer count on a steady demand over many years for a newly developed product. Instead, he must continually be actively searching for innovative products to succeed the existing ones, while the time available to reap the benefits has been significantly reduced.
b. New products are becoming increasingly complex and their development necessitates the combination of different areas of knowledge. For example, sometimes part of the technical knowledge is not available in-house and must be obtained from external sources, such as research institutes and possibly competitors. In other situations the development of an innovation demands application know-how that exists with customers.
c. Because of the increasing complexity of industrial products, the growing competition and the shortened product life cycles, developing industrial innovations has become an expensive and high-risk activity.
d. The increasing complexity of industrial products has also resulted in a demand for standardization. Customers no longer want each manufacturer to develop his own version of a product but prefer the development of industry standards.
e. Industrial markets are becoming increasingly global. The manufacturer can no longer confine himself to developing a product for a local market only. More and more, the product should be aimed at

international markets, which may not always be easily accessible to the manufacturer.

Because of these current tendencies in industrial markets, manufacturers are increasingly developing innovations through cooperation with other organizations. These potential partners are not limited to the firm's present customers or potential users of the innovation. In addition, many other organizations, such as competitors, research institutes and distributors may contribute to the product development process (e.g. an industry standard may be developed through cooperation between a number of competitors and major customers). By means of these interactive relationships manufacturers can shorten the duration of the total product development process, share the costs and risks involved, obtain the necessary technical, market and/or application knowledge, gain access to international markets and create industrial standards. Cooperation during product development is regarded by manufacturers as a means to attain an innovation process that is both more effective and more efficient. Therefore the most compelling reason for studying the development of innovations from a network perspective is that it matches reality.

Despite this reality, Dutch researchers of industrial marketing have paid only limited attention to the network concept. This could partially be due to the abstract and theoretical nature of most publications about networks to date. In a broader perspective, however, an increasing number of articles and books about networks is being published by Dutch researchers, evidence of recognition of the relevance of the network concept. The sociological, economic, geographical, logistic and management aspects of networks are considered in Boekema and Kamann (1989). Some recent empirical studies concern coordination mechanisms in horticultural networks (Kamann and Strijker, 1989) and dynamics and countervailing power in charter networks (Kamann, 1989). Commandeur and Taal (1989) investigate networks in connection with the firm's production processes. However, application of the network concept to the area of developing innovations is still quite limited. Beye (1989) attempted to integrate information-transfer within and between organizations with traditional economic theory at an abstract theoretical level. Wissema and Euser (1988) studied a number of widely varying case studies (involving both consumer and industrial innovations) and discuss the

functioning of networks from a managerial point of view at a relatively high level of abstraction. Although, as Mattsson (1985, p. 286) stated, "at the present stage of development of the network approach we are more interested in description and understanding of complex processes than empirical generalizations", the ultimate purpose of research into networks should be to generate guidelines that can assist managers in their decision making, e.g. with respect to product development within networks. Just as research into interaction processes has generated results relevant to industrial marketing practice, the network approach holds potential in that direction too. Before describing the functioning of networks in the field of medical technology, the next chapter will present the results of the preliminary investigation involving cases from various industries.

CHAPTER 5. USER INVOLVEMENT IN PRODUCT DEVELOPMENT: FIVE CASE STUDIES

> Always push for a field-trial, ... there's nothing like a customer saying, "Hey, this stuff really works like you said it would and I want to buy some".
>
> (Michael A. DeSesa, NL Chemicals.)

This chapter illustrates the involvement of potential users in developing industrial innovations by presenting five actual cases. The descriptions are based on in-depth personal interviews with the people involved in both the manufacturing and buying organizations. Third parties, such as distributors and advisors, insofar as they contributed significantly to the product development process, were interviewed too. In some cases it was necessary to interview competitors and industry experts to obtain information about the current developments in the market in question. The present chapter consists of two major parts. The first part gives brief descriptions of the individual cases, while the second discusses some general conclusions and offers a tentative framework for testing prototypes with customers.

Each individual case description starts with a short account describing the firm, its products and recent developments on the market. The particular innovation's benefits are discussed explicitly. Next, the product development process is briefly described from idea generation to market introduction, emphasizing user involvement. The major shortcomings during product development are then enumerated. Finally, the customer's buying process is given some attention as well. The cases are presented in the order of increasing technical and/or marketing complexity.

After all five cases have been described, general conclusions are presented regarding (a) product development as a phased process, (b) differences between having industrial and consumer products tested by potential users, (c) derived demand, (d) product champions, (e) networks and (f) the marketing of knowledge. Since some of the firms experienced various problems with (g) testing a prototype with users, more detailed attention will be paid to this particular stage of the

product development process. But there are more reasons for this explicit attention.

a. For industrial products in general, the costs of the total product development process (which includes the market introduction) are considerable. The external testing stage, that is testing a prototype with potential users, functions as a last crucial check (before production is started) to ensure that product characteristics meet customer requirements.
b. In industrial markets the personal relationship between manufacturer and customer is of major concern. Introducing a product that does not meet customer requirements will be detrimental to this relationship. Besides, testing with potential users emphasizes the manufacturer's market orientation.
c. The innovative character of the products under study aggravates the uncertainties with which the manufacturers are confronted; this stresses the importance of external testing.
d. Every company that attaches great importance to interaction with customers during the product development process engages in external testing. Both Cooper and Kleinschmidt (1986, p. 79) and Moore (1987, p. 14) found that approximately 70% of the firms studied had new products tested by potential customers.

Based on the firms' experience in having users test prototypes, a tentative framework is derived. However, this framework should not be considered as a general model that is universally applicable. Its principal aim is to assist managers in making better decisions as regards testing industrial innovations with potential users.

5.1 RESEARCH METHODOLOGY

Selection of firms for preliminary investigation was guided by the following criteria:

a. their being Dutch manufacturers conducting their product development activities in the Netherlands,
b. being of medium size (i.e. between 50 and 500 employees),
c. enjoying an innovative image in the market and

d. being willing to discuss a recent innovation project in great detail.

Only two cases (Cases 2 and 3) did not meet all these criteria. Case 2 (Packitt) involves a large industrial firm with more than 500 employees, but is included in the sample because it illustrates some of the important consequences of operating on an industrial market. Case 3 (Dräger) concerns the introduction in the Dutch market of an innovation developed abroad. However, as users contributed to product development after market introduction, the case offers some interesting additional insights and is not excluded. Moreover, it serves as a first introduction to the field of medical technology, in which the follow-up investigation was undertaken (Chapters 6 and 7). The firms were selected in such a way as to represent a wide variety of products (ranging from a simple new belt for conveying products to a very complex process installation), industries and competitive situations. This resulted in a broad view of the problems concerning the development of industrial innovations. Even though widely varying situations were studied, many similarities were found to exist between the experiences of the individual firms.

The cases were investigated along the following lines.

1. Selecting a manufacturer
   The selection of the five firms was based on newspaper clippings and chance contacts.
2. Contacting the manufacturer
   Typically, either a director of the firm or a business unit manager was contacted. After being briefed on the nature and objective of the study, they were asked to take part in the investigation.
3. Interviewing the manufacturer
   Next, the basic information was gathered by means of semistructured in-depth personal interviews with one or more persons at the manufacturer (such as managing directors, business unit managers, production employees, R&D managers and sales representatives), the people most closely involved with the project being interviewed more than once (see Appendix B for the questionnaire). Each interview took between two and four hours. Interviewees were asked to describe in general the product development process at their company and to give a detailed description of the most recent innovation project.

Specific questions concerning the innovation project included the following. What is the most recent innovation? What are the benefits it offers to users? What is the firm's competitive position regarding the innovation? Which stages make up the process of product development? During what stages did the firm interact with other organizations? What problems occurred during the development process and what measures were taken to solve them? The results of the interviews were written down in comprehensive reports and reviewed with the interviewees, thus inviting them to correct errors of fact and supply additional information.

4. Studying additional sources of information

   The information thus obtained was supplemented by (a) the incidental study of documents (e.g. market introduction brochures and product information leaflets) and physical artefacts (e.g. the innovation) and (b) direct observation (e.g. of the functioning of prototypes at test sites).

5. Interviewing competitors and industry experts

   In two cases it was necessary to interview competitors and/or industry experts to gain insight in the market structure, the competitive position of the firm, the products offered by major competitors and the current technological and market developments.

6. Interviewing users and third parties

   Subsequently, the potential users and third parties, insofar as they contributed substantially to the product development process, were interviewed to obtain additional information and cross-check the information provided by the manufacturer (see Appendix B for the questionnaire). Typically, one interview of two hours proved to be sufficient to obtain the needed information. Because of existing relationships, the users in particular, and many of the third parties as well, were contacted through the manufacturer.

7. Reviewing the final results with the manufacturer

   Based on all interview reports, a comprehensive case description was drawn up. Discrepancies between the information obtained from different sources were generally eliminated by conducting one follow-up interview (where necessary, cross-checked by telephone). The case description, including an analysis of the situation in the form of summary conclusions, was eventually reviewed by the manufacturer.

5.2 ACTUAL CASES OF USER INVOLVEMENT IN PRODUCT DEVELOPMENT

5.2.1 CASE 1: A NEW BELT FOR CONVEYING PRODUCTS

Ammeraal Conveyor Belting B.V. is a firm specialized in the development, production and marketing of process and conveyor belting. It has subsidiaries in ten different countries, while its products are sold in more than 60 countries all over the world. Worldwide, Ammeraal is one of the major suppliers of process and conveyor belting.

Process and conveyor belting are used in various industries, for example airports, postal services, industrial bakeries and agriculture. Ammeraal's customers can be divided into two categories. The first one consists of end users who need new belting to replace existing ones (replacement demand). The second category (initial demand) encompasses two groups:

a. original equipment manufacturers (OEM's) who manufacture complete process and conveyor equipment and use belting as components and
b. large end users who design and sometimes build their own conveyor equipment.

5.2.1.1 Development of a process and conveyor belt made of synthetic materials

Process and conveyor belts are bought by firms and used for the conveyance of various products. It is hard to think of any solid product that, during its production, has not somehow been in contact with a belt. In recent years, the engineers of conveying equipment formulated higher, and more specific, demands with respect to belting, obliging manufacturers to replace the traditional canvas belts with belts of synthetic material. Innovative developments concerning belting usually involve the use of new materials that result in improved product characteristics.

Synthetic belting became increasingly popular as a solution to almost all existing belting problems. In the food industry, customers began to place higher demands upon belting, too. They wanted

a. to use belting for more purposes than just simple conveying (e.g. accumulation of products),

b. due to the higher priority given to hygiene (e.g. in bakeries), belting to which a minimum of the conveyed product would attach itself and
c. belting that can be easily cleaned.

These requirements led Ammeraal to reconsider its current range of process and conveyor belting.

5.2.1.2 Advantages of the new belting

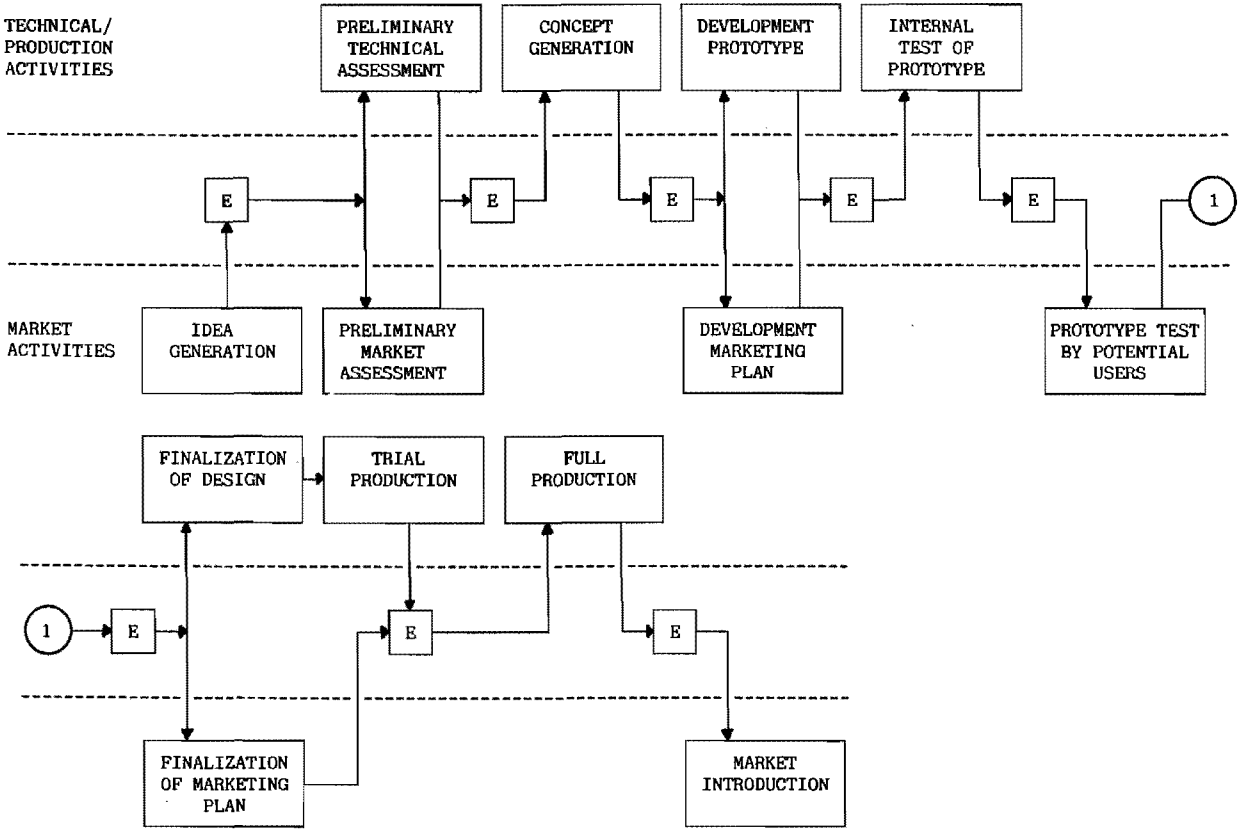
Based on the observed market trends, Ammeraal started to develop a new belt made of synthetic materials. Eventually, the R&D activities resulted in a belt with several distinct advantages.

a. The new belt is resistant to oil and greases.
b. The top layer of the belt is rather hard, which means that, during conveying, the conveyed product cannot easily attach itself to the belt.
c. Due to the new synthetic materials, the belt is easy to clean, thus representing potential cost savings for the user.
d. Compared to existing belting manufactured and sold by Ammeraal's major competitors, the new belts last longer.
e. The belt can relatively easily be adapted to accomodate specific wishes, so that other functions (such as accumulation) can be realized.
f. Since the new belt can revolve around drums with an exceptionally small diameter, it can be used in many areas and specific applications in which other existing belts are useless.

5.2.1.3 User involvement in product development

The new belt was developed in accordance to signals Ammeraal received from the market. Major competitors already sold belting made of the new synthetic materials, while Ammeraal's main customers expressed a need for a new belt in terms of ability to perform secondary functions, ease of cleaning and resistance to oil and grease. These demands were translated by Ammeraal into a number of proposals for a new belt, one of which was eventually selected for development. Due to the new materials, this translation of a general need into product specifications necessitated a great deal of research.

After being developed, the belt was first tested internally. For this purpose, Ammeraal possesses a small-scale system that closely



E : evaluation point

Figure 5.1 The process as regards the development of the new belt at Ammeraal.

resembles the actual systems used by customers. The results of the internal tests proved to be quite satisfactory and confirmed the advantages of the new belt compared to existing belts of Ammeraal and its major competitors.

Next, the new belt was tested by existing customers who could be expected to be potential buyers of the new belt (it was not tested by OEM's, since they cannot really test new belts under real-life circumstances). For the external test, Ammeraal selected several companies in its home market, who were mainly operating in the food industry (where the need for the new belt originated). The customers were provided with a free sample on condition that it would be used in an actual process setting.

The results of these tests led to the decision to add the new belt to the existing range of products and start large-scale production. At the production stage, however, some problems became apparent. These, and other problems, will be discussed in the next section. The product development process is depicted in Figure 5.1.

Eventually the new belt was introduced into the market in three successive phases.

1. In the countries in which Ammeraal has its own subsidiary, the head of the sales department was fully informed about the new belt (internal introduction) and was expected to submit a plan for introduction.
2. In other countries, Ammeraal selected a number of important customers, who would almost certainly buy the new belt, and asked them to test it (pilot introduction). Virtually without exception, this resulted in orders, improved self-confidence of the sales staff and references that could be used during the next phase.
3. The limited introduction was followed by large-scale introduction into the whole market.

5.2.1.4 Deficiencies during product development

Despite the fact that the new belt turned out to be a success, some shortcomings can be noted. Most of these are somehow related to the testing procedure used in external testing, the only stage of the product development process (apart from idea generation and market introduction) in which potential users were involved. Let us look at the most obvious deficiencies.

Ammeraal had not conducted the external tests at the right moment (timing of the tests). Having a product tested by potential users raises expectations concerning future delivery of the new product (see further on). After having completed the external tests, however, Ammeraal was confronted by problems concerning large-scale production. The high quality and specific characteristics of the new belt necessitated Ammeraal to demand high-quality raw materials of its suppliers. Due to both the suppliers' unfamiliarity with the new synthetics and Ammeraal's strict demands, production was slowed down. In fact, the suppliers were unable to produce the synthetic with a consistent high quality. Within Ammeraal there was also some disagreement about the exact definition of 'reproduceability' (the extent to which a product can be manufactured with a quality that remains within the acceptable boundaries). All this resulted in Ammeraal being unable to manufacture the new belt at a consistent quality level (causing a delayed market introduction).

With respect to the test objectives, it is essential to distinguish between Ammeraal's objectives and those formulated by the customers testing the new belt, because they need not be the same (or even be compatible). The following mistakes were made. (a) Test objectives were not plainly formulated; tests were performed while it was unclear what aspects of the new belt were tested. (b) Test objectives were not formulated correctly. One of the customers testing the new belt was a large chemical firm. The test results were judged negatively because certain acids caused delamination (separation of the various layers of the belt). However, it was known in advance that the acids in question would cause delamination. The belt was tested by this specific customer for other reasons having nothing to do with acids and delamination. (c) Test objectives were not formulated at all. Since the customers did not need to pay for the new belt, they often neglected to formulate test objectives. For them it was just a matter of receiving a new belt free of charge, which meant that they did not need to buy a new one for the next couple of years!

Ammeraal paid insufficient attention to the execution and support of the external tests. In one instance, serious problems arose because Ammeraal's sales representative had not stressed that the new belt was just a prototype and that its addition to the existing range of belting was by no means certain yet. This resulted in considerable communication problems with a major customer. The customer had tested the new

belt, found it to be the perfect solution for an existing problem, and placed a large order at once. At the same time, however, Ammeraal had run into production problems which necessitated postponement of market introduction. Several meetings at top management level were necessary to restore the good relationship between the two firms.

Since the objectives were not always correctly formulated (or not formulated at all), the evaluation of the test was not always done correctly (or was impossible to undertake).

A last shortcoming, regarding having potential users test prototypes, concerns the follow-up of the test. The manufacturer should not neglect feedback to the customers who tested the prototype. Several customers reported that they were unaware of the exact results of the external tests and the purposes for which they were being used. One specific customer was not even aware that the test at his facility was already finished; he thought it was still going on! Needless to say, this kind of negligence can cause serious damage to Ammeraal's image and the personal relationships with its customers.

To facilitate acceptance of the new belt, Ammeraal used the names of the firms that had participated in the external testing program in promotional material and during sales presentations. However, the names of customers were not used systematically; the potential of this promotional tool was not fully realized.

It is not merely the communication between Ammeraal and its customers which is of prime importance. Internal communication deserves careful attention as well. In this particular case, sales repesentatives were already selling the new belt before it was actually introduced into the market (before it was even decided that the new belt would in fact be introduced!). Such situations can be prevented by an extensive internal communication program that includes careful briefing of all sales personnel.

5.2.1.5 The buying process

As regards the new belt, the buying process was extremely simple. The innovation concerned a product comparable to existing products and was offered to existing customers. After the belt was tested by potential buyers with positive results, orders were placed on a routine basis. The decision was made by the engineer who was also involved in the test, while the actual placement of the order was left to the purchasing department.

5.2.2 CASE 2: STEEL DRUMS, A NEW DESIGN

Packitt (for reasons of confidentiality the name of the firm is disguised) is an international company with a long history in manufacturing packaging for all kinds of products sold to industrial customers. Ever since its establishment, the firm has been developing innovative products, resulting in its present market position. The largest division manufactures and sells steel drums.

5.2.2.1 Developments in the market for steel drums

The market for steel drums can be characterized as being very traditional and not very innovative. Drums are bought by industrial firms and used mainly for oil and chemical products. During the last few years, some important developments have occurred in the market. Traditionally, steel drums were loaded into freight trucks, railroad wagons or ships and thus transported by land and sea. The last decade, however, has witnessed an increasing tendency to load the steel drums into large containers instead, which are subsequently transported by freight truck, railroad or ship. Thus, the drums need to be loaded and unloaded only once. When changing from freight truck or railroad to ship, one simply moves the container itself instead of all the separate drums.

Steel drums were traditionally available in many sizes, while the dimensions of the containers are standardized according to international norms. This caused customers to complain since, with certain types of steel drums, it was impossible to make optimal use of the space available in the standardized containers. To minimize transportation costs, customers started to look for steel drums with the right dimensions. Packitt got more and more requests for a new steel drum, having optimal dimensions and at least the same volume as the existing drums.

5.2.2.2 Advantages of the new steel drum

Such a type of steel drum has several advantages for the parties involved.

a. Packitt might generate profits by successfully developing and marketing the desired drum (especially when it succeeds in establishing a new standard for steel drums). In addition, it would contribute positively to Packitt's present market position and confirm its 'innovative' image.

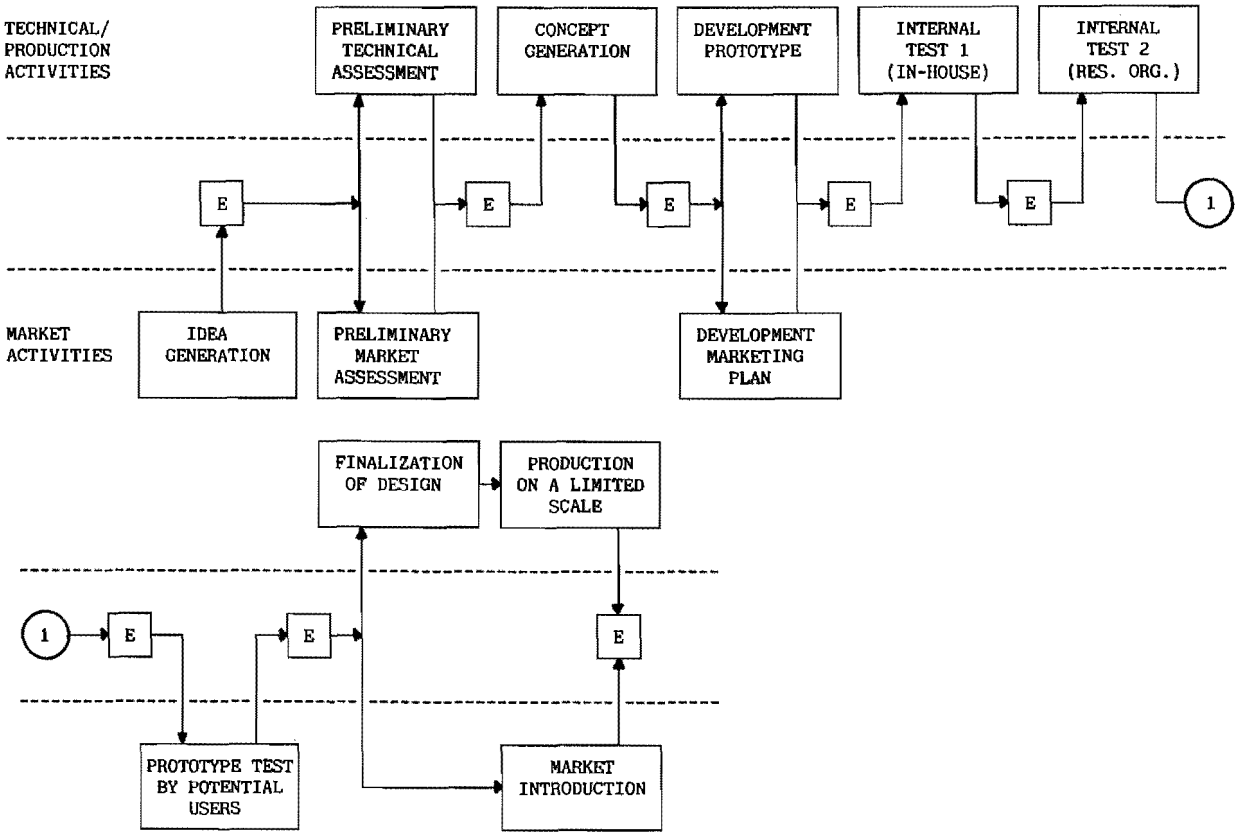
b. As using the new drum allows for the transportation of a greater volume per container, Packitt's customers can reduce the total costs of transportation.
c. Because the traditional drums do not possess standardized dimensions, it is often necessary to apply some pressure to fill the container with the desired number of drums. With a new standardized drum an equal (and sometimes even larger) number of drums can be loaded with more ease and therefore less time, thus offering savings to the shipping company.
d. Since a container can be loaded with such new drums without exerting undue pressure on them, it would result in less damage during transport and thus fewer claims to insurance companies.

5.2.2.3 User involvement in product development

The notion of a new steel drum originated in the market and was subsequently picked up by the major manufacturers of steel drums, including Packitt. However, the customers formulated the idea only generally in terms of a need and did not offer detailed product specifications. Thus, we may conclude that the need was voiced by customers, while the actual specifications were developed by Packitt itself. In fact, Packitt generated several solutions to the problem and eventually selected one of them.

After the concept was developed, Packitt went on to develop a prototype and produce it on a limited and experimental scale. This prototype was subsequently tested internally by Packitt itself (internal test 1). Apart from that, every new steel drum needs to be tested by an external research organization as well (internal test 2) to obtain the necessary 'seal of approval' (because this test is identical in character and objective to the test conducted by Packitt, it, too, is termed 'internal test'). Therefore, the tests conducted by Packitt were identical to the ones to be conducted by the external organization (the most important being the 'drop test': the drum is filled with a specified amount of water and dropped from various heights on to a concrete floor, after which it is tested for leakage).

After the prototype had been subjected to these two types of 'internal' tests it was tested under actual working conditions. For this purpose, Packitt selected a shipping company with whom it had been doing business for many years. Two containers were loaded with the new steel drums and shipped by freight truck, railroad and ship using the



E : evaluation point
RES. ORG.: research organization

Figure 5.2 The process as regards the development of the new steel drum at Packitt.

shipping company's facilities. Simultaneously, a third container, loaded with the traditional drums, was transported for purposes of comparison. All drums were filled with water. During the test, the time needed to load the drums into the container and the ease of handling were recorded by observers from Packitt. Afterwards, the drums were tested for leakage and the amount of damage determined. The results were very satisfactory: compared with the traditional drums, it took less time to load a larger number of the new drums into the containers and the amount of damage after transportation was within acceptable limits. Other large customers were also supplied with a free sample batch of the new drum for testing under actual conditions. These results contributed to the decision to produce the drums on a limited scale on an existing production line and introduce them into the market.

To facilitate acceptance by the market, the product was introduced at an important trade show. The obvious cost savings offered by the new drum seemed to justify a slightly higher price. However, actual sales of the new drum were disappointing.

The above description shows that potential users were only slightly involved in the development process. Apart from voicing the need they only took part in testing a prototype. The product development process is summarized in Figure 5.2.

5.2.2.4 Deficiencies during product development

Naturally, the lack of success had a number of causes. Due to the limited space available and the objective of our study, we will concentrate on the test performed by potential users. This stage of the development process should be conducted with great care because the decision whether or not to start production is based on the results of the external tests. Let us consider a few things that went wrong in this particular case.

Our investigation revealed that Packitt had paid insufficient attention to the selection of the potential users who were to test the new drum. The most important external test (employees of Packitt were actually present to supervise the test's progress) was conducted by a shipping company selected for this task because of an existing and good personal relationship of long standing. However, this turned out to be a major error because the company was not representative of Packitt's

customers in general. The handling equipment of even the major customers in Packitt's home market turned out to be unsuitable for handling the new drum. This major shortcoming of the new drum was not discovered during the test by the shipping company, since by pure coincidence that particular company happened to use equipment that could handle the new drum.

There is another problem in connection with the selection of potential users. Packitt sells to industrial customers, thus facing a derived demand. Not only Packitt's customers, but also the customers' customers influence the acceptance of the new drum. Packitt's customers use the drums for shipping their products (mostly oil and chemicals) to their customers. As these final users are located, virtually without exception, in less developed countries, they do not possess equipment suitable for handling the new drum.

Packitt paid insufficient attention to the execution and support of the test by the customers. Packitt shipped a sample batch of the new drum to its major customers, who tested them on their own sites. These tests were not attended by employees from Packitt. Therefore Packitt was unable to check whether the new drums were handled correctly. Packitt was not even aware of the nature of the tests conducted by these customers!

Due to its complete absence during the tests, and the fact that it was unware of the exact nature of the tests, Packitt was unable to really evaluate the test results. In some cases Packitt even neglected to inquire about the results of the specific tests!

Packitt neglected to involve users in the development of the concept. Because of the deficiencies in the external testing procedure, the shortcomings of the new design were not noted and rectified by means of feedback to earlier stages of the product development process (for instance by changing the design).

After market introduction of the new drum, Packitt did not show enough commitment to the new product, both internally and externally. The new drum was only produced in limited batches on an existing product line and did not get high priority. The existing sales representatives were expected to promote the innovation without receiving substantial support from the main office. This lack of corporate commitment no doubt contributed to the disappointing sales.

Packitt's sales representatives contacted members of the purchasing department. As these buyers are highly focussed on the price of drums

and regard them as a commodity product, they were not enthusiastic about the relatively expensive innovation. Because using the new steel drum can result in significant savings in transportation costs, Packitt should contact distribution or material-handling managers instead. However, this requires a representative from Packitt with the authority to make the proper decisions (Biemans and De Vries, 1987b, pp. 36-37).

5.2.2.5 The buying process

Because steel drums are regarded as a commodity, they are traditionally ordered by a member of the purchasing department. Two problems are apparent in this situation.

In most cases, customers do business with only a few large suppliers, since they do not want to be dependent upon one supplier (multiple sourcing strategy). As there are no competitive suppliers of the new steel drum, this is a huge disadvantage for Packitt.

Because the new drum offers cost savings which are not clearly visible to the purchasing manager (the new steel drum was offered at a slightly premium price), it is crucial for Packitt to establish contact with other persons within the buying organization, such as distribution and export managers. These new contacts should be handled with great care, so as not to disturb the existing relationships with purchasing managers (Bellizzi and Walter, 1980, p. 140).

Many parties exert direct or indirect influence on the buying decision:

a. members of the buying organization,
b. the customers of the buying organization, who need to be able to handle the new drum,
c. shipping companies that have to transport the drums,
d. security officials who may advise on the relative safety of specific drums,
e. insurance companies that can lower the premium on transportation insurances and
f. government officials who draw up regulations concerning the tranportation of dangerous chemicals.

5.2.3 CASE 3: A PULSE OXIMETER FOR MONITORING OXYGEN

From a global viewpoint, Dräger is one of the leading manufacturers of breathing equipment for hospitals. Apart from that, it imports medical equipment that fits within its own product range. Its customers consider Dräger to be selling high-quality products, rendering good service and maintaining good personal relationships. The corollary to Dräger's good reputation is the relatively high price of its products.

To be innovative has traditionally been an important objective of Dräger. This is, among other things, shown by its taking up the distributorship for an innovative patient monitor: the pulse oximiter. This case differs from the preceding ones in that Dräger is the distributor and not the manufacturer of the innovation. As the monitor was developed in the United States with the help of local users, the following discussion focusses on the introduction of the monitor into the Dutch market.

5.2.3.1 Trends in monitoring oxygen

Several methods concerning monitoring oxygen can be distinguished. However, we will restrict ourselves to the three main methods relevant to this discussion.

Traditionally, the only method available was to measure the oxygen tension by analysing a blood sample. Because this method is invasive the patient has to be disturbed regularly. Furthermore, it takes some time before the blood is analysed and the results are known. In some particular instances this time difference between taking the blood sample and receiving the results can lead to complications. A final disadvantage is that the measurement is discontinuous.

These disadvantages led to the development of transcutaneous monitoring, which uses membranes that heat the skin. Thus, the oxygen tension level can be measured continuously and non-invasively. However, aside from these advantages there are some distinct disadvantages, too. Application to adults is less useful, due to the thickness of their skin. In addition, the monitor must be calibrated after every measurement, which can take up to twenty minutes, and use of the instrument necessitates extensive maintenance. In some specific instances the readings can even be misleading. Finally, when used on children, there is the additional disadvantage of potential minor injury caused by skin burning.

The third important method in this context is pulse oximetry. It is essentially different from the first two methods, because it measures the oxygen saturation level instead of the oxygen tension level. There is, however, a very complex relationship between these two variables. Pulse oximetry is a non-invasive, continuous measuring method. Compared with transcutaneous monitoring, it uses an essentially different technology. The skin is not heated, but probed by a sensor containing two sources of light with different wavelengths.

5.2.3.2 Advantages of the pulse oximeter

The pulse oximeter offers the following advantages to the various parties involved.

a. The specialist obtains reliable measurements of the oxygen saturation level on a continuous basis. A wide range of sensors makes the monitor useful for many applications.
b. The nurse is supplied with an instrument that is easy to use and does not need calibration after each measurement.
c. Because the method is non-invasive the patient is not really subjected to discomfort.

5.2.3.3 User involvement in product development

That the new monitor was developed in the United States did not preclude users in the Netherlands from improving on the original design. Leading specialists who were dissatisfied with the quality of the sensors complained to Dräger. When action was not directly forthcoming they developed their own improved sensors.

From this we can conclude that even when the main product is developed somewhere else, innovative users can improve on certain minor details of the innovation. In this way they contribute to development of the product during adoption. This phenomenon is called re-invention and Agarwala-Rogers (1978, p. 139) defines it as "the process by which an innovation is changed by a user in the process of its adoption or implementation after its original development". Rogers (1983, pp. 180-182) mentions several reasons for the occurrence of re-invention. Regarding innovative high-technology health-care products, Styles (1984, p. 118) stresses the importance of maintaining continual contact with customers after product launch in order to get information about possible improvements by the incorporation of modifications.

5.2.3.4 Introduction of the pulse oximeter in the Netherlands

At the time of introduction of the first pulse oximeter into the Dutch market, wide attention was given to free publicity and field trials. Monitors were placed at strategic sites, for example university hospitals and regional hospitals that function as opinion leaders for a specific medical specialism. The new monitor could be tested during a period of from two up to twelve weeks, depending on the importance of the hospital in question to Dräger. Thus specialists (who are the principal decision makers regarding medical equipment of this kind) were offered the opportunity to get acquainted with the new monitor. Apart from this, professors working at hospitals or medical research institutes were encouraged to experiment with the product and publish about their experiences. This resulted in free publicity by leading professors who can be considered to be opinion leaders in the medical community. All in all, the strategy was to convince potential buyers by their own experiences with the pulse oximeter, and by the experiences of specialists (or institutions) regarded as opinion leaders in the medical community. Another advantage of field trials is the quick response. For consumer products too, sampling is considered to be the quickest way to introduce a good new product or kill a bad one (Marketing News, 1987, p. 19).

5.2.3.5 The buying process

Specialists mentioned trade publications and colleagues as the most important sources of information concerning new products and technological developments. Congresses and trade shows were not rated as very important because they almost never offer anything that is really new. On the other hand, they do offer the possibility of actually seeing and touching new products. In addition, congresses have been found to be an essential part of the network of relationships between colleagues (Shaw, 1987, p. 259).

Most of the specialists who tested the new monitor had already read about the existence and advantages of the new technology in the (American) trade literature. Although the specialists wanted to test the new monitor themselves before they would contemplate buying it, the test procedure was usually not very comprehensive. There are two reasons for this seeming contradiction:

a. since the pulse oximeter offered by Dräger was the first of its kind, the tests never contained a comparison between different brands and
b. since the specialists had already read evaluative reports in trade journals it was not thought necessary to conduct extensive tests; the specialists used the test as a try out of the monitor in their own specific situation (they were already convinced of the reliability of the measurements).

In most cases two or three different parties were involved in testing the monitor. The specialist has to be convinced of the usefulness and reliability of the innovation. Since the nursing staff has to operate the new product, their opinion is usually asked for. The specialist's opinion is clearly the most important, however. A possible third party is the technical department of the hospital, which is interested in the electrical safety and ease of maintenance and repair.

When the specialist was convinced of the advantages of the innovation, the usual procedure was that it would be placed on the priority list for next year's purchases. Subsequently, it would be evaluated by the board of directors. In some specific instances, however, funds were available at once. This budgeting procedure represents a big disadvantage for Dräger. It means that purchases of the innovation will be postponed which, in turn, gives competitors the opportunity to enter the market. By emphasizing the innovation's advantages Dräger tried to encourage the raising of funds outside the normal budgeting procedure.

Not surprisingly, the reliability of the measurements and user friendliness were clearly the most important buying motives. Apart from these, Dräger's image and the experiences with its products played a major part in persuading the specialists to buy the new monitor (cf. Hutton, 1984, p. 166). Every specialist was already familiar with Dräger through its artificial respirators.

In this specific market, three different kinds of opinion leaders could be distinguished:

a. hospitals where teaching takes place (specialists are favourable disposed towards the equipment used in their training; see Bennekom (1987, p. 59),
b. specialized (parts of) hospitals and
c. specialists who publish regularly.

These three categories can be used as references and function as a source of free publicity.

5.2.4 CASE 4: AN ADVANCED ELECTRONIC ACCESS-CONTROL SYSTEM

The N.V. Nederlandsche Apparatenfabriek Nedap started as a manufacturer/supplier of electrotechnical parts, but for some years now it has been developing and selling its own products. Ever since its establishment, Nedap has been actively searching for potential new products. Indeed, in its annual report "the development and production of innovations" is stated as one of its central goals. In fact, approximately 70% of sales is generated by products developed during the last five years.

The most important innovations recently developed involve systems for the identification of animals, people and goods, which all depend on the same basic technology, in accordance with Nedap's strategy of "growing through diversification". This section concerns one of the most recent, and quite successful, developments: a new kind of access-control system. The incorporated advanced electronic technology provides the product with its distinctive features.

5.2.4.1 The market for access-control systems

Access-control systems are bought by a large and heterogeneous group of customers. Theoretically, every organization may be considered a potential buyer of an access-control system. Such a system can be used for only the main entrance to the building, the entrances to the computer centre, or nearly all the doors inside the building.

Until recently, the Dutch market for access-control systems was largely dominated by American suppliers. The first systems were quite simple and were used for just one entrance. Nowadays, customers tend to link an increasing number of doors inside the building to an access-control system and integrate it with other existing systems, such as security, payroll and time-registration systems. Obviously, this has important consequences for the software to be used.

Three main categories of access-control systems, differing in degree of complexity and reliability, can be distinguished. The first systems to appear on the market were the magnetic-card systems. Instead of the traditional key, a small card is used that looks like a credit

card, to which a magnetic strip is attached. This magnetic strip contains an individual code, which is read by inserting the card into the slot of a card reader. The obvious disadvantages are the ease with which the code can be cracked and copied and the possibility of sabotage (putting the reader out of order by stuffing foreign objects into the slot). A higher degree of reliability was attained with the proximity systems. With these systems, the code is read by holding a pass (because the card is much thicker, it is more appropriate to speak of a pass) in front of the reader. The pass can be read from a distance of up to fifteen centimetres. The obvious advantages are better protection of the code and elimination of the possibility of sabotage. A major disadvantage that still exists, however, is the fact that, in order to open the door, it remains necessary to perform specific actions (namely, offering the pass to the reader). This disadvantage is eliminated by the hands-free system.

5.2.4.2 Advantages of the hands-free access-control system

This new generation of access-control systems has several distinct advantages.

a. The pass can be read from a distance of seventy-five centimetres, so that the door can be opened without having to perform certain actions (hence, the name 'hands-free'). The pass can be equipped with a picture and worn like a name-badge on the lapel of a suit or carried in a briefcase. This enables a person to enter a room even when he needs both hands to carry something.
b. Due to the advanced technology embodied in the system, the individual code is very hard to crack and copy, which enhances the reliability of the whole system.
c. Since the reader does not contain a slot, it can be built into a wall. This invisible reader, combined with a pass that, disguised as a name-badge, is worn on the lapel, makes the actual operation of the system virtually undetectable by outsiders.
d. The developed software allows the admittance of identified persons during specified time intervals to specified rooms/areas. Furthermore, the system can be used for time-registration and be integrated with other systems, such as fire-alarm systems and payroll systems.

5.2.4.3 User involvement in product development

The idea for the new product largely originated within the company. The technology was already used for another product and could be modified to match the requirements of an access-control system. The innovation was based on Nedap management's conviction that hands-free represented the future in access-control systems, instead of on comprehensive market studies that showed a latent need for the system. Due to the advanced nature of the system, the market was not ready for it yet, but certainly would be in the very near future. However, at this stage a study was made of existing systems offered by competitors.

The product concept was formulated internally with some technological assistance from external experts. During the development stage, the existing technology was adapted to the requirements of an access-control system. Advanced negotiations with a major service company led to the decision to install (after internal testing) the developed prototype, consisting of more than fifty readers and several thousand passes. Due to its prominent position within the market segment, the organization was considered a very suitable first customer that could be used to accelerate market acceptance of the innovation. The customer proceeded to test Nedap's system simultaneously with the system of a major competitor. The results of the test were in favour of Nedap's hands-free system.

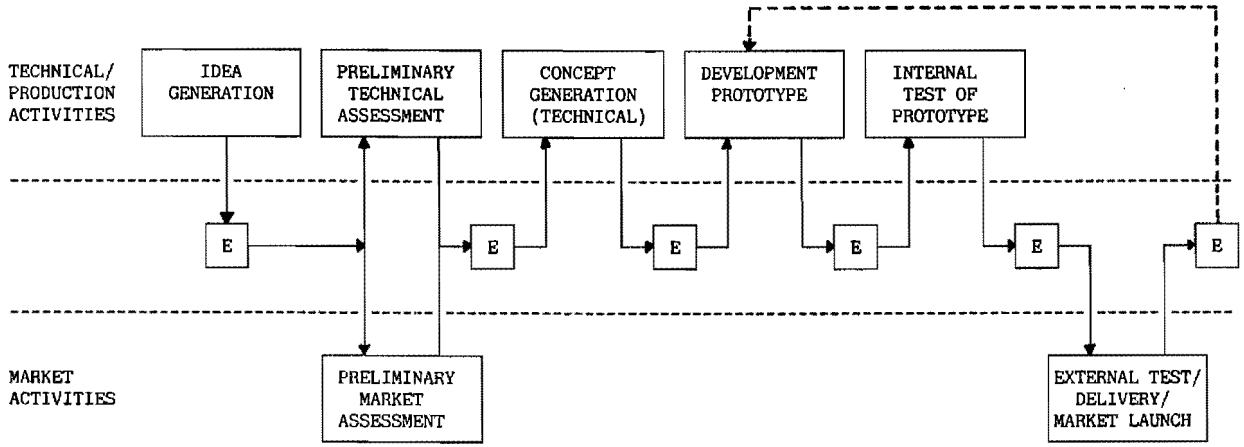
At the time of installation, however, Nedap was unable to deliver the central processing unit (CPU), which forced the customer to buy the CPU and the necessary software from other suppliers.

Nedap had to return to the product development stage (see Figure 5.3) and concentrate on developing the CPU and the corresponding software. Based on the experiences of the first customer, the hardware needed to be modified as well. This resulted, among other things, in improved, that is sturdier passes.

The exclusion of potential users from the product development process resulted in large and costly changes in the marketed product. However, due to the unique user benefits realized by means of the product's advanced technology, the innovation has been quite successful.

5.2.2.4 Deficiencies during product development

Most of the problems arose because Nedap neglected to involve potential users in the development of the new product. Apart from this, some other aspects warrant attention.



E : evaluation point

Figure 5.3 The process as regards the development of the new access-control system at Nedap.

The above description shows that Nedap introduced the new product before it was fully developed and tested. This created the situation that Nedap could not deliver certain essential parts of the total access-control system.

Nedap is very technology driven. It is run by engineers who are experts in technology, while marketing knowledge is less developed. This caused Nedap's management to rely entirely on its own vision with respect to future market developments, trust in its own capabilities and ignore potential input from the market. This overconfidence led to the sale of a product that was not yet fully developed.

Because the new product was aimed at a market segment unfamiliar to Nedap, management had problems in identifying and negotiating with the most suitable distributors. In the home market this led initially to some friction with the selected dealer, while dealers abroad were not systematically analysed and evaluated.

After the CPU and the appropiate software were developed, the hands-free access-control system became a relatively great success. It made the company one of the major manufacturers of technologically advanced access-control systems with a high level of reliability.

5.2.4.5 The buying process

Virtually every customer investigated followed the same procedure in purchasing the hands-free access-control system. This buying procedure has some interesting characteristics and is graphically displayed in Figure 5.4.

The buying process starts with recognition of the problem, after which people start to look for possible solutions. At the same time, an external orientation takes place, for example investigation of a possible reduction in the insurance premium. Apart from an access-control system, other solutions, such as all kinds of organizational changes (extra reception personnel, a doorman on night duty), are considered at this stage. However, due to excessive costs these are quickly discarded. Access-control systems are subsequently compared with other existing systems (mechanical locks, cameras). When eventually a decision is made in favour of an access-control system, Nedap is usually selected as the supplier because its product is perceived as the only system that satisfies requirements.

The above description demonstrates that the hands-free system competes with more than just the proximity systems. Looking beyond the

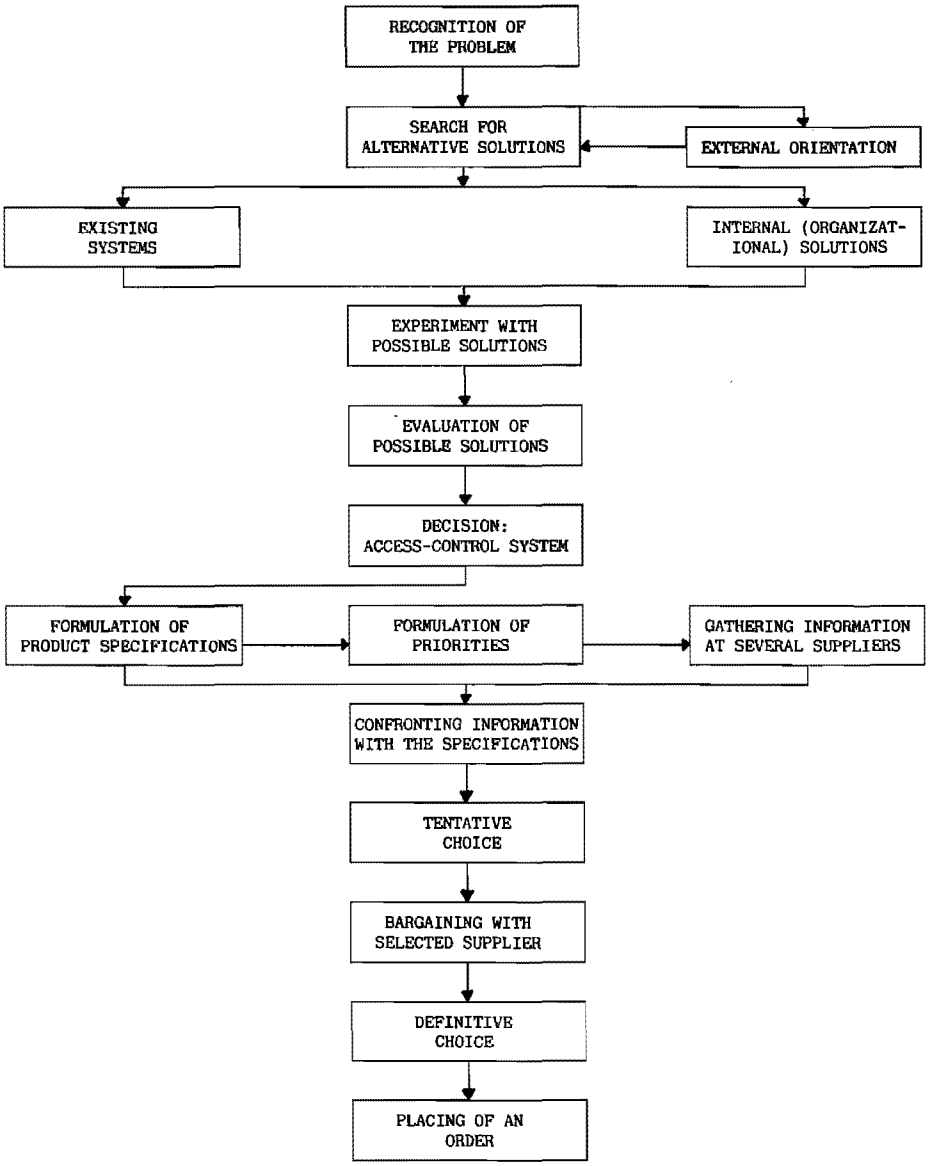


Figure 5.4 The buying process for Nedap's hands-free access-control system.

technology incorporated and adopting the viewpoint of the customer seeking a solution to a problem, it becomes clear that the hands-free system competes with a host of possible solutions. Only for costumers interested in a sophisticated access-control system with a high level of reliability, the possible solutions are reduced to the proximity systems and the hands-free system. When the additional feature of user friendliness is requested, Nedap becomes the sole supplier of a reliable system.

Usually there are many parties involved in the buying process. Within the buying company, the following five parties can be distinguished:

1. the users, who are being asked to formulate product specifications,
2. the technical department, which evaluates several possible systems,
3. the advisor, who has specific knowledge on the subject of security systems in general (while this is often someone from the security department, it may also be an external agency),
4. the works council, which guards the interests of the employees (privacy in connection with time registration!) and
5. the board of directors, who are the formal decision makers.

5.2.5 CASE 5: A FREEZE-CONCENTRATION PROCESS FOR THE FOOD INDUSTRY

Grenco Process Technology B.V., a relatively young subsidiary of Grasso's Koninklijke Machinefabrieken N.V. which has a long history as a manufacturer of industrial machinery, is specialized in engineering and assembling industrial process installations. The steel frames and advanced components are manufactured by outside suppliers. The installations are used for removing water from aqueous solutions and are based on an advanced technology, of which Grenco is the sole supplier. This monopoly rests on the exclusive possession of advanced technological know-how, co-developed by the present managing director. The new technology has been applied to diverse sectors in the food industry, with Grenco continually searching for new applications. The basic technology needs to be adapted to every new application, which means that the product must be developed anew. At the moment, the company is developing an application for the petrochemical industry in close collaboration with a major chemical firm.

5.2.5.1 The removal of water

At present, evaporation and freezing are the dominant technologies for removing water. The process of evaporation is difficult to control since, together with the water, aromatic substances disappear, resulting in a loss of taste and quality. Freezing, on the other hand, may also lead to the involuntary removal of essential substances. Therefore the freeze-concentration process developed by Grenco addresses the problem of removing water out of watery solutions without loss of taste or quality. This offers several potential benefits to customers. Consider the case of such products as beer and orange juice, which contain a substantial percentage of water. Long-distance transportation of products such as these leads to costs which are unnecessarily high, since a large part of the total costs is caused by the transportation of water! A substantial part of the total amount of water can be removed at the factory, after which the 'basic substance' of the beer or orange juice can be transported to the desired location. Here, water can be added again to regain the original product. In this manner, significant savings in transportation costs can be realized. The case of instant coffee illustrates another potential benefit of the process. An essential step in the production process of instant coffee consists of removing water from a watery solution. This stage largely determines the quality of the end product and a large amount of energy is necessary to obtain the desired results. Improvement of this stage leads to a better end product and/or savings in energy costs.

5.2.5.2 Advantages of the freeze-concentration process

Implementation of the innovative freeze-concentration process developed by Grenco, offers the buyer several distinct competitive advantages.

a. Through the efficient removal of water, significant savings in transportation, storage and energy costs can be realized.
b. While the quality of the end product is not impaired by the process, in specific instances it can even be improved economically.
c. In some cases totally new products can be developed through application of the new technology.

5.2.5.3 User involvement in product development

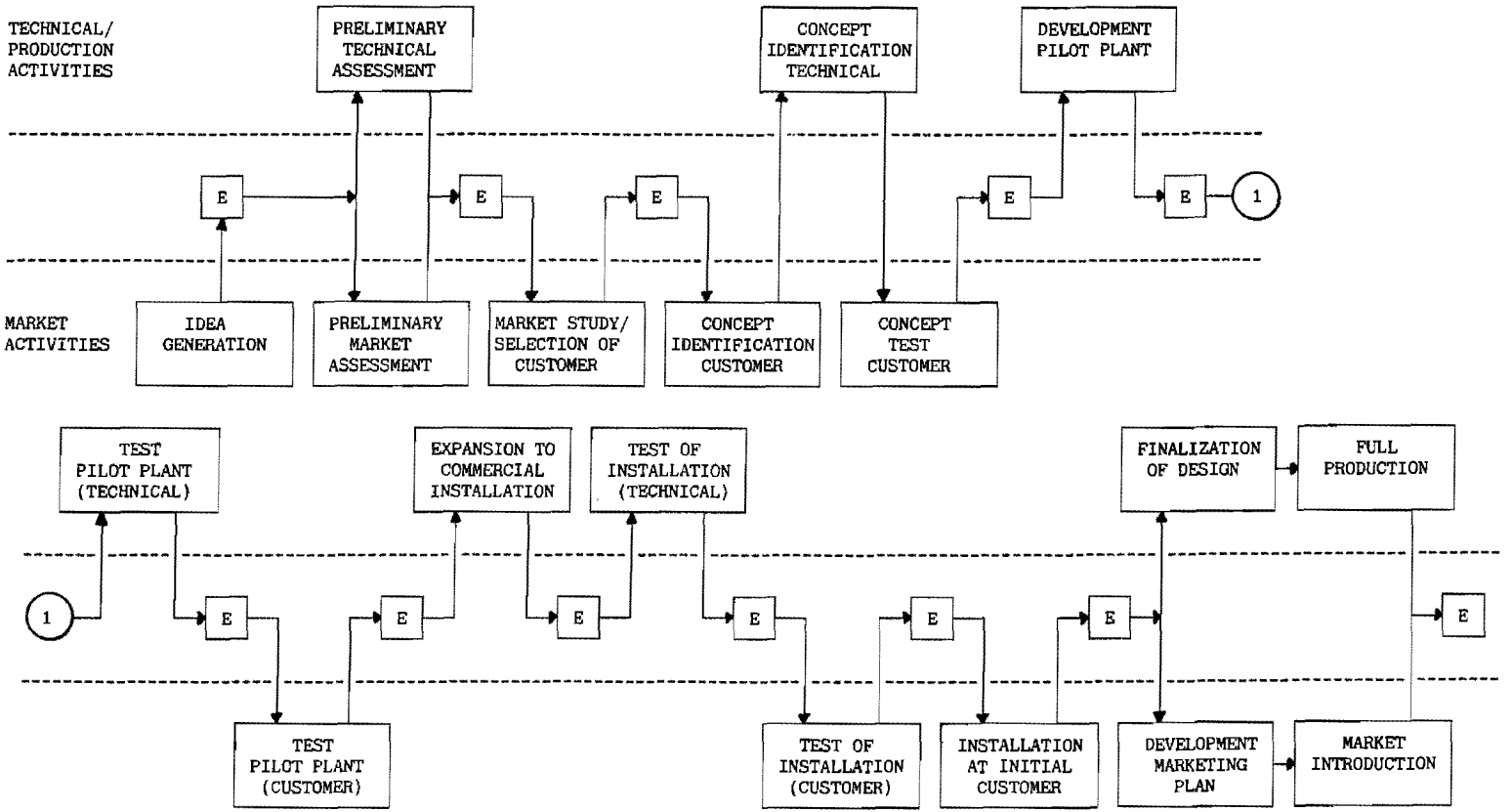
Application of the basic technology in a specific industry necessitates a new product development process (Figure 5.5).

The basic technology underlying the various applications has already been developed by Grenco, which is continually searching for new potentially profitable markets. The market structure and the degree to which the inherent advantages can be realized by potential customers are the most important criteria for selecting a market. A great deal of the necessary information can be obtained from annual reports. A problem is that the companies in the specific market, identified by Grenco as possessing great potential, are not always aware of the need for the process. The process offers them opportunities they have not thought of before. In these cases Grenco takes the initiative by studying the structure of the specific market and determining the firm that appears most promising as a partner for jointly developing the application. Grenco has chosen this strategy of joint development because

a. the potential customer has the necessary application know-how,
b. cooperation can result in the development of a product that better fits the requirements of the market,
c. the high development costs can be shared with the customer,
d. the application knowledge acquired can be used when selling the developed product to subsequent customers in the same market,
e. the name and reputation of the customer can be used as a reference when selling to other customers (for example in promotional material and sales presentations) and
f. the high complexity of the new technology necessitates training and instruction of the customer at an early stage.

Potential partners for joint development have to satisfy several criteria, such as efficient size, a dominant position and/or influence within the market and possible profitable application of the freeze-concentration process. The chosen customer is subsequently contacted and the negotiations are started. During the bargaining, Grenco tries to convince the customer of the potential advantages of implementing the new technology and get him interested in jointly developing the application. The customer may agree because

a. acquiring a new advanced technology at an early stage will result in an improved competitive position,
b. the technology represents an essential part of the customer's production process and
c. the joint development process can help to maintain an innovative image ('operating on the frontier of technology').



E : evaluation point

Figure 5.5 The process as regards the development of the new freeze-concentration installation at Grenco.

The development activities take place on the customer's premises. A pilot plant is built that imitates the production process on a small scale, and the application is developed and tested. Grenco engineers work full-time at the customer's premises to start up the pilot plant and debug the installation. The eventual purchase will be accelerated by a successful test that demonstrates to the customer how the pilot installation actually functions in his particular situation. Afterwards, the pilot plant is gradually expanded to a full-sized commercial installation. Only when the customer is convinced of the opportunities and advantages offered by implementing the new technology in the production process, will purchase of a full-size installation follow. This commercial installation (i.e. the developed application) can subsequently be marketed to other potential buyers in the same market. Grenco tries to contractually commit the first buyer in a particular market to assist in this.

Since the product development and testing stages take place at the customer site with the help of Grenco engineers, immediate feedback is possible. This results in an iterative process in which it is hard to distinguish between the development and testing stages. Another distinction that becomes somewhat artificial in this situation is the one between developing and introducing the product into the market, because the customer who participates in the development process is the first buyer of the innovation as well.

Extensive contracts have to be drawn up to lay down the rights and duties of both parties. Since the initial customer has invested a great deal of time, money, knowledge and energy in developing the application, he will want to limit sales of the innovation to competitors (limit market penetration). Examples of clauses that can be included in the contract to prevent a rapid diffusion of the newly developed application among competitors are:

a. the initial customer gets exclusive use for a specified period and
b. when selling to competitors Grenco is not allowed to divulge information about past experiences acquired during start-up of the installation, which means that every new buyer has to face the same problems and invent the same wheels again and again.

Personal relationships played a crucial role in developing an application. Grenco's managing director was a key figure in many instances. He promoted the new technology and motivated his staff to develop new applications. This role was based upon his expertise in technological aspects, commercial capabilities and hierarchical position. Frequently he had to take care of initial problems that occurred too. This combination of technological and commercial knowledge is a big advantage to Grenco, but also makes it very vulnerable. Within the potential customer too, someone has to be convinced of the advantages of the new technology and be willing to promote it within the organization. For this reason, the managing director considers the initial contact with the right person within the potential customer firm to be of major importance. In most cases, the ideal person is an R&D manager who has such a position of authority within the organization that he can make decisions and motivate people. He has to be prepared for resistance within the organization and he should be able to keep the project going despite initial setbacks. As one manager remarked: "There where times when I felt terribly lonely". Particularly during the early stages of the development process, the personal relationship is of prime importance. At this point, the actions of the individuals involved are not so much dictated by the terms of a formal agreement as by an open and trusting atmosphere. This feeling of mutual trust is a prerequisite for successful cooperation.

5.2.5.4 Deficiencies during product development

Problems arose in specific instances because the suppliers of the components were unable to deliver on time. This meant that Grenco had to postpone delivery of the installation to the customer, which directly impaired the harmony of the existing relationship and in a longer term could harm the corporate image. A tight control over the delivery schedules of the suppliers is of great relevance to Grenco's success.

The basic technology is extremely complex. A great deal of time was spent on the instruction and training of the customer's engineers. Much patience was demanded of the customer because of the long period till start-up of production and the many small problems that occurred during the pilot stage. Grenco's management underestimated the complexity of the technology and the difficulty that customers experienced in trying to understand enough of the basic principles to be able to use it.

5.2.5.5 The buying process

The freeze-concentration installation of Grenco represents a crucial part of the customer's production process, which implies that every potential buyer will require more or less extensive testing of the product before actually purchasing it. In every new situation the product has to be adapted to some extent to the customer's specific production process and requirements. This leads to a buying process that is similar in structure to the one described above for the first buyer.

The high complexity of the underlying technology has several important consequences. The fact that the basic technology was developed by the managing director of the firm causes additional trust in Grenco's capabilities. Grenco's customers did not really have much choice, anyway, since no competitive products that could deliver the same quality existed. For this reason, one particular customer added a clause to the contract that regulated the transfer of knowledge in case Grenco should for some reason be unable to deliver in the future.

Selling the installation involves more than just selling a product, it entails selling technology. Much effort is spent on training and instructing the customer's engineers. It is not necessary (and not desirable either!) that the customer learns about all the ins and outs of the new technology; a certain level of operating knowledge is sufficient.

Personal relationships play a central role when selling to subsequent buyers in the same segment as well. The process installation involves the heart of the customer's production process and represents a large investment. Identifying the right person within the potential buying company, convincing this individual of the specific advantages and supplying him/her with the right information to convince his/her superiors can be a slow and lengthy process indeed. The right person to contact is an R&D manager who is situated neither too low (lacks the power to make decisions) nor too high (has the power to take action, but the people at the lower levels will not feel committed to his/her decisions) within the organizational hierarchy.

A last remark concerns the testing of the new process installation. In some cases, using the new installation results in a changed quality of the customer's product or even in completely new products. In these instances, the customer will want to test the changed/new product with his own customers too.

5.3 PRELIMINARY CONCLUSIONS AND CONCEPTS

Although the five case descriptions present very different firms, products and situations, a number of general preliminary conclusions can be formulated. However, when reading these conclusions it should be borne in mind that they are based on the five cases only, which leads us to consider the scientific value of the results presented in this section. First of all, it should be stressed that the conclusions rest on a limited number of case studies, so that broad generalizations should be made with the utmost care. There is no indication as to whether the results are applicable to industrial firms in general. But, referring to Chapter 1, the purpose of the case studies presented in this chapter was to explore the subject under investigation and this exploration has resulted in a number of preliminary conclusions. As these conclusions are based on in-depth case studies, they may be of great practical value to other industrial firms in similar situations. Second, it was found that the preliminary conclusions partly concur with the findings of other investigators, as will be noted in the text, thus lending additional support to them. Third, after the preliminary investigation of five cases, an additional sample of seventeen cases has been studied. These were taken from one particular industry (i.e. medical technology) since innovation processes may differ greatly between industries. This follow-up investigation offered the opportunity to test, supplement and refine the preliminary conclusions for one particular industry. Finally, Chapter 8 explicitly evaluates the research methodology employed and presents a model for conducting case research in marketing, which is based on our own experiences.

The preliminary conclusions presented in this chapter relate to the following topics:

a. product development as a phased process,
b. differences between having industrial and consumer products tested by users,
c. derived demand,
d. product champions,
e. networks,
f. marketing of knowledge and
g. having potential users test industrial prototypes.

5.3.1 PRODUCT DEVELOPMENT AS A PHASED PROCESS

The model of the product development process, selected as a basis for our investigation and used to illustrate the cases described in this chapter, consists of a series of distinctly separated stages. When we selected this model in Chapter 3, we drew attention to the fact that in practice this distinction between separate stages may be very unclear and somewhat artificial. This remark is unequivocally supported by the case studies described above.

Consider the distinction between developing a prototype and testing it. When the innovation is jointly developed by the manufacturer and a major customer, the two stages are no longer clearly separated. The development and testing activities may even be conducted at the customer's premises with assistance from the manufacturer's engineers, as illustrated by the case of Grenco (Case 5). When this occurs, the frequent instant feedback loops and close manufacturer-customer interaction result in a continuous and iterative development/internal testing/external testing cycle.

Another distinction with overtones of artificiality is the one between having the innovation tested by users and introducing it into the market. The names and reputations of major customers, who tested the new product under real-life conditions, can be used in promotional material and during sales presentations. These customers can also be used do demonstrate the product in operation to potential purchasers, thus accelerating diffusion of the innovation. The customers who participated in the external testing stage are quite often the initial buyers of the innovation, too. Moreover, as a result of the external testing stage, the innovation is unlikely to remain confidential. Testing in the market is a means by which information is disseminated as well as gathered (Foxall, 1984, p. 222).

5.3.2 DIFFERENCES BETWEEN HAVING INDUSTRIAL AND CONSUMER PRODUCTS TESTED BY POTENTIAL USERS

In this chapter we have focussed especially on having potential users test new industrial products. This external testing stage, however, is relevant not only to industrial products. New consumer products are generally also tested by customers before being introduced into the

market. Some differences between field tests in industrial versus consumer markets are enumerated below.

Number of potential users involved

In general, a relatively large sample of customers is selected to test new consumer products. However, due to the typically limited number of potential users of new industrial products, the latter are usually tested by only a few customers (such as industrial firms or research institutes).

Number of persons involved

New consumer products are usually tested by a single person. People are asked individually to taste a new variety of soup or try a new vacuum cleaner. With industrial products, however, the number of people within the organization testing the innovation can become quite large. Often, persons from various departments and levels are involved. For example, the new monitor from Case 3 (Dräger) was tested by both specialists and the nursing staff, while the technical department was quite often involved as well.

Personal relationship

In general, the testing of new consumer products does not involve a personal relationship between the manufacturer and the persons testing the new product. As industrial innovations (a) are often of great importance to the user's competitive position, (b) may represent a vital part of the user's production process and (c) may necessitate detailed instructions (and sometimes even training) to understand their operation, the personal relationship between the manufacturer and the organizations testing the new product strongly determines the value and significance of the test results.

Using customers as reference

Due to the usual anonymity of the people testing new consumer products, their names will not be used as references during market introduction. Instances where famous people are used for testing the new product (for instance, a renowned sportsman testing new equipment) are obvious exceptions. However, potential users testing new industrial products are frequently selected because their names, reputations and test results can be used in promotional material and during sales presentations. Therefore these initial customers are also referred to as 'launching customers'.

Distinction between product testing and market introduction

When developing new consumer products, the product testing and market introduction stages are clearly separated. With industrial innovations this distinction becomes artificial since the firms testing the new product are generally the first buyers too and are used as commercial references. In these situations the 'testing customers' will be 'launching customers' as well.

Use of external research organizations

Manufacturers wanting to test new consumer products often hire an external market research organization to conduct the product tests. These organizations have the specialized knowledge and staff to perform such tests and often use established consumer panels for these purposes. Only the large manufacturers of consumer goods have the expertise and facilities to perform market tests themselves (that is, to arrange having consumers test their prototypes). Nevertheless, they also often use external agencies to obtain objective results. On the other hand, the complexity of industrial innovations and the importance of personal relationships with customers make it imperative for manufacturers to perform the tests themselves (thus running the risk of distorted information).

The reader should take care not to confuse market testing (as the term is used here, i.e. external testing) with test marketing, a concept that can often be found in the literature concerning consumer goods. Test marketing refers to testing a new or modified product together with the marketing mix by introducing it into a limited area of the total market. The purpose is not just to identify and correct possible weaknesses in the product, but also evaluate the marketing mix and estimate the sales potential (Cadbury, 1975).

5.3.3 DERIVED DEMAND

As opposed to consumer products, industrial products are faced with what is called a derived demand (Hutt and Speh, 1989, p. 6). This may have important additional implications for having the products tested by users. Industrial products are bought by industrial customers and used for the production of either consumer products or other industrial products; sometimes industrial products are incorporated in consumer products (for instance, electronic integrated circuits are bought by a

manufacturer of consumer electronics and used as components for a video recorder). When the use of an innovation by the industrial customer results in changes in his own end product, as illustrated by the case of Packitt (Case 2), the manufacturer cannot confine himself to having only his own customers test the innovation. In these situations, the manufacturer should take care that his customer's customers are involved as well, since they indirectly influence the acceptance of the innovation. In other instances (as in the case of Grenco (Case 5)), the customer testing the innovation will take the initiative himself and test his changed end product with his own customers before he decides whether or not to purchase the innovation.

This aspect of derived demand is of importance:

a. when the innovation is used for the production of the end product and results in changes in the product's characteristics (e.g. a numerically controlled production machine),
b. when the innovation is used as a component of the end product and thus changes its characteristics (e.g. a transistor),
c. when the innovation is sold in combination with the end product (e.g. a packaging) and
d. when use of the innovation offers the opportunity of producing completely new products (e.g. a new process installation).

5.3.4 PRODUCT CHAMPIONS

An innovation is a new product that represents a change. To the user it represents a change from using one kind of product to using another. This new product may be technically complex and require adaptation from the people that have to use it. To the manufacturer, the innovation may represent a new production technology that disrupts the normal course of activity. Due to the product's innovativeness, potential customers could be reluctant to buy it or become convinced of its superiority. The change represented by an innovation is accompanied by uncertainty, which relates to

a. its technological functioning (it is uncertain whether the innovation will be technically feasible),
b. its yield (the financial returns are difficult to estimate at the start of the development process),

c. the costs (the total development costs can only be estimated very roughly) and
d. the time span (at the outset it is not clear how long the process will take).

This uncertainty is even increased in the case of technically complex innovations.

People, as well as organizations, try to resist that change and uncertainty. For an organization a certain amount of resistance against change is not only normal, but even desirable. Without it an organization would continually be put on another track and be unable to function optimally. To overcome this inner resistance to innovations, someone within the organization has to feel strongly committed to the new product. According to Schon (1963, p. 84), the following pattern is often observed:

1. at the outset, the innovation encounters sharp resistance from within the organization,
2. to overcome this resistance, the innovation is strongly promoted,
3. for the introduction, promotion and development of the innovation, informal communication channels are used and
4. in most cases, one man emerges as champion of the innovation.

Such a person is not only important at the start of the innovation process, as suggested for example by Chakrabarti (1974, p. 58), but also plays a crucial role during later stages. For example, when the attention within the organization to the innovation project diminishes or problems concerning the development crop up which lead to costs higher than those originally estimated. To prevent potentially successful projects from being terminated prematurely, a person is needed who continues to believe in the project despite the initial setbacks.

This central person is often referred to as a product champion and defined as an individual who is intensely interested and involved in the overall objectives and goals of the innovation project and who plays a dominant role in many of the interaction events through some of the stages, overcoming technical and organizational obstacles and pulling the effort through its final achievement by the sheer force of his will and energy (adapted from a Materials Advisory Board study, 1966). He believes in the potential of the project, shows total commitment and is willing to take risks for the sake of the innovation. This

identification with the innovation often goes far beyond the requirements of the job. For many of them the price of failure means professional suicide. To accentuate their strong commitment to the innovation they are called 'crusaders' by Davidow (1986, pp. 150-152) and decribed as follows: "They are easy to spot. They're the ones with fire in their eyes and blood on their swords."

Our investigation shows that we can distinguish between two different kinds of product champion. The buyer's product champion is someone within the potential buying organization who is convinced of the innovation's use and potential (for instance in Case 3 (Dräger): a specialist who is enthusiastic about the ease with which patients can be monitored). His enthusiasm and belief in the new product can act as the driving force behind the buying organization's interest in the innovation. He spends a lot of time trying to convince his superiors to try the new product and, at a later stage, when there may be some problems, to keep the project going. According to Gemünden, buyer's product champions "are very influential, but they show a janus-face. On the one hand they are partners in developing and implementing an innovative solution, advocates who sell a product in the buying organization, fund raisers who look for the money, and allies against opponents to innovation. On the other hand they demand more problem-solving support, bargain harder, and interact more intensively with competitors" (Gemünden, 1985, p. 146). The seller's product champion is the person within the manufacturing organization who motivates people inside the company to keep investing (not just money, but time and energy as well) in the new product (for example in Case 5: the managing director of Grenco who co-developed the new technology). Both kinds of product champion fulfil the same role: to establish and maintain the organization's interest in the innovation project.

Product champions can be characterized as occupying central positions in both formal and informal networks and using them extensively (for example influential engineers). Many studies have argued that top management support has a positive influence on the success of the innovation. From this it can be concluded that we can distinguish between

a. a product champion by power, who is influential because of his hierarchical position within the organization (Case 4 (Nedap): in one particular instance the access-control system was bought because

the director was charmed by the advanced technology; a less sophisticated solution would have functioned just as well), and

b. a product champion by know-how, who is able to exert influence because of his specific expertise (Case 3 (Dräger): the specialists had a strong position since they were the only ones able to evaluate the medical aspects of the new monitor) (Gemünden, 1985, p. 141).

Referring to the two types of product champion mentioned above, an organization can have the following product champion structures.

1. A know-how-based structure: a product champion by know-how is able to exert influence, but is rather restricted by the absence of power based on his hierarchical position (Jervis, 1975, p. 23). This makes him/her less interesting to sales representatives of the seller.
2. A power-based structure: a product champion by power has great opportunities for influencing the project, but is dependent on others for its technical aspects. Since he is in a position to authorize expensive purchases, he offers the seller more opportunities. However, due to his lack of expertise, he is also very dependent on the problem-solving abilities of the seller.
3. A tandem structure: the combination of a product champion by know-how and a product champion by power offers many opportunities, especially within large organizations. This seems the ideal structure, because it combines the problem-solving capabilities of the product champion by know-how with the authority to make decisions of the product champion by power.
4. A personal-union structure: both types of product champion combined in one person can be highly effective and is found especially in smaller firms (for instance the director/owner of a small company).

The concepts presented above can be recognized in the individual cases, as summarized in Table 5.1. It clearly demonstrates the existence of product champions. The less complex products show either no product champion at all (Ammeraal) or only a product champion in the selling organization who bases his influence on his hierarchical position (Packitt). As the innovation becomes more complex (a) product champions can be discerned at the buying organization as well and (b) their influence is no longer solely based on power; specific expertise starts to be relevant too. The most complex innovation investigated offers strong evidence of the importance of having a product champion at both

FIRMS / PRODUCT CHAMPIONS	AMMERAAL	PACKITT	DRÄGER	NEDAP	GRENCO
AT THE SELLER:					
1. Product champion by power	o	+	n.a.	+	++
2. Product champion by know-how	o	o	n.a.	+	++
3. Product champion structure	o	power-based	n.a.	tandem	personal union
AT THE BUYER:					
1. Product champion by power	o	o	+	+	+
2. Product champion by know-how	o	o	+	+	++
3. Product champion structure	o	o	personal union	power-based or know-how based	personal union

o product champion (structure) not in evidence
\+ product champion in evidence
++ product champion strongly in evidence

Table 5.1 The occurrence of product champions in the individual cases.

the selling and buying organization (Grenco). The quality of the personal relationship between both product champions strongly influences the success of the innovation project. The importance of product champions has also been demonstrated by Rubenstein et al. (1976, p. 18) who reported that "an overwhelming majority of the projects studied indicated that certain individuals had played (often informal) roles in their initiation, progress and outcome". A recent study by Ettlie (1986) showed that the most important factor for a successful implementation of advanced industrial products was the supplier-user relationship, while the existence of a product champion at the user was mentioned as a separate factor in explaining its success. Chakrabarti (1974, p. 59) compared forty-five cases of new industrial products and found a strong correlation between the presence of a product champion and the eventual success of the new product (Table 5.2).

In a study of the development of applications software, Voss (1985b, p. 126) found that the development and commercialization stages often had separate champions. The results of his study also indicated a positive relationship between the existence of a product champion and the success of the new product. Finally, Kuczmarski (1988, p. 264) went

	NUMBER OF RELATIVELY SUCCESSFUL CASES	NUMBER OF LESS SUCCESSFUL CASES	TOTAL
NUMBER OF CASES WHERE THE PRESENCE OF A PRODUCT CHAMPION WAS IDENTIFIED	16	1	17
NUMBER OF CASES WHERE A PRODUCT CHAMPION COULD NOT BE IDENTIFIED	1	27	28

Table 5.2 Identification of a product champion in forty-five cases.

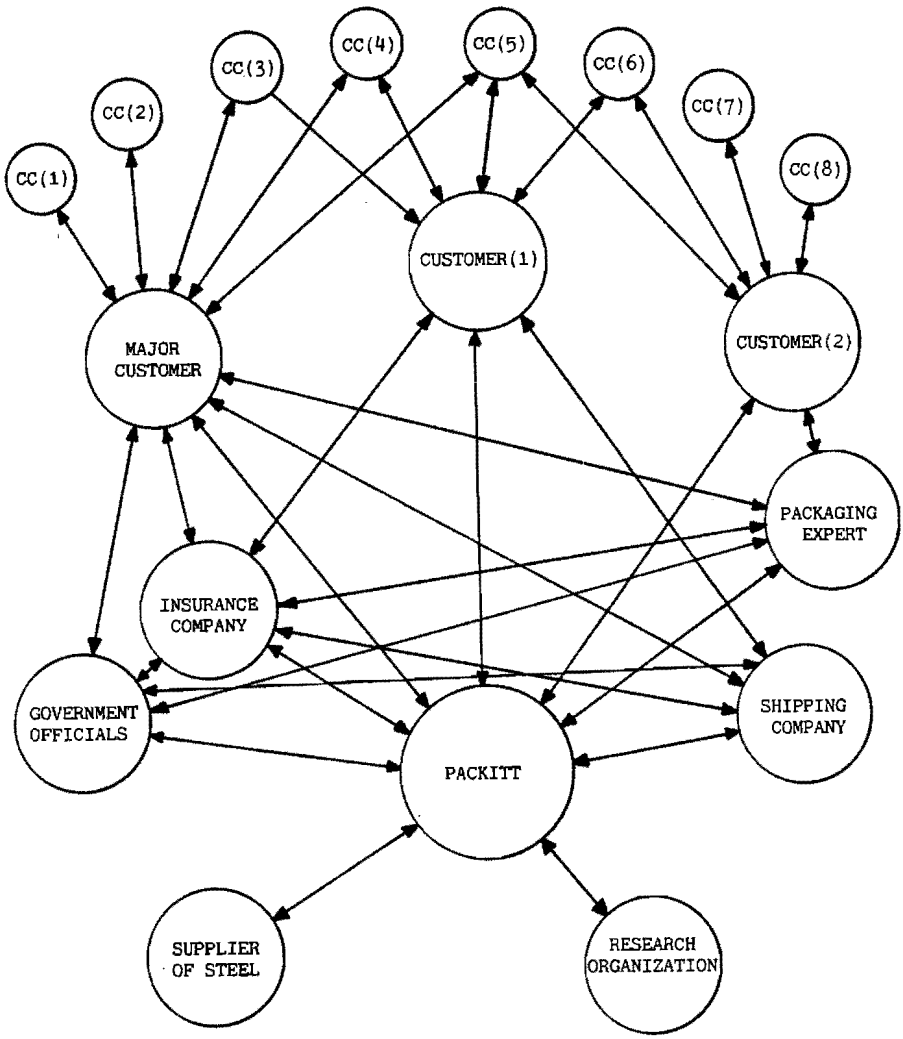
Source: A.K. Chakrabarti, 'The Role of Champion in Product Innovation', California Management Review, Winter 1974, p. 59.

so far as to conclude that "the importance of a product champion to the success of new product development cannot be overstated".

5.3.5 NETWORKS

The cases described in this chapter stress the relevance of the network concept. Due to the derived demand of industrial products, several parties may be involved in the product development process and/or the purchasing decision and complicated networks may be the result. Take, for example, the network concerning the development, adoption and diffusion of a relatively simple product like a steel drum (Figure 5.6). Packitt developed the new drum because of problems ventilated by major customers. The prototype was tested internally as well as by an external research agency. After having been successfully tested by a shipping company, the product was introduced into the market. Apart from these major parties, a number of other persons/organizations influenced the eventual market acceptance:

a. insurance companies, who may lower the insurance premium because the new drum results in less damage,
b. government officials, who draw up regulations as regards the transportation of dangerous chemicals,



CC(i) : customer's customer i

Figure 5.6 The parties involved in the development, adoption and diffusion of a new steel drum.

c. packaging experts, who are consulted by Packitt, insurance companies, government officials and major customers and
d. the customer's customers, who must be able to handle the new steel drum as well.

As already indicated in this chapter, the last-named category is very important in industrial markets and should be involved in the product

development process (for example during concept testing or testing a prototype).

When we take a look at a very complex innovation, such as the extremely complex process installation developed by Grenco in close cooperation with a major customer, we find a network consisting of essentially the same elements as the one described above. In this specific situation, both the customer's customers and the manufacturer's suppliers play a crucial role, thus stressing the importance of indirect relationships even more (Biemans and De Vries, 1988, p. 46).

All other cases exhibit elements of networks as well, while the importance of specific parties within individual networks depends on the circumstances and situation involved. In the Ammeraal network the key customers are clearly the most important counterparts, while distributors and original equipment manufacturers also have a role to play. The network in which Dräger functions is completely different. In this case, which described the market acceptance and diffusion of an innovation within the medical community, opinion leaders are of great importance. Product diffusion is accelerated by demonstrating the innovation to leading hospitals that have a positive influence in the market (such as university hospitals and specialized regional hospitals). The case of Nedap hardly shows the operation of a network, contrary to what would be expected, considering the complexity of the access-control system. Nevertheless, the product is successful because it offers the customer unique product benefits that cannot be matched by competitors (yet).

5.3.6 MARKETING OF KNOWLEDGE

The marketing of technically complex industrial innovations involves much more than the marketing of a mere new product. Apart from the physical product, considerable attention should be paid to the knowledge embodied in the innovation as well. This knowledge component plays a role during all stages of the product development process.

When jointly developing an innovation with a major potential customer (e.g. Case 5: Grenco), the marketing starts early in the product development process, namely when the manufacturer selects a potential customer. Both the manufacturer and the customer are expected to invest in a project whose outcome is uncertain; they do not know whether the

innovation will function and be commercially interesting. Thus, the manufacturer is in effect marketing a solution that has not even been developed yet. The quality of the buyer-seller relationship at the individual level and the extent to which mutual trust is successfully developed greatly influence the success of the collaboration and continue to play a central role during the product development stage. However, as the development process continues, attention shifts from a vague subjective feeling of trust to a more objective evaluation of each other's contributions to the project (Vollering, 1986, p. 8). From the customer's point of view, confidence and trust refer to the feeling of certainty that the manufacturer will do what he promises and spare no effort, that his claims with respect to his product and service can be accepted without serious question and that he can be counted upon to go all out to give aid in emergencies (Alexander, 1969). These assurances may more than offset significant price concessions offered by less trustworthy suppliers. The manufacturer must earn this confidence either by good performance over a long period of time or the display of extraordinary commercial skills. On the other hand, from the manufacturer's perspective, confidence refers to the feeling of certainty that the customer will do his stint of the duties, share in the total costs of the project and demonstrate continuing commitment by devoting the time, manpower, money and energy to the project that it requires. This dominating influence of trust, confidence and integrity has been noted with respect to existing complex products too. Davidow (1986) argues that, as high-tech products are becoming more and more alike and at the same time incomprehensibly complex, the manufacturer is increasingly obliged to differentiate on the basis of other characteristics than the product itself. The key ingredient in selling the product is no longer the product itself, but the direct relationship between the customer and the seller.

The innovation's knowledge component is also of importance when testing a prototype with potential users. The manufacturer who intends to have a technically complex innovation tested by product users should make sure that they are, at the very least, familiar with the way it works. Neglecting to educate the users concerning the product's correct operation may significantly reduce the usefulness of the test results.

Naturally, close attention should be paid to the knowledge embodied in the innovation during market introduction and subsequent selling. When potential customers are confonted with an innovation that is based

on a new advanced technology, they will have difficulty in evaluating the offered advantages and opportunities. Therefore the manufacturer must try to translate the innovation's technological characteristics into quantified benefits and present them to the real decision makers within the Decision-Making Unit (Berry (1980) calls this 'managing evidence'). For example, Grenco supplied potential customers with detailed calculations that showed the savings in costs which could be realized by implementing the new technology in their specific situation. The necessary numbers were obtained by detailed study of the customer's operations. Confidence and trust, based on the buyer-seller relationship and the seller's commercial capabilities, reputation and image become important factors influencing the purchasing decision. Considering the importance of personal buyer-seller relationships, technically complex industrial innovations place specific demands on the manufacturer's sales representatives. In addition to their commercial skills they should have some technical training, so that they can initiate the buyers into the basic technical aspects of the innovation. At the same time, the manufacturer's engineers should be able to think in commercial terms, in order to be able to communicate effectively with customers during product development. The buying organization, on the other hand, should provide its employees with enough technical background to be worthy interlocutors.

The knowledge embodied in the innovation can even be of importance after the sale. For example, if a potential customer is convinced of the advantages of innovative, complex machinery and decides to use it in his production process, he will be interested in guaranteed future delivery and servicing. If the manufacturer of the innovation is in sole possession of the embodied technology and (for some reason) should go out of business, the buying organization could be in trouble. One way to ensure continued delivery is to contractually arrange for transfer of knowledge in case the manufacturer should be unable to deliver in the future. If this should happen, the manufacturer can be obligated to transfer the knowledge to either the buying organization or a competing supplier.

Marketing of the innovation's knowledge component is quite similar to the more general field of marketing of services. With services as well, the intangibility of the 'product' is of critical importance. As Gelderman and Leeflang (1988, p. 100) point out, a customer orientation in

a service organization can only be effective if its contact personnel is customer oriented. The organization should be involved in 'internal marketing', that is "applying the philosophy and practices of marketing to the people that serve the external customer so that (1) the best possible people can be employed and retained and (2) they will do the best possible work" (Berry, 1980).

5.3.7 TESTING INDUSTRIAL INNOVATIONS WITH POTENTIAL USERS: A TENTATIVE FRAMEWORK

> Men are generally incredulous, never really trusting new things unless they have tested them by experience.
>
> (Niccoló Machiavelli)

In the case descriptions we paid explicit attention to the critical external testing activities. As Leiva and Obermayer (1989, p. 48) remarked, "Evaluation, which must be performed under 'live' conditions using real customers, is a key to minimizing surprises at market entry". The collective experiences of the managers interviewed were used to derive a general framework regarding testing industrial innovations with potential users. The framework (based on Biemans and De Vries, 1987a) consists of nine steps (Figure 5.7), which are briefly discussed.

1. Timing

   The first step concerns determining when the tests by potential users should be conducted (i.e. the timing of the external tests). On the one hand, the external tests should be conducted after the prototype has been tested internally with positive results. At the same time, the external testing stage must be concluded with positive results before full-scale production is started. Conducting the external tests too early entails the risk of testing a product that is not fully developed yet: its characteristics may still change as a result of the internal tests. Starting it too late means running the risk of facing large and costly changes in the production process.

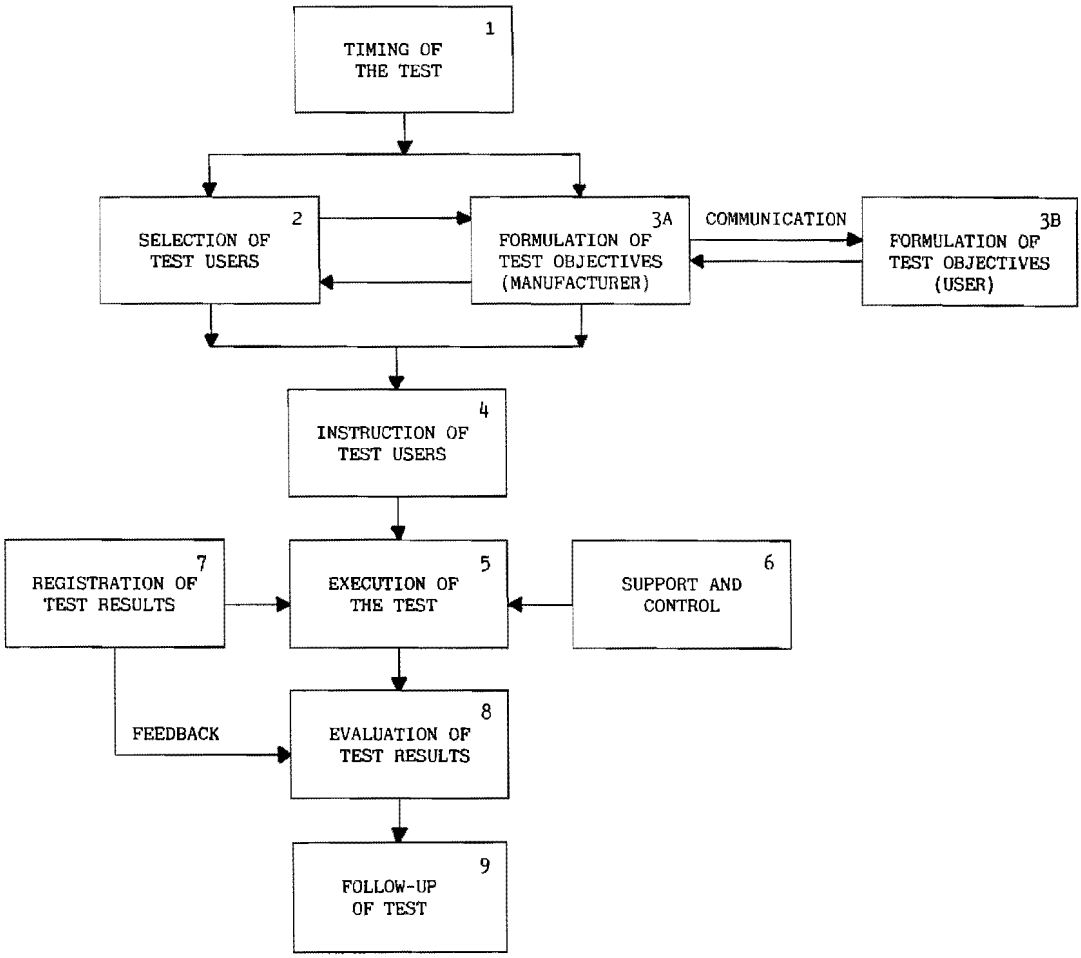


Figure 5.7 A tentative framework for having potential users test a developed prototype.

2. Selection of the test users

Picking the right potential users to test early versions of a product can be critical to the product's ultimate success (McKenna, 1985, p. 77). Ensuring that the selected users are representative of the market segment in question, is of the utmost importance as it determines the managerial value of the test results. In industrial markets, the matter of representativeness may be quite complex. Due to the derived demand, the manufacturer must not limit himself to his own customers when identifying the persons influencing the purchasing decision (Biemans and De Vries, 1987b, p. 35). We asked a

limited number of firms (members of the study group 'Commercialization of Industrial Innovations', including some of the firms described in this chapter) to determine the most important criteria in selecting potential users to test an innovation. As it concerned just a handful of firms, the results of the discussion should be considered indicative rather than conclusive. In order of decreasing importance the following criteria were agreed upon:

(1) objective of the test,
(2) user's representativeness of the specific (segment of the) market,
(3) willingness to cooperate and/or innovation orientation,
(4) market position and/or firm size and
(5) existence of a relationship (Biemans and De Vries, 1987a, p. 28).

The first criterion refers to the distinction between technical and commercial objectives. When the purpose of the test is purely technical, the manufacturer must select a user capable of evaluating the technical performance of the product. In this situation, the representativeness of the user is of minor importance, since the external test is in effect an extension of the technical tests performed in-house by the manufacturer. Afterwards, the innovation still needs to be tested by a number of representative users to test the innovation's functioning in practice. If, on the other hand, the test stresses the commercial aspects, the manufacturer should select users with a positive image and influence in the market. In practice, there is no dilemma in choosing one test objective in preference to the other; in fact, the selection of the test objective is determined by the complexity of the product and situation in question. Frequently, manufacturers try to combine both objectives and need to compromise.

Criterion 3 mentions a combination of the willingness to cooperate and the innovation orientation of the user. It assumes that potential users who are innovative themselves are more inclined to cooperate (Johne, 1984, p. 194). Innovative customers have the added advantage that they often play a central role in the diffusion process (Midgley, 1977, p. 51). The importance of having new products tested by innovative customers has also been observed in

connection with expensive consumer products (Samli, Palda and Barker, 1987, p. 49). The criterion of innovativeness seems to be in contradiction to the demanded representativeness. However, sometimes both criteria can be combined. For example, when a selected innovative customer is representative with respect to a specific application. In other instances, the manufacturer must look for a meaningful trade-off between both criteria.

Market position and size are combined in one criterion because of the obvious relationship between both variables. Sometimes it is advisable to select a large firm that is able to quantify the innovation's advantages, such as reduced maintenance costs.

It is remarkable that the existence of a relationship is only mentioned in fifth place, while in practice this criterion is often given much higher priority (cf. the case of Packitt).

3. Formulation of objectives

Although test objectives must be formulated by both the manufacturer (Step 3a) and the potential users who test the innovation (Step 3b), they do not need to be identical. The manufacturer's objective may be either technical or commercial, while the user may simply wish to keep up-to-date with tehnological developments. Whatever they may be, explicit objectives are necessary to allow for evaluation of the results. To avoid misunderstandings, both the manufacturer and the users should be informed about each other's objectives.

4. Instruction

Even though the actual testing takes place at the customer site, it does not mean that the manufacturer does not need to be involved. Due to the innovative character of the product, the manufacturer may have to give detailed operating instructions to the user in order to prevent negative test results that are in fact caused by incorrect handling of the product. The manufacturer needs to instruct the user on the nature of the various tests to be undertaken, while he should also be familiar with any additional tests performed by the user.

5. Execution

The fifth step of the framework, the actual execution of the market test, is carried out by the test user. However, the manufacturer may be involved indirectly (see Step 6).

6. Support and control

As the external test involves a prototype, there is always the possibility of things going wrong, which can be very serious if the

innovation involves the heart of the user's production process. Therefore the manufacturer is expected to guarantee quick corrective measures. For example, since the belts of Ammeraal are a vital part of the user's production process, the firm guarantees fast replacement of broken or malfunctioning belts and bears all expenses. Under normal circumstances, a representative of the manufacturer could visit the user to check on the progress of the test. Such a regular inspection serves to (a) demonstrate the manufacturer's commitment to the test, (b) check whether the test is actually performed correctly, (c) get a first impression of the test results and (d) encourage the user to mention minor problems.

7. Registration

When the manufacturer is not actually present during the test, it is of the utmost importance that the user (a) knows what to measure and how to measure it and (b) passes the information in the desired format on to the manufacturer. To obtain objective test results it is desirable to have the test users fill in standardized evaluation forms.

8. Evaluation

The test results can only be evaluated when the objectives of the tests have been stated unequivocally. To avoid misunderstandings, the results should be evaluated by the manufacturer together with the test user.

9. Follow-up

The final, and often forgotten, step concerns the follow-up of the test. 'Follow-up' is a general term that can imply many different things. For example, the manufacturer should inform the potential user who performed the test of

a. the general results of the tests performed with other potential users,
b. what will be done with the test results and
c. the termination of the test (naturally, if the user is actually involved in the evaluation of the test results, he will be aware of the fact that the test has ended).

A totally different form of follow-up consists of using the names of the customers who performed the tests successfully, together with their experiences regarding the innovation, in promotional material and sales presentations. It is up to the industrial marketer to take

the initiative in these matters (Webster, 1970, p. 189). McKenna (1985, p. 77) mentions that an impressive customer list can give the company a reputation as an innovator or a technological leader.

The above description could suggest that the individual steps should be taken one after the other. Figure 5.7, however, shows the selection of potential users and the formulation of the test objectives drawn in parallel, since the manufacturer cannot clearly separate these two activities. Consider the following example. When the sole objective of the test is to discover whether the product realizes the specified functions, the manufacturer will select a user who is able to evaluate the product from a technical and functional viewpoint. When, on the other hand, he plans to use the user's name as an important promotional tool at the time of market introduction (the 'launching customer principle'), he will choose a user who is well known in the market and enjoys a good reputation. Small firms that are technologically advanced, but rather unknown in the market, can be used to test the product's functioning but are useless as commercial references. The link between selecting the test users and formulating the test objectives is also expressed by the fact that 'objective of the test' was mentioned as the most important criterion for selecting potential users to test an innovation. Steps 5 (execution), 6 (support and control) and 7 (registration) concern parallel activities, too.

The framework presented above should not be treated as a rigid model, a description of reality that can be used under all circumstances. Clearly, the relevance and content of the steps depend on the specific product and market situation. When a firm introduces a modified product into a market segment in which it has been selling for a long time, the whole procedure will be rather routine. The firm is familiar with the market structure, has relationships with major product users and has probably tested new products with them before. When, on the other hand, a company introduces a very complex and innovative product into a market that is totally new to the firm, it has to conduct a detailed market study both to determine the structure of that market and identify the potential users most suitable for testing the innovation. The framework must be looked upon as a general scenario that offers guidelines to management that will prevent them from overlooking important aspects and will improve their decision making with respect to testing prototypes with potential users.

This chapter presented the tentative conclusions and concepts as a result of a preliminary investigation into five cases of industrial product development. These results will be tested, supplemented and refined by conducting a more extensive follow-up investigation, consisting of seventeen cases of developing innovative medical equipment. The next chapter introduces the field of medical technology.

CHAPTER 6. MEDICAL TECHNOLOGY

The development of innovations for industrial markets has been assumed to take place within networks consisting of individual organizations connected by means of interactive relationships. The case studies described in Chapter 5 demonstrate the existence of networks in various situations and stress the importance of personal relationships. Having prototypes tested by potential users was found to be of major importance to the eventual success of an innovation but lacking a structured approach. Based on the case studies, a tentative framework was proposed to provide practical guidelines to management. To test, supplement and refine the findings of the last chapter, a follow-up investigation was undertaken. The investigation was limited to one specific industry so that the individual cases could be more easily compared and provide more detailed conclusions. To this end, the field of medical technology was considered to be most suitable for several reasons.

a. In the Netherlands, an Advisory Committee on Industry Policy was set up at the beginning of 1981 and published its first report on reindustrialization a few months later (Wagner, 1981). Based on the existence of a home market and the fit with existing industrial activities, expertise and knowledge, the Advisory Committee selected fourteen major areas for special attention, including medical technology. Ever since then, medical technology has been regarded as an area of strategic importance and great potential. An extensive stimulation program was initiated, involving several ministries (Economic Affairs (EZ), Welfare, Health and Cultural Affairs (WVC) and Education and Science (O&W)), research groups and private enterprise (Ministry of Economic Affairs, 1987a, p. 17). The budget provided by the Ministry of Economic Affairs has been 17.5 million guilders per year since 1987. In addition, several other relatively small budgets exist.

b. The field of medical technology has been characterized as one with a relatively high level of innovative activity, thus offering a wide range of innovations for investigation (Shaw, 1986, p. 53; Vanden Abeele and Christiaens, 1987, p. 52). However, Roberts (1989, p. 35)

recently remarked that most of these innovations are modifications of previous products and reflect incremental advances in technology.

c. The market testing stage, which was found to be essential in the preliminary investigation, is of crucial importance with respect to medical technology. Because of the possible direct influence on the patient's health, every new piece of equipment intended for clinical use requires clinical assessment and trial before market introduction. This aspect tends to be unique for the innovation process for medical equipment, which makes it a very appropriate field to study.

d. An empirical investigation of the British medical equipment industry by Shaw (1986, p. 53) showed that "the prime characteristic ... of the innovation process in medical equipment is that there is multiple and continuous interaction between the user and the manufacturer" (emphasis added). (Quite recently, the importance of close contact with a clinical environment was confirmed by Roberts (1989, p. 37). A recent paper by Shaw (1988, pp. 516-517) points to the existence of interpersonal networks, while Beneken (1988, pp. 3-5) emphasizes the crucial role of networks by stating that medical equipment innovations are usually developed through cooperation between a manufacturer, the health sector and researchers.)

e. Due to budgetary constraints, the Dutch public health sector is more and more expected to operate commercially (Commissie Structuur en Financiering Gezondheidszorg, 1987). Although this offers specific opportunities for both directors and medical specialists in hospitals (Van Lammeren, 1987) and can be realized by means of more intensive cooperation with manufacturers and research institutes, the intensity and quality of the relationships between users, manufacturers and research institutes are often found wanting (Ackermans, 1987; Zijlstra, 1985, p. 63; Ministry of Economic Affairs, 1986, p. 15).

f. Since hospitals do not directly compete with one another, purchasing decisions in hospitals are probably strongly influenced by informal communication between buyers (i.e. personal relationships between medical specialists from different hospitals) (Webster, 1971, pp. 187-188). This offers an opportunity to study the diffusion of innovations along with related concepts such as opinion leadership, commercial references, etcetera.

Apart from the major reasons mentioned above, the easy identification of and access to the customer group, the opportunity of comparing non-profit organizations (hospitals) with the industrial firms from the preliminary investigation and the availability of slightly comparable research results pertaining to the UK medical equipment industry (Shaw, 1986) led to the decision to study medical equipment innovations.

After having explained what is meant by medical technology in general, the scope of our investigation is defined. We then proceed to describe the main characteristics of the Dutch market for medical technology. After presenting some of the existing literature concerning the development, adoption and diffusion of medical innovations, the chapter concludes with a section stressing the central role played by networks in this particular field of inquiry.

6.1 MEDICAL TECHNOLOGY: SCOPE OF THE INVESTIGATION

Many definitions of medical technology can be found in the available literature. For the purpose of our investigation we will employ the following description.

> "(Medical technology refers to) the production of all products that can be used for scientific research and medical diagnosis, therapy, treatment, alleviation or prevention of illnesses, or for improvement of the structure or the functioning of the body" (Naastepad, 1983, p. 1).

Strictly speaking, the term 'medical technology' is incorrect, since it does not refer to one specific technology, but rather to a broad spectrum of diverse technologies originally developed in other disciplines (such as imaging techniques, sensor technology, laser technology, biomaterials and informatics) which are used in medical products. Thus, medical technology does not relate to a specific industry but rather to a field of application. Nevertheless, the term medical technology has become widely accepted by researchers, managers, medical specialists and policy makers and will be used here as well.

Most definitions of medical technology (including the one presented above) encompass medical equipment as well as pharmaceutical products and medical supplies. However, pharmaceutical products are very different from medical instruments and involve different development processes (Roberts, 1989, p. 34), while the medical supplies are not complex products. Therefore we will limit our present investigation to medical equipment. According to Nafe (1984, p. 15), who discussed the market for medical equipment in the European Community, the products which come under the general heading of medical equipment can be divided into three main groups, that is diagnostic equipment (75% of the total; 50% of which is X-ray equipment and 50% devices for electrodiagnosis and other component sectors), therapeutic equipment (20% of the total; transfusion and infusion equipment, devices for radiation, ultrasound therapy and diathermy) and instruments (the remaining 5%; dental drills, dialysis and anaesthetic equipment, devices for ophthalmology). Thus, medical equipment refers to a wide range of products, varying from relatively simple disposables to advanced and highly complex instruments such as scanners based on Computer Tomography and Nuclear Magnetic Resonance. This is illustrated by the detailed classification system developed by The National Hospital Institute of the Netherlands (NZI), which distinguishes between 3000 products.

For the purpose of our investigation, we define a medical equipment innovation as a medical instrument that represents a significant (non-trivial) departure from previous patterns of diagnosis, treatment or prevention (based on Bernstein, Beaven, Kimberly and Moch, 1975, p. 86).

Willems (1985, p. 6) groups medical technological products into four categories, based on differences in the purchasing structure.

a. Inventory, storage and consumption articles.
b. Durable products that are not written down (i.e. having a price lower than 1000 guilders).
c. Durable products that are written down (i.e. having a price higher than 1000 guilders).
d. Patient-specific products that leave the hospital together with the patient (pacemakers, prostheses, etcetera).

As the investigation under consideration should be regarded as a follow-up to the preliminary study (the results of which can be found in the preceding chapter), we will focus on relatively expensive

complex innovations, that is the products designated in category C. Even though we limit our investigation to these complex innovations, in the rest of the book they will generally be referred to as 'medical equipment innovations'. The products from categories A and B are excluded as they are not complex industrial products. The special nature of the products belonging to category D can be expected to strongly influence the characteristics of the product development process. Therefore, only one case belonging to this category is included for illustrative purposes.

6.2 THE DUTCH MARKET FOR MEDICAL TECHNOLOGY

In this section we will discuss (1) the size of the Dutch market for medical technology, (2) the number of firms manufacturing complex medical equipment, (3) research and development expenditures and (4) the major characteristics of the Dutch market for medical technology.

6.2.1 SIZE OF THE MARKET

The existence of many different definitions of medical technology leads to problems when estimating the magnitude of the Dutch market for medical technology. Thus, different sources offer varying estimates, depending on the definition used.

Willems (1985, p. 7) estimates the total market volume to be approximately two thousand million guilders per year, a figure that is relatively close to the estimate given by the Ministry of Economic Affairs (1986, p. 13) which mentions that of the total budget of the public health sector (around 35 thousand million guilders per year) roughly 2.5 to 3 thousand million is intended for investments and consumables.

Other relevant estimates are given by the cooperative society 'Het Instrument'. This society of suppliers of instruments distinguishes between four main sectors, that is electronics, industrial automation, laboratory and medical technology, the last named being defined as "instruments and accessories for examination of the patient, for surgery and for therapeutical treatment" (Het Instrument, 1985, p. 6). Het

Instrument claims to provide quite reliable estimates as its members represent at least 90% of the suppliers and more than 95% of the sales in these four sectors. Total sales for 1985 were estimated as 838 million guilders, which had increased by 1988 to 1,044 million guilders, with some reduction expected for 1989 (during the first six months total sales had declined by 0.9%; Het Instrument, 1989). Compared with the numbers given above, these estimates of total sales are much lower, because Het Instrument explicitly excludes some specific categories of instruments, including X-ray machines. X-ray equipment is mainly sold by Philips Medical Systems and Oldelft, the former of which alone represents about one quarter of the activities in the Dutch market for medical technology (Ministry of Economic Affairs, 1986, p. 14). Therefore the estimates given by Het Instrument should be increased by at least 33%.

More detailed sales estimates, that is total sales per specific product category, do not exist since the field of medical technology covers a very broad spectrum of products. Apart from this, many firms operate both within and outside the field of medical technology, while many manufacturing firms realize a significant part of their sales by simply trading in medical products. The matter is further complicated because, due to the small number of sizable manufacturing firms, their anonymity would be affected by detailed sales estimates; for example, the Central Bureau of Statistics (CBS) does not offer information with respect to electro-medical instruments, due to the dominant position of Philips Medical Systems in this field.

6.2.2 NUMBER OF MANUFACTURERS

In the Netherlands there are about 500 firms operating in the field of medical technology. About half of them are trading companies importing medical products. The manufacturing firms comprise Philips Medical Systems (about 2500 employees in the Netherlands), some twenty-five medium-sized firms and a large number of small ones (Ministry of Economic Affairs, 1986, p. 14). Table 6.1 presents the distribution of firms according to the number of employees. Table 6.1 shows that the population of medium-sized firms, the focus of our investigation, is quite limited. However, it should be borne in mind that Table 6.1 refers to firms manufacturing medical technological products instead of complex

NUMBER OF EMPLOYEES	NUMBER OF FIRMS
0 - 9	41%
10 - 19	16%
20 - 49	18%
50 - 99	14%
100 - 199	5%
200 - 499	4%
500 - 749	0%
≥ 1001	1%

Table 6.1 The number of Dutch firms manufacturing medical technological products.

Source: Ministry of Economic Affairs, Stimulerings-programma Medische Technologie (Stimulation Program Medical Technology), June 1986, p. 40.

medical equipment. Therefore the number of medium-sized firms manufacturing complex medical equipment is very small indeed. This has two important consequences. First, assuming that most of the medium-sized firms are willing to cooperate, the investigation can be expected to lead to results with a high degree of representativeness. Second, although Philips Medical Systems is a very large firm, it cannot be excluded from the investigation because of its dominant position in the market. A number of small firms will be investigated as well, so that the results of the investigation can be related to firm size.

It should be noted that there is only limited information available concerning the (number of) firms manufacturing medical equipment. The numbers mentioned above should be regarded as very rough estimates. The Executive Agency for Technology Policy of the Stimulation Program Medical Technology is currently gathering and analysing more detailed data. However, the problem of limited data availability will not be solved easily.

6.2.3 RESEARCH AND DEVELOPMENT EXPENDITURES

In the Netherlands, about 900 million guilders per year are spent on R&D related to health care (which represents approximately 15% of the total research capacity): 500 million by universities and university

hospitals, 200 million by research institutes (for example the Netherlands Organization for Applied Scientific Research (TNO)) and another 200 million by industrial firms (Ministry of Economic Affairs, 1986, p. 17). These sizable investments lead to products that are sold to various buyers, the major customer being the public health sector (R&D institutes 14.5%, industry 1.8%, government 0.8%, public health sector 82.8%; Het Instrument (1985, p. 14)).

6.2.4 MAJOR CHARACTERISTICS

The Dutch market for medical equipment exhibits a number of distinguishing features. The most important of these characteristics will now be described (based on Willems, 1985, pp. 16-22) and their implications for the present investigation discussed.

a. A wide range of products
   As already mentioned, medical technology refers to the application of many diverse technologies to one particular field. The market for medical technological products is made up of hundreds of smaller submarkets, each with its own specific characteristics. This problem of diversity is significantly reduced by limiting the investigation to expensive complex medical equipment.
b. Complexity of product development
   Developing medical equipment innovations involves harmonious cooperation between various complex skills within the organization, such as medical knowledge, technological know-how and marketing expertise. The marketing expertise is usually less developed in (particularly the small) Dutch firms producing medical equipment (Ministry of Economic Affairs, 1986, p. 7). This implies that, where possible, representatives of all relevant disciplines within the organization must be interviewed.
c. Competition by means of product differentiation instead of price
   Since hospital budgets have until recently always sufficed for the purchase of the latest medical equipment, buyers of medical instruments are not very price conscious. This has resulted in competition by means of product differentiation and thus a high level of innovative activity. The investigation will explicitly address the

question whether the price of medical equipment has gained in importance due to increasing budgetary constraints.

d. Limited number of potential customers

The market for complex expensive medical innovations can be characterized by a limited customer base. This means that Dutch manufacturers can produce only relatively small production series and cannot afford to restrict themselves to the Dutch market. Instead, they are in fact forced to export a large percentage of their products. The Dutch market for medical technology displays a double 90/10 situation: while 90% of production is exported, 90% of all purchases is imported (Figure 6.1). This will influence the formulation of product specifications, the selection of cooperation partners, the testing of prototypes, etcetera.

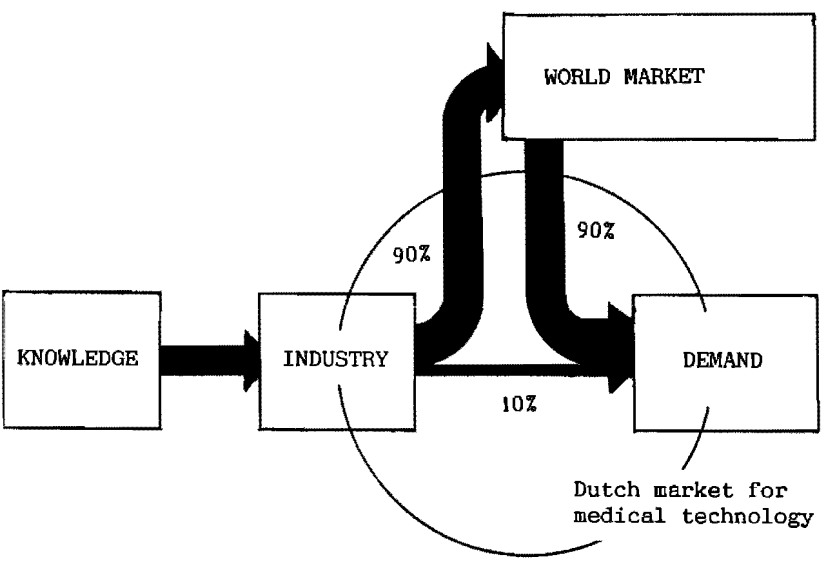


Figure 6.1 Demand and supply of medical technolcgical products.

Source: W. Willems, Marktaspecten Medische Technologie (Market Aspects Medical Technology), University of Technology Delft, Centre Medical Technology, April 1985, p. 16.

e. Extensive regulation

As medical equipment is used by physicians to diagnose and treat patients, it directly involves life and death. The possibly serious consequences of incorrectly functioning medical instruments explains the existence of extensive regulation (see NEHEM (1987) for a discussion of present and future regulation) and the need for clinical

testing before market introduction. Although these regulations differ greatly between countries (Broadhurst, 1984, p. 129), it is generally assumed that the opening up of the European market in 1992 will significantly improve the existing situation.

f. Complex Decision Making Unit at the customer

Many different persons, such as physicians, engineers, purchasers, advisors and members of nursing staffs, may be involved in buying medical products, thus complicating matters for the manufacturer. However, since the investigation focusses on user involvement during the development of complex medical instruments, the parties involved will probably be limited to the physicians (Hutton, 1984, p. 162).

g. Shift from product to service

As regards medical equipment, the focus has shifted from the physical product to the provision of related services, such as maintenance, repair, instruction and training. Although this concerns a fundamental shift of great importance to a manufacturer of medical equipment, our study will focus on the development of physical products. The service aspect will only be taken into account marginally.

h. Importance of relationships

The relationship between the customer and the manufacturer is of crucial importance with respect to developing and selling medical products. The dominant role of these relationships and networks has already been cited as one of the major reasons for selecting the field of medical technology for the present investigation.

i. Compatibility

When the purchase of complex medical equipment is considered, the question of compatibility is often raised. Advanced equipment from one particular manufacturer is in many cases not compatible with that made by a competitor. For example, if most hospitals have equipped their operating rooms with Hewlett-Packard equipment, Philips may have a hard time introducing an innovation that necessitates a switch to Philips hardware. This lack of compatibility increases the demands on the product development process.

6.3 THE DEVELOPMENT, ADOPTION AND DIFFUSION OF MEDICAL EQUIPMENT INNOVATIONS

In the foregoing section we noted that the Dutch market for medical technology has a number of special characteristics. In this section we present some literature on the development, adoption and diffusion of medical equipment.

6.3.1 THE DEVELOPMENT OF MEDICAL EQUIPMENT INNOVATIONS

Although the literature abounds with models describing the process of developing new products (see Chapter 3 for a survey), models dealing with developing medical equipment hardly exist. Roberts (1989, p. 34) provides a general characterization of the process when he states that "innovation in medical devices results by and large from engineering-based problem-solving by primarily individuals or small firms, that is usually incremental in character, that seldom reflects long periods of basic research, and that does not in general depend upon the recent generation of fundamental new knowledge".

The most salient feature of the medical equipment development process appears to be the fact that the end user of the equipment often plays an important role in its initial invention and subsequent development. This fact was first reported by Von Hippel (1976, pp. 220-221), who studied 111 first-to-market innovations (including many medical instruments) in the United States and found a clearly user-dominated innovation process.

More recent studies by Shaw (1986, p. 53) in the UK medical equipment industry and Vanden Abeele and Christiaens (1987, p. 52) in Belgian high-tech firms largely corroborate these findings. Shaw studied a sample of 34 medical equipment innovations from eleven companies, divided into basic equipment innovations, major improvement innovations and minor improvement innovations. The principal conclusion from this investigation is that the medical equipment product development process is characterized by a multiple and continuous interaction between the user and the manufacturer. Of the total sample of 34 innovations, 26 were developed through multiple and continuous user-manufacturer interaction, resulting in 22 being successful, one too early to be judged

and three failures. As Table 6.2 indicates, the multiple user-manufacturer interaction may consist of (a) joint prototype development and product testing and evaluation and marketing, (b) joint prototype development and product marketing, and (c) joint specification and marketing of the product.

Classification of innocations	No.	%	Multiple user—manufacturer interaction					
			Joint prototype testing and product evaluation and marketing		Joint prototype development and product marketing		Joint product specification and marketing	
			No.	%	No.	%	No.	%
Basic equipment innovation	10	29	10	100	8	80	8	80
Major improvement innovation	8	24	8	100	6	75	4	50
Minor improvement innovation	10	29	5	50	3	30	1	10
Failures	6	18	2	33	2	33	0	0
Total	34	100	25	74	19	56	13	38

Table 6.2 Frequency of multiple and continuous user-manufacturer interaction by classification of innovation.

Source: B. Shaw, 'Appropriation and Transfer of Innovation Benefit in the UK Medical Equipment Industry', Technovation, 1986, p. 54.

"The degree of interaction is very high when developing the 'basic' and 'major' improvement innovation. With the 'minor' improvement there is increased likelihood that the manufacturer has the knowledge and expertise to extend the performance of the 'basic' and/or 'major' equipment previously developed or to develop a new piece of equipment which gives the user only a minor increase in utility. However, even here multiple user-manufacturer interaction (albeit not so intense) was found to be necessary to achieve commercial success" (Shaw, 1986, p. 54). The manufacturer gained initial knowledge of the user-invention through a variety of communication channels, such as attendance at conferences, personal contacts with researchers and the perusal of medical journals.

The studies of Von Hippel, together with an early publication of Shaw (1983), led Rothwell (1984, p. 183) to represent the medical instrument product development process as depicted in Figure 6.2. The model clearly shows the intimate involvement of the user in developing medical equipment innovations.

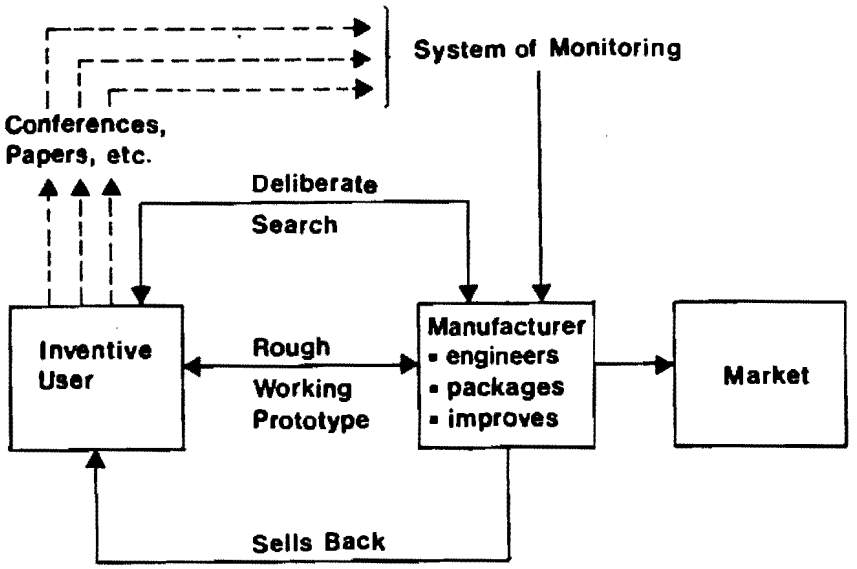


Figure 6.2 The medical equipment innovation process.

Source: R. Rothwell, 'Public Procurement and Technological Innovation', in: The Health Service Market in Europe - Hospital Equipment, R. Rapparini (ed.), Elsevier Science Publishers B.V., Amsterdam, p. 182.

Styles (1984) described some special problems related to the conception, realization, launch and subsequent support of innovative high-technology health care products. The major problems relate to

a. the organization of market research leading to an innovative health care product (the employment of consultants is a much-used method at an early stage of development);
b. the organization of the market tests which, with respect to medical equipment innovations, are usually referred to as clinical trials, while maintaining product security;
c. the choice of manufacturing/quality assurance/performance standards (e.g. IEC norms with respect to the electrical safety of medical equipment) and the satisfaction of all relevant regulations (e.g. Good Manufacturing Practice as laid down by the Food and Drug Administration (Roberts (1989, p. 40); Foote and Mitchell (1989, pp. 149-151) go into the potential effects of extensive regulation);
d. the organization of a successful new product launch (which can only be considered complete when the marketing department has monitored a series of patients being treated or examined with the product, to

ensure that these initial users fully understand the operation of the equipment);

e. the establishment and maintenance of adequate post launch support for the product (e.g. visits by field-support personnel and distributor meetings);

f. the establishment and maintenance of a regular dialogue between supplier and user of the product, which serves to ensure maximum dissemination of information regarding new applications, to generate improvements possible by the incorporation of modifications and to stimulate feedback from users as to the acceptability or otherwise of the product.

To develop complex medical equipment innovations that fulfil customer needs and are commercially successful, firms must combine their technological capability with customer requirements. In the Netherlands, however, firms operating in the field of medical technology have been found to be too technologically oriented; marketing expertise seems to be less developed (Willems, 1985, p. 40). One possible reason is that, although subsidies are granted for technological research and development, there aren't any for market research and development. Small firms and individual inventors, in particular, experience problems in translating their ideas into commercial products. Some centres functioning as knowledge brokers try to assist them by scouting for ideas and people, bridging existing gaps and providing support during the stages of product development.

6.3.2 THE ADOPTION OF MEDICAL EQUIPMENT INNOVATIONS

Most studies on the adoption of medical equipment by hospitals focus on the involvement of different professional groups during the various stages of the purchasing process. Hutton presents a review of hospital purchasing procedures in the countries of the European Community and concludes that "although the organisation and financing of health care systems differ markedly between member countries purchasing procedures were found to be similar in certain aspects" (Hutton, 1984, p. 160). He describes the procurement process as consisting of six stages:

1. identification of need,
2. search for products,

3. evaluation of alternatives,
4. choice of preferred item,
5. budget allocation and
6. procurement authorization.

A possible seventh stage, performance review, would complete the cycle. The way in which each of the stages is carried out and what professional groups are involved, will largely depend on the type of product. The principal professional groups involved are the users (nursing staff, doctors and scientists), advisors (hospital physicists, engineers, users in other hospitals), administrators (finance officers concerned with the operation of the whole hospital) and buyers (procurement officers whose expertise is dealing with suppliers and obtaining secure sources of supply at the lowest cost). According to Hutton, the decision to purchase sophisticated electronic equipment may be taken by one or two medical specialists. He refers to the growing influence of governments when he remarks that "in general the more expensive or sophisticated the item to be purchased, the less freedom is given to individual hospitals to make independent decisions" (Hutton, 1984, p. 160). Concerning these advanced medical instruments, user preference carries the most weight, as it is difficult for the non-specialist to argue with the expert. In the words of Hutton (1984, p. 167), "selection of the make and model of equipment is made by the user and is seldom challenged but whether the equipment is purchased depends on the availability of finance and committee approval". Formal evaluation is seldom undertaken, instead the choice is usually based on the reputation of the supplier and the opinion of colleagues ('peer-review' system). The fact that a physician, during his formal education, has become familiar with medical equipment from a certain manufacturer has a favourable influence on later adoption decisions. For this reason, manufacturers are often willing to supply university hospitals with equipment free of charge (Bennekom, 1987, p. 59).

Another trend observed worldwide is the change from an evaluation of medical equipment per se towards an assessment of the value of the technological procedure, an evaluation known as technology assessment (Arnstein, 1980; Biggs, 1980; Andreasen, 1984, p. 136). Such a technology assessment could assist hospital managers and medical specialists in choosing from among many alternatives (Stolte, 1984, p.

177) and limit the widespread and uncontrolled diffusion of technology of unproven or restricted value (Staehr Johansen, 1984, p. 146).

In studying medical equipment, Foote and Mitchell (1989, p. 156) note that buyers "are more likely to purchase equipment from stable companies. Expensive high-technology equipment requires continuing training and repair. It is no surprise that instability leads to concern about maintenance and repair, as well as access to incremental product advances that can be incorporated into existing equipment".

The situation in the Netherlands seems to correspond closely to the description given above by Hutton. Based on personal interviews with fifteen persons in seven hospitals, Willems (1985, pp. 24-34) concluded that the composition of the Decision Making Unit depends very much on the type of product and the hospital and people involved. While the influence of individual medical specialists is notably large in small hospitals, the larger hospitals generally use multidisciplinary purchasing committees. Of special interest are the members of the purchasing department. In most hospitals all contacts with suppliers' representatives must be established through the purchasing department. In practice, however, it is quite usual for salesmen to contact users directly. Although earlier studies (e.g. Laczniak, 1979, pp. 60-61) have described hospital purchasers as playing a supplementary role in buying medical instruments due to their lack of expertise and medical responsibility, this situation is clearly changing. The purchasing department's professionalization and influence have been found to increase (Willems, 1985, p. 26).

Another major development influencing the involvement of various professional groups within the hospital in purchasing medical equipment is the implementation of a budgeting system per January 1st 1984. Although this external budgeting system places an absolute limit on expenditures per hospital, not all hospitals have set up an internal budgeting system yet. Nevertheless, this will occur in due course, which means that more attention will be paid to the operating costs rather than just the purchase price. Thus, medical specialists are expected to lose part of their influence to financial directors and other administrators. Another consequence of the budgeting system is that hospitals are increasingly leasing rather than purchasing medical equipment (Bennekom, 1987, p. 57).

That the imposed limitations of the new budgeting system can result in creative solutions is demonstrated by the following example (Van der Sluijs and Hogenkamp, 1987). In 1987 it was decided that the government would put no limit to the number of kidney stone pulverisers to be purchased by hospitals. Due to the excessively high costs involved, not many hospitals were expected to purchase these instruments. The heavy investments and the limited budgets of the hospitals led 18 hospitals in one region to cooperate and buy a mobile kidney stone pulveriser. The mobility of the instrument simplifies cooperation between the hospitals involved and allows each patient to be treated in his own hospital. The kidney stone pulveriser was bought by one hospital which subsequently signed individual agreements with all the other hospitals involved. The complete decision process, from initiative to ultimate decision, took less than half a year and demonstrates that, in the absence of government regulation, individual hospitals are able to purchase expensive equipment through cooperation. This solution of sharing an expensive piece of mobile equipment was also suggested for computer assisted tomography (CAT) scanners (Barneveld Binkhuysen and Van Waes, 1988, p. 137) and realized in November 1988 when a number of regional hospitals purchased the first mobile CAT scanner in the Netherlands.

Based on a study of empirically-based literature on organization theory, investment decision theory and buying behaviour, Verzellenberg (1988) developed a supporting model for investment decisions in hospitals. The model contains three major elements, that is (a) content (the requirements to be fulfilled by an investment to be undertaken), (b) procedure (the activities that should be carried out to ensure that the content is realized) and (c) structure (how the activities should be divided between members of the Decision Making Unit and how they should be coordinated). The model was subsequently compared with 36 actual decisions concerning the purchase of medical equipment in four Dutch general hospitals.

6.3.3 THE DIFFUSION OF MEDICAL EQUIPMENT INNOVATIONS

Regarding the diffusion of medical innovations, most studies relate to pharmaceutical products rather than medical equipment. A famous study is the one conducted by Coleman, Katz and Menzel (1966) who studied the

introduction, adoption and diffusion among prescribing physicians in the Midwestern United States in the 1950s. The investigation was remarkable since it used actual data, that is the prescriptions written by the physicians, so that there were no problems concerning recollection and distortion of the facts. The nature of the results made it a landmark study as well, since it determined the existence of effective social networks operative in terms of friendship, as well as professional patterns of advice, consultation and discussion. The investigation showed that there was a definite association between participation by the physician in the medical community and use of the new drug; opinion leaders could clearly be identified. This kind of study has been repeated by other researchers (e.g. Ryan and Murray (1977) who studied the diffusion of a pharmaceutical innovation among Irish physicians), who have generally confirmed the existence of opinion leaders among physicians who are strongly interactive and can be singled out for initial attention in gaining acceptance and usage of a new drug.

As regards the diffusion of medical equipment, various investigators have tried to model the process by estimating functions of various shapes. For example, Schmittlein and Mahajan (1982) applied the maximum likelihood estimation procedure to survey data for four pieces of radiological equipment. Wind, Robertson and Fraser (1982) pointed out that this type of single market forecast may be inappropriate if the market is segmented. They studied diffusion patterns by market segments of the CAT scanner and found that, in general, the segmentation results were superior to the total market results. Thus, Wind et al. concluded that to ignore the difference in diffusion patterns among market segments can lead to wrong predictions concerning the speed of product acceptance, the rate of diffusion and the saturation level. Inappropriate conclusions concerning any of these factors can lead to misguided production, inventory and marketing strategies.

A somewhat analogous line of thinking has been presented by Talaysum (1985), who argues that the number and character of prospective users of a new technology change with the passage of time. He illustrates his reasoning by showing how the CAT scanner was adopted over a period of time by different subpopulations of adopters. One group of adopters followed another as the initial product was improved upon, the functional utility extended and cheaper versions became available. Thus, the ultimate diffusion curve for a technology may be

conceived as the aggregation of a time-separated series of smaller diffusion curves.

Based on interviews with almost 300 physicians in the USA, the United Kingdom and Canada, Greer (1988, p. 17) concludes that the development and introduction of new medical technologies often does not fit with the assumptions of classical diffusion theory. The results of her study led Greer to differentiate between 'formed' and 'dynamic' technologies. While formed technologies are more or less completed products when they are introduced into the market, dynamic technologies are still emerging, still in part ideas and experiments. This distinction is important, since it determines the innovation's diffusion pattern. Formed technologies can be regarded as defined products and diffuse quickly and predictably. Dynamic medical technologies, on the other hand, develop as they diffuse according to a complicated pattern.

In enumerating the most important factors influencing the diffusion of medical equipment, Baruch (1980, p. 46) draws attention to the specific way in which some factors may play a role. For example, the degree of complexity is an oft-quoted factor influencing diffusion. "As equipment complexity increases, teaching hospitals readily adopt it, but the rate of diffusion down through the less sophisticated institutions is impeded by lack of expertise. However, once it penetrates around 50 percent of the market, the equipment ... becomes the general-use standard; consequently, an enormous new force acts upon its adoption by other organizations. Frequently these organizations will buy the equipment, even though they cannot initially cope with its complexity". Baruch (1980, p. 47) concludes that the third-party-payer system has the most positive influence on the speed of diffusion. A comprehensive survey of the various aspects regarding the diffusion of medical technology is presented by Gordon and Fisher (1975).

6.4 THE ROLE OF NETWORKS

Earlier in this chapter we stated as one of the main reasons for selecting medical technology as the field of investigation, the fact that networks seem to play a major role in developing medical equipment innovations. Beneken (1988, p. 3) stressed that, in general, three parties are involved in the development of new medical instruments:

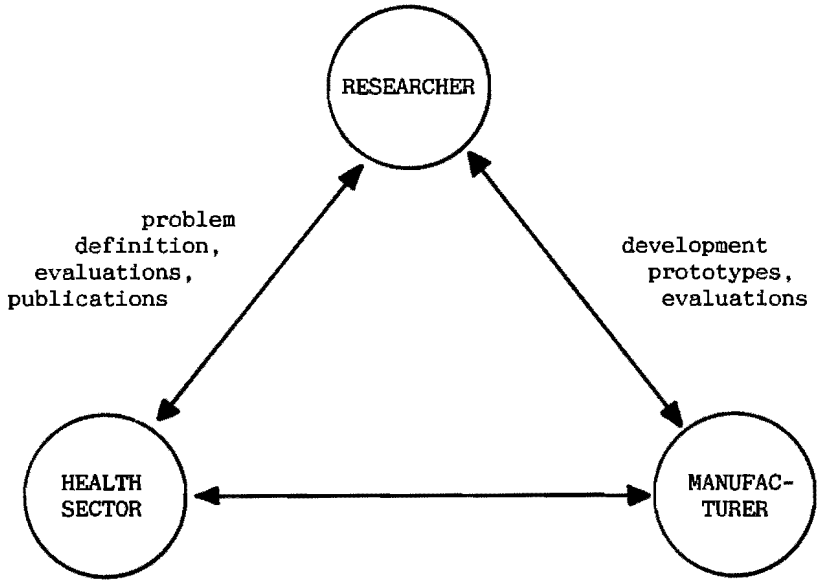


Figure 6.3 The three major parties involved in developing new medical euiqpment.

Source: J.E.W. Beneken, De Problematiek van Communicatie binnen de Medische Technologie (The Problems of Communication in Medical Technology), Paper presented at the WTCE Seminar on Medical Instrumentation and Communication, 14 September 1988, p. 4.

a researcher, a manufacturer and the public health sector (Figure 6.3). If the researcher were employed by the manufacturer the diagram would be less complicated, but the necessity for good communication would remain. Generally, the idea for a new medical instrument originates through an exchange of ideas between an engineer and a physician. If the idea looks promising and sufficient research capacity is available, the problem definition will be translated into a prototype, which will then be evaluated and the results of the evaluation published. Next, the engineer can try to interest a manufacturer in the idea. The manufacturer will analyse the market, build a number of prototypes to test with potential users and decide whether or not to start production. Often the prototype needs to be redesigned owing to the results of the market tests.

Frequently, the researcher from Figure 6.3 will work at a university. In the future, cooperation between universities and industrial firms is expected to increase. Due to increasing budgetary restraints,

the universities are forced to seek external funds, while ever shorter product life cycles force industrial firms to speed up product development processes (Snyder and Blevins, 1986, p. 136). By means of cooperation contracts, universities can assist industry in developing new products (Hise, Futrell and Snyder, 1980; Roberts and Peters, 1982). Therefore we will briefly discuss some of the aspects involved in industry-university cooperation. Cooperation between industrial firms and universities offers advantages to both parties (Dekker, 1986, pp. 8-9). Through cooperation with universities, the manufacturers obtain (a) access to basic and applied research, (b) the opportunity to test prototypes, (c) feedback, such as information for the specification of improved and new products, (d) promotion of a new product among academics and (e) assistance in recruiting personnel. For their part, through cooperation with industry, the universities obtain (a) clear research objectives, which simplifies the comparison of costs and benefits and the acquisition of subsidies, (b) contracts, and thus access to more money and equipment for advanced research, (c) a larger 'critical mass', and thus faster research of higher quality and (d) recognition by 'peers'.

Despite these advantages of industry-university cooperation, the literature mentions some distinct problem areas, too (Azároff, 1982; Dietrich and Sen, 1981; Fowler, 1984; McDonald and Gieser, 1987; Snyder and Blevins, 1986). The most important potential problems relate to

a. publication of research results: while academics want rapid and frequent publication, industry prefers to keep matters secret for some time;
b. patents: industrial sponsors feel that, since they are paying for the research, any discovery rightfully belongs to them; potential disagreements can be overcome by shifting from sponsorship to contract research;
c. performance: industry often criticizes the speed and efficiency with which the universities carry out research;
d. orientation: while universities are interested in broad scientific developments (academic freedom), industry focusses on short-term profits and product improvements;
e. attitudes: differences in attitudes can create a general culture gap and lack of understanding.

Despite these potential problem areas, the consensus appears to be that industry-university cooperation is workable. In most cases, all of the problems mentioned above can be worked out in advance.

We can conclude that the Dutch market for medical equipment appears very suitable for conducting our follow-up investigation. For example, the importance of clinical tests allows us to test and refine the tentative framework for testing prototypes with potential users. Nevertheless, the Dutch market for medical equipment displays a number of typical characteristics that may influence our investigation. For example, the number of firms manufacturing complex medical equipment is not very well documented. Different sources supply us with different numbers, since they are based on different definitions of various key concepts. This complicates assessing the representativeness of the findings. Furthermore, some general trends can be observed which directly affect our investigation. For instance, the increasing cooperation between industrial firms and universities poses special problems in the development of medical equipment, while the changing influence of physicians and purchasers changes the character of the buying process. The next chapter presents the findings from the study of seventeen cases concerning the development of complex medical equipment and addresses all the issues discussed above.

CHAPTER 7. AN INVESTIGATION INTO SEVENTEEN MEDICAL EQUIPMENT INNOVATIONS: CONCEPTS AND FINDINGS

For various reasons outlined in the preceding chapter it was decided to conduct a comprehensive follow-up investigation in the field of medical technology. This second investigation into the development of innovations for industrial markets served three major purposes:

a. testing the results of the preliminary study in one specific industry,
b. supplementing the findings by shifting the emphasis from predominantly simple manufacturer-customer interaction to the functioning of networks, and
c. refining the results of the preliminary investigation (a comprehensive study of a larger number of cases from one specific industry allows us to study the phenomena of interest in greater detail).

Seventeen innovations in the Dutch medical equipment industry were investigated. Brief descriptions and analyses of all individual cases are presented in Appendix C. This chapter will discuss the overall results from a comparison of the individual case analyses. The managerial implications and recommendations will be described in Chapter 8. The discussion of the results with respect to developing innovative medical equipment within networks, as presented in this chapter, is structured as follows. We start by describing the sample and research methodology and continue by defining the concept of interaction which is then analysed according to a number of significant dimensions. Subsequently, some of these dimensions will be used to derive a typology of individual interactive relationships between organizations. This is followed by a discussion of the involvement in product development of manufacturers, users and various kinds of third parties. Owing to the nature of the medical equipment innovation process, specific attention will be paid to interaction between industrial firms and universities. The interaction between manufacturers on the one hand, and users and third parties on the other, leads to the concept of networks. Two different classifications of networks are distinguished and the advantages and disadvantages in developing medical equipment

innovations within comprehensive networks will be examined (resulting in a third classification of networks). The section concludes with a treatment of a number of shortcomings in the development of innovative equipment within networks. The chapter ends with some comments on the adoption and diffusion of innovations in the Dutch medical equipment industry.

7.1 THE RESEARCH

Before discussing the results of the follow-up investigation, the sample and research methodology used will be described briefly.

7.1.1 SAMPLE FRAME

As with the preliminary investigation, consideration of the objectives of the follow-up study led us to conclude that case research would be the most suitable research method. A total of seventeen medical equipment innovations, both successful and unsuccessful, developed and marketed by thirteen firms in collaboration with users and third par

FIRM SIZE	FIRMS		INNOVATIONS			
	No.	Perc.	TOTAL	SUCCESS-FULL	UNSUCCESS-FULL	TOO EARLY TO JUDGE
SMALL	5	38%	7	3	0	4
MEDIUM	7	54%	9	3	3	3
LARGE	1	8%	1	1	0	0
TOTAL	13	100%	17	7	3	7

Small : 50 employees or less
Medium: between 50 and 500 employees
Large : 500 employees or more

Table 7.1 The number of firms and innovations related to firm size.

ties, were studied. Table 7.1 shows how the number of firms and innovations is related to firm size. With respect to firm size, it should be noted that only the number of employees involved in medical equipment is taken into account. For each firm the most recent innovation project

involving a complex piece of medical equipment was studied. The number of cases studied (seventeen) exceeds the number of firms investigated (thirteen) since

a. in two firms there were strong interdependencies between subsequent projects, while
b. one other firm had recently been involved in two interesting and different innovation projects.

The selection of the firms to participate in the investigation was largely based on 'Holland Health Care', an export catalogue of Dutch companies and organizations in the field of health care and medical technology, issued by the Ministry of Economic Affairs. As pointed out in the introduction, "a representative cross selection of ... companies can be found in this catalogue, which presents a fair picture of the wide variety of equipment, products and services available to the various consumer markets both in the Netherlands and abroad" (Ministry of Economic Affairs, 1987b, p. 3). Nine of the thirteen firms investigated were actually selected because of the information provided by the catalogue, while the remaining four firms (three small and one medium-sized firm) were included in the investigation through chance contacts (haphazard sampling). The catalogue mentions another twenty firms which were not included in the investigation, because

a. the products offered by the firms were not complex medical equipment, but medical furniture, rehabilitation aids, nutritional specialties, textiles, plastics, pharmaceutics, lifts, various services, etcetera (sixteen firms), or
b. the time available was limited (four firms).

In order to take part in the follow-up investigation, companies had to satisfy three major criteria. Firstly, they had to be developing, producing and marketing complex medical equipment. Secondly, a substantial part of the development activities had to take place in the Netherlands. And finally, the managers involved should be willing to spend time and effort on a frank discussion of the firm's most recent project regarding the development of a complex medical equipment innovation. Furthermore, the attempt was made to obtain a sample consisting of firms offering widely varying products to widely varying markets. Thus, even though all the firms and innovations investigated relate to the field of medical technology, the variation in the data thus

acquired enhances the significance of the final results. In the course of the investigation only one firm (offering both pharmaceutics and medical equipment), which had initially agreed to take part in the study, decided after three interviews to end their cooperation. The firm, and the limited data already obtained, was further excluded from the sample.

Since the sample of firms that eventually took part in the investigation is largely based on the export catalogue 'Holland Health Care' their claim to representativeness can be adopted. Moreover, the representativeness of the eventual sample was typically confirmed by the managers and industry experts interviewed. Nevertheless, since no hard data on the number and distribution of Dutch manufacturers of complex medical equipment exist (see Chapter 6) no scientifically valid claim to representativeness can be established. Instead, the results and implications should be interpreted as being strongly indicative.

7.1.2 RESEARCH METHODOLOGY

The seventeen cases in the Dutch medical equipment industry were investigated by using practically the same methodology as employed during the preliminary investigation (see Chapter 5). We shall therefore limit ourselves to discussing the main activities insofar as they deviate from those described in Chapter 5.

1. Selecting a manufacturer
   A sample of thirteen firms was selected on the basis of literature and expert interviews.
2. Contacting the manufacturer
   Typically, the person contacted and interviewed was either a marketing manager or R&D functionary. In specific cases a number of interviews with various persons had to be conducted in order to identify and reach the person most closely involved with the most recent innovation project.
3. Interviewing the manufacturer
   See Chapter 5.
4. Studying additional sources of information
   The information obtained through the in-depth personal interviews was supplemented by (a) the incidental study of documents (for

example schematic representations of the product development process, written review procedures, market introduction brochures, product information leaflets, articles and books) and physical artefacts (such as the innovation, mock-ups, test models and simulation devices) and (b) direct observation (for instance of the testing of developed software, discussions between the manufacturer and major customers and the functioning of prototypes at test sites).

5. Interviewing users and third parties
   Subsequently, the potential users and third parties who contributed substantially to the product development process were interviewed. Typically, one interview of two hours, supplemented by a limited number of telephone conversations, proved to be sufficient to obtain the needed information.
6. Reviewing the final results with the manufacturer
   See Chapter 5.

In seven of the thirteen firms investigated, the comprehensive procedure outlined above was followed, sometimes resulting in as many as ten in-depth interviews involving eleven different persons. In the remaining six companies (five of which were small and one of medium size) however, the managers were under extreme time pressure and had only a limited amount of time available. In these cases, the desired information had to be gathered by means of only one personal interview, complemented by a few follow-up inquiries by telephone to obtain additional information. As a final step, all thirteen firms were asked by mail to provide some additional information on the adoption and diffusion of medical equipment. (See Chapter 8 and Appendix F for further remarks concerning advantages and pitfalls of case research as a research methodology.)

7.2 THE RESULTS

The results of the follow-up investigation into seventeen cases of new product development in the Dutch medical equipment industry can be broadly described as falling into two categories. The first consists of concepts covering interaction and networks. The second group embraces the findings as to the extent, ways and effectiveness of involving

potential users and various third parties in the development of innovative medical equipment, as well as the adoption and diffusion of such innovations.

7.2.1 DEFINITION OF INTERACTION

The results presented in this chapter focus on the interaction between manufacturers and users and/or third parties operating in a network. In the context of developing innovations for industrial markets, the concept of interaction refers to an exchange of values between two parties. Although it is essential that both parties transfer values, these need not be of the same kind. For example, a manufacturer may purchase strategic components from a supplier and thus exchange money for products. Or a manufacturer may be required to write detailed reports in order to be granted a subsidy by the national government and thus exchange information for money. The values transferred in the context of an interactive relationship may belong to one or more of the following four categories (cf. Hakansson, 1982, p. 16).

a. Transfer of products/components or services

   Users and/or third parties may provide a tangible contribution to the product development process by delivering specific strategic components or even a complete product (which is subsequently modified by the manufacturer by the addition of a specially developed component). Furthermore, the manufacturer may employ specialized organizations to provide specific services, such as testing developed prototypes, taking care of industrial design, and introducing and marketing the innovation.

b. Transfer of information

   During all stages of the product development process the manufacturer may interact with other parties to obtain information. While at the outset of the development process the information thus obtained will be of a general nature, it will become more specific and better defined as the project continues. The information provided by other parties may refer to such diverse topics as the future needs of a market segment, the technical feasibility of a product concept, a possible solution to an existing technological problem and the functioning of a prototype in actual practice.

c. Transfer of financial resources

Both the national government and scientific foundations may grant subsidies for various purposes, such as fostering industry-university cooperation, stimulating the development of innovations in a specific area or assisting small firms in their product development efforts. In the same way, a manufacturer may sponsor experimental research at a university to stimulate the development of new products or new techniques.

d. Transfer of social content

Social exchange serves the purpose of strengthening an existing bond between two parties or helping to establish a new one. A manufacturer may supply a major customer who tests the first version of a new and complex process installation, with an engineer during one day per week. Not just to assist in the operations, train the operators and solve problems, but also to explicitly demonstrate commitment and create trust, both vital ingredients of relationship management. However, the development of trust also strongly depends on the successful transfer of the other three values.

While an interactive relationship implies the mutual exchange of values between two organizations, the interaction is most successful when both parties derive benefit from the relationship. Mutual benefit and concurring objectives are strongly conducive to a positive outcome. An example is provided by Enraf-Nonius, which frequently cooperates with The Netherlands Organization for Applied Scientific Research (TNO) in the development of specific components and the testing of new products. The evaluative reports of TNO are used by Enraf-Nonius during market launch as support from an independent research institute, while it gives TNO the opportunity to increase its reputation/prestige in international markets.

7.2.2 DIMENSIONS CHARACTERIZING INTERACTIVE RELATIONSHIPS

A large number of dimensions can be used to describe individual interactive relationships between the various organizations involved in product development networks. In this section, we will distinguish between the type, purpose, intensity, duration and extent of formalization of interaction.

7.2.2.1 TYPE OF INTERACTION

In Chapter 4 we distinguished between three different types of interaction depending on the type of counterpart, that is (1) vertical interaction, which includes all interaction between sellers and buyers, (2) horizontal competitive interaction, encompassing interaction between companies which basically are competitors and (3) horizontal complementary interaction, which includes cases of interaction between manufacturers of complementary products. However, our investigation argues the necessity to discern a fourth category, namely (4) diagonal interaction, which contains all cases of interaction between two partners belonging to two different systems. This distinction is particularly relevant with respect to instances of extensive technical cooperation between the parties involved. The cases of industry-university cooperation that were studied illustrate the point: the inherent differences between the scientific world of the university and the commercial reality of the industrial firm formed the underlying factor accounting for most of the problems and frustrations that occurred during the process of product development.

7.2.2.2 PURPOSE OF INTERACTION

Depending on the purpose of interaction, we can divide individual interactive relationships into two categories. The objective of the interaction can be either to perform or stimulate specific development activities. Two organizations may interact in order to perform specific development activities jointly (e.g. jointly drawing up product specifications) or separately (e.g. when an industrial supplier lets an original equipment manufacturer (OEM) conduct the external tests). In other instances, interaction between two parties may be initiated to stimulate specific development activities, for example through (a) sponsoring of experimental research at a university by an industrial firm, (b) granting of credits by the government to stimulate industry-university cooperation, and (c) granting of subsidies by the government or scientific foundations in order to stimulate industrial firms to develop specific new products.

7.2.2.3 INTENSITY OF INTERACTION

Looking at interactive relationships from the manufacturer's viewpoint, a third relevant characteristic is the intensity of interaction, which may vary widely. While in some cases the interaction may consist of no more than an ad hoc visit in order to gather specific information, other interactions may amount to an extensive cooperation project to jointly develop and market a new product. Thus, as regards the intensity of interaction, individual interactive relationships may be classified in six separate categories, running from 'use as reference' to 'joint performance of activities'.

1. Use as reference
   The diffusion of an innovation can be facilitated by using the names and reputations of users and/or third parties as references during market introduction. Frequently, the organizations used as reference also allow potential buyers to inspect the innovation at their premises.
2. Passive acquisition of resources
   The manufacturer may obtain relevant resources (mostly information) as input to the product development process in an ad hoc and passive way. For example, during a visit of a sales representative, a major customer may mention some significant problems with an existing product and offer some suggestions for a solution. Another example involves the manufacturer who is approached by a university researcher with an idea for a new product or a crudely put together home-made device.
3. Active acquisition of resources
   In contrast with the previous category, the manufacturer may acquire resources, such as general information or money, by means of a planned process governed by predetermined objectives. The most common example is any kind of market research by the manufacturer, such as the systematic interviewing of a selected group of major customers in order to determine future product requirements. Other examples include a number of visits to major research centres to assess the latest trends in technology, the sponsoring of experimental research at a university, or the application for a subsidy in the context of a stimulation program from the national government.

4. Response, feedback on specific issues
   Major product users and important third parties may also be approached in order to obtain response on specific issues. For example, users may be asked to evaluate a tentative product concept, while a specialized research institute may be approached to assess the technical feasibility of a new product idea.
5. Separate performance of specified activities
   Certain clearly defined activities are often conducted by users or third parties instead of by the manufacturer. One of the most obvious examples is the testing of a prototype by a potential user. Others include the industrial design by an outside agency, the production of strategic components by a major supplier, and the introduction and marketing of the innovation by a distributor.
6. Joint performance of specified activities
   Finally, the manufacturer may decide to jointly perform certain specified activities with a customer or third party. Examples involve the manufacturer and major customer who jointly develop and test a prototype, and the manufacturer and OEM who jointly formulate the product specifications.

Defined like this, the intensity of interaction can be measured as an ordinal variable consisting of six categories, with increasing intensity representing increasing commitment of the parties involved. Because of the nature of the interaction, the first two categories may be termed passive interaction, while the others are examples of active interaction.

Some of the categories enumerated above are closely intertwined. Consider the use as a reference of a major customer or university at the time of market introduction. This practice only makes sense when the customer or university in question has been involved in previous product development activities, such as developing and/or testing a prototype (i.e. 'separate performance of specified activities').

Naturally, there are several gradations within each separate category as well. For example, the case of Medlab illustrates how a firm increased the extent of its sponsoring as the project gained strategic interest. The case of AIR shows how a firm decreased its sponsoring activities. After having concluded the development project, AIR did not totally terminate the sponsoring of experimental research at the Dutch University but continued to supply funds, albeit a minimal amount. This

provided AIR with direct access both to existing knowledge and new scientific developments. Granovetter (1973) has stressed the importance of such weak ties and, describing the various functions and advantages of weak ties, writes about 'the strength of weak ties'. While strong ties, that is intensive and comprehensive relationships, may be used to mobilize external resources for the firm's product development, weak ties perform an important function as communication channels. A company can have a large number of weak ties, since they do not demand large resources as strong ties do. Weak ties are mostly used in order to receive information from different areas. With the help of weak ties a firm can cover very large areas without making large investments of time and money. Therefore weak ties should not be considered substitutive but rather complementary to strong ties. A final important function of weak ties is that they are potential strong ties. For example, a firm sponsoring experimental research at a university may increase its commitment and the amount of money as the research starts to pay off in the form of newly developed original designs that are of interest to the firm.

7.2.2.4 DURATION OF INTERACTION

A fourth variable to characterize individual interactive relationships is the duration of interaction. Depending on the purpose and intensity of interaction, the duration varies from short (e.g. a one-hour visit) to long (e.g. a three-year contract). The duration of interaction can be measured in two distinct ways: (a) the number of time periods or (b) the number of product development activities. While both measures are certainly correlated, they need not be identical. Due to technical problems and continual setbacks (occurring problems that force the firm to go back to previously completed product development activities), the joint development of a prototype by a manufacturer and a major customer may cover a prolonged period of time but only a limited number of product development activities.

A single visit to a customer to see whether there are problems with existing products and a one-hour visit to a university to obtain specific technological information are both examples of interaction of a short duration. An extensive joint development project with a major customer covering several years is positioned towards the other end of

the continuum. Another example of a longer-term interactive relationship concerns the firm and the university hospital which have signed a contract according to which the hospital contributes to the development activities of the firm (for example by commenting on new product ideas, evaluating product concepts, testing prototypes and promoting the product through publications and lectures) in exchange for equipment and salaries of researchers. However, contracts of this kind can usually be terminated from year to year, depending on the strategic interests of the firm and the desired direction of research at the university hospital (cf. the cases of Sentrex and Medlab).

7.2.2.5 EXTENT OF FORMALIZATION OF INTERACTION

In addition to the characteristics discussed above, the extent of formalization of interaction may be used to describe individual relationships between organizations. One should take care not to equate the distinction between formal and informal interactions with the difference between very intensive and less intensive forms of interaction. Very close collaborations between two firms involving the joint development of expensive process equipment may initially be based on trust, confidence and individual commitment, while detailed contracts are only drawn up at a later stage (cf. the case of Grenco from Chapter 5). An obviously less intensive form of interaction, such as the granting of specific credits by the national government, may require the filling out of comprehensive application forms and the formulation of extensive evaluation reports and thus be very formal indeed! These bureaucratic procedures, combined with a relatively low chance of actually receiving such credits, may impede the application for such credits by small firms (as was mentioned by the president of Applied Laser Technology and confirmed by industry experts during a workshop on The Transfer of Knowledge to Small and Medium-Sized Firms, Eindhoven University of Technology, 2 March 1989).

7.2.2.6 INTERRELATIONSHIPS BETWEEN THE FACTORS

The dimensions characterizing individual interactive relationships discussed above are not totally independent. Although universally applicable statements can hardly be made, some general trends can be observed (Table 7.2).

DIMENSION OF INTERACTION	TYPE OF INTERACTION			
	VERTICAL	HORIZONTAL COMPETITIVE	HORIZONTAL COMPLEMENTARY	DIAGONAL
PURPOSE	P	P	P	P/S
INTENSITY	low-high	high	high	low-high
DURATION	low-high	high	high	low-high
EXTENT OF FORMALIZATION	low-high	high	high	low-high

P: the purpose of the interactive relationship is to perform development activities
S: the purpose of the interactive relationship is to stimulate development activities

Table 7.2 The relationship between the type of interaction and the purpose, intensity, duration and extent of formalization of interaction.

When we compare the type of interaction with all other dimensions involved, we find that most types of interaction aim at performing specific development activities. The goal of stimulating specific development activities is more characteristic of diagonal interactions, where, for instance the government stimulates innovation programs or an industrial firm sponsors experimental research at a university. The intensity, duration and extent of formalization of interaction depend very much upon the specific case involved (as is illustrated by the cases described in Appendix C). Nevertheless, the horizontal types of interaction are typically more project oriented and therefore more intensive, covering a longer period of time and tend to be more formalized (that is, based on comprehensive cooperation contracts with respect to clearly defined activities to be performed within the context of one specific project; cf. Hakansson (1987a, p. 7) and the case of AIR).

7.2.3 CLASSIFICATION OF INTERACTIVE RELATIONSHIPS

The type, purpose, intensity and extent of formalization are all dimensions that may be used to characterize individual interactions between two organizations during one stage of the product development process

(i.e. a limited number of product development activities). For example, during the idea stage, a manufacturer may interact with a number of important customers in order to generate ideas for potential new products. Or, during the testing stage, a manufacturer may interact with a research institute to have his developed prototype tested. However, the cases investigated show that, in reality, an interactive relationship between two organizations need not be limited to one particular stage and may very well cover several stages of the development process (i.e. a large number of product development activities). For example, when a manufacturer selects a major customer to jointly develop, test and market a new product.

The findings of the investigation suggest a quite complex relationship between the dimensions 'intensity' and 'duration' of interaction. The complex nature of the correlation between the two factors can be illustrated as follows. As previously suggested, the intensity of interaction will be measured along a continuum consisting of six categories. The duration of the interaction will refer to the number of product development stages involved; three categories, i.e. low (one stage), medium (two or three stages) and high (four or more stages), are distinguished. Both dimensions can be combined to construct a matrix consisting of eighteen cells. The complex correlation between the two dimensions can be graphically displayed by, for each of the cases investigated, positioning within the matrix all major interactive relationships between the manufacturer and users and/or third parties (Table 7.3). In Table 7.3 the cells containing numbers represent combinations of the dimensions intensity and duration of interaction that were actually found during the investigation. As is clearly shown, not all the matrix cells are filled. Three different reasons may be suggested for the occurrence of empty cells.

a. Owing to the definition of terms, certain cells may represent improbable combinations of the dimensions 'intensity' and 'duration'. For example, the use of a major customer as a reference was found to be inherently connected to one particular stage of the product development process, namely the launch.
b. Due to the nature of the sample, certain combinations may be probable but not found in practice. Consider the combination 'response, feedback on specific issues - medium duration'. Although this combination was not actually found, a manufacturer may very well use a major customer or research institute to provide response

INTENSITY OF INTERACTION	DURATION OF INTERACTION		
	LOW (1 stage)	MEDIUM (2-3 stages)	HIGH (≥4 stages)
USE AS REFERENCE	1,3,6,7, 8,13,14, 15,17		
PASSIVE ACQUISITION OF RESOURCES	2,3,4,5, 7,8,9,11, 12,13,15		
ACTIVE ACQUISITION OF RESOURCES	2,6,8, 11,15, 16,17	16	
RESPONSE, FEEDBACK ON SPECIFIC ISSUES	1,5,6,7,8, 10,11,13, 15,16		
SEPARATE PERFORM-ANCE OF SPECIFIED ACTIVITIES	1,3,5,6,7, 8,9,13,14, 15,16,17	4,5,7, 8,12	4,7, 10,11
JOINT PERFORM-ANCE OF SPECIFIED ACTIVITIES	1,4,7,8, 9,11,14, 16	12,16	

improbable combinations

probable combinations that were not found in practice

combinations that were simply not found in practice

Table 7.3 Individual interactive relationships positioned on the dimensions 'intensity' and 'duration' of interaction (the numbers refer to the cases).

to both a product concept and an initial version of a prototype (during the development stage). Something similar holds for the situation in which, for instance, a manufacturer and a major customer jointly perform a considerable number of stages.

c. The remaining cells represent combinations that were simply not found in practice. While these combinations are not inherently impossible, they are less likely to occur. For example, although passive acquisition of resources is bound to be limited to only one stage, this need not necessarily be the case. Similarly, it would not be logical for a manufacturer to use a major customer to provide

response to specific issues during a large number of product development stages. Instead, a more intensive interaction would probably be more efficient.

In turn, the graphical representation of the correlation between the intensity and duration of interaction can be used to generate a classification of interactive relationships between manufacturers and users and/or third parties. Consideration of all filled cells (plus the cells representing a combination characterized as very probable) leads us to distinguish between two major categories: single-level and multiple-level interactive relationships.

7.2.3.1 SINGLE-LEVEL INTERACTIVE RELATIONSHIPS

The first category consists of single-level interactive relationships between two organizations, that is relationships involving only one level of intensity. The single-level interactive relationships are divided into five classes, running from the passive acquisition of resources to the joint performance of activities, embracing comprehensive projects in which a manufacturer and a major customer jointly generate, develop, test and market an innovation, for example. The various classes are ranked in order of increasing commitment of the parties involved. Each class is illustrated with some examples from the cases investigated.

1. A single-level interactive relationship consisting of the passive acquisition of resources used as input to the product development process.
   a. A major customer mentions some problems with existing products to a manufacturer's sales representative.
   b. An important inspection agency informs the manufacturer of its changed evaluation criteria.
2. A single-level interactive relationship involving the active acquisition of resources used as input to the product development process.
   a. A manufacturer periodically visits (for instance twice a year) a major customer or important research institute to stay in touch with noticed significant developments.

b. A manufacturer interviews a number of important customers, industry experts, distributors and competitors to find out about future product requirements.

c. A manufacturer applies for and obtains subsidies or credits from the government or scientific foundations.

d. A manufacturer sponsors experimental research at a research institute, by (partly) paying the salaries of researchers and/or providing services, equipment, etcetera to stimulate the development of relevant new techniques, products and/or processes.

3. A single-level interactive relationship in which the manufacturer obtains response, feedback to specific issues during the process of product development.

   a. A manufacturer uses a research institute to test the characteristics of its existing products.

   b. A manufacturer visits major customers, distributors, industry experts or important research institutes to obtain response to a concrete new product idea or product concept.

   c. A manufacturer shows a mock-up (for example an empty box) at a trade show to obtain response from product users to the product concept.

   d. A manufacturer shows a prototype at a trade show to obtain response from product users.

4. A single-level interactive relationship in which the manufacturer employs other parties for the separate performance of specified activities during the process of product development.

   a. A manufacturer uses customers to test a prototype under actual conditions.

   b. A manufacturer employs a distributor to launch and market the new product.

   c. A manufacturer uses a customer to formulate the product concept, and develop and test a prototype.

   d. A manufacturer contracts a university to solve a specified technical problem and test the solution.

5. A single-level interactive relationship consisting of the joint performance of specified activities during the process of product development.

   a. A manufacturer and major customer jointly formulate a product concept.

   b. A manufacturer and major customers jointly develop (part of) a prototype.

7.2.3.2 MULTIPLE-LEVEL INTERACTIVE RELATIONSHIPS

The second category of interactive relationships between two organizations consists of relationships involving more than one level of intensity. Numerous individual multiple-level relationships can be constructed by combining different levels of intensity of interaction. We can distinguish between two different kinds of multiple-level interactive relationships.

1. An interactive relationship in which different levels of intensity of interaction are realized at different stages of the product development process. A number of examples actually encountered during the investigation are enumerated below.
   a. A manufacturer jointly formulates the product concept with an OEM and uses the OEM to test a prototype, formulate the marketing plan and introduce and market the new product.
   b. A manufacturer and major supplier jointly formulate a product concept, develop and test a prototype, and finalize the design, after which the supplier produces a strategic component.
   c. A manufacturer is approached by a major customer with a new product idea, after which they jointly assess the potential of a new product idea and formulate the product concept, and separately develop and test parts of the prototype.
   d. A manufacturer is approached by university researchers with a home-made device and uses the researchers during the development stage to address specific issues.
2. An interactive relationship in which different levels of intensity of interaction are realized during (at least) one stage of the product development process. Although this type of multiple-level interactive relationship has not actually been encountered in the course of the investigation it is not theoretically precluded. For example, a manufacturer may employ a major customer to jointly develop a strategic component and separately develop some other less important product features.

7.2.4 INVOLVEMENT OF MANUFACTURERS, USERS AND THIRD PARTIES IN PRODUCT DEVELOPMENT

Having addressed the issue of how to define interaction and what characteristics to use in describing individual interactive relationships between organizations, we will now turn to the following central questions.

a. During what stages of the product development process may a manufacturer benefit from interaction with other organizations (timing of the interaction)?
b. What kinds of organizations are most eligible as collaboration partners (selection of interaction partners)?

7.2.4.1 INTERACTION STRATEGIES

In answer to these two questions, let us first discuss how the firms investigated generally interact with other parties during the process of product development (Table 7.4). For the purpose of this discussion, the product development process will be conceptualized as a series of seven subsequent stages, that is idea, preliminary assessment, concept, development, testing, trial and launch (see Chapter 3, Figure 17 and Appendix A).

As can be gathered from Table 7.4, potential product users and research institutes were most often mentioned as interaction partners. Almost three-quarters of the firms investigated (69%) reported to interact with users during the development process. Product users were mentioned as predominantly involved in generating product ideas, testing prototypes and launching the final product. Research institutes (including universities) were mentioned by 38% of the firms as important interaction partners. Due to their specialized knowledge, their contribution was reported to be most evident during the actual development of the prototype. The important role ascribed by the firms to product users and research institutes is further illustrated by the fact that only one firm mentioned another important party involved in the product development process, viz. distributors. Finally, as three of the firms investigated were only recently founded, nothing definite could be stated about their interaction strategies.

INTERACTION PARTNERS	NUMBER OF FIRMS TOTAL No.	Perc.	SMALL	MEDIUM	LARGE	INVOLVEMENT IN THE STAGES OF THE PRODUCT DEVELOPMENT PROCESS IDEA	PR.AS.	CONCEPT	DEVEL.	TESTING	TRIAL	LAUNCH
(POTENTIAL) USERS	9	69%	1	7	1	+	+	+	+	+++	-	++
RESEARCH INSTITUTES	5	38%	0	4	1	-	-	+	+++	+	-	-
OTHER PARTNERS	1	8%	0	1	0	+	+	+	-	-	-	+
AS YET UNKNOWN	3	23%	3	0	0							

small : 50 employees or less
medium: between 50 and 500 employees
large : 500 employees or more
PR.AS.: preliminary assessment
DEVEL.: development
- : the interaction partner is not involved
+ : the interaction partner is involved
++ : the interaction partner is strongly involved
+++ : the interaction partner is very strongly involved

Table 7.4 General involvement of interaction partners in the product development process (the percentages refer to the fraction of the total number of firms, N=13).

7.2.4.2 REALIZED INTERACTION

To answer the central questions posed at the beginning of this section in more detail, we will discuss the actual contribution of various organizations to the product development process, as studied in seventeen individual cases. We will distinguish between three major parties: the manufacturer, potential users and a group of organizations termed 'third parties'. Users and third parties have been investigated insofar as they contributed substantially to the development activities.

Table 7.5 summarizes for all seventeen individual cases the involvement of the various parties in the process of product development. It should be noted that Cases 2, 3, 4 and 5 all consist of two partly overlapping development processes.

The information contained in Table 7.5 has been condensed to percentages describing the involvement of the manufacturer, potential users and third parties in the product development stages (Table 7.6).

In the rest of this section we will describe the contribution of the various parties to the product development process. After having discussed both user and third party involvement, the major differences between manufacturer-user and manufacturer-third party interaction will be analysed.

7.2.4.2.1 MANUFACTURER INVOLVEMENT IN PRODUCT DEVELOPMENT

In six out of the seventeen cases studied (i.e. 35%; viz. Cases 2, 3, 4, 5, 7 and 13) users and/or third parties dominated the initial stages of the product development process while the manufacturer became the dominant party during the actual development of the prototype. In more than half of the cases investigated (53%) the product development process was initiated by a user or third party. However, as the development process proceeds manufacturer involvement quickly increases to 100% (Table 7.6).

Regarding the involvement of manufacturers in the process of product development we would like to comment on Von Hippel's observations with respect to such 'user-dominated' innovation processes. Von Hippel (1977b, p. 13) states that in such a process

CASES	STAGES OF THE PRODUCT DEVELOPMENT PROCESS						
	IDEA	PR.AS.	CONCEPT	DEVEL.	TESTING	TRIAL	LAUNCH
1	M	M	M+U+T	M+U	M+U	M	M+U
2	T	T	T	T	T	-	-
	-	-	-	M	M	-	-
3	T	T	T	-	-	-	M+T
	-	-	M	M	M+U+T	M	M+T
4	T/U+U	T/U	T/U	T/U	T/U	-	-
	-	T+U	M+T	M+T	M+U+T	M+T	M+U+T
5	U+T	U+T	U+T	U+T	U+T	-	-
	-	M	M	M+T	M+U	M	-
6	M	M+U+T	M+U	M+U+T	M+U+T	M	M+U+T
7	U+T	M	M+T	T	M+U+T	M	M+T
8	U	M+U	M+U	M+U+T	M+U+T	M	M+T
9	U	M	M+U	M	M+U	M	M
10	M	M	M+U+T	M+T	M+T	M+T	M+T
11	M+U+T	M+U	M+U+T	M+T	M+T	M+T	M+T
12	U	M+U	M+U	M+U	M+U	-	-
13	U	M	M+U	M	M+U+T	M	M+U+T
14	M	M	M+T	M	M+T	M	M+T
15	M+U	M+U	M+U	M	M+U	M	M+U
16	M+U+T	M+U+T	M+U+T	M+U+T	-	-	-
17	M	M+U	M	M	M+U	M	M+U

PR.AS.: preliminary assessment
DEVEL.: development
M : manufacturer
U : potential user
T : third party
T/U : university linked to a university hospital

Table 7.5 Involvement of the manufacturer, potential users and third parties during the process of product development.

STAGES OF THE PRODUCT DEVELOPMENT PROCESS	INVOLVEMENT OF MANUFACTURERS, POTENTIAL USERS AND THIRD PARTIES								
	NUMBER OF CASES	INVOLVEMENT OF THE MANUFACTURER		INVOLVEMENT OF POTENTIAL USERS		INVOLVEMENT OF THIRD PARTIES		INVOLVEMENT OF POTENTIAL USERS + THIRD PARTIES	
		No.	Perc.	No.	Perc.	No.	Perc.	No.	Perc.
IDEA	17	8	47%	10	59%	7	41%	5	29%
PREL. ASS.	17	14	82%	9	53%	6	35%	4	24%
CONCEPT	17	16	94%	12	71%	10	59%	6	35%
DEVELOPMENT	17	16	94%	7	41%	9	53%	5	29%
TESTING	16	16	100%	12	75%	11	69%	7	44%
TRIAL	14	14	100%	0	0%	3	21%	0	0%
LAUNCH	13	13	100%	6	46%	9	69%	3	23%

PREL. ASS.: preliminary assessment

Table 7.6 Involvement in product development of the manufacturer, potential users and third parties (the percentages refer to the fraction of the number of cases as stated in the first column).

"it is the initial user who perceives the need for the product innovation, conceives of a solution, builds a prototype device, proves the value of the prototype by using it and diffuses detailed information ... to other potential users and to firms which might be interested in manufacturing the device on a commercial basis. Only when all of the above has transpired does the first commercial manufacturer become active in the innovation process. Typically, the manufacturer's contribution is to perform product engineering work on the user's device to improve its reliability, convenience of operation etc. ... (and to) ... manufacture, market and sell the innovative product".

The findings of our investigation do not support these observations. As can be gathered from Table 7.6, while manufacturer involvement was found to be only 47% during the idea stage, it nearly doubles (to 82%) during the subsequent preliminary assessment stage and increases even more (to 94%) during the concept stage. It is during these stages that the manufacturer defines and assesses the value of the new product idea. After having undertaken these critical initial development activities, the manufacturer typically needs to modify the user-developed original design considerably. In specific instances, these modifications may go beyond performing mere product engineering and may entail redefining the product concept and its operating principles (cf. Case 13: Ultrolab). Furthermore, in four out of the six cases in which users or third parties dominated the initial stages of the product development process, the manufacturer admitted to having spent insufficient

resources on these initial development stages. In their opinion, more proficiency during these initial stages could have prevented many problems and shortened the whole development process.

In the literature, the importance of these predevelopment activities, consisting of

1. generating and screening ideas,
2. undertaking a preliminary market and technical assessment, and
3. identifying, developing and testing the concept,

has been stressed as well. These initial stages have been described as the pivotal steps in the product development process since "it is these early stages where success and failure are largely decided" (Cooper, 1988, p. 237). Cooper and Kleinschmidt (1986) studied 203 industrial product launches and found that the proficiency with which activities, such as initial screening, preliminary market and technical assessment and detailed market study were undertaken was strongly correlated with the eventual success of the innovation. As Leiva and Obermayer (1989, pp. 46, 48) put it: "Do your homework, especially early in the product development cycle ... More work at the definition phase of the project always translates into savings of both time and money as the project nears completion".

Therefore the differences between Von Hippel's findings and the results of the present investigation may only be partly explained by differences in sample composition (Von Hippel's comments are based on the study of 111 scientific instruments which include many medical instruments). Irrespective of the industry concerned, Von Hippel's reasoning should be expected to severely underestimate the necessary involvement of a manufacturer in the initial stages of the process of product development. For, even when a manufacturer is approached by a user with a home-made device that has been built, tested and used in practice, the manufacturer needs to carry out the critical initial stages of the product development process.

7.2.4.2.2 USER INVOLVEMENT IN PRODUCT DEVELOPMENT

The second major party of interest in the context of developing innovations for industrial markets consists of the potential users of the innovation. We speak of 'potential' users, since the product is still

under development and has not been introduced yet. Nevertheless, sometimes the product/prototype is actually used by a customer. For example, an expensive piece of medical equipment (such as Magnetic Resonance Imaging equipment) may be used by a hospital for two years. During the first six months the basic equipment is tested, while the remaining period is used to test newly developed clinical programs and minor additions to the basic hardware. Therefore, the terms 'potential users' and 'users' will be used interchangeably.

In this chapter the term 'users' will refer to the people/organizations using the innovative medical equipment. In the vast majority of the cases the users are medical specialists working in a hospital. The only exceptions are Enraf-Nonius (Cases 7 and 8) and Medsound (Case 14). In the Netherlands, many of the physiotherapists using Enraf-Nonius equipment work in a hospital. The majority, however, works in the private sector, that is in a group practice consisting of from two up to twenty persons. In other countries a different structure and different trends may exist. The physiotherapists working in the private sector are clearly different from the ones working at hospitals: the former are more oriented towards costs and benefits of equipment rather than ways of treatment and can make quicker decisions regarding the purchase of new equipment. A similar situation exists for the users of Medsound's equipment.

By involving potential users in the process of product development, the manufacturer may (a) develop a product that better fits user needs, (b) shorten the duration of the total development project and (c) accelerate market acceptance of the product.

As has been found by numerous researchers (see Chapter 4), users may be involved in many stages of the product development process. The results of our own investigation support these observations. Table 7.6 indicates that potential users were found to contribute to all but one stage of the product development process (namely the 'trial' stage, which consists of finalization of the design, trial production and finalization of the marketing plan). Their contributions consisted of

1. suggesting a new product idea (either directly or indirectly by criticizing existing products),
2. providing general information on user requirements,
3. commenting on formulated new product concepts,
4. assisting in the development of prototypes,

5. testing developed prototypes and
6. assisting in the marketing of the innovation.

Predevelopment stages

The cases investigated show varying ways of user involvement at the predevelopment stages (that is, the idea, preliminary assessment and concept stages). In 59% of the cases, potential users were involved in idea generation through the formulation of problems encountered with existing products, the suggestion of concrete improvements or the generation of a new product idea. In 53% of the cases, potential users were somehow involved in the preliminary assessment stage, while in 71% of the cases they were involved in the concept stage either by defining or testing the product concept. (However, these numbers include the one case (Case 2) in which the manufacturer was not involved in the predevelopment stages.) From a manufacturer's viewpoint, user involvement during the predevelopment stages in these cases was frequently less than optimal. Taking a closer look at the individual case studies reveals that this suboptimal situation was typically caused by

a. a limited number of users involved, (quantitative user selection) and
b. the absence or arbitrariness of the selection criteria (qualitative user selection).

FIRM SIZE	NUMBER OF USERS			
	NONE	ONE	≤ FIVE	≥ SIX
SMALL	2	2	1	2
MEDIUM	0	4	1	3
LARGE	0	0	0	1
TOTAL	2	6	2	6

small : 50 employees or less
medium: between 50 and 500 employees
large : 500 employees or more

Table 7.7 The number of users involved in the manufacturer's predevelopment activities (quantitative user involvement).

Table 7.7 shows that, in the majority of the cases investigated (i.e. ten out of sixteen, or 63%) only a limited number of potential users (or none at all) were involved in the critical predevelopment stages by

the manufacturer. At the same time, in only eight cases (57%; Table 7.8) potential users were selected on the basis of such well-considered criteria as the available expertise or representativeness (however, in one of these cases the user selected because of the supposedly present knowledge was eventually found not to possess that knowledge after all). In four cases (29%) it was the user who took the initiative for the first contact (and no real selection took place), while in the remaining two cases (14%) the manufacturer selected the potential user(s) because of (a) present knowledge in a related field, (b) existing relationships or (c) chance contacts.

FIRM SIZE	SELECTION CRITERIA		
	NO SELECTION	ARBITRARY	CONSIDERED
SMALL	2	1	2
MEDIUM	2	1	5
LARGE	0	0	1
TOTAL	4	2	8

small : 50 employees or less
medium: between 50 and 500 employees
large : 500 employees or more

Table 7.8 Criteria used for selecting users during the predevelopment activities (qualitative user involvement).

Development stage

The involvement of users in the actual development of a prototype (41% of the cases) typically consisted of assisting in the actual development activities or in providing feedback to developers in the industrial firm and answering specific questions. In some instances the original design of the new product was developed by a user (cf. Cases 2 (Eye-Tech), 4 (AIR), 5 (ALT) and 13 (Ultrolab)).

The fact that the original design of innovative medical equipment is developed by a university linked with a hospital is generally considered by industry to be a major advantage. Thus the innovation can be developed by engineers with ready access to a clinical environment. The direct and intensive dialogue between engineers and physicians is assumed to result in a high quality product. During the actual development stage, new improved versions of the original design can continuously be tested by physicians on real patients. Both the physicians

and the engineers are motivated to cooperate closely, since the tests may be used to generate scientific research results and publications and thus to increase the prestige of the institute, the department and the individual scientists. Nevertheless, developing an original design within a clinical environment may have some potential disadvantages as well. When an original design is developed within a university linked with a university hospital, actual user involvement in the development activities is nonetheless often quite limited. This 'user involvement paradox' can be explained as follows. Although the original design may be developed through an intensive dialogue between engineers and physicians, typically only a few physicians are actually involved in the development activities. Therefore industrial firms should address the question whether the results thus obtained are representative of the market segment in question. In the case of Eye-Tech this evaluation resulted in the decision to terminate the development project, since the market segment held insufficient potential for profit. The case of Ultrolab exemplifies how the evaluation led to significant changes in product specifications and to new development activities initiated by the manufacturer in order to satisfy the requirements of a wider market.

Theoretically, the initially limited involvement of users can be corrected by having other hospitals test the original design as well. In practice, however, this ideal situation is not easily realized. For example, in the case of AIR, problems arose since the physicians held on to all existing units of the developed original design in order to experiment and publish profusely. Thus they were able to maintain a monopoly on publications and it became virtually impossible to test the various versions of the original design in other university hospitals. This situation also interfered with an efficient transfer of the original design from the Dutch University to AIR.

Testing stage

The market testing stage is of crucial importance to medical equipment innovations. Because of the possible direct influence on the patient's health, every new piece of equipment that is intended for clinical use, first needs clinical assessment and trial. Therefore it is not surprising that the majority of the firms investigated involved users in product development by testing a developed prototype (75% of the

cases). Only about half of the firms investigated employed comprehensive clinical evaluation protocols or evaluation forms. Potential users to test new equipment were mostly selected because of their assumed medical expertise, an existing relationship and their position in the market. In a minority of cases the geographical proximity was mentioned as an additional selection criterion (see also the section on shortcomings during the product development process).

Launch stage

In 46% of the cases, users were found to be involved in the launch of the innovation. This finding is consistent with the fact that 'commercial potentialities' was very frequently mentioned as a criterion for selecting users to test a newly developed prototype. Nevertheless, many firms neglected to fully capitalize on the available opportunities with respect to employing users during market introduction. The most frequently used mechanisms for involving users in marketing the innovation were demonstration of the new equipment to other potential users, functioning as references, presenting scientific papers at both national and international conferences and promotion of the product among colleagues. In one case a user, who had tested a prototype, actually set up a business to market the innovation in one particular country.

7.2.4.2.3 THIRD PARTY INVOLVEMENT IN PRODUCT DEVELOPMENT

Various kinds of third parties were found to be involved in the product development process. The third parties encountered during the investigation include distributors, universities (quite often linked with a university hospital), research institutes (e.g. The Netherlands Organization for Applied Scientific Research (TNO), an organization consisting of thirty-five specialized institutes), government agencies (various ministries), scientific foundations (e.g. The Technology Foundation (STW), a government organization established to finance research projects), competitors, suppliers, original equipment manufacturers, consultants and inspection agencies (e.g. the German Technischer Uberwachungsverein).

The principal contributions of third parties to the product development process consisted of

1. influencing cooperation strategies,
2. funding user and manufacturer research,
3. providing market information,
4. providing engineering skills and specific technological knowledge,
5. providing specific services, such as industrial design,
6. testing of developed prototypes,
7. producing strategic components,
8. carrying out specific marketing-related activities, such as having the prototype tested by customers and introducing the product, and
9. assisting in the diffusion of the innovation.

Excepting the studies of Mantel and Rosegger (1987), who studied the role of third parties in the diffusion of innovations, and Shaw (1988) who drew attention to some of the mechanisms mentioned above, third-party involvement in the process of product development has received little attention. Our investigation indicates that this overlooked aspect of innovation may be critical to the successful development of new products for industrial markets: third parties performed key activities for more than half (64%) of the products that were actually launched on the market. These critical activities consisted of developing the original design, formulating the product concept, solving major technical problems, developing, testing and producing strategic components, and launching and marketing the final product.

Predevelopment stages

Unlike users, third parties were found to actively participate in all stages of the product development process (see Table 7.6). They contributed to the predevelopment activities by generating and screening new product ideas (41% of the cases), providing both commercial and technical information (35% of the cases) and generating and evaluating new product concepts (59% of the cases). Although distributors, universities and research institutes were the third parties most frequently employed during these stages, other less obvious and often overlooked third parties may provide significant information too. For example, one manufacturer commented on the use of competitors during the preliminary assessment and concept stages: "Because of existing personal relationships and by using subtle interview techniques, competitors can be induced to provide significant market and technical information".

In one specific case, a third party was found to determine the cooperation strategy of a university which had developed a first prototype. Since the original design was found to function and the innovation appeared to be of interest to a wider market, the university applied for a subsidy. An external foundation provided the funds necessary for further development on condition that the university would search for a Dutch industrial firm to manufacture the product. Because of this stipulation, a cooperation contract with an obvious, but foreign, manufacturer was out of the question.

Development and testing stages

Third parties were also found to contribute substantially to the development (53% of the cases) and testing (69% of the cases) activities. Regarding these stages of the product development process their contribution usually consisted of supplying highly specialized technological expertise, developing clearly defined parts of the new product, solving specified technical problems and performing specific technological tests. Third-party involvement at the testing stage includes the case of a university that develops an original design and tests it before transferring it to an industrial firm.

In four of the cases investigated (24%) a university contributed substantially to the development of a functioning prototype, while in another case an industrial firm cooperated with a university in formulating the product concept. In addition, there were numerous instances of cooperation with universities in order to develop parts of the product, to test prototypes, to solve technological problems, etcetera. The cases of industry-university cooperation point to some major causes of coordination problems (which are discussed in the section on shortcomings during the product development process; see also Appendix D).

Trial stage

In 21% of the cases investigated, third parties were involved in the trial stage of the product development process. In two cases this refers to a major supplier manufacturing part of the product and thus carrying out the trial production as well. A third case involves an original equipment manufacturer who markets the innovation and therefore formulated the final marketing plan too.

Launch stage

Finally, in nine cases (69%) third parties were involved in the launch stage by

a. assisting the manufacturer in marketing the innovation (in seven cases), or
b. manufacturing strategic components of the product (in two cases involving one small technology-oriented firm).

7.2.4.2.4 DIFFERENCES BETWEEN MANUFACTURER-USER AND MANUFACTURER-THIRD PARTY INTERACTION

Although the data in Table 7.6 indicate that both users and third parties contribute substantially to the process of product development, the percentages provide only a quantitative indication of their involvement in the product development process. Moreover, the percentages demonstrate that in 53% of the cases the new product idea is generated and evaluated by users and/or third parties, while in a number of cases they perform the preliminary assessment (18% of the cases) as well. In one case the manufacturer was not even involved at the concept stage either. In these cases (some of) the predevelopment stages are undertaken by a user or third party before a potential manufacturer is even approached. Thus, the percentages offer only limited (quantitative) information about the involvement of manufacturers, users and third parties during the stages of the product development process and fail to furnish information regarding the interaction between the manufacturer on the one hand, and users and/or third parties on the other. The numbers in Table 7.6 indicate that there is no significant difference between the quantitative involvement of users and third parties during the product development process. (Even only a mild correction for continuity results in a chi-square of 3.512 at six degrees of freedom, this being well below the critical value and thus leading to rejection of the hypothesis that differences exist.) Nevertheless, there is a great difference between manufacturer-user interaction and manufacturer-third party interaction during product development. The difference can be illustrated by taking a closer look at how the intensity of interaction (providing qualitative information) varies during the stages of the product development process.

The intensity of the interaction can be measured along the continuum presented earlier in this chapter. For each case the intensity

of all major individual interactive relationships was subjectively assessed by the researcher for each relevant stage of the development process (Table 7.9).

CASES	STAGES OF THE PRODUCT DEVELOPENT PROCESS													
	IDEA		PREL.ASS.		CONCEPT		DEVELOPMENT		TESTING		TRIAL		LAUNCH	
	U	T	U	T	U	T	U	T	U	T	U	T	U	T
1	0	0	0	0	6	4	4	0	4/5	0	0	0	1	0
2	0	2	0	0	0	0	0	3	0	0	-	-	-	-
3	0	2	0	0	0	0	0	0	5	5	0	0	0	1/5
4	2	2	0	0	5	5/6	5	5	5	5/5	0	5	6	5/6
5	2	2	0	0	0	0	0	5	4/5	5	0	0	-	-
6	0	0	3	3	4	4	5	5	5	5	0	0	1	1
7	2	4	0	0	0	6	0	5/5	5	5/5	0	5	0	1/5
8	2	0	3	0	4	0	6	5	5	5	0	0	0	1
9	2	0	0	0	6	0	0	0	5	0	0	0	0	0
10	0	0	0	0	4	4	0	5	0	5	0	5	0	5
11	2	2	3	0	6	4	0	5	0	5	0	5	0	5
12	2	0	6	0	6	0	5	0	5	0	-	-	-	-
13	2	0	0	0	4	0	0	0	5	5	0	0	1	1
14	0	0	0	0	0	6	0	0	0	5	0	0	0	1
15	2	0	3	0	4	0	0	0	5	0	0	0	1	0
16	3	3/6	3	3/6	3/6	3/6	4	5	-	-	-	-	-	-
17	0	0	3	0	0	0	0	0	5	0	0	0	1	0

PREL.ASS. : preliminary assessment
U : potential user
T : third party

Table 7.9 Intensity of manufacturer-user and manufacturer-third party interaction during the product development process (the intensity of interaction being measured on a six-point scale).

Figure 7.1 presents the occurrence in percentages of each level of intensity of interaction at each product development stage. As is demonstrated by the percentages, the intensity of interaction varies dramatically, depending on the stage of the product development process and the counterpart involved. The intensity of manufacturer-user interaction tends to increase during the predevelopment stages: during concept generation and testing, the number of cases with 'no interaction' had dropped to 33%, while typically the intensity of interaction had increased substantially. The intensity of manufacturer-user interaction tends to decrease considerably during the actual development stage (the number of cases with 'no interaction' has nearly doubled). Finally, manufacturer-user interaction is characterized by a peak of 67% at a relatively high level of intensity ('separate performance of activities') during the testing stage and another peak of 38% at a relatively low level of intensity ('use as reference') during

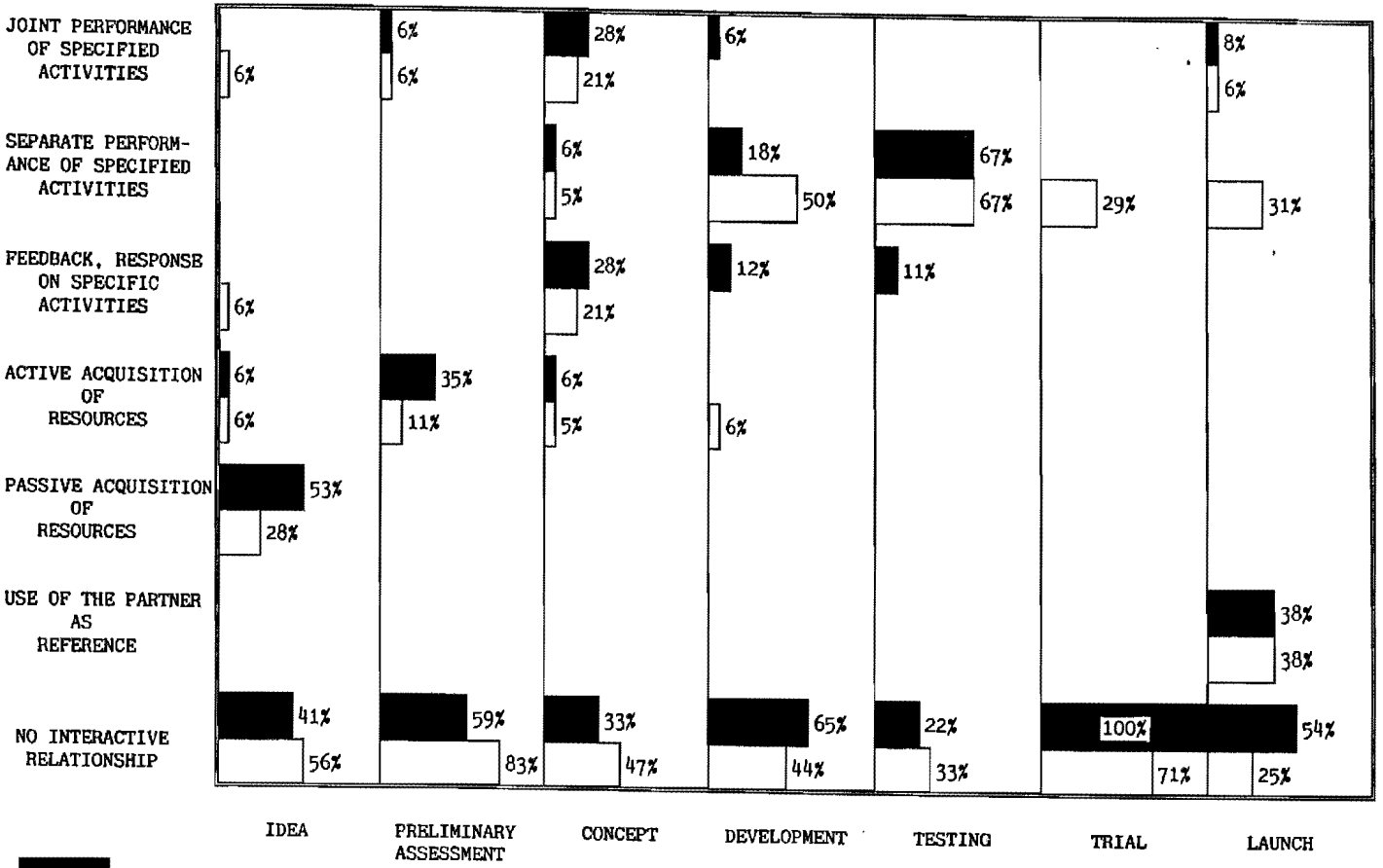


Figure 7.2 The occurrence of intensity of interaction (expressed as a percentage) during the process of product development.

the launch stage. The intensity of manufacturer-third party interaction, on the other hand, tends to increase steadily during the stages of the product development process, only to finally decrease during the launch stage.

7.2.5 PRODUCT DEVELOPMENT WITHIN NETWORKS

In the preceding sections we discussed the involvement of both users and third parties in product development processes and focussed on the interaction between manufacturers on the one hand, and potential users or various third parties on the other. However, the findings of our research indicate that only 24% (four out of seventeen) of the medical equipment innovations investigated were developed through a network in its simplest form, that is to say, a single interactive relationship between a manufacturer and a user or third party. Three quarters (76%) of the innovations studied were developed within networks consisting of a number of different organizations linked together by individual interactive relationships of varying strength, nature and duration. The relevance of networks is further illustrated by the last column of Table 7.6, which indicates that manufacturers frequently employ both users and third parties during the various product development stages.

7.2.5.1 SIMPLE AND COMPLEX NETWORKS

Thus the results of the present investigation demonstrate that, in the Dutch medical equipment industry, innovations are developed within networks of varying complexity. At the one extreme we found simple networks consisting of a single interactive relationship between the manufacturer and a user, university or inspection agency, while at the other extreme we discovered complex networks in which the manufacturer interacted, for example with a university linked with a university hospital, the government, users and an original equipment manufacturer (OEM). The simple networks were found to suffice when

a. the product development process was uncomplicated, or
b. the manufacturer possessed most of the necessary know-how (and, for instance needed a user only for some specific application knowledge).

Complex networks, on the other hand, were necessary when

a. the development process involved a very complex innovation,
b. the manufacturer lacked knowledge or expertise with respect to some relevant areas, or
c. unanticipated problems arose during product development which necessitated the hiring of specialized organizations.

Based on the occurrence of specific interactive relationships, the various networks can be divided into three categories (see Table 7.10): (a) networks dominated by manufacturer-user interaction (six (35%) of the cases investigated), (b) networks dominated by manufacturer-third party interaction (five cases (29%)) and (c) mixed networks consisting of a manufacturer having major relationships with both users and third parties (six of the cases studied (35%)). The four simple networks investigated were equally distributed over the first two categories.

FIRM SIZE	TYPE OF NETWORK		
	NETWORK DOMINATED BY MANUFACTURER-USER INTERACTION	NETWORK DOMINATED BY MANUFACTURER-THIRD PARTY INTERACTION	'MIXED' NETWORK
SMALL	2	3	2
MEDIUM	3	2	4
LARGE	1	0	0
TOTAL	6	5	6

small : 50 employees or less
medium: between 50 and 500 employees
large : 500 employees or more

Table 7.10 The occurrence of three types of networks related to firm size.

In the rest of this section we will explore some of the advantages, intricacies and pitfalls of developing innovations within networks. These will be demonstrated by describing and analysing the case of AIR (Case 4) in greater detail, since this case concerns the development of a medical equipment innovation through interaction between a number of essentially different organizations (such as a manufacturer, a university linked with a university hospital and an OEM) and illustrates many of the aspects involved.

7.2.5.2 PRODUCT DEVELOPMENT WITHIN COMPLEX NETWORKS

The discussion on product development within complex networks will start with a detailed description of a product development process at Applied Instruments for Respiration. Next, the advantages and disadvantages of developing innovations within complex networks will be presented and the section concludes with some observations on the distinction between internal and external networks.

7.2.5.2.1 THE CASE OF AIR

Introduction

Applied Instruments for Respiration (AIR) is a worldwide operating manufacturer, specialized in the development, manufacture and marketing of instruments used in respirators. Since AIR has specialized in the production of component instruments, rather than entire respirators, AIR's customers are original equipment manufacturers (OEM's) who use AIR's advanced instruments as components of artificial respiration and monitoring systems. This implies that AIR is very dependent on the market information relayed by the OEM's. For example, product specifications are largely formulated by the OEM because of its direct knowledge with respect to user requirements (thus, the OEM is always known at the outset of the product development process). The process of product development at AIR does not finish with a comprehensive market introduction. Individual contracts are entered into with OEM's who carry out the market launch.

A number of years ago a competitor introduced an innovative respirator. However, users experienced major problems with the new product. AIR significantly improved the existing product through the development of an advanced microelectronic component. This component is built into existing respirators bought from an outside supplier. Subsequently, the modified respirator is sold to an American OEM who integrates it into artificial respiration and monitoring systems used in operating-rooms in hospitals (Figure 7.2). Thus, by the addition of the advanced microelectronic component, the performance of the whole system is greatly enhanced. Thanks to the implemented technology, AIR has a competitive edge and, although competition will follow, competitors are not expected to introduce similar products in the very near future.

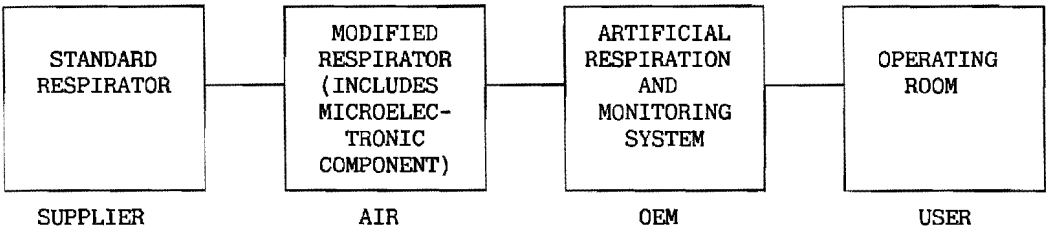


Figure 7.2 The innovation in relation to the whole system.

The product development process

For the sake of clarity, we will divide the process of product development into three separate parts (Figure 7.3). The first part, starting with idea generation and ending with the construction and testing of the original design, is conducted by the Dutch University (DU). The second part, performed by AIR, starts with the development of an industrial prototype and ends with the production of the ultimate product. Finally, the third part, conducted in parallel with the first two parts, consists of the contributions of the OEM to the product development process.

The initiative for the cooperation between AIR and the DU lay indirectly with a third party: the government, which aimed at stimulating industry-university cooperation through the granting of credits. AIR's management had discovered an interesting market segment and was searching for a university to provide existing basic knowledge in order to develop and manufacture me-too products. The DU was considered a suitable collaboration partner since (a) the DU possessed the desired expertise and (b) was linked with a university hospital so that a clinical environment was immediately available. The department of Experimental Respiratory Techniques (ERT) of the DU, on the other hand, wanted to develop an innovative product and was looking for an industrial partner to provide the necessary funds. Eventually, a contract was drawn up: AIR would sponsor experimental research to be conducted by the DU and in return would obtain the desired technological know-how. Furthermore, AIR would have first claim on any new product developed as a result of the experimental research.

The department of Experimental Respiratory Techniques of the Dutch University looked at the development of a significantly improved version of the existing product as an ideal project. However, due to the

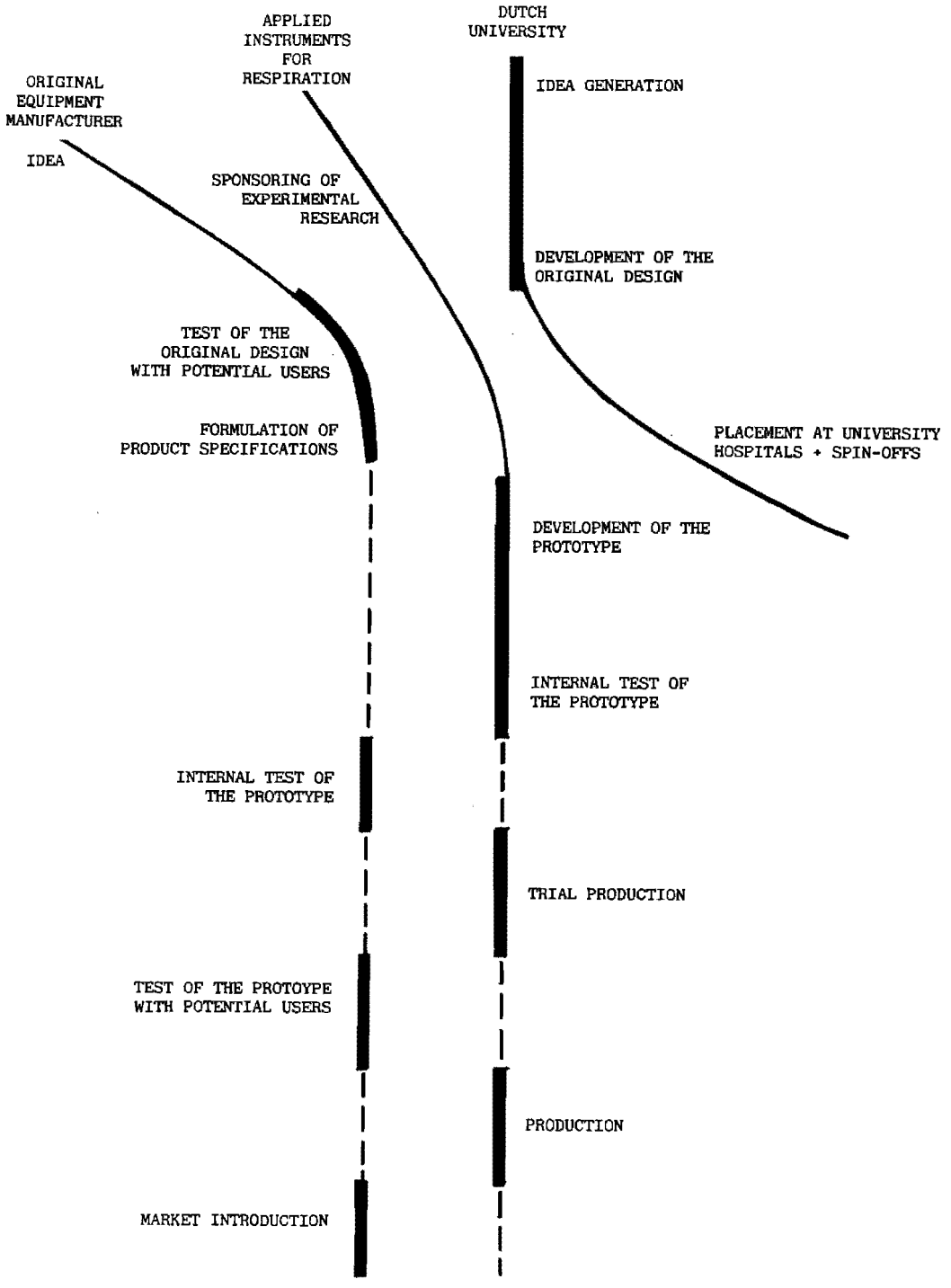


Figure 7.3 The contributions of the three major parties to the product development process (Case AIR).

supposed limited size of the market segment AIR's management did not express interest in this specific application and would rather have the DU concentrate on more traditional applications. Thanks to the persistence of the university researchers, the development project was eventually approved by AIR. These differences between the objectives and expectations of AIR and the DU led to many frustrations during product development.

The idea for the new product originated with the engineers at the DU as a reaction to complaints expressed by users with respect to an existing product. The product specifications were drawn up in the course of an intensive dialogue between engineers of the DU and physicians of the university hospital. The requirements formulated by the users were combined with the technological possibilities and development of the original design commenced. After almost two years, an original design had been developed which, compared with the existing product, represented a significant improvement. It was tested both by the engineers (internal technical test) and on patients. During the next six months it was demonstrated at various national and international congresses to obtain response from users. The first reactions were positive and the DU was contacted by an OEM who expressed interest in marketing the product. Since the DU lacked both the ability and the interest in manufacturing the product, the OEM was referred to AIR. Only when AIR was confronted with this potential customer was enthusiasm for the project displayed.

The user was involved in the development process through the close collaboration between physicians and engineers in developing the original design. The development activities at Applied Instruments for Respiration were based on user requirements too, since the OEM provided most of the product specifications. The OEM's knowledge of the market was very important in guiding product development at AIR. Theoretically, AIR could turn this knowledge into profit by selling to other OEM's as well. Therefore, the contract stipulated that for a period of one year after first delivery, AIR was not allowed to sell to other OEM's. The development activities at AIR took more than one year since several important aspects of the developed original design needed to be modified.

Initially, the original equipment manufacturer had started a similar development project. However, when it learned of AIR's development activities, it decided to terminate its own development project

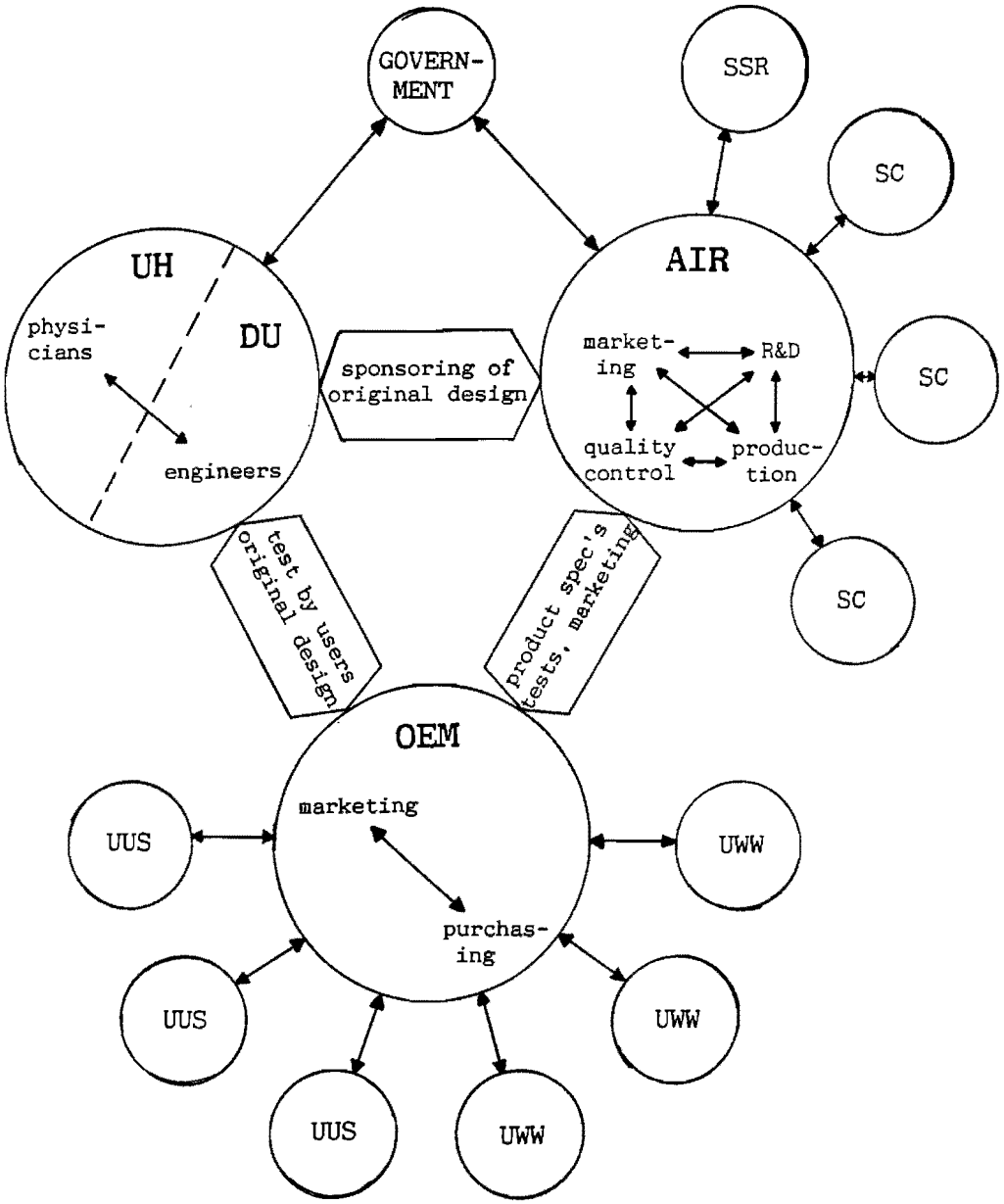
and cooperate with AIR. A separate project would take too much time and, through cooperating with AIR and demanding exclusivity during a specified period, the OEM could obtain a lead on potential competitors. The OEM was involved in the product development process in five different ways.

1. The OEM tested some units of the original design with users in the United States. Thus a more universal response was obtained, while the information acquired could be used to draw up the product specifications.
2. In collaboration with AIR, the OEM formulated the product specifications.
3. The OEM duplicated the internal (technical) tests performed by AIR with the prototype. In addition, the OEM conducted a number of specialized technical tests which AIR could not conduct itself.
4. The OEM conducted the external tests because of its existing relationships with users. The prototype was sent to the OEM in the United States, who subsequently sent it to customers all over the world. The test results were used by AIR to finalize the design.
5. Obviously, the OEM carried out the last stages of the product development process, that is introducing and marketing the product.

7.2.5.2.2 ADVANTAGES AND DISADVANTAGES

The case description demonstrates that the innovation was developed through cooperation between many different parties, the most important parties being a university linked with a university hospital, an industrial supplier of component instruments and a supplier of whole systems. This resulted in overlaps, duplications, simultaneous developments and spin-offs. For example, while AIR sponsored the development of the original design, the OEM had started a comparable development project. At a later time, the DU placed the original design at other university hospitals' disposal for scientific research which resulted in various spin-offs. The whole network is presented in Figure 7.4. Developing a new product through close cooperation between a number of different organizations linked together to form a comprehensive network offers obvious advantages to the parties involved.

a. The contribution to the product development process of every party involved can be limited to its own specialized activities. For



UH : university hospital
DU : Dutch University
AIR : Applied Instruments for Respiration
OEM : original equipment manufacturer
SSR : supplier of standard respirator
SC : supplier of component
UUS : user United States
UWW : user worldwide

Figure 7.4 The complete network (Case AIR).

example, because of its existing direct relationships with users, the OEM is best suited to conduct the external tests.

b. Deficiencies caused by one party at an early stage of the development process can be corrected by another party at a later stage. For example, the substantial involvement of users in developing the industrial prototype (by means of the comprehensive product specifications based on market information supplied by the OEM) compensated for the limited involvement of users in developing the original design.

However, the case of AIR exemplifies some major disadvantages of product development within comprehensive networks as well.

a. Overrating of each other's capabilities may result in friction and misunderstanding between the partners.
b. The limited involvement of users in developing the original design may slow down the development of the industrial prototype.
c. Further delays may be caused by inefficiently conducted activities (e.g. the external tests).
d. Involvement of various parties in product development may lead to duplication of some activities; for example, developing and testing both an original design and an industrial prototype.

These disadvantages could have been prevented or reduced through more intensive cooperation and open communication between all parties involved.

7.2.5.2.3 INTERNAL VERSUS EXTERNAL NETWORKS

Analysis of the cases studied leads us to conclude that networks should be considered at two different levels. While each of the major parties involved in the product development process is part of a large external network, every one of them has its own internal network as well. An illustration is provided by the network depicted in Figure 7.4. The successful development of the original design within the DU necessitated close cooperation between engineers from the department of Experimental Respiratory Techniques and physicians at the university hospital. The successful translation of the original design into an industrial new product by AIR was made possible through effective

communication and coordination between the departments of marketing, R&D, production and quality control. Finally, the purchasing and marketing departments of the original equipment manufacturer had to coordinate their activities. The distinction between external and internal networks is crucial, since the functioning of each of the internal networks directly influences the efficiency and efficacy of the external network. This point is demonstrated by the case of Sentrex, where the geographical distance between the marketing department on the one hand, and the departments of R&D, production and quality control on the other, formed a serious impediment for the successful development of new products.

7.2.6 SHORTCOMINGS DURING PRODUCT DEVELOPMENT WITHIN NETWORKS

Appendix C contains brief descriptions of all individual case studies, each one ending with summary conclusions. Although practically every case has its own idiosyncratic problems, comparison of all these individual case descriptions uncovers a number of general problem areas regarding the development of medical equipment innovations within networks. These general shortcomings are deduced by quantifying (where possible) various qualitative aspects of the cases. In this section we will present the most salient of these deficiencies, concerning

1. integration of marketing and R&D,
2. performance of the predevelopment activities,
3. resources allocated to the actual development activities,
4. testing prototypes with users,
5. timing of the market introduction,
6. use of the names and reputations of users during market introduction,
7. cooperation between industrial firms and universities, and
8. specific problems of small firms.

7.2.6.1 INTEGRATION OF MARKETING AND R&D

When asked about their firm's general product development strategy, only two of the managers interviewed (15%) responded by characterizing it as being a 'balanced mixture of R&D and marketing' (Table 7.11). Five of the thirteen firms investigated (38%) maintained that they

based their new product development predominantly on 'future oriented R&D' activities. Three of these firms were quite small in size, very much technology oriented and lacked any formal marketing department. In one of them the marketing activities were undertaken by engineers with some commercial knowledge, while in the two other firms marketing activities were practically absent. The remaining two medium-sized firms were in transition from basing the development of new products on research and development activities alone to founding it on a careful balance between directed research and development activities and a clearly formulated marketing strategy.

FIRM SIZE	PRODUCT DEVELOPMENT STRATEGY		
	FUTURE-ORIENTED R&D	MARKETING	BALANCED STRATEGY
SMALL	3	2	0
MEDIUM	2	4	1
LARGE	0	0	1
TOTAL	5	6	2

small : 50 employees or less
medium: between 50 and 500 employees
large : 500 employees or more

Table 7.11 The general product development strategy related to firm size.

Finally, almost half (46%) of the firms let 'marketing' considerations guide their product development activities. However, only a minority of the firms investigated employed a formal marketing plan to guide the product development activities. Instead, most firms relied on an explicitly stated market introduction strategy. In general, the firms studied showed a growing awareness of the need to integrate marketing with the product development activities. However, at present this objective has been realized by only a small minority.

7.2.6.2 PERFORMANCE OF PREDEVELOPMENT ACTIVITIES

The findings of our investigation into the development of innovations in the Dutch medical equipment industry lend partial support to Cooper's conclusion with respect to the predevelopment activities, that "it is these early stages ... that often receive the least management

attention and resources, and are so often found lacking in industrial firms' new product processes" (Cooper, 1988, p. 241). According to our results, in only one of the cases investigated was the manufacturer not involved in the predevelopment stages. However, in many of the remaining cases, the manufacturer was actively involved in these early stages but carried out the activities inadequately. A closer look at the case descriptions reveals that the inadequate performance of the predevelopment activities takes many forms.

1. Not undertaking preliminary assessment

   As mentioned above, in one case the manufacturer was not involved in the predevelopment activities. In the case of Eye-Tech (Case 2) the firm was approached by university researchers who had developed a functioning original design of a new piece of medical equipment. Enthusiasm on the part of the director carried the firm directly, that is to say, without performing a preliminary assessment, into actual product development. Only after quite some resources had been spent on product development, was a market assessment undertaken and it was discovered that a broader (and profitable!) market did not exist for that particular innovation. The case of Eye-Tech serves to illustrate the importance of undertaking a comprehensive preliminary assessment. Execution of this stage is essential in order to check the product's characteristics against general user requirements. Other firms, that were approached by users or third parties with a new product (idea), generally found that the developed original design (or product concept) needed to be considerably modified in order to satisfy more universal user requirements (cf. the cases of Spinex, AIR, ALT and Ultrolab).

2. Involving only one type of cooperation partner

   The majority of the firms took insufficient advantage of the different types of cooperation partners who were available. Thus, for example, in six of the cases studied (38%) the firms confined themselves to acquiring information from their major customers and neglected to use other potential sources of relevant information, such as distributors (who typically possess a broader view of the market), industry experts (who can provide information regarding general trends in technology and the market), inspection agencies (who can assist in drawing up product specifications), research institutes (which have information with respect to new technological

developments) and competitors (who can provide first-hand information about product specifications and production techniques).

3. Involving a limited number of cooperation partners

In addition to limiting themselves to just one type of cooperation partner, mostly major customers, during the predevelopment activities, in three cases (19% of the cases investigated) the firm made the mistake of relying on just one customer. In four other cases (25%) firms were satisfied with incorporating user requirements in their product specifications through a dialogue with one particular user, but supplemented it by interacting with various third parties, such as universities, a research institute, a competitor and an original equipment manufacturer. Finally, in the case of Medsound, the firm interacted with only an inspection agency during the predevelopment activities.

4. Neglecting to apply well-considered selection criteria

As can be seen from Table 7.8, in only eight cases was the selection of users (chosen to generate and screen new product ideas, provide user information, and generate and evaluate product concepts) based on such well-considered criteria as representativeness and the available expertise. In two of the cases studied, users were selected on the basis of rather arbitrary criteria, while in another four cases the manufacturer was approached by a user and neglected to interact with other potential users during the predevelopment stages. Typically, the selection of research institutes and other third parties was based on such objective criteria as the available know-how.

5. Performing the predevelopment activities superficially

About a quarter of the firms investigated combined many of the deficiencies noted above in quickly and superficially carrying out the predevelopment activities (Table 7.12). Typically, this course of action was rationalized by saying "We have been selling on this particular market for years; we know how many customers there are and know exactly what they want." Thus, the predevelopment activities can be characterized as having been performed only perfunctorily in four cases (25%), reasonably in five cases (31%) and well in seven cases (44%).

FIRM SIZE	PERFORMANCE OF PREDEVELOPMENT ACTIVITIES		
	PERFUNCTORY	REASONABLE	WELL
SMALL	2	3	2
MEDIUM	2	2	4
LARGE	0	0	1
TOTAL	4	5	7

small : 50 employees or less
medium: between 50 and 500 employees
large : 500 employees or more

Table 7.12 Performance of the predevelopment activities related to firm size.

Inadequate performance of the predevelopment activities may result in problems during later stages of the product development process. In most cases this meant that the actual development activities took much longer than expected, leading to increased development costs, a prolonged product development process and a postponed market introduction, thus giving competitors ample opportunity to catch up with their own development activities (cf. Leiva and Obermayer, 1989, p. 48).

7.2.6.3 ALLOCATION OF RESOURCES TO THE ACTUAL DEVELOPMENT ACTIVITIES

Typically, the firms studied tended to underestimate the time, money and resources needed for the actual development activities, that is the employment of technological resources, such as R&D, engineering and industrial design, to the transformation of product specifications (the product concept) into a prototype. The majority of the managers interviewed admitted that the actual development activities had taken longer than planned. In general, they stated that both the experienced risks and the total costs involved were considerably larger than anticipated. Product development processes (from idea generation till market introduction) that took up to twice as long as planned proved to be the rule rather than the exception.

Also in the case of a manufacturer who is approached by university researchers who developed and built an original design, must adequate resources be allocated to the redevelopment activities. The findings of our investigation clearly show that in these cases the developed device

typically needs to be considerably modified before it is suitable for large-scale industrial production and satisfies more universal user requirements.

7.2.6.4 TESTING PROTOTYPES WITH USERS

The majority of the firms investigated (69%, see Table 7.4) reported to interact predominantly with potential users during the process of product development. The interaction was mentioned as occurring particularly during the testing and launch stages, as would be expected, since users who have tested the prototype can be employed for promotional purposes during market introduction. This general strategy is reflected by the fact that in 75% of the cases studied the manufacturer employed users to test a newly developed prototype (Table 7.6). While the firm's in-house tests mainly concern the innovation's technical aspects, particularly its technical functioning and electrical safety, the clinical tests with users serve a totally different purpose. These are generally undertaken as a last check on the match between the product characteristics and user requirements and to discover any problems that may arise in actual use of the product in a clinical environment. Despite the manifest importance of undertaking clinical tests, in many of the cases investigated the firm paid insufficient attention to this critical stage of the product development process.

1. Planning

   Four of the thirteen innovations that actually reached the market (31%) were introduced without ever having been clinically tested by potential users. In all cases the firms in question displayed an excessive amount of confidence in their own technical abilities and the functioning of the product. Based on the initial positive results of the in-house tests, two products were modified slightly and subsequently introduced. A clinical evaluation was not thought to be necessary. In another case, a firm started production directly on the basis of product specifications formulated by a distributor. After having been confronted with subsequent failure in the market, the firm had to start from scratch and formulate new product specifications. Eventually, the prototype was tested by a user, but this concerned only the product's safety rather than its functioning in a clinical environment. Finally, the fourth case concerns Medsound which decided against testing prototypes with users as a matter of

principle. The decision was based on prior negative experiences with gynaecologists who were afraid to injure their patients by using unsafe new products and tested a new prototype only superficially on themselves. Although, by skipping the clinical evaluation stage, a firm may manage to stay ahead of the competition, it is at the same time running the risk of launching an imperfect product.

2. Timing

In two other cases (15% of the innovations actually introduced) the firms involved launched the new product prematurely owing to pressure of time. In one case this was due to an important trade show while, in the other case, an impending annual sales meeting rushed the firm into an untimely market introduction. Typically, at the outset of the project, the products had been scheduled for introduction during the trade show or sales meeting, but the actual development activities took longer than was anticipated. In order to achieve the scheduled introduction date (market launch between two important trade shows or sales meetings was generally considered useless), the clinical testing stage was skipped. This resulted in the initiation of redevelopment activities, modification of the product, strained relationships with distributors and customers, loss of credibility in the market, and a postponed market launch.

3. Determining the number of users

Although undertaking clinical evaluations may be an important determinant of the product's eventual success, its influence largely depends on both the number and quality of the users involved. Table 7.13 shows that, in six cases, the firms employed more than three

FIRM SIZE	NUMBER OF USERS		
	ONE	TWO OR THREE	≥ FOUR
SMALL	2	1	1
MEDIUM	1	1	5
LARGE	1	0	0
TOTAL	4	2	6

small : 50 employees or less
medium: between 50 and 500 employees
large : 500 employees or more

Table 7.13 The number of users involved in clinical evaluation related to firm size.

users to test the developed prototype, the large majority of these firms being of medium size. In four cases the prototype was tested by only one user. Sometimes this limited quantitative user involvement can hardly be avoided. One firm, selling expensive and complex medical equipment, was compelled to use just one site to test a prototype as the high investments and the essential intensive interaction with the user prevented the use of more than one.

4. Selection of users

The firms investigated reported a wide variety of criteria for selecting users to test newly developed prototypes (Table 7.14). In nine cases (75% of the cases where users tested a prototype) the reputed know-how of the medical specialist or hospital in question was reported to be a major selection criterion. An existing relationship was mentioned seven times as a selection criterion (58% of the cases). Often a specific university hospital with a positive attitude towards the manufacturer and its products was habitually employed to test new prototypes. The perceived commercial potentialities were mentioned in only half of the cases as an important reason in selecting users to test prototypes. In these cases the choice was generally based on the reputation of the specific physician (or institute) involved, and the willingness to test prototypes, publish the results, present the findings at national and international conferences and promote the new product with colleagues. This figure of 50% should be regarded as being low, due to the obvious link between the testing and launch stages. In two

FIRM SIZE	SELECTION CRITERIA					
	NOT SELECTED	KNOW-LEDGE	COMMERCIAL POTENTIAL-ITIES	EXISTING RELATION-SHIP	GEOGRAPH-ICAL PROXIMITY	REPRES-ENTATIV-ENESS
SMALL	1	2	3	1	0	1
MEDIUM	1	6	3	5	1	0
LARGE	0	1	0	1	1	0
TOTAL	2	9	6	7	2	1

Small : 50 employees or less
Medium: between 50 and 500 employees
Large : 500 employees or more

Table 7.14 Criteria used for selecting test users related to firm size.

cases (17%) the 'selection' was based on a chance contact, that is the manufacturer was approached by a user with a new product idea, after which the manufacturer commenced development activities and employed the same user for testing the prototype. Because of the need for intensive interaction, culminating in frequent visits to the customer, geographical proximity of the customer was considered to be a great advantage by the manufacturer in two other cases. Finally, in only one case (8% of the cases studied) the manufacturer mentioned the representativeness of the user for the specific market segment as strongly influencing the selection of user sites.

5. Formulation of objectives

Nearly all the firms employed users to test their prototypes with the explicit objective of testing the new product under actual conditions in a clinical environment. However, there was the one exception of a firm that asked a hospital's technical department to test the electrical safety of the innovation (thus changing the character of the test by a customer and making it a simple technical test).

6. Instruction

Without exception, the firms provided the users with instructions as to the innovation's operation. In one case the complex nature of the prototype demanded extensive training of the physicians and nurses who would have to use the equipment. The importance of instruction is further illustrated by the case of Medsound (as mentioned above under the heading 'planning'): by improving the instruction of the physicians and registration of the test results (by determining the desired format of the needed information and informing the physicians of it) Medsound could use gynaecologists to evaluate prototypes meaningfully.

7. Execution

In two of the cases investigated (17%) the execution of the clinical evaluations left something to be desired, too. Eye-Tech had an important hospital clinically evaluate a prototype while (the slightly modified) units of the trial production were already available. In the case of AIR, due to the involvement of an OEM who had direct relationships with users, the clinical evaluations were undertaken somewhat inefficiently. This resulted in delays and possibly in distorted information as well.

8. Support and control

In a limited number of cases the managers interviewed commented on the need to visit the user frequently during the execution of the clinical evaluation. In the case of a manufacturer selling very complex and expensive medical equipment, an engineer was present at the customer site one day per week to instruct the users, demonstrate new software, answer questions, solve problems, obtain first-hand information and check the equipment's functioning and the way it is used.

9. Registration and evaluation

Despite the importance of clinical evaluations and the need for detailed and structured information, in only half of the cases investigated did the manufacturer affirm the need for and existence of comprehensive formalized evaluation protocols (Table 7.15). In specific situations, such as the case of Vitatron which manufactures pacemakers, quite elaborate evaluation protocols are demanded by the government because of the involved potential dangers to the patient. In the other 50% of the cases the firm relied on oral information from the user. It should be noted that three quarters of the small firms testing prototypes with users relied on oral information. One manager (of a firm with no existing relationships in the field of medical technology) justified it by saying "You cannot ask them to fill out comprehensive forms; you should be glad that they are willing even to talk to you!"

FIRM SIZE	MODE OF EVALUATION	
	ORAL EVALUATION	EVALUATION PROTOCOLS
SMALL	3	1
MEDIUM	3	4
LARGE	0	1
TOTAL	6	6

small : 50 employees or less
medium: between 50 and 500 employees
large : 500 employees or more

Table 7.15 The mode of evaluating clinical test results related to firm size.

10. Follow-up

Considering the criteria used in selecting potential users to test prototypes, the most obvious kind of follow-up to the clinical evaluation stage is having the same users assist in launching the innovation. The involvement of reputable physicians or institutes in the launching stage lends additional credibility to the manufacturer's claims and confirms the user's reputation in the medical field. Nevertheless, only 60% of the innovations clinically evaluated by users were subsequently launched by the manufacturer with the assistance of these users (see also the section entitled 'employing users as references during market introduction').

The general conclusion is that the experiences and activities of the firms investigated largely support the tentative model for testing prototypes with potential product users based on the results of the preliminary investigation (Chapter 5). All the steps distinguished in the original model were identified during the follow-up investigation in the medical equipment industry. Apart from this, the cases investigated point to the need to discern two additional steps, that is 'planning the external testing stage' and 'determining the number of users' to test the prototype.

7.2.6.5 TIMING OF MARKET INTRODUCTION

The timing of the market introduction has often been cited in the literature on product development as an important determinant of the innovation's success. As regards complex medical equipment, the right time to introduce a new product may be strongly determined by a limited number of annually organized (inter)national trade shows. These trade shows are very important to the manufacturer, since they attract a significant number of potential users, who come to acquaint themselves with the latest technological developments. For this reason, many firms commented on the need to be present at certain selected trade shows, while launching a new product between two important trade shows may be considered less effective and require substantial additional support of promotional effort. In four of the cases studied (24%), an annual trade show or sales meeting greatly influenced the scheduling of the product development efforts. In three of these cases the resulting tight

schedule led to an untimely showing of the product at either a trade show or sales meeting.

Firms may shorten the duration of the total product development process by consciously skipping the clinical evaluation stage, as was done in four of the cases investigated (31% of the innovations that were actually launched). The reasons for skipping the clinical evaluations were (a) confidence in the technical abilities of the firm, (b) confidence in the functioning of the product and (c) lack of confidence in the ability of physicians to meaningfully evaluate prototypes. In one case the product failed in the market and the firm started reformulating the product specifications anew.

Nowadays, in addition to the hardware, complex medical equipment increasingly contains the software needed to control and direct the product's operation. The case of Philips Medical Systems illustrates how this may suggest another way to advance the time of market launch, namely by means of a basic package introduction. According to this strategy, the firm develops and introduces the hardware and the basic software, consisting of (1) the operating software and (2) software to perform the innovation's most basic functions, that is the basic package. Additional software (various clinical programs) can be developed after launching the basic package and can be introduced in a number of subsequent releases. The most significant advantage is obvious. The hardware plus the accompanying basic software can be introduced relatively early, resulting in market penetration at an early stage, a competitive advantage and confirmation of the firm's innovative image (leading to a prominent position in the minds of leading physicians). However, this strategy entails some potential disadvantages, too. Although most of the software is launched in future releases, they must fit with the previously introduced hardware and therefore be specified quite early in the development process. This may result in the situation where the development of certain clinical programs found to be of interest to physicians must be postponed until it is time to develop a second updated version of the hardware. If the development of announced clinical programs should be delayed, customers may get the impression that the manufacturer does not live up to his promises, thus impairing the firm's reputation.

7.2.6.6 EMPLOYING USERS AS REFERENCES DURING MARKET INTRODUCTION

Only six of the thirteen innovations that actually reached the market (46%) were introduced with the help of users. However, just ten of these innovations had actually been clinically evaluated by users. This implies that only 60% of the innovations that were tested by users and eventually introduced in the market were launched by the manufacturer with the assistance of these users. Employing the names and reputations of users as references during market introduction is the logical consequence of having them test newly developed prototypes. For this reason, these users may be referred to as launching customers and some manufacturers do speak of luminary sites when selecting users to test prototypes. As has been shown previously (see Table 7.14), the 'reputed know-how', an 'existing relationship' and the perceived 'commercial potentialities' were by far most frequently mentioned as selection criteria. This particular combination of criteria appears to point to the regular use of reputable physicians or institutes which, mostly due to their repeatedly proven medical expertise, occupy central positions in the medical community. Considering this, the number of 60% is surprisingly low, even more so, as informal communication and opinion leadership have often been said to be of great importance in institutional markets (Webster, 1971, p. 187; Schiffman and Gaccione, 1974). Thus we may conclude that, in addition to paying insufficient attention to the external testing stage, a sizable portion of the firms investigated neglected to fully capitalize on the available opportunities with respect to employing users during market launch.

7.2.6.7 COOPERATION BETWEEN INDUSTRIAL FIRMS AND UNIVERSITIES

In four out of the seventeen cases studied (Cases 2 (Eye-Tech), 4 (AIR), 5 (ALT) and 16 (Medlab)) university researchers developed the original design or contributed substantially to the development of the prototype. In addition, there were numerous instances where industrial firms interacted with universities in order to have the latter develop parts of the product, test prototypes or solve technological problems. In three of the four cases mentioned both university researchers and physicians from a university hospital were involved in the development project through intensive interaction. The four cases of intensive

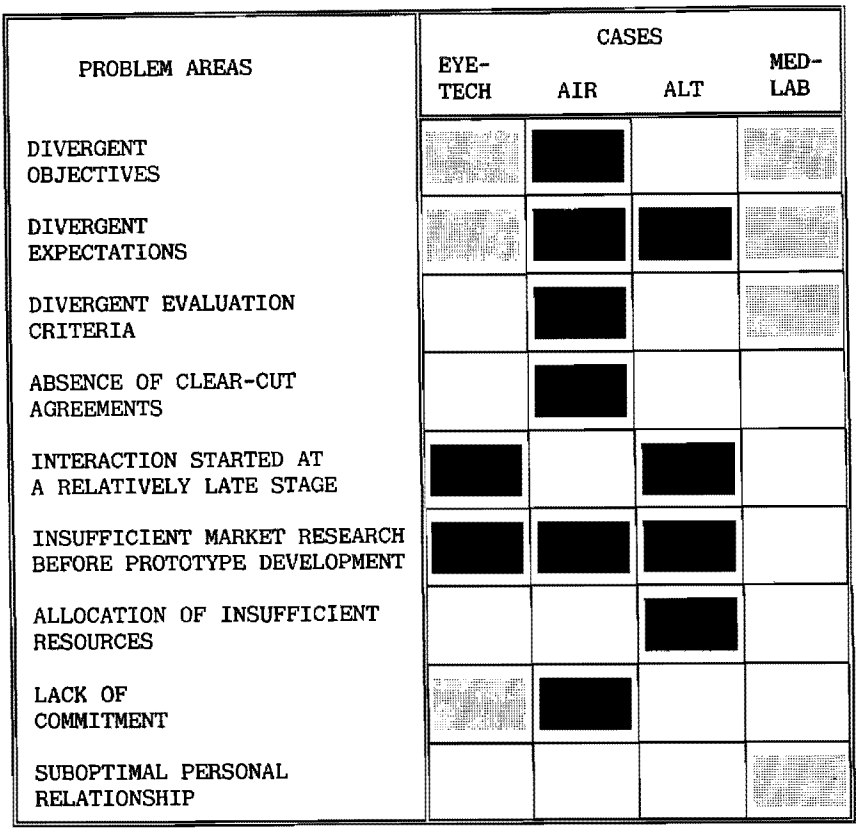


Table 7.16 Problem areas involved in intensive industry-university cooperation.

industry-university cooperation indicate the existence of many potential problems (Table 7.16).

An issue that warrants special attention in the context of intensive industry-university cooperation is the transfer of the original design from the university researchers to the industrial firm. Due to mutual misunderstanding and overrating/underrating, this transfer may be a major source of friction between both parties. Typically, the university researchers expect the developed original design to be only slightly modified before start-up of production and underestimate the extent of development needed to be undertaken by the industrial firm.

The firms, on the other hand, typically overestimate the capabilities of the universities by expecting them to develop industrial prototypes.

These problems may be significantly reduced if industrial firms and universities cooperate more closely during product development. Take, for example the joint development project at AIR and the Dutch University. Instead of limiting itself to sponsoring experimental research at the DU, AIR could have assisted in the development of the original design (thus incorporating the requirements of the industrial firm at an early stage of development). Next, the DU could assist AIR in translating the original design into an industrial prototype (thus applying the knowledge and experience acquired through developing the original design). Such a set-up would not only prevent many frustrations and misunderstandings, but would shorten the total duration of the development project as well. In all instances of joint development, close attention should be paid to project management, that is the division of tasks and responsibilities, documentation, and drawing up clear-cut agreements and procedures. If project managers are appointed at both the university and the industrial firm, the communication and coordination at the interpersonal level assume the utmost importance. Trust, openness and commitment become the key concepts determining the eventual success of the cooperation.

7.2.6.8 SPECIFIC PROBLEMS OF SMALL FIRMS

More than one third of the firms investigated (five firms, or 38%) are characterized as being small, that is having less than 50 employees. Although these firms, for the most part encountered the same problems as the somewhat larger firms, due to their small size they experienced some specific problems, too. These problems relate to the functional interdependence, availability of cash and existence of marketing expertise and realistic GO/NO GO decisions.

a. Strong functional interdependence

   In all of the small firms, various problem areas, such as finance, organization, product development, marketing and production, were found to be strongly intertwined. Thus the marketing decisions, problems and activities could not be considered separately from the overall running of the company. For example, in the case of ALT the deteriorated financial position determined the outcome of fundamental marketing-related decisions during product development.

b. Limited cash funds

Typically, the limited cash available in small companies had major effects on their own activities and dealings with other organizations.

- Two very small firms (five or six people) reported they were heavily dependent on subsidies. One of them even went so far as to mention the grant of a subsidy as a major criterion in selecting and initiating new product development projects.
- Functioning and promising prototypes, developed by university researchers, cannot be paid for with a lump sum. Instead, the university has to be satisfied with a certain percentage of future sales.
- Each of the small firm's investigated, mentioned that they could afford only one or two development projects at a time. Although this simplifies the management of the product development process, it makes the company's continuation strongly dependent upon the success of just a few products.

c. No real marketing expertise

All of the five firms investigated did not possess any real marketing knowledge. Typically, no special marketing department existed and the marketing function was fulfilled by the general director of the firm. The very small firms (that is, those having only five or six employees) were very much technology oriented and relied on their distributors for the relevant marketing information.

d. No realistic GO/NO GO decisions

Each of the managers interviewed at small firms maintained that, in their situation, the product development process did not contain realistic GO/NO GO decisions. After having passed a certain stage of the product development process, a NO GO decision would be equivalent to discontinuing the firm. However, in the large firm studied, a relatively small group of people became convinced of the feasibility of a comprehensive development project, managed to persuade top management in favour of the project and functioned as internal product champions. Despite the existence of extensive official review procedures, a NO GO decision was unlikely to be made.

7.3 THE ADOPTION AND DIFFUSION OF COMPLEX MEDICAL EQUIPMENT

The investigation concerned the development of complex medical equipment within networks. Of special interest was the way manufacturers interact with potential product users during the product development process. Nevertheless, some basic understanding of how these users (mostly hospitals) evaluate and purchase medical equipment, was often found to be essential in understanding the contribution of potential users to the product development activities. While we did not systematically interview a representative sample of product users, we did gain some basic understanding by incidentally asking

1. the manufacturers about their experiences in selling their complex medical equipment to hospitals,
2. the persons interviewed at hospitals about hospital purchasing procedures and
3. industry experts about general trends as regards hospital buying behaviour.

In addition, the manufacturers were requested to write down their opinion about a number of specified issues. Ten of the thirteen manufacturers complied with this request, thus supplementing the information already given. These three sources of information provide (a) a general picture of the way hospitals buy complex medical equipment and (b) a number of important recent trends. The fact that all the people interviewed present a coherent picture, which is consistent with observations in the literature, underlines the validity of the information thus obtained. Despite this coherence and consistence, it should be stressed, however, that this fragmented, limited information is only a by-product of the way the present investigation was conducted.

7.3.1 THE ADOPTION OF COMPLEX MEDICAL EQUIPMENT

About ten years ago, the way hospitals bought complex medical equipment was quite uncomplicated. The relevant physician was clearly the most important person involved in the buying decision. As the members of the nursing staff often had to operate the new equipment, they were generally consulted by the physician. Therefore, manufacturers of medical equipment used to focus their sales effort on personal contact with the physicians, stressing the medical benefits of the new equipment. These

visits by sales representatives were supplemented by advertisements in the relevant trade journals and presentations at the most important (international) trade shows. As the physicians were traditionally quite impressed by any new product representing a technological advance and there were no serious limits to the hospital's expenditures, innovative medical equipment used to be readily adopted by the medical community. The adoption by hospitals of complex medical equipment was thus reduced to a purchasing decision made by a single individual and often based on nonrational motives. Thus, hospital buying behaviour was quite different from the purchasing behaviour of industrial firms.

The implementation of a budgeting system as from January 1st 1984 has started to change hospital buying behaviour considerably. As the budgeting system places an absolute limit to the hospital's expenditures, hospitals are increasingly focussing on the costs involved. In general, the emerging picture is the following.

a. Purchasing decisions are being made by buying committees instead of single individuals.
b. These buying committees do not consist of only physicians and members of the nursing staff, but typically include a purchasing agent, a member of the technical services department, a financial director and an engineer specialized in medical technology as well.
c. All the people involved in the purchasing decision use different criteria in evaluating innovative medical equipment. While a physician may still focus on the innovation's medical benefits, the technical services department will stress the serviceability of the product and its electrical safety, and a financial director will emphasize the operating costs in addition to the purchase price.
d. The physician is clearly losing influence to the purchasing department, the financial director and the members of the technical services department.

Thus, the way hospitals purchase complex medical equipment is undergoing considerable change (Figure 7.5). About ten years ago, the decision to buy a new piece of medical equipment in effect used to be made by an individual physician, whose decision was based on emotional-psychological motives (e.g. peer pressure or status considerations) without being influenced by organizational guidelines or restrictions. Nowadays, the decision to purchase innovative medical equipment is made by a group of people, who base their decision on rational (often

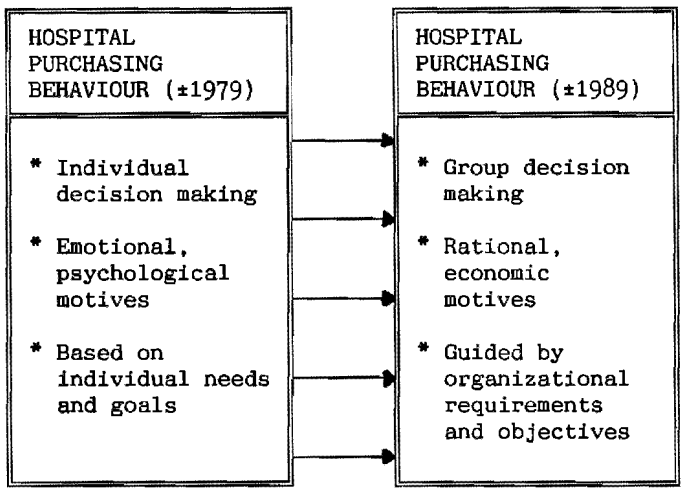


Figure 7.7 Changes in hospital purchasing behaviour.

economic) motives guided by organizational requirements and objectives. While these two situations are presented as two very opposite extremes, it illustrates the major point to be made. In the Netherlands, hospital buying behaviour is becoming more and more similar to the purchasing behaviour of industrial firms. Although hospitals still consider the medical benefits of new equipment, they increasingly emphasize the costs involved. Therefore, new medical equipment which offers improved medical benefits at higher costs stands less chance of being adopted than new equipment which performs an existing medical function more efficiently and/or at a lower price.

Naturally, the change depicted above did not occur overnight. In fact, most hospitals are still in transition. The position of an individual hospital strongly depends on its size. While the larger university hospitals have generally come a long way in adopting many aspects of organizational buying behaviour, small regional hospitals may still employ powerful physicians who dominate purchasing decisions. In addition, young physicians are more likely to adapt to the new procedures than older physicians who are really losing their traditional influence.

7.3.2 THE DIFFUSION OF COMPLEX MEDICAL EQUIPMENT

In discussing the diffusion of medical equipment, people often distinguish between university hospitals and regional hospitals. The manufacturers were asked their opinion about possible differences between both types of hospitals concerning

a. the parties involved in the buying process,
b. the time required to decide to purchase the equipment,
c. the evaluation criteria employed and
d. the time interval between the time of market introduction and that of adoption.

Due to the limited information provided, the issue of the diffusion of new medical equipment remains unclear. Most manufacturers do not have sufficient insight into diffusion processes, while one of them sells its equipment through distributors and possesses only limited market information. Of the nine manufacturers who responded and were able to comment on these specific issues, four stated that there were no differences between university hospitals and regional hospitals as regards the criteria mentioned above. The remaining managers concluded that some general differences did exist.

a. Four managers characterized university hospitals as employing an elaborate decision-making unit, usually including engineers and financial directors. In regional hospitals the buying process is dominated by the actual product user.
b. Two managers considered university hospitals to be slower and more bureaucratic in their decision making.
c. Only one manager stated that there were differences in the evaluation criteria. University hospitals evaluate new equipment on the level of technology incorporated, while regional hospitals stress economic criteria.
d. Two managers concluded that university hospitals tend to adopt innovative equipment earlier than regional hospitals.

Surprisingly, the differences between university hospitals and regional hospitals are not considered to be very great. Nevertheless, manufacturers typically prefer to involve university hospitals in their product development processes. This is because university hospitals are generally more interested in and knowledgeable about new technologies

and have extended facilities for testing new equipment (and often for comparing it with existing products). Despite all this, manufacturers generally need to develop equipment of interest to both university and regional hospitals. The strong emphasis on cooperation with university hospitals can still be justified by stressing the innovative image of university hospitals. Because of this image, product acceptance by university hospitals has a positive effect on, and is therefore necessary for acceptance by regional hospitals.

We would like to conclude by stressing again the indicative nature of the findings presented in this section. Additional research into the adoption and diffusion of complex medical equipment is highly desirable.

This chapter has presented both the structure and the major results of the follow-up investigation, involving the in-depth study of seventeen cases of developing innovative medical equipment. The next and final chapter presents the total investigation's major conclusions and their managerial implications.

CHAPTER 8. CONCLUSIONS, MANAGERIAL IMPLICATIONS AND RECOMMENDATIONS

The complete investigation described in this thesis has resulted in a large amount of information which can be structured in many ways. While Chapters 5 and 7 provide the major findings of the preliminary and follow-up investigation, this final chapter aims at summarizing, discussing and evaluating both the research findings and the research methodology employed. Therefore the chapter starts with a brief summary of the complete investigation, its objectives and the research method. This is followed by the major conclusions and their managerial implications, constituting the largest part of the chapter. Since case research is not so often employed by researchers in the field of marketing and actually brought the investigator face to face with several problems, we will pay special attention to this subject by evaluating case research as a research methodology. Finally, both the results of the investigation and the research method employed lead to some recommendations as regards future research into the area of developing industrial innovations within networks and the use of case research. Thus, the chapter broadly consists of four parts:

1. a brief summary of the objectives and structure of the investigation,
2. the major conclusions together with their managerial implications,
3. an evaluation of case research and
4. recommendations for future research.

8.1 THE OBJECTIVES AND STRUCTURE OF THE INVESTIGATION

The study was designed to investigate the way manufacturers of products for industrial markets interact both with users and various third parties, such as universities, distributors, etcetera, during the development of complex innovations within networks. This investigation was conducted with two major objectives in mind:

a. to contribute to existing theory on developing complex innovations within networks and

b. to provide industrial marketing management with practical guidelines to improve the interaction both with users and third parties, and thus to enhance the quality of the industrial product development process.

The investigation was made up of two parts. The first part, that is the preliminary investigation, consisted of the in-depth study of five cases. While the firms studied were taken from very diverse sectors of industry, their experiences in developing new industrial products showed many similarities. For example, four out of five made serious mistakes in having their prototypes tested by potential users. Their collective experiences led to the construction of a tentative framework for testing prototypes with potential users. The findings of the preliminary investigation led to a follow-up investigation designed explicitly to test, supplement and refine these findings. For various reasons, the field of medical technology appeared to be very suitable for this purpose. In the course of the follow-up investigation, seventeen more cases of industrial new-product development were investigated. All twenty-two cases were investigated by means of personal in-depth interviews using semistructured questionnaires. Apart from the manufacturers, many (potential) users and various third parties were interviewed to obtain complete and realistic case descriptions. Comparison of all these individual case descriptions resulted in a number of conclusions with managerial implications.

8.2 CONCLUSIONS AND MANAGERIAL IMPLICATIONS

The investigation has yielded observations of both a scientific and a practical nature. However, because of the objectives and the practical character of the investigation, most of these observations lead directly to implementable recommendations to industrial marketing management. These observations concern subjects such as the critical nature of predevelopment activities, the activities to be undertaken when a manufacturer is approached by a user with a working prototype, the involvement of potential users and various third parties in product development processes, and the functioning of firms within complex networks. In addition, the investigation has contributed a number of theoretical concepts to existing theory as regards interaction and

networks, which will be briefly discussed first. Although these concepts seem highly theoretical, they have some important implications for management as well.

The discussion of the major conclusions and their managerial implications (numbered correspondingly) will be structured around a number of major themes. Thus, this section consists of the following parts:

1. conceptual contributions to existing theory regarding interaction and networks,
2. the role of the manufacturer in product development,
3. interaction between the manufacturer and potential users,
4. interaction between the manufacturer and various third parties and
5. the functioning of organizations within networks.

Many of the conclusions and managerial implications concern complex innovations for industrial markets in general. When they exclusively refer to medical equipment innovations, this is explicitly stated in the text.

8.2.1 CONCEPTUAL CONTRIBUTIONS TO EXISTING THEORY REGARDING INTERACTION AND NETWORKS

CONCLUSIONS

1. Definition of interaction

   The results of the investigation led to a clear definition of the concept of 'interaction', that is the mutual exchange of values which may belong to one or more of the following categories: (a) products/components or services, (b) information, (c) financial resources and (d) social content.

2. Dimensions characterizing individual interactive relationships

   The results indicated the existence of five important dimensions characterizing individual interactive relationships, that is (a) the type, (b) purpose, (c) intensity, (d) duration and (e) extent of formalization of interaction. These dimensions can be divided into a number of subdimensions and are to some extent interrelated.

3. Active versus passive interaction

   Six levels of intensity of interaction can be distinguished. While most of them are examples of (a) active interaction, two of them are better described by the term (b) passive interaction. These are the

situations in which (1) the manufacturer uses the names and reputations of test users during market introduction (use as reference) and (2) the manufacturer is supplied with resources (e.g. information) without actively acquiring them (passive acquisition of resources).

4. Classification of individual interactive relationships
   Individual interactive relationships come in many different kinds. The intensity and duration dimensions of the interaction can be used to classify them into two major categories, that is (a) single-level and (b) multiple-level interactive relationships.
5. Classification of networks
   The investigation's results illustrate the existence of various kinds of networks and suggest a number of ways to classify them. The complexity of the network leads to a continuum from (a) simple to (b) complex networks. According to this terminology the 'classic' case of manufacturer-user interaction is considered a 'simple network'. The nature of the major cooperation partners leads to the distinction between (a) networks dominated by manufacturer-user interaction, (b) networks dominated by manufacturer-third party interaction and (c) mixed networks. The environment of the interactive relationships results in a division into (a) internal and (b) external networks.

MANAGERIAL IMPLICATIONS

1. Interactive relationships may refer to the exchange of four general categories of values between organizations. While all four types of values may be involved in a specific individual interactive relationship, this need not necessarily be the case. For example, a manufacturer may trade information with a major customer. However, most interactive relationships (should) somehow involve three or all four kinds of values. When this fact is ignored or forgotten, a manufacturer may, for instance exchange services for money without paying attention to the transfer of information or social content. This may result in unnecessary misunderstandings and personal relationships which do not function optimally.
   The fact that interaction involves the mutual exchange of values indicates the need for harmony which may be obtained through timely and detailed communication. Interactive relationships are most successful when both parties benefit from the relationship. While a

shared goal is frequently mentioned as an important ingredient for success, this is not a universal law. Two organizations may pursue different objectives and still enter into a highly effective and efficient collaboration, so long as they state and accomodate for their deviating goals.

2. The dimensions used to characterize interactive relationships serve to pinpoint some of the most relevant aspects to be considered before starting such a relationship and when estimating the chances of success. For example, the dimension 'duration of the interaction' must be carefully considered and might even be laid down in a contract. A contract with no real time limit, but terminable by any partner from year to year, is not advisable, since it (a) strongly depends on specific incidental situations and (b) undermines mutual trust, commitment and the development of structural relationships. A better alternative would be to have the contract automatically continue from year to year with a substantial term of notice (e.g. two years).

   It should also be noted that the dimensions may change over time. For example, a manufacturer may provide a university with money to conduct exploratory research, representing interaction with a low level of intensity (weak tie). If the university researchers should come up with some concrete idea of interest to the firm, both parties may initiate a joint development project, that is a relationship with a high level of intensity (strong tie). Thus, a weak tie represents a potential strong one. Because of the relatively low costs involved, a manufacturer can maintain a large number of such weak ties and thus keep in touch with the major developments.

3. The distinction between active and passive interaction serves to alert management to the existence of passive forms of interaction. Although these forms of interaction are passive, management can actively employ them and improve their handling of them. Passive interaction consists of (a) using a partner as a reference and (b) the passive acquisition of resources.

   (a) Potential users who have tested a prototype frequently become actual buyers of the product. Management should seriously consider the possibility of using such customers as references and having them demonstrate the innovation to prospective buyers.

(b) As regards the passive acquisition of resources, management should establish an optimal receptiveness in the firm and its employees. That is, sales managers should be easily accessible to customers, customers with complaints should be phoned back without delay (the customer may have problems with the product, but possibly he has some suggestions to improve it as well!), sales representatives should be receptive to any suggestions from customers and seriously analyse them, etcetera.

4. The findings of the investigation show how relationships can be grouped in a number of distinct categories. Although many alternative classification schemes are conceivable, this one helps a manager to consider the benefits and investments related to various types of interactive relationships by focussing on the two major dimensions 'duration' and 'intensity' of interaction. When these two dimensions are combined with the potential interaction partners to be considered (as is done in the examples given in Chapter 7), the resulting framework becomes an important tool in evaluating the potential of various relationships and reducing the chance of overlooking promising ones. For example, consider the manufacturer who is thinking of cooperating with potential users. For this purpose he takes the standard matrix constructed by combining the product development stages (i.e. the duration of interaction) and the levels of intensity of interaction (Figure 1). Then, for every column (or development stage) he considers the various intensities of interaction with potential users. In this way, each individual cell of the matrix is analysed in terms of opportunities, benefits and investments. This procedure may be conducted with one type of cooperation partner (e.g. potential users) or a specific cooperation partner (e.g. a major customer) in mind. The analysis should be repeated for all potential cooperation partners, while accounting for possible 'interaction effects' between distinct relationships. For example, cooperation with one major competitor may exclude another competitor from consideration. Finally, it should be noted that this is just a general framework. Every firm can modify the dimensions to fit its own needs and specific market situation.
5. Characterizing networks according to (a) their complexity, (b) the major cooperation partners or (c) the environment of the interactive relationships, leads to a number of managerial implications which will be discussed in the section on the functioning of organizations within networks.

(TYPE OF) COOPERATION PARTNER:	STAGES OF THE PRODUCT DEVELOPMENT PROCESS Idea	Prel.Ass.	Concept	Developm.	Testing	Trial	Launch
INTENSITY 1. Use as reference							
2. Passive acquisition of resources							
3. Active acquisition of resources							
4. Response, feedback on specific issues							
5. Separate development of specified act.							
6. Joint development of specified act.							

Figure 8.1 The standard matrix for evaluating potential cooperation partners (constructed by combining the 'intensity' and 'duration' of interaction).

8.2.2 THE ROLE OF THE MANUFACTURER IN PRODUCT DEVELOPMENT

CONCLUSIONS

1. Dominance of technology over marketing

   Manufacturers of complex medical equipment are predominantly technology oriented, while marketing is treated only as a secondary function. This is illustrated by the fact that, although the majority of the manufacturers report that they generally interact with users during product development, such interaction was found to be poorly conducted in the actual cases of product development investigated. The secondary position of marketing is also reflected by the lack of integration of marketing with the product development process.

2. Inadequate performance of predevelopment activities

   In developing medical equipment, manufacturers typically performed the predevelopment activities inadequately. They (a) did not undertake them at all, (b) involved only one type of cooperation partner, (c) involved only a limited number of cooperation partners or (d) did not use well-considered selection criteria. Most of the firms combined some of these aspects into inadequate performance of the predevelopment activities.

3. Uncritical attitude of manufacturer when confronted with a working prototype

   Sometimes a manufacturer is approached by a user or by university researchers who have had an idea for a new product, built an original design, tested it and even used it in practice. The fact that the original design has actually been used under working conditions and found to offer benefits to the user, often convinces the manufacturer of the design's validity. In these situations the manufacturer typically either starts (re)development at once (to improve the product's efficiency, etcetera) or pays only superficial attention to the initial stages of the product development process (evaluating the product and its potential). This usually results in cancelled development processes, problems during actual development of the prototype or costly delays.

MANAGERIAL IMPLICATIONS

1. Obviously, marketing should be given its legitimate position within the organization. For many manufacturers this means that they should

rely on experienced marketing managers, rather than sales managers bearing the title, but lacking the expertise. Naturally, this advice only makes sense for medium or large-sized firms, as many of the small ones lack the financial resources to employ experienced marketers. Acquiring the necessary marketing expertise is a prerequisite for integrating marketing with the product development process. While this integration may be achieved in many ways (as is shown throughout this book) it is best started by realizing that marketing should be involved in all product development stages. Often this can be accomplished effectively in very simple ways. This is shown by the case of Philips Medical Systems which had an extensive user manual drawn up before actual development began! This obliged the people involved to consider the product specifications both carefully and in detail, leading to better specifications, reduced problems during actual development, improved internal communication, shorter duration of the development process and early market introduction.

2. The recipe for improving the performance of the predevelopment activities is quite obvious, considering the nature of the shortcomings. In all situations, the manufacturer should undertake the predevelopment activities (see also the next point) and undertake them well by carefully considering the following three questions.
(1) What type of cooperation partners should be involved? Manufacturers frequently make the mistake of relying solely on major customers for their information. Much specific information can be provided by other potential cooperation partners, such as distributors (broad view of the market), industry experts (general technological and market trends), inspection agencies (product specifications), research institutes (new technological developments) and competitors (product specifications and production techniques). As each partner offers different information, the choice of a partner may depend on the specific predevelopment stage. For example, a firm may use distributors and potential users to evaluate a new idea and employ a research institute in evaluating the technical aspects of a product concept.
(2) How many cooperation partners should be involved? For each category of potential cooperation partners the manufacturer must determine the optimal number to cooperate with. The optimal number strongly depends on the category involved. For example, in the whole

world there may be only two or three renowned industry experts (often termed 'gurus') as regards the specific medical subdiscipline involved, but thousands of potential users of the new product.
(3) How should the cooperation partners be selected? In selecting cooperation partners, the manufacturer should determine the partner's representativeness, knowledge, objectivity, willingness to cooperate, market position and ability to keep confidential information. For example, because of close contacts with a major competitor, a key user may be questioned in a roundabout manner, so as not to divulge the exact nature of a new product idea.

3. When approached by a user or university researcher with a home-made device, a manufacturer should not limit his contribution to the product development process to carrying out minor engineering just to improve the product, and subsequently producing and marketing it. In these situations it is of the utmost importance for the manufacturer to carefully assess the product concept and its commercial potential, that is, he must
   a. identify the potential users of the product,
   b. formulate the user requirements,
   c. determine whether the new product meets a significant user need,
   d. assess the market potential,
   e. analyse the competitive market situation,
   f. determine and evaluate the necessary investments and inherent risks,
   g. evaluate the new product's fit with the firm's existing products,
   h. define the product concept in terms of user benefits,
   i. define the technical aspects of the product concept and
   j. test the product concept with a representative group of potential users, distributors and industry experts.

8.2.3 INTERACTION BETWEEN THE MANUFACTURER AND POTENTIAL USERS

CONCLUSIONS

0. Manufacturers of medical equipment often interact insufficiently with potential users during the critical predevelopment stages. However, this subject has already been covered in the previous section.

1. Contribution during nearly all product development stages
   Potential users may actively contribute to nearly all stages of the product development process. Their contribution typically consists of activities such as (1) suggesting a new product idea, (2) providing information about user requirements, (3) commenting on new product concepts, (4) assisting in the development of prototypes, (5) testing prototypes and (6) assisting in diffusion of the product.
2. Limited user involvement in actual development activities
   Potential users of medical equipment were not extensively involved in the actual development of prototypes. When an industrial firm developed a prototype, the contribution of potential users typically consisted of answering specific (medical technology) questions and commenting on submitted issues. Only in an exceptional case did the user actually develop part of the new product. When a university, linked with a university hospital, develops an original design, potential users may be more closely involved. Nevertheless, due to the small number of physicians involved, actual user involvement is often still quite limited.
3. Emphasis on having prototypes tested by users
   Manufacturers of industrial products made much of the external testing stage, that is having their prototypes tested by potential users under working conditions. However, despite all this, most of them carried out this critical activity quite carelessly. All in all, the experiences of all firms resulted in the formulation of a comprehensive framework for having potential users test prototypes.
4. User potential insufficiently exploited in diffusion of the product
   Although the large majority of manufacturers of medical equipment employed potential users to test their prototypes, only about half of them employed them during market introduction and subsequent diffusion of the product. This is very surprising considering (a) the logical link between both activities and (b) the importance of word-of-mouth communication in hospital buying behaviour.
5. Differences between hospitals and industrial firms
   In our investigation we studied both industrial firms and hospitals as the organizational buyers of complex innovations. Though considerable differences used to exist between the buying behaviour of

the two types of organizations, these differences are getting smaller. In the Netherlands, hospital buying behaviour is becoming more and more like that of industrial firms.

MANAGERIAL IMPLICATIONS

1. The conclusion that potential users may contribute to nearly all stages of the product development process serves to make management aware of the many forms of manufacturer-user interaction. For example, many of the firms investigated limited their interaction with potential users to having them comment on product concepts and test newly developed prototypes. By not involving them in such stages as the development and launch stages, manufacturers fail to make optimal use of the full potential of users. The following three points discuss manufacturer-user interaction during three specific stages (i.e. the development, testing and launch stages) in greater detail.
2. The physician's expertise lies in a specific medical (sub)discipline rather than in the latest technology. Therefore physicians are best suited to formulating problems with existing products, suggesting ideas for new products, evaluating new product concepts and testing newly developed prototypes. During the actual development of the technologically complex prototype their contribution should, by necessity, be limited to reacting to questions and requests from the manufacturer's engineers about highly specific medical (technology) issues. As the engineers are unfamiliar with this medical knowledge, the manufacturer should carefully select physicians (based on their reputation in the field) and build up a good personal relationship. Only if the physician is working in a large hospital, with a major technical services department, is the potential user likely to provide a more substantial contribution.
   When an original design is developed by engineers of a university linked to a university hospital, there will be close cooperation between the engineers of the university and the physicians of the hospital. Thus the original design will actually be developed within a clinical environment. While this should be encouraged by the manufacturer, he should make sure that (a) he is involved in formulating the specifications for the original design, (b) there is a good relationship between the engineers and the physicians, (c) the original design will also be tested by physicians at other hospitals and (d) the original design will be transferred to the firm in time.

Thus again emphasizing the need for detailed and timely communication.

3. Having prototypes tested by potential users under actual working conditions is a very critical stage in the development process that should be performed with care. This stage can be broken down into a series of activities which all deserve careful attention from management. As Chapter 7 describes in great detail a general framework for testing prototypes with potential users, containing all these individual activities and decisions, it is not necessary to go into this subject here (a tentative version of the framework, together with many practical considerations, can be found in Chapter 5).
4. Manufacturers of innovative medical equipment should employ test users more actively during market introduction and subsequent diffusion. The names and reputations of the physicians who tested the prototype, together with their positive experiences with the product, are powerful instruments in convincing prospective buyers of the innovation's benefits. However, this highly effective strategy presupposes that (1) renowned physicians can be identified in the medical discipline in question, (2) at least one of them is willing to test the prototype, (3) experiences with the new product are positive and (4) the physician is willing to have the firm use his name and reputation. In the ideal case, the physician will even present papers, write articles about the product and demonstrate it to colleagues. When it concerns a relatively small and simple piece of medical equipment, which can be sent by mail, the renowned physicians may be identified globally. If, on the other hand, the equipment is bulky, expensive and requires frequent checking by an engineer, the manufacturer must identify a local renowned physician (that is, someone in the Netherlands, West-Germany or Belgium, preferably as close as possible).
5. Due to implemented budgeting procedures and an accompanying growing cost awareness in hospitals, the buying behaviour of hospitals is undergoing considerable change. Whereas the decision to buy a new medical instrument typically used to be made by the physician, such decisions are nowadays being made by a buying committee. Such a committee may consist of a physician, nursing staff, an administrator, a purchasing manager and a representative of the technical services department. Several of the large hospitals even employ an expert on medical technology who is able to evaluate the various

alternative technologies offered by the manufacturers. In the smaller hospitals, however, the physician may still be the major decision maker. This development has important implications for the way manufacturers interact with potential customers. (1) As hospitals are increasingly in the possession of technological expertise in addition to medical know-how, they may be more intensively involved in product development processes (for instance during the concept and the actual development stages). (2) During market introduction, manufacturers should interact with all relevant persons involved in the purchasing decision. Instead of approaching only the physicians, manufacturers also need to establish and maintain good relationships with purchasing managers, administrators and engineers. (3) In introducing new medical equipment, manufacturers should match the communication channels and selling propositions to the targeted decision makers. For example, while physicians can still be approached through sales representatives and advertisements in trade journals stressing the medical benefits of the innovation, an administrator should be confronted with calculations emphasizing the cost effectivess of the new product.

8.2.4 INTERACTION BETWEEN THE MANUFACTURER AND VARIOUS THIRD PARTIES

CONCLUSIONS

0. Manufacturers of medical equipment often interact insufficiently with various third parties during the critical predevelopment stages. However, this subject has already been covered in a previous section.
1. Broad range of third-party contributions
   Many different organizations, termed third parties, such as distributors, universities, government agencies, competitors and suppliers, contribute a wide range of activities to the product development process. While potential users are basically employed to provide user information, the involvement of third parties includes such activities as influencing cooperation strategies, funding research, providing information and producing components.
2. Substantial contribution to the development stage
   Third parties contribute substantially to the actual development of prototypes. These third parties are mostly universities, specialized

research institutes and suppliers, who possess very specialized advanced technological knowledge needed by the firm.

3. Third-party involvement in launch stage
   Frequently, third parties are involved in the launch stage by (a) assisting in marketing the innovation or (b) manufacturing strategic components.
4. Industry-university cooperation
   Although industrial firms and universities are increasingly cooperating in the development of new products, this kind of interaction may be accompanied by a number of special problems, most of them caused by the inherent differences between both partners. For example, while (a) an industrial firm often expects a university to develop an industrial prototype and (b) a university often expects a firm to start manufacturing its original design as it is, neither of these viewpoints is very realistic.

MANAGERIAL IMPLICATIONS

1. Both (a) the many different organizations, termed third parties, and (b) the broad range of activities they contribute to the product development process draw management's attention to forms of interaction which are frequently forgotten. For example, manufacturers often question potential users of the product during the predevelopment stages. However, at these stages important information may also be provided by third parties such as universities, or even competitors. While competitors are hardly employed during the predevelopment stages, they can be a reliable source of first-hand information as regards certain products and specific production techniques. To use this source of information effectively, managers in the manufacturing firm need to establish and maintain good personal relationships with their counterparts in the firm's major competitors. Thus, instead of a formal network of competitors, an informal network consisting of relationships between colleagues should be established.
2. Some of the firms developing innovative medical equipment depend on outside sources for specific technological knowledge. In some cases, it is a medium-sized firm in the need of some very specific knowledge from a specialized research institute. In other cases, it is a small firm which does not possess all the technical expertise to develop the new product. Both cases do not pose special problems to

management. Research institutes are well publicized and easy of access. In addition, each firm can check with the universities and specialized suppliers as to the availability of the necessary know-how. By using some kind of snowballing interview technique, that is asking each person for other references, potential cooperation partners are easily identified.

3. Third parties may be involved in the launch stage through the production of strategic components. This situation often occurs when a (small) firm has a supplier developing and producing a part of the new product. In these situations the manufacturer must (1) select a high-quality supplier to develop the component, (2) formulate the product specifications together with the supplier so as to use both knowledge areas optimally, (3) carefully control the development of the component (deviations from the original design must be discussed) and (4) test the component both separately and as part of the complete product.

   If the developed prototype is tested by an external research organization, its name and reputation can be used during market introduction. Sometimes a small firm may lack marketing expertise and use an established distributor to market the innovation. In this situation, the firm needs to undertake the maintenance and repair, as well as the technical training of the operators.

4. The basic remedy for improving industry-university cooperation is detailed and timely communication, that is, at the start of the cooperation project, all relevant aspects must be discussed and agreed upon by both parties. Appendix D contains a check list of ten important factors to bear in mind when considering cooperating with a university in developing an innovation.

8.2.5 THE FUNCTIONING OF ORGANIZATIONS WITHIN NETWORKS

CONCLUSIONS

1. Development of innovations within networks

   Innovations for industrial markets were invariably found to be developed within networks consisting of two or more organizations linked together by interactive relationships. Typically, manufacturers interact with both potential users and various third parties in developing complex innovations. Nevertheless, both users and

third parties are involved in different ways and at different levels of intensity, depending on the stage of the development process.

2. Classification of networks

   As previously mentioned, networks can be classified in three important ways. The underlying dimensions are (a) the network's complexity, (b) the nature of the major cooperation partners and (c) the environment of the interactive relationships.

3. Product development within complex networks

   Developing innovations within a complex network, that is one that consists of more than two different organizations cooperating by means of interactive relationships, has several advantages and disadvantages. While the obvious advantages are (a) specialization and (b) correction, the major disadvantages are (a) friction, (b) delays and (c) duplication.

4. The Dutch medical equipment industry and 1992

   The year 1992 is generally taken as a milestone, with the European market opening up and obliging manufacturers to operate globally and interact more intensely with users and competitors. Therefore 1992 can be said to stimulate the development of industrial networks. Nevertheless, the consequences to the Dutch medical equipment industry will be limited.

MANAGERIAL IMPLICATIONS

1. As has been stated before, a manufacturer wanting to develop a complex piece of medical equipment needs to evaluate cooperation with a number of potential partners. The choice of cooperation partner and the desired level of intensity of interaction depends on the stage of the development process. For example, one manufacturer of innovative medical equipment decided that distributors, rather than physicians, are best suited to assess the potential of new product ideas. Because physicians are generally in favour of any new product representing a technological advance, they were thought to be useless in assessing the value of an abstract product concept (nevertheless, they may still provide relevant information during these predevelopment stages!). However, physicians are the obvious choice when it comes to testing and criticizing a concrete prototype. Not only because of their access to a clinical environment, but also because Dutch physicians can be characterized as being very critical of new equipment.

2. (a) When a firm interacts with just one partner (a simple network), management can direct all its attention to managing that relationship. On the other hand, when a firm collaborates with a number of partners (a complex network), management is confronted with the task of managing a portfolio of relationships, some of which may be influencing each other. Individual relationships need to be evaluated in terms of investments, benefits and potential interaction effects. The advantages and disadvantages of developing innovations within a complex network are discussed further on.
   (b) Whether the network is dominated by interaction with users or third parties strongly influences the content and intensity of the interactive relationships. As both types of interaction have been discussed previously, we will not further elaborate on them.
   (c) The distinction between internal and external networks is of critical importance to every organization that is part of the total network. As the effectiveness and efficiency of the total external network is determined by the functioning of all internal networks, each organization involved must take care of its own internal network. That is, each organization must ensure that all the relevant parties within the organization are involved and that good communication exists between them.
3. Developing an innovation within a complex network has the benefits of specialization and correction of deficiencies, thus suggesting a highly efficient and effective operation. However, the involvement of many parties in product development may also lead to several disadvantages, which may be overcome to some extent. (a) The friction between the parties involved is typically caused by insufficient communication and/or widely differing cultures. However, widely differing cultures need not always result in misunderstandings and friction. Take, for example, the enormous differences between the scientific world of the university and the practical reality of the industrial firm. Appendix D enumerates ten ways to improve industry-university cooperation and avoid friction between both partners through detailed and timely communication. (b) When several parties are involved in developing the innovation, both information and products (e.g. an original design, components, a prototype) must be transferred from one organization to another in the course of the development process. Although this will obviously lead to some delays, they should be minimized through detailed and

timely communication and by making agreements concerning division of tasks, responsibilities, deadlines, etcetera. (c) Duplication of activities can also be minimized through detailed and timely communication and carefully drawing up agreements. If all development tasks are carefully divided among the partners involved, together with responsibilities, development schedules, etcetera and the partners interact freely during the development process, duplication of activities will hardly occur.

4. The results of the investigation clearly show that all Dutch manufacturers of complex medical equipment are very dependent on export. The Dutch market generally represents only about two to ten percent of their total sales. Therefore the manufacturers have traditionally been forced to think globally in order to survive. The year 1992 is not expected to change this situation very much. Most manufacturers will continue doing business in the way they have done till now. There is, however, one important aspect that may change, and that is the regulations. At present, all countries have their own regulations which hinder manufacturers selling their equipment abroad (e.g. through enforcing strict regulations on safety tests). In 1992, the process of harmonizing all existing regulations will start. Nevertheless, considering all the wide differences, the ideal of 'European regulations' will probably remain a distant dream for a long time.

In this section we briefly discussed some of the major conclusions and their managerial implications. The most relevant observations are summarized in the check list presented in Appendix E. While these conclusions and implications are of interest to all firms developing innovative medical equipment, they are relevant to small firms in particular. The very small firms, consisting of up to ten employees, are typically very much technology oriented and do not have the resources to hire experienced marketers. In many cases they have just started and are unfamiliar with the field of medical technology. Moreover, the success of these firms strongly depends on the success of one or two innovative products. Therefore these firms stand to benefit the most from reading these conclusions and implications, applying them to their own specific situation and acting on them.

8.3 RESEARCH METHODOLOGY: CASE RESEARCH REVISITED

The experiences acquired by having studied twenty-two cases clearly demonstrate the advantages of the research method. (a) It offered the opportunity of investigating product development processes in industrial firms in detail. (b) The semistructured questionnaire proved to be flexible enough to obtain the desired information efficiently, while at the same time it was found to be structured enough to control the course of the interview. (c) The strategy of interviewing most people more than once allowed us to return to subjects covered during previous interviews.

Despite all these manifest advantages, a number of important limitations were discovered as well.

a. Large amount of time required. Conducting case studies requires a great deal of time. As an indication, we estimate a single interview, together with such activities as preparing the interview and writing the report, as taking up approximately eight hours of time. This has two important implications for the use of case research. (a) Only a limited number of cases can be investigated. (b) The construction of detailed case studies requires the investigator to take up a lot of the interviewee's time.

b. Subjective information. As investigating the cases relies heavily on personally interviewing the people involved, the information provided is generally subjective. People tend to overrate their own (or their own firm's) contribution to the development of a specific innovation. The objectivity of the acquired information can be enhanced by (a) obtaining additional information from more objective sources, (b) interviewing several persons within the same organization, (c) interviewing persons within other organizations and (d) using the right interview technique.

c. Imperfect memory. When conducting case research, the investigator always runs the risk of obtaining inaccurate or distorted information because of the imperfect memory of the persons interviewed.

d. Simplification of reality. It should be stressed that the final case description always remains a simplification of reality. Sometimes, there will even be some distortion because the desired information has to be forced into the format of the framework used for analysis.

e. Difficulty in analysing the final results. The nature of the data gathered during the investigation allows for only a limited quantitative analysis. To perform some analysis, the various case studies should be compared in accordance with an underlying general framework.

These personally experienced limitations suggest that a general conceptual model for conducting case research could possibly benefit other researchers. Such a model would enhance the efficiency and effectiveness of conducting case research through pointing out potential problem areas and suggesting ways of avoiding them. Appendix F describes a fourteen-step model for conducting case research which is structured in such a way as to minimize the limitations mentioned above (a more detailed and practical description of the model is given by Barius and Biemans (1990)).

8.4 RECOMMENDATIONS FOR FUTURE RESEARCH

The total investigation has proved successful in generating conclusions of both theoretical importance and direct relevance to industrial marketing practice. Nevertheless, the investigation is limited in the sense that it involves only a limited number of cases which are mainly taken from one specific industry. Therefore, after having finished investigating the cases and evaluating the results, many recommendations for future research suggest themselves to the researcher. We shall discuss some of the most important ones.

a. The general framework for testing prototypes with potential users should be further tested in a number of other industries. As the framework is formulated in quite general terms, this will probably lead to its additional confirmation, more detailed definition of the individual stages and a better understanding of the specific requirements of different industries.
b. The functioning of industrial firms within networks should be investigated in other industries as well. The contribution of potential users and third parties to product development processes may be strongly influenced by the industry involved. An investigation of the subject across industries is necessary to identify the factors that determine both user and third-party involvement in product development.

c. The present investigation studied the development of complex medical equipment within networks. To obtain a more complete picture, one should subsequently investigate the adoption and diffusion of such equipment among hospitals. The central concepts of interaction and networks may be fruitfully employed in this context as well. A research proposal regarding the adoption and diffusion of complex medical equipment is already in preparation.
d. The procedure suggested for evaluating the potential of various interactive relationships should be further refined. Subsequent research may address issues such as (1) the nature of the investments and benefits to be considered, (2) the criteria to employ in evaluating relationships, (3) ways to determine the weights indicating the relative importance of various criteria and (4) ways to account for potential interaction effects between relationships.
e. The use of case research in investigating marketing problems may lead to a better understanding of both the potential value and benefits as well as the possible problems and pitfalls of conducting case research. This improved understanding may be used to refine and add to the conceptual model, thus assisting other investigators in designing the most suitable research methodology.

The present investigation largely built on existing knowledge and concepts generated by other researchers. Hopefully, the concepts and knowledge it generated will assist industrial marketers in making better decisions and be used by other investigators to arrive at a better understanding of the functioning of organizations within networks.

APPENDIX A. THE STAGES AND ACTIVITIES OF THE PRODUCT DEVELOPMENT PROCESS

DEVELOPMENT STAGES	ACTIVITIES	DESCRIPTION
IDEA	- IDEA GENERATION - SCREENING	An idea results when technological possibilities are matched with an expected market demand. First evaluation of the idea; the initial decision to commit resources.
PRELIMINARY ASSESSMENT	- PRELIMINARY MARKET ASSESSMENT - PRELIMINARY TECHNICAL ASSESSMENT	Conducting a quick market study, using in-house information, secondary data and outside sources. Assessing the idea's technical viability.
CONCEPT	- CONCEPT IDENTIFICATION - CONCEPT DEVELOPMENT - CONCEPT TEST	Identifying a market need and the way to meet it. Formulating the basic design. Translating the market requirements into an operational concept. Conducting a market study to test market acceptance of the concept.
DEVELOPMENT	- DEVELOPMENT PROTOTYPE - DEVELOPMENT MARKETING PLAN	Employing technological resources to develop a prototype. Formulating a general marketing plan, based on the concept stage.
TESTING	- IN-HOUSE TESTS (INTERNAL TESTS) - TESTS WITH USERS (EXTERNAL TESTS)	Testing the technical functioning of the prototype. Testing of the prototype under working conditions by real customers.
TRIAL	- PILOT PRODUCTION - FINALIZATION MARKETING PLAN - BUSINESS ANALYSIS	Testing the production method that will be used for full scale production. Formulating the final marketing plan. Undertaking a pre-commercialization business analysis.
LAUNCH	- FULL PRODUCTION - MARKET LAUNCH	Starting up full production. Introducing the product into the market.

APPENDIX B. THE SEMISTRUCTURED QUESTIONNAIRES

QUESTIONNAIRE: MANUFACTURER

1. THE FIRM

1.1. Name of the firm.

1.2. Type of firm: - manufacturing versus manufacturing/trade,
- supplier to end users versus supplier to OEM's.

1.3. Size of the firm: - total number of employees,
- number of employees involved in medical equipment.

1.4. Name of the interviewee.

1.5. Function of the interviewee.

1.6. Total sales of the firm.

1.7. Percentage of total sales that is realized through export (dependence on foreign markets).

1.8. Kind of products manufactured and marketed by the firm.

1.9. Firm's relative market position.

2. NEW PRODUCT DEVELOPMENT

2.1. Kind of new products developed by the firm.

2.2. Differential advantage of new products developed by the firm.

2.3. Product development strategy followed by the firm.

2.4. Stages of the general product development process.

2.5. Kind of customers and/or third parties the firm interacts with during the process of product development.

2.6. Stages of the product development process during which the firm interacts with customers and/or third parties.

2.7. Criteria used for the selection of interaction partners.

2.8. Objective of the interaction.

2.9. Intensity of the interaction.

2.10. Problems that occurred during the interaction.

3. A SPECIFIC INNOVATION PROJECT

3.1. Brief description of the most recent innovation project.

3.2. Position of the innovation with respect to competitive products.

3.3. Kind of customers for the innovation (new versus existing).
3.4. Origin of the idea for the innovation.
3.5. Reason for developing the innovation.
3.6. Degree of newness of the innovation.
3.7. Eventual result: - unsuccessful,
- successful,
- too early to judge.
3.8. The product development process.
3.8.1. Comprehensive description of all subsequent stages.
3.8.2. Duration of the total product development process.
3.8.3. Stages during which the firm interacted with customers and/or third parties.
3.8.4. Criteria used for selecting customers and/or third parties.
3.8.5. Types of interaction partners.
3.8.6. Number of interaction partners.
3.8.7. Initiative for the interaction.
3.8.8. Intensity of the interaction.
3.8.9. Nature of the interaction.
3.8.10. Duration of the interaction.
3.8.11. Objective of the interaction.
3.8.12. Parties involved in the interaction.
3.8.13. Problems that occurred during the interaction.
3.8.14. Way in which the problems were solved.
3.8.15. Lessons the firm has learned from the experiences during the product development process.

QUESTIONNAIRE: USER / THIRD PARTY

1. THE ORGANIZATION

1.1. Name of the organization.
1.2. Type of organization: - customer,
- third party: type of third party.
1.3. Size of the organization.
1.4. Name of the interviewee.
1.5. Function of the interviewee.

2. INTERACTION WITH THE MANUFACTURER DURING THE SPECIFIC INNOVATION PROJECT

2.1. The product development process.

2.2.1. Comprehensive description of all stages during which the organization interacted with the manufacturer.

2.2.2. Initiative for the interaction.

2.2.3. Intensity of the interaction.

2.2.4. Nature of the interaction.

2.2.5. Duration of the interaction.

2.2.6. Objective of the interaction.

2.2.7. Parties involved in the interaction.

2.2.8. Problems that occurred during the interaction.

2.2.9. Way in which the problems were solved.

2.2.10. Lessons the firm has learned from the experiences during the interaction with the manufacturer.

ONLY WITH RESPECT TO HOSPITALS:

3. ADOPTION OF MEDICAL EQUIPMENT

3.1. Parties involved in the adoption process.

3.2. Role played by the various parties involved in the adoption process.

3.3. Relative influence of each of the various parties involved in the adoption process.

3.4. Criteria employed in adopting medical equipment.

3.5. Relative importance of the criteria employed in adopting medical equipment.

APPENDIX C. SEVENTEEN CASE STUDIES FROM THE FIELD OF MEDICAL TECHNOLOGY

This appendix presents seventeen cases from the field of medical technology. For the data collection procedure the reader is referred to the remarks on research methodology in Chapter 7. Each individual case description is structured as follows. After a short introduction about the firm in question, its products, product development strategy and cooperation partners, the description focusses on the development process regarding the most recent technically complex innovation. The contribution of potential product users and various third parties is taken as the central theme, and the problems encountered are briefly outlined. Each case description ends with a number of summary conclusions. In the case descriptions marked with (*), the firm and the innovation studied have been disguised for reasons of confidentiality.

CASES 1 AND 2. EYE-TECH: THE LASERLINC AND A DEVELOPMENT PROJECT IN COOPERATION WITH A UNIVERSITY (*)

In ophthalmology laser technology has become a well-known tool in diagnosing and treating the human eye. In the Netherlands, Eye-Tech ranks first in developing innovative medical instruments based on laser technology. Eye-Tech has a sales total to the amount of 30 million guilders and has 125 employees (one-fifth being employed in R&D). Most of the production is contracted out to small specialized outside suppliers on a contract basis. Eye-Tech only produces the strategically important components, embodying the key technology, and assembles the whole product. Due to the small market and the highly specialized products, Eye-Tech is very dependent on export; less than 5 percent of its sales is in the Netherlands.

STRATEGY: REACTIVE, SECOND-BUT-BETTER

Eye-Tech carefully screens new product opportunities: new products need to be based on laser technology and must be intended for Eye-Tech's present customer base. Despite its leading position in the Netherlands, Eye-Tech cannot be considered a trendsetter in global markets. Instead,

it pursues a well articulated strategy of second-but-better. Innovative products, introduced by major competitors and proven successful, are improved by Eye-Tech. Instead of simply copying the innovation, the strategy entails: (1) simplifying the original design (e.g. reducing the product functions to their bare essentials), (2) adding an essential benefit for the customer. This strategy enables Eye-Tech to sell the new product at a competitive price.

COOPERATION PARTNERS

Objective, high-quality hospitals (both in the Netherlands and abroad) with which Eye-Tech has built up a relationship of trust are involved in testing prototypes. Due to the relative price advantage of Eye-Tech's products, purchasing managers (apart from physicians and engineers) are important interlocutors. Until now, Eye-Tech has not cooperated extensively with universities, but this type of cooperation is expected to increase in the near future.

THE LASERLINC

The LaserLinc is an example of an innovation developed by Eye-Tech according to the strategy outlined above. The original product was introduced 10 years ago by a key competitor and brought about a small revolution in the field of ophthalmology. The competitor quickly gained a worldwide market share of approximately 60% and its product became standard equipment in most hospitals. Because of the widespread use of the competitor's product, Eye-Tech decided to duplicate the basic elements of the product. However, Eye-Tech developed an additional component to reduce the level of emitted energy without impairing the performance. Due to the growing discussion among physicians about possible negative side effects of energy emitted by lasers, this represents an important competitive advantage.

The product concept was developed through close cooperation with a local university hospital and tested with dealers abroad. Development of the product started on the basis of initially positive reactions. The development activities were conducted by Eye-Tech with feedback to physicians at the local hospital. Next, the developed prototype was tested in-house, demonstrated at an important annual trade show for end users and tested by the local hospital. A test series of 10 units was produced for (1) introduction during the annual dealers meeting and (2) clinical evaluation at hospitals in the Netherlands and abroad. After

modifying some details of the product's design, the first production run of 25 units was started. While the first orders generated by the enthusiastic dealers arrived, an evaluation centre in Germany (which had tested a unit of the first production run) uncovered some essential defects. This necessitated (1) stopping delivery, (2) taking back and modifying the units already delivered, and (3) discouraging the demand generated by the dealers. After modification of the products, Quality Control discovered another defect. The products were modified again and eventually the new product was re-introduced during the next annual dealers meeting.

SUMMARY CONCLUSIONS

1. Eye-Tech ran a great risk by introducing the new product at the dealers meeting before it was clinically evaluated. This risk was thought acceptable because of the confidence based on the initial results of the in-house test and the test in a local hospital.
2. Mistakes were made in proceeding from trial production to the first production run. Accordingly, the product eventually introduced was not identical to the product tested by the hospitals.
3. Quality Control failed by not noticing the initial product defects.
4. Discouragement of the demand generated by the dealers resulted in disturbed relationships with both dealers and ultimate users.
5. The selected local hospital did not have the expected expertise in laser technology. In addition, substantial commitment and special attention to the project were absent.
6. For some time, the clinical evaluation at the local hospital was undertaken with the prototype. After recognition of the mistake the prototype was replaced by a unit of the trial production.

DEVELOPMENT PROJECT IN COOPERATION WITH A UNIVERSITY

Another example of an innovation project at Eye-Tech will be discussed briefly. Researchers at a university noticed a new product opportunity and a development project was initiated. However, potential manufacturers were not contacted at this stage. A prototype was developed, built and tested by the university. Only after the prototype had been shown to function technically, the university researchers started to look for a potential manufacturer. During the negotiations with Eye-Tech the enthusiasm of the university researchers was picked up by a member of the board of directors, who subsequently promoted the project

internally. After having spent considerable resources on the project, Eye-Tech discovered that the innovation was only of interest to a very limited group of customers (i.e. highly specialized research laboratories), and thus represented insufficient potential for profit. Eye-Tech discontinued the development activities and terminated the project. One of the lessons Eye-Tech learned from these experiences is that a university and Eye-Tech should join forces in developing an innovation. Integration of development efforts can be accomplished by having an employee of Eye-Tech involved in the activities at the university and having a university researcher involved in the development activities at Eye-Tech. A necessary precondition for this integration is that contact between the university and Eye-Tech will be established at a much earlier stage.

SUMMARY CONCLUSIONS

1. The project proposed by the university was insufficiently evaluated by Eye-Tech; no attempt was made to identify the basic customer group and to estimate market potential.
2. Enthusiastic top management support hampered objective judgement.
3. Coordination problems were caused by the development activities at the university (development of a prototype) being clearly separated from those at Eye-Tech (transformation of the prototype into a marketable industrial product).

CASE 3. SPINEX: THE ULTRA-LOW-TEMPERATURE FREEZER (*)

Because of promising opportunities in markets for medical instruments, Spinex was established in 1986 as an independent subsidiary of a company already selling to hospitals. Spinex' subsequent growth is based on the success of the firm's main product, the ultra-low-temperature freezer. Although expansion is predicted for the near future, the company still consists of 5 employees: one R&D, three Production and one Marketing. Total sales are 4 million guilders. Components are, for the most part, manufactured by outside suppliers. Spinex only produces the strategically important components and assembles the final product. Despite a growing export, the greater part of sales is realized within the Netherlands.

STRATEGY: REACTIVE, SECOND-BUT-BETTER

Ideas for new products are carefully considered by Spinex. They originate, for example, from the discovery of a successful product that is not sold in the Netherlands yet. Another important source consists of expired patents. New product ideas are only considered for development if (1) Spinex will be granted a subsidy for the project, (2) the product can be considered a significant improvement compared with an existing product, and (3) competition is limited (Spinex' expertise lies in R&D instead of marketing; accordingly, Spinex can only flourish by developing and selling technically superior products).

COOPERATION PARTNERS

The involvement of hospitals in the product development process is limited to testing prototypes. These tests usually emphasize the new product's technical aspects (e.g. safety). Universities or other research institutes do not contribute to Spinex' development projects.

THE ULTRA-LOW-TEMPERATURE FREEZER

Spinex's main product, an ultra-low-temperature freezer, exemplifies the second-but-better strategy pursued by the firm. The product is used for freezing at long notice for numerous purposes in the medical industry and was first introduced 25 years ago by the American firm Tempamed. Ever since, this firm has enjoyed a virtual monopoly because the innovation was protected by patents. The recent expiration of the patent allowed for the development of Spinex' ultra-low-temperature freezer.

The new product opportunity was recognized by the founder of Care, a Dutch distributor of medical products, who started to look for a firm to manufacture the product. Spinex, then just established, was elected. Spinex started production based on the specifications of Tempamed's freezer. The product was supplied to hospitals in the Netherlands and promptly proved to be a failure. All units were returned with a number of complaints, and every product had to be modified individually. About this time, the R&D functionary of Spinex was replaced. The newcomer recognized the mistake of trying to manufacture exact copies of Tempamed's freezer, noticed the faulty design, and defined new product specifications. The latter were drawn up without involvement of physicians. Instead, they were based on technological facts readily available in the literature (some of which had been overlooked by

Care's founder). The resulting product represented a significant departure from Tempamed's product and offered an improved product performance. A prototype was developed and tested both internally and by a technician of a Dutch university hospital (test of electrical safety). After market introduction, the product was tested by The Netherlands Organization for Applied Scientific Research (TNO) to get the 'stamp of approval' needed for export. Before starting the second production run, the product needed to be slightly modified to meet the IEC standards. By now, the ultra-low-temperature freezer has proved to be such a success (both in the Netherlands and abroad) that Spinex plans to take over the distribution from Care and recruit additional production employees.

SUMMARY CONCLUSIONS

1. Due to its small size, Spinex is strongly R&D oriented and hardly possesses marketing expertise. This resulted in only a minimal contribution of users to product development.
2. Various problem areas, such as finance, organization, product development, marketing and production are strongly intertwined.
3. Spinex' success depends on a limited number of products.
4. Initiation of a new product development project is only possible if Spinex is granted a subsidy.
5. Because the marketing was initially done by a distributor, Spinex lacks a market image. This can be overcome by investing in marketing (communication) activities.

CASE 4. AIR: ADVANCED MICROELECTRONICS FOR A RESPIRATOR (*)

Applied Instruments for Respiration (AIR) is a subsidiary of Instruments Inc., a worldwide manufacturer of advanced instruments (1200 employees, total sales amounting to 200 million guilders), and specialized in the development, production and marketing of instruments used in respiratory equipment. Since AIR produces components for respiratory equipment, it depends on original equipment manufacturers for acquiring specific market information and drawing up product specifications. Owing to the small Dutch market, about 90% of the total sales is realized abroad.

STRATEGY: REACTIVE, PREDOMINANTLY RESPONSIVE

AIR's actual product development strategy can generally be described as being reactive. In general, new products are developed in reponse to customers' requirements.

COOPERATION PARTNERS

Due to the complexity of AIR's products, users are scarcely, if at all involved in the development process. Users can initiate a development project by mentioning a medical problem, but AIR is best equipped to translate a general problem formulation into a concrete product. Universities' contribution to product development is limited because of their narrow scientific orientation and dispersed research efforts. Newly developed prototypes are always tested in hospitals in the Netherlands (mostly university hospitals since they have the means to conduct comparative research).

ADVANCED MICROELECTRONICS FOR A RESPIRATOR

Around 1980, an American firm introduced an advanced respirator with innovative functions that was sold in the Netherlands as well. When using the product, however, medical specialists discovered some major disadvantages and improvements were required. The department of Experimental Respiratory Techniques of the Dutch University (DU) was very interested in developing an innovative solution. A cooperation contract was drawn up by AIR and the DU, according to which the DU would develop an original design which would subsequently be transformed into a commercially viable product by AIR and sold to an OEM. In developing the original design it was a distinct advantage that the DU was linked to a university hospital, so that physicians could contribute to the development process and prototypes could be tested in a clinical environment. Nevertheless, only a limited number of physicians and patients were actually involved.

Subsequently, AIR developed an industrial prototype based on the original design and the product specifications were drawn up in cooperation with an OEM. Due to a less than optimal cooperation between the DU and AIR, the transformation of the developed original design into an industrial prototype took much longer than was anticipated.

The OEM contributed to the product development process in five different ways: (1) testing the original design with users in the United States, (2) drawing up the product specifications in cooperation

with AIR, (3) duplicating internal tests conducted by AIR and performing some specialized technical tests, (4) having the prototype worldwide tested by users and (5) introducing and marketing the total product.

SUMMARY CONCLUSIONS

1. The cooperation between a university (DU) and an industrial firm (AIR) was less than optimal since the collaborating partners (a) had different objectives, (b) had different expectations and (c) used different criteria for evaluating the cooperation.
2. Lack of understanding and underestimation/overestimation on both sides interfered with the transfer of the original design from the DU to AIR.
3. The involvement of three major different parties (a university, an industrial supplier and an OEM) has advantages and disadvantages.
4. Development of the original design in a clinical environment represented a market orientation, but hindered the acquisition of generally valid information and the transfer of the original design.
5. The functioning of the total network largely depends on the functioning of the various networks within each individual organization.

CASE 5. APPLIED LASER TECHNOLOGY: THE DIODOPP

Applied Laser Technology (ALT) originally started as a one-man business and grew to become a manufacturer specialized in laser applications. The firm currently consists of 5 employees with a predominantly technical background, while one or two of them have some commercial expertise as well. ALT's main activities involve the development of new products, while it imports and sells some additional products too.

STRATEGY: PROACTIVE, RESEARCH AND DEVELOPMENT

Despite ALT's recent founding, a distinct proactive innovation strategy can be discerned. The firm strives to develop technically superior products based on advanced R&D activities.

COOPERATION PARTNERS

Owing to the recent founding of ALT, general comments with respect to cooperation partners can hardly be made. The following example, however, describes a collaboration with both a university of technology and a university hospital.

THE DIODOPP: A MICROVASCULAR PERFUSION MONITOR

The DIODOPP is an easy handling, compact instrument that offers clinicians and scientists the opportunity to reliably and continuously monitor skin blood flow. The product was developed through close cooperation between Groningen University Hospital (GUH) and the University of Twente (UT). Based on practical problems regarding the use of an existing Swedish measuring instrument for use in obstetrics, a physician at the GUH contacted the Biophysics Group of the UT to see whether there was a solution to their problem. Since no solution existed, a research project was initiated in which a student from the UT attempted to solve the problem. During this project the idea for the new product was born. A prototype was built and tested, and a grant of application was submitted to The Technology Foundation (STW). According to the subsidy arrangement, the UT would develop the technical aspects, while the GUH would focus on the application aspects, and a Dutch firm to manufacture and market the product had to be found. The last requirement made it impossible to cooperate with the Swedish manufacturer of the existing product, who showed great interest in the innovation. Due to problems with the electronic parts and the limited manpower available, developing the prototype took longer than was expected. After negotiations with various firms, a contract was eventually drawn up with ALT through which ALT acquired the diagrams in exchange for a certain percentage of future sales. ALT started with engineering on the prototype and showed it just one month later at the trade show of the British Medical Laser Association. The prototype was developed in a great hurry and was barely finished in time. Although the visitors at the trade show displayed great interest in the new product, some deficiencies were soon discovered. After spending five months on redeveloping the electronic parts, ALT discovered a crucial problem regarding the behaviour of the laser. The UT was brought in and eventually solved the problem. After a few more months spent on redevelopment, a prototype was ready for production. However, at that time ALT did not possess enough funds to start production. Because of this limitation and

the firm's mentality to attempt to manufacture a product of good quality, ALT started redevelopment activities again and over the next eight months improved the design. During these months ALT was confronted with growing external pressure due to the introduction at the trade show and announcements to potential distributors. Eventually the prototype was tested worldwide at five different sites. At present, the product is being introduced on various markets abroad (the Dutch market will be of only limited importance).

SUMMARY CONCLUSIONS

1. The requirement of the STW, that the firm to manufacture and market the new product must be Dutch, excluded the willing and most logical partner (the Swedish firm) from consideration.
2. ALT underestimated the time and energy needed to transform the prototype, developed by the UT in close collaboration with the GUH, into a marketable industrial product.
3. The UT agreed to exchange the diagrams for a percentage of future sales rather than a lump sum at once because (a) ALT would have been unable to pay a lump sum and (b) the fact that the prototype eventually reached the market would help the UT in acquiring future subsidies from the STW and motivate the researchers involved.
4. For a small firm like ALT, the product development process does not contain realistic GO/NO GO decisions. After having reached a certain point, taking a NO GO decision would be equivalent to discontinuing the firm.

CASE 6. MIJNHARDT: THE OXYCONβ AND OXYCONΣ

Mijnhardt, founded in 1961, is the only Dutch firm specialized in the development, production and marketing of lung function diagnosis equipment. Mijnhardt has 55 employees and the total sales amount to 12 million guilders, 11 million of which is accounted for by export. While, at least in the Netherlands, the cheaper products are sold through a distributor (50% of total sales) the more expensive items are sold directly. The products of Mijnhardt are directed at three distinct segments, differing in market structure. Although Mijnhardt's market share depends on the market segment, its products enjoy the reputation of being of good quality: no high tech, but certainly dependable.

STRATEGY: IMPLEMENTING AVAILABLE NEW TECHNOLOGIES

The market for lung function diagnosis equipment cannot be characterized as highly dynamic; significant new developments are limited. Accordingly, Mijnhardt's strategy in developing new products is more reactive than proactive. The firm uses available new technologies to develop new products which offer the user an improved solution with distinct advantages.

COOPERATION PARTNERS

Ideas for new products are often generated through a discussion with experts in the Netherlands and abroad who possess both influence in the medical community and technological expertise. Distributors can be used as well, since they have a more general view of the market. Medical specialists, who function as opinion leaders within their field, are of great importance in testing the developed prototypes and promoting the new product. University hospitals, universities and research institutes often contribute to the development of new products.

THE OXYCONβ AND OXYCONΣ

The new generation of the Oxycon series, that is the Oxyconβ and the OxyconΣ, represents instruments for detailed and precise metabolic measurements on children and adults, patients or athletes, at bedside or in the laboratory. Because of strategic considerations Mijnhardt's management decided to update one of its products. The existing Oxycon4 was selected for improvement, based on information with respect to both the market (a growing market with a limited number of competitors) and the technology (advanced techniques offer new opportunities). At an early stage of the development process a comprehensive market study was undertaken, consisting of interviews with users, opinion leaders, distributors and competitors in the various areas of application. Until then there existed two independent major techniques for metabolic measurements: the more conventional mixing-chamber technique and the breath-by-breath method which is perceived by users as being high-tech because it employs fast computers. Based on the results of the market study and the technological opportunities available to the firm (components, technological knowledge and manpower could be obtained from a sister company), it was decided to try to combine the two techniques in one product. In conformity with the underlying market-oriented strategy, the breath-by-breath technique would no longer be positioned as a

highly advanced method, but repositioned as the basic method for metabolic measuring. Eventually, two versions of the new generation of the Oxycon series were developed: the Oxyconβ, based on only the breath-by-breath technique, and the OxyconΣ, which combines the basic breath-by-breath method with the mixing-chamber technique. While the Oxyconβ represents a high-quality instrument offering the basic functions for routine measurements at a reasonable price, the OxyconΣ should be regarded as a functionally complete top-of-the-line instrument suitable for research purposes. In developing the prototype, Mijnhardt was assisted by the University of Limburg, the Academic Medical Centre Amsterdam, the University of Twente and the Netherlands Organization for Applied Scientific Research (TNO). (In the meantime, Mijnhardt introduced an Oxycon5, which was no more than existing instrumentation in a new box, because the market demanded an update and the competition's attention could thus be diverted from the real new developments.) The prototype of the Oxyconβ was tested extensively by various customers: (a) a barracks, with military athletes in top condition to test the functioning at the upper end, (b) a hospital, with real patients to obtain clinical information, (c) a business company, that intended to measure large numbers of employees, to test the durability and user friendliness of the device and (d) healthy young children to test the functioning at the bottom end. In the near future very young sick patients will be used to test the product under even more extreme conditions. At the time of market introduction (scheduled for the near future) no comparison will be made between the two existing techniques, but instead the Oxyconβ will be positioned as being an open, rather than a closed, system at a competitive price. From a marketing point of view this aspect is more relevant since it reflects both the user friendliness and the patient friendliness of the new product. The OxyconΣ will be positioned as a top-of-the-line product with research capabilities.

SUMMARY CONCLUSIONS

1. The generation of the concept and the development of the prototype were strongly based on an extensive market study conducted at an early stage of the product development process.
2. Although the possibility of combining the two techniques could not be established at the concept generation stage, the development

process was continued on the basis of the personal conviction of the people involved.

3. The availability of strategically important components, technological knowledge and manpower at a sister organization was an important determinant in developing the desired product at a competitive price.
4. During the whole process of product development many different parties were involved at various stages, such as concept generation, concept testing, prototype development and prototype testing.
5. The product development process was characterized by a continuous and close interaction between market-oriented activities and R&D activities.
6. In a market where significant developments are scarce, innovations can be developed by combining available new technologies with creative marketing.

CASES 7 AND 8. ENRAF-NONIUS: THE SONOPULS 434

Enraf-Nonius came into existence in 1965 through the fusion of Enraf (founded in 1924; manufacturer of X-ray equipment) and Nonius (established in 1948; manufacturer of X-ray diffraction cameras). Enraf-Nonius is a group of high-technology companies specialized in the design, manufacture and marketing of scientific, industrial and medical instrumentation. Each product group contributes about 20 to 30% to the turnover. In the medical field, Enraf-Nonius is the world's largest manufacturer of physiotherapy equipment. The whole group employs about 1000 people and total sales amount to some 200 million guilders in value. Sales of medical products amount to 50 million guilders, 70% of which is realized through export.

STRATEGY: PROACTIVE, FROM PURELY R&D TO A BALANCE WITH MARKETING

The firm's strategy with respect to its medical products can clearly be characterized as proactive. Although new products were initially mainly generated by means of investments in future-oriented R&D, the present-day strategy strives to balance an R&D focus with a marketing orientation.

COOPERATION PARTNERS

In developing new products, Enraf-Nonius always closely cooperates with physiotherapists. A distinction should be made between physiotherapists working in a hospital and those carrying on their own practice. The latter are more price conscious and are the first to adopt new equipment offering substantial cost savings. Users are very active in generating ideas for new products and in some cases they even develop and patent prototypes. External research institutes and technological universities often contribute their specialized knowledge to the development of new products.

THE SONOPULS 434

In developing the Sonopuls 434 the principal objective was to optimize the ultrasound beam and simultaneously eliminate stray radiation to protect the physiotherapist's hands. The ultimate product was the result of a series of incremental product improvements. It all started with a physiotherapist complaining about pain in the joints of her hand after using a competitor's ultrasound equipment. Eventually a specialized institute of the Netherlands Organization for Applied Scientific Research (TNO) conducted a number of tests on ultrasound equipment from various manufacturers and concluded that the problem was caused by stray radiation. Although the Enraf-Nonius product proved to be one of the best available, it emitted too much stray radiation itself. This led to a first provisional solution to the problem. Around this time TNO had conducted some additional tests on Enraf-Nonius products and another problem (a nonheterogeneous ultrasound beam) was discovered. Based on these problems and the wish expressed by users to have fully interchangeable treatment heads, Enraf-Nonius initiated new product development activities. Since Enraf-Nonius did not have the necessary technological knowledge, it contacted various large firms with experience in manufacturing ultrasound equipment, all of whom proved to be unable to solve the technological problems. Eventually, TNO solved the problems, but the objective of fully interchangeable treatment heads was not realized. During the internal testing stage, problems, related to the material used, were encountered. These problems were solved by switching to magnesium and the product was quickly introduced during an important biennial trade show. This introduction proved to be too soon, as there were problems with the magnesium as well. Again, it was TNO that solved the problem (eventually, delivery

to physiotherapists had to be postponed for a period of one year). Production problems at TNO (that manufactured the new treatment head), complaints from users abroad and specific demands from users initiated a new development project. Ultimately, the Sonopuls 434 was developed; a product solving the problems mentioned above and offering advanced benefits to users. At the present time, Enraf-Nonius is continuing its quest for innovation and is looking into new possibilities to improve the Sonopuls 434.

SUMMARY CONCLUSIONS

1. A significant innovation proved to be the result of a number of incremental product improvements, implying that every specific development project should be studied in a broad context.
2. Previous development projects influence (a) the direction of future development activities, (b) the execution of specific development activities and (c) the choice of cooperation partners.
3. Various sources, such as complaints and wishes by users and technological problems and opportunities, were combined to generate new products.
4. Contributions to the product development process were made by both physiotherapists (idea generation, design, external testing) and research institutes (specialized technological knowledge).
5. Because of an important trade show, a new product was introduced before it had been tested externally.
6. A position of market leadership can only be sustained by a continuous commitment to innovation.

CASES 9, 10 AND 11. DAHEDI: THE PORTABLE INFUSION PUMPS

Dahedi is a medical equipment manufacturer established in 1986 by splitting off the medical electronics activities from Dahedi Elektroniks, a firm producing electronic parts based on specifications of industrial customers. Dahedi manufactures several versions of a portable infusion pump and has a market share of 80% in the Netherlands. The firm currently consists of eight employees. Although the total sales are predominantly realized in the Netherlands, about half of the infusion pumps are sold abroad.

STRATEGY: PROACTIVE, RESEARCH AND DEVELOPMENT

Dahedi's new products are based on future-oriented research and development activities.

COOPERATION PARTNERS

Due to Dahedi's recent founding, general comments with respect to cooperation partners can hardly be made. The case description in question, however, shows close cooperation with both users and suppliers.

RW81, RW91 AND RW91P: PORTABLE INFUSION PUMPS

Dahedi's portable infusion pumps are based on an existing product which was the first of its kind and had many shortcomings. It is a piece of equipment which can inject measured quantities of a drug automatically into a patient periodically throughout the day. A Dutch specialist for internal diseases started to look for a firm to develop an improved version of the innovation. After another firm had started and terminated a development project, Dahedi was contacted and decided to commence development activities. Based on purely technical considerations and specifications drawn up by the physician, the original product was improved upon. A prototype was developed (the RW81), eighty units were produced and tested both internally and by patients. During the market test of the RW81, the idea for a miniaturised version of the product occurred. Since the results of the market test were promising, additional investments seemed justified. Together with Hymec, a Dutch manufacturer of hybrid circuits, the RW91 was developed. Compared with the RW81, the size was reduced and the performance improved. This time, attention was paid to the market as well: market potential was estimated superficially, competing products were analysed and the product concept was presented at a trade show to gauge users' reaction. Two years later, new German safety regulations dictated that part of the control electronics needed to be duplicated to ensure fault-tolerant operation. Because of the limited space available, this was only made possible by using an ASIC (Application Specific Integrated Circuit). An ASIC also allowed for the addition of self-test functions. Furthermore, the German users (representing a significant part of Dahedi's market) requested the infusion pump to be programmable. Based on these considerations and the experience gained through the production of earlier versions, it was decided to develop a new model. This new model exists in two versions: (a) a simple infusion pump, i.e. the original RW91

with duplicated electronics, named RW91 as well, and (b) a simple programmable infusion pump with duplicated electronics, named the RW91P. The product specifications for the RW91P were drawn up in close collaboration with leading German physicians, while a supplier contributed to the development of the product. The product was not tested by patients, since it represented a purely technical improvement of an existing product.

SUMMARY CONCLUSIONS

1. Both personal relationships and coincidence played a major role in Dahedi's becoming involved in the original development project.
2. The eventual innovation, the RW91P, was the result of a number of incremental product improvements.
3. The successive development projects demonstrate the operation of learning effects in two distinct ways: (a) a shift from a purely technical to a more balanced development project and (b) quicker development due to experience gained in developing earlier versions.
4. Even though increasing attention is paid to marketing-related factors, a formal marketing plan was never formulated.
5. Although the RW91P represented a significantly new product it was never tested externally.
6. External organizations, possessing specialized knowledge, played a central role in developing later versions of the infusion pump.
7. For a small firm like Dahedi, the product development process does not contain realistic GO/NO GO decisions. After having reached a certain point, taking a NO GO decision would be equivalent to discontinuing the firm.

CASE 12. SENTREX: THE SPECTRO PHOTOMETER (X)

Sentrex is a firm specialized in the design, development, production and marketing of filters and membranes for industrial use. The firm employs 1100 people and has total sales to a value of 250 million guilders, whose medical instrumentation group accounts for approximately 25 million. Until recently, the instrumentation group has suffered losses which were amply compensated by large profits from the disposables. Nowadays, strategic reorientations and organizational changes

are carried out in order to turn the medical instruments division into a profitable business.

STRATEGY: PROACTIVE, MARKETING

During the last two decades the development of new medical instruments has not been guided by any strategy whatsoever. Management neglected to capitalize on the existing contacts established through the marketing of filters and membranes. In the near future, however, new products will be based on observed market niches. Product development will be guided by market research rather than R&D, since technology is a rather stable factor in the market under consideration.

COOPERATION PARTNERS

The absence of a marketing policy and a structured product development approach led to the development of only minimal product improvements. New products were based on wishes expressed by users, while users were also consulted during product development.

THE SPECTRO PHOTOMETER

Spectro photometers are used for the analysis of body fluids in human and veterinary medicine. The idea for the new spectro photometer originated in a university hospital, where clinical chemists used an existing spectro photometer for a new application and were confronted with several shortcomings. Based on these experiences and the conviction that a specially developed product must have great market potential, the Technical Service Department (TSD) hit on the idea to develop the new spectro photometer. In the past, members of the TSD had had an idea for a new product and had approached industry after having fully developed a prototype. The result was somewhat frustrating because the prototype had to be considerably modified. Therefore, this time TSD decided to contact a manufacturer at an early stage of development. Sentrex appeared to be the ideal cooperation partner since (a) the hospital had a good existing relationship with Sentrex through the purchase of filters and membranes, (b) Sentrex had experience with the specific area of application and (c) Sentrex had developed a similar product in cooperation with a hospital before. Sentrex showed interest in the project because of the expected market potential. The product specifications were formulated by the members of TSD. The actual development of the prototype was split in two: Sentrex would develop

the mechanical part, while the hospital would see to the electronics and assembly. Developing the prototype took about 2.5 years due to continuous changes in the product specifications. Agreed deadlines were not met, which led to frustrations. After internal testing, the prototype was tested on patients in the hospital. At this stage the project was discontinued for several reasons. (a) The results of the tests were unsatisfactory: the software still required considerable improvement, for which the hospital needed additional funds. (b) In the meantime the market had changed considerably: increasing competition would limit future profits. (c) Due to the newly discovered technical problems, the duration of the total development project would become unacceptable. (d) A similar American product had become available. Sentrex started to import the American product, while the hospital had to terminate the project.

SUMMARY CONCLUSIONS

1. The appointment of two separate project managers with equal authority led to coordination problems.
2. The coordination problems were aggravated because a good personal relationship between the two project managers did not exist.
3. Shortcomings in planning (neglecting to make clear agreements) and execution (insufficient documentation of software development) resulted in a prolonged product development process.
4. A protracted product development process, in combination with changed market conditions, can be the cause of terminating the development of a technically sound product.
5. The geographical separation at Sentrex of production and R&D from marketing interfered with the implementation of a marketing policy.

CASE 13. ULTROLAB: THE ENDOSCOPE DISINFECTOR

Ultrolab was founded in 1984 as a trading concern specialized in medical laboratory equipment. Before long, Ultrolab decided to consolidate its position by taking up production as well, thus making it less dependent on manufacturers and obtaining the opportunity to export. The firm started to diversify by taking over a company producing laboratory equipment for industry. Next, Ultrolab signed a contract with an Italian firm, according to which it could manufacture a new

product under licence. Ultrolab started with 6 employees and now employs 20 workers. It is expected that, after introduction of the endoscope disinfector, 80% of Ultrolab's own production will be exported.

STRATEGY: OFFERING UNIQUE BENEFITS

Although Ultrolab has been involved in the development of just one new product, it follows a distinct strategy of only selling products that offer unique benefits to the customer (that is special product characteristics or a favourable price/performance ratio.

COOPERATION PARTNERS

Since Ultrolab has developed just one new product, nothing definite can be sais about cooperation partners during product development.

THE ENDOSCOPE DISINFECTOR

Until recently, endoscopes were disinfected manually in hospitals. Although manual disinfection is theoretically sufficient, research has shown that in practice the results are not always satisfactory. Both increasing awareness of the necessity of effective disinfection (due to the occurrence of diseases such as AIDS) and forthcoming regulations (making automatic disinfection compulsory and providing standards for automatic disinfectors) have made hospitals more receptive to fully automatic disinfectors.

Initially, Ultrolab conducted negotiations with a potential manufacturer of endoscope disinfectors about a dealership in the Netherlands. Although the potential manufacturer already had a dealer in the Netherlands, verbal agreements about division of the total market were already made and Ultrolab hired a stand at a forthcoming trade show to introduce the new product. One month before the trade show, the potential manufacturer terminated the agreements. However, a couple of months earlier Ultrolab had come across a member of the Technical Service Department of a hospital who had developed and built an automatic endoscope disinfector which was actually used in the hospital. This prototype was shown to the public at the trade show and the technician was hired by Ultrolab. The product concept was tested by users: (a) physicians abroad (with whom Ultrolab already had a relationship) examined it and (b) a hospital wanting to purchase it tested it for six months. As a result of these evaluations the original prototype had to

be modified; redevelopment took about one year. Next, the modified prototype was tested both internally and by various hospitals in the Netherlands and Sweden as well as the Russian Ministry of Health. After the prototype was slightly altered, production commenced. The new product was introduced through mailings to various groups in hospitals (hygienists, medical staff, specialists for internal diseases, purchasers and members of the Technical Service Department; the influence of each group varies per hospital) and demonstrations at trade shows. The new product is presently being tested by TNO in order to objectively demonstrate the product's efficacy. At present, the only competitor is a Japanese firm that offers rebuilt washing machines as endoscope disinfectors.

SUMMARY CONCLUSIONS

1. A trading concern can strengthen its market position by taking up production and initiating product development activities.
2. Due to the small size of the market a formal marketing plan was never drawn up. Instead, Ultrolab carefully formulated a market introduction strategy.
3. Even though a prototype was developed by a user, who proved its value through actual use, Ultrolab had to spend one year on product development to modify the prototype according to the requirements of a far larger user group.
4. The results of a test conducted by an objective external research institute can be used during market introduction.

CASE 14. MEDSOUND: THE ULTRASOUND SCANNER (*)

Medsound, established in 1979 and currently having 20 employees, is specialized in real-time ultrasound diagnostics. Although the firm originally focussed on the Dutch market, nowadays approximately 40% of their total sales is realized abroad. In recent years the growth in total sales offered the opportunity to hire people with specialized training in such fields as marketing, strategy development and finance, thus upgrading the professional level of the whole firm.

STRATEGY: PROACTIVE, MARKETING

Medsound can be regarded as a trendsetter in the market and is closely watched by its competitors. Most new products are based on problems formulated by users and are subsequently transformed by the firm into commercial new products.

COOPERATION PARTNERS

Medsound hardly cooperates in developing new equipment (the present case forms an exception: an external agency was hired to provide the design). The necessary and highly specialized know-how can usually not be offered by universities, but is available within the firm. Gynaecologists, who are able to critically evaluate medical equipment, are hired by the firm and contribute to the product development process. External gynaecologists are no longer used to test newly developed products.

THE ULTRASOUND SCANNER

The most recently developed innovation concerns a new ultrasound scanner. The development project was initiated for three major reasons. Firstly, Medsound offered a number of only slightly different ultrasound scanners, leading to huge inventories and production scheduling problems. Secondly, during the last decade ultrasound technology had progressed considerably and could be used to update existing products. Finally, the experience gained in that time in developing and manufacturing ultrasound equipment, could be used to develop an improved product.

The technical product specifications were drawn up in close collaboration with a German inspection agency, which tested the newly developed prototype, too. The cooperation was limited to this German inspection agency, because (a) it made high demands on new products (so that, after the product had been approved by the German agency, inspections in other countries would probably be less problematic) and (b) the costs would thus be limited. In the course of earlier development projects Medsound had tested new prototypes with gynaecologists. However, because of negative experiences with this procedure (the gynaecologists were unable to critically evaluate the unfinished products and were afraid to injure their patients by using unsafe new products), Medsound decided against having the new ultrasound scanner tested by gynaecologists.

The new ultrasound scanner integrates the functions of the various previous models and is extremely user friendly. An external agency was hired to provide the design, an essential aspect of the new scanner.

SUMMARY CONCLUSIONS

1. Because of the specialized know-how available in-house, Medsound hardly cooperates with other organizations during the process of product development.
2. Due to negative prior experiences with customers in testing prototypes, Medsound has decided against prototypes being tested by potential users. These negative experiences could possibly have been prevented by providing better instructions and exerting tighter control over the external tests.
3. The users are considered unable to evaluate the advanced technologies incorporated in the newest equipment. Instead, users evaluate new products by using such criteria as design and ease of operation.
4. A relatively large amount of money was spent on the design of the new product.
5. The integration of the functions of various scanners into one new product could be achieved because of (a) experience acquired over the last decade, (b) advances in the available technology and (c) the close attention paid to design.

CASE 15. VITATRON: THE RHYTHMYX

Vitatron, a Dutch manufacturer of pacemakers, currently employs about 275 people (230 of whom work in the Netherlands) and has total sales to a value of 65 million guilders. Export accounts for approximately 90% of the total sales. The firm enjoys an innovative image which is maintained through the continuous development of new products. Although Vitatron has been a subsidiary of Medtronic, the world's largest manufacturer of pacemakers (worldwide market share of 40%), since 1986, it functions as a relatively independent business which develops and markets its own products.

STRATEGY: PROACTIVE, FROM PURELY R&D TO A BALANCE WITH MARKETING

Vitatron's product development strategy is definitely proactive. Until recently, new products were predominantly based on future-oriented

research and development activities. In the near future, however, product development processes will increasingly be guided by market(ing)-related factors.

COOPERATION PARTNERS

Vitatron maintains regular contacts with important heart specialists functioning as key opinion leaders, who are selected because of their expertise, interest in and commitment to research and their influence on the market (through conferences, publications and informal communication). Although the heart specialists have no formal connection with the firm, they contribute on a regular basis to product development activities.

THE RHYTHMYX

Vitatron's most recent product development project involves the Rhythmyx, a new-generation rate-responsive pacemaker which adapts its pacing rate to changes in the heart's electrical timing. At the beginning of the 1960s pacemakers were based on the 'fixed rate' principle, that is the pacemaker fixes the patient's heartbeat at a single rate (usually about 70 beats per minute). At the end of the 1960s, the pacemaker based on the 'on demand' principle was developed, which only stimulates the heart if no heartbeat is detected. Nevertheless, the pacemaker still stimulates the heart according to a single rate.

At the end of the 1970s Vitatron made the strategic decision to develop an innovative rate-responsive pacemaker, which was eventually implanted for the first time in 1981. The rate-responsive pacemaker adjusts itself to the individual patient's activity. The more strenuous the activity, the faster the pacing rate. The new pacemaker proved to be a pronounced success and became Vitatron's image product.

Although the new pacemaker proved to be a major advance, in practice some disadvantages were noted. The pacemaker reacted too slowly to the patient's exertion, while its programming by the physician was quite a laborious task. Sufficient funds were made available to initiate a new development project. Since Vitatron had previously made the strategic decision to develop a rate-responsive pacemaker, which had subsequently become a major product, it was in effect forced to improve on the concept and develop a new generation to eliminate the existing

disadvantages. Furthermore, because of experiences with prior development projects, Vitatron had learned to be more receptive to user requirements.

Key opinion leaders were involved at the predevelopment stages by contributing to the formulation of the product concept. The newly developed Rhythmyx both offers a better fit with the individual patient's condition and specific situation and can be implanted more efficiently.

Due to concerns about safety and government regulations, newly developed pacemakers can not always be tested in patients. Since a prototype's reliability has not been proven yet and the production cannot be fully traced at this stage, patients often cannot be asked for permission to implant a new pacemaker. Typically, in these cases the prototype is tested by implanting it in animals and/or by conducting comprehensive controlled experiments. However, since the innovative element of the Rhythmyx concerned only the software it could be tested in patients. The innovative software was coupled to the existing hardware of the original rate-responsive pacemaker, introduced as a new product and implanted in patients. The results of these 'tests' were used to modify both the existing hardware and the new software and the resulting Rhythmyx was eventually introduced on the market.

SUMMARY CONCLUSIONS

1. Because of its strategic commitment to the original rate-responsive pacemaker, Vitatron was in effect forced to develop the new generation.
2. The Rhythmyx could be tested by combining the new concept (the innovative software) with existing equipment (the original hardware).
3. Key opinion leaders played a major role in formulating the new product concept and developing the new software.
4. Concerns about the patient's safety often prevents the test of a new pacemaker in patients. Where a new pacemaker can be tested in patients, the testing procedure is accompanied by extensive evaluation protocols.

CASE 16. MEDLAB: THE ANAEROBIC WORK STATION (*)

Medlab is a medium-sized Dutch subsidiary of a large American industrial firm and is specialized in the development, production and marketing of high-quality products for use in health care and research labs as well as hospitals, institutes and universities. In the Netherlands the firm employs approximately 150 people for research and development and production. The large majority of products are sold abroad.

STRATEGY: PROACTIVE, BALANCE BETWEEN R&D AND MARKETING

Medlab's product development strategy is characterized by a clear balance between future-oriented research and development activities and a marketing orientation.

COOPERATION PARTNERS

Three main types of cooperation can be found at Medlab: (1) half-yearly contacts with universities and hospitals in order to stay in touch with important broad developments, (2) sponsoring of research projects through the provision of services and/or the payment of salaries, and (3) intensive collaboration by means of joint research projects.

THE ANAEROBIC WORK STATION

The project originally started with Medlab sponsoring, by providing equipment, experimental research at a technological university. Since Medlab provided only a minimal amount of money, it had no direct influence on the research project. Nevertheless, it could formulate some general areas of interest to be investigated. Some years later, Medlab, with a major competitor, investigated the idea of developing an integrated anaerobic work station. Although the project was found to be technically feasible, it was terminated because of differing opinions about essential marketing questions (such as defining the major product users). However, the cooperation continued at a low level of intensity. For some years, the technological university carried out experimental research and, although it did not result in concrete new products for Medlab, it provided vital information to be used during later stages of the development process. Eventually, the university, in collaboration with another university linked to a university hospital, proposed to

develop an integrated anaerobic work station and started to define the product concept.

When the universities needed more money for research, Medlab intensified the sponsoring of the experimental research in order to profit maximally from the generated insights and information. At the same time, however, Medlab decided the time was right to initiate its own development project and intensified the collaboration with the competitor; clear-cut agreements were made regarding the division of the development tasks. Eventually, when the development activities at Medlab overtook the progress at the universities, the sponsoring of the experimental research was more or less terminated.

Because of (a) an existing relationship, (b) the presence of a competent physician and (c) the central position on the German market (which is of great importance to Medlab) a German clinic was selected to assist in formulating the product specifications (i.e. software procedures). Because of the costs involved, only one clinic was asked to contribute to the concept stage.

Next, a first functioning model was presented at a trade show to obtain a great many diverse reactions. Subsequently, the relative importance of the critical comments received was discussed, while the results of this evaluation served as input for the clinical development. Many physicians and nurses (selected because of existing relationships or references) contributed to the clinical development stage; at this stage the central characteristics of the product may still be changed. At present, Medlab is still working on the clinical development.

SUMMARY CONCLUSIONS

1. Experimental research conducted at universities was of critical importance in defining the product concept.
2. The amount of money allocated to the sponsoring of experimental research at the universities varied, depending on the strategic interests of the industrial firm.
3. Innovative users were used in a number of subsequent evaluative stages to formulate the product specifications (i.e. the software procedures).
4. Even during the clinical development stage potential users were strongly involved through commenting on the formulated software. At this stage the software procedures can still be modified.

5. The collaboration with the university can be characterized as quite erratic. Frequently, the contract was terminated for a number of months and subsequently renewed.

CASE 17. PHILIPS MEDICAL SYSTEMS: THE DIGITAL CARDIAC IMAGING SYSTEM

Philips Medical Systems (PMS) is one of the world's leaders in advanced high-technology diagnostic and therapeutic systems for the medical profession. The firm employs approximately 11000 people worldwide and has a total sales to the amount of three thousand million guilders. Its major product groups are diagnostic X-ray, radiation therapy systems, magnetic resonance, and ultrasound and nuclear medicine imaging systems. Only a very small minority of its products are sold in the Netherlands.

STRATEGY: PROACTIVE, BALANCE BETWEEN R&D AND MARKETING

The product development strategy followed by Philips Medical Systems can be characterized as having a clear balance between future-oriented research and development activities and a marketing orientation.

COOPERATION PARTNERS

During the development of new products, PMS typically cooperates with users (typically, university hospitals). The users with whom PMS collaborates form the top segment of the market; despite the small size of this segment it consists of the users operating at the 'frontiers of technology' (e.g. influential cardiologists and clinics). The organizational structure of PMS contains special application groups consisting of people (with a predominantly technical background) who establish and maintain the contact between the technical and marketing departments of PMS and the customers. Cooperation with universities during product development is typically based on initial contacts with the clinics linked with the universities.

THE DIGITAL CARDIAC IMAGING (DCI) SYSTEM

In 1982 Philips Medical Systems introduced the Digital Vascular Imaging (DVI) system. This innovative system subtracts digital video images of exposures which have been made before and after an intravenous injection with contrast medium. The subtracted images show only those areas

filled with contrast medium and are displayed live on a video monitor. The images are stored in a memory from which they can later be recalled and processed. The success of the DVI system eventually led to the development of an entirely new digital imaging system dedicated to the needs of cardiac applications. This system is known as the Digital Cardiac Imaging (DCI) system.

Because of PMS' experiences with both the cardiac market and the DVI system the idea for the new DCI arose. Since a small group (three people from development, marketing and application) was convinced of the potential and feasibility of a DCI system, a systematic market study was undertaken at an early stage. A large number (about twenty) of pre-eminent physicians in both Europe and the United States, selected because of their dominant position in the market as well as their knowledge, were visited and interviewed. During these interviews the concept of DCI was not discussed explicitly. Based on these interviews the product specifications could be drawn up and the market potential for the new system estimated. At this early stage a tentative user manual was written, which greatly facilitated the subsequent development of a prototype. After the prototype was tested internally it was tested by a Dutch university hospital. The selection of the hospital was based on three major criteria: (a) an existing relationship, (b) the availability of many patients and (c) the geographical proximity. Comprehensive evaluation protocols were used and the hospital was frequently visited by an application specialist. Only a short time later the first DCI system was introduced. It consisted of the hardware and the basic software (i.e. the operating software and the most basic clinical programs). Later, new clinical programs were developed and introduced in subsequent releases. After market introduction some problems arose since the written software did not perfectly fit with the developed hardware. A new release of the basic software solved the problem. At present, the system is still being expanded through the development and release of new clinical programs. These are developed and tested by another university hospital in the Netherlands. Until now, the DCI system has proved to be an indubitable success.

SUMMARY CONCLUSIONS

1. Even though a large number of knowledgeable and influential users were interviewed at an early stage, the exact nature of the product concept was not revealed to them for competitive reasons.

2. Drawing up a tentative user manual at an early stage facilitated the development of the prototype.
3. Due to the nature of both the product and the product development process, the developed hardware and software had to match exactly.
4. The market launch of the innovation could be expedited by introducing only the hardware and the most basic software. Additional software was introduced in subsequent releases.
5. Selection of the hospital to test the prototype was based on rather practical reasons. Since the promotional potentialities of the hospital in question were perceived to be low, the hospital was only marginally employed at the time of market launch.

APPENDIX D. IMPROVING INDUSTRY-UNIVERSITY COOPERATION

In developing complex medical equipment innovations, a manufacturer often collaborates with universities. This collaboration may consist of nothing more than developing a minor component of the product, but in many instances the cooperation goes much further and intensive industry-university interaction occurs. In our investigation, about one quarter of the cases studied (Cases 2, 4, 5 and 16) involved such an intensive collaboration between the manufacturer and a university. Due to the different nature of industrial firms and universities, such cooperation may be accompanied by a number of problems. While these are partly of a general nature, some of them are specific to industry-university cooperation. The collective experiences of the firms involved resulted in the recommendations enumerated below. The recommendations are illustrated by examples from the cases.

a. STATE THE OBJECTIVE OF THE COOPERATION

At the outset of the cooperation project, both partners should unequivocally state their objectives, since they need not concur. In the case of AIR, the university cooperated with industry to obtain funds for conducting experimental research in exchange for existing knowledge. AIR, on the other hand, was looking for the basic technological know-how required to develop and manufacture me-too products.

b. STATE THE EXPECTATIONS

At the outset of the cooperation project, both partners should also express their expectations, since they may differ substantially from each other. Again, in the case of AIR, the university expected to use the funds to develop a new diagnostic method of interest to the academic community. AIR expected assistance during the start-up of production. Furthermore, AIR expected the university to conduct clinical tests with prototypes.

c. STATE THE CRITERIA FOR EVALUATION

At the outset of the cooperation project, both partners should state the criteria they will use to evaluate the cooperation. Once more the case of AIR provides an example. The university would consider

the cooperation with AIR to be successful if it led to more scientific publications, increased project efficiency, faster clinical experience, improved diagnostics, enhanced status and competitive scientific position. AIR, on the other hand, would characterize the cooperation with the university as being successful if it resulted in a shortened start-up period, lowered costs, higher product quality, critical external quality assessment and inexpensive access to a 'brain tank'.

d. MAKE CLEAR-CUT AGREEMENTS ABOUT THE PUBLICATION OF RESULTS, DIVISION OF ACTIVITIES TO BE PERFORMED, RESPONSIBILITIES, TIME SCHEDULES, ETCETERA

In order to prevent frustrations and misunderstandings, at the outset of the cooperation project the parties involved should make clear-cut agreements about publication of the research results by the university researchers, the activities to be carried out by each party and the accompanying time schedule. Specific attention should be paid to the division of responsibilities; ideally, the final responsibility and authority should rest with one person. In the case of AIR, the divergent objectives and expectations were partly responsible for the absence of such clear-cut agreements.

e. START THE COOPERATION AT AN EARLY STAGE OF DEVELOPMENT

In the cases of Eye-Tech (Case 2) and ALT (Case 5), university researchers were found to contact industrial firms only after the original design had already been developed. This resulted either in costly delays since the original design had to be modified considerably (ALT), or in termination of the development project since the innovation's market potential was found to be unattractive (Eye-Tech).

f. CONDUCT MARKET RESEARCH TO EVALUATE A DEVELOPED ORIGINAL DESIGN

When an industrial firm is contacted by a university that has developed an original design, the firm should conduct substantial market research in order to evaluate the innovation's commercial attractiveness. Such a market study is necessary to determine general user requirements and estimate market potential. The market study should be supplemented by an evaluation of the technological requirements and opportunities. In the cases of Eye-Tech and ALT, the firms neglected to conduct such a preliminary assessment. In the case of AIR, enthusiasm for the project was not based on the results

of an extensive market study, but rather on the interest displayed by an original equipment manufacturer.

g. ALLOCATE SUFFICIENT TIME, MONEY AND RESOURCES TO THE REDEVELOPMENT ACTIVITIES

In general, the industrial firms investigated tended to seriously underestimate the time, money and resources needed to transform the original design developed by university researchers into a commercially viable industrial product. For instance, initially ALT hardly spent any time on redevelopment of the original design and introduced it too early at a trade show. Typically, the small-scale production techniques used by a university in a laboratory proved to be unsuitable for large-scale industrial production (an example is provided by the case of AIR).

h. SHOW COMMITMENT TO THE COOPERATION PROJECT

When an industrial firm cooperates with a university to obtain a developed and tested original design, both parties should display commitment to the project. For example, from the manufacturer's perspective, approving a university research program and providing part of the necessary funds (as in the case of AIR) is not sufficient for a fruitful collaboration. Instead, the firm needs to participate in the development activities in order to demonstrate commitment and ascertain that its own objectives are being met.

i. MAKE SURE OF PROPERLY FUNCTIONING PERSONAL RELATIONSHIPS

Even when sufficient resources are allocated to a cooperation project and the necessary agreements are put down in writing, the collaboration may still fail. As success ultimately depends very much on the people involved, great care should be taken to establish personal relationships that function well. In the case of Medlab, the suboptimal personal relationship between the representatives of two parties hindered effective collaboration.

Apart from the problem areas discussed above, the cases reveal an important factor for success (that is, a potential problem area) as well, namely the one dealt with below.

j. DEMONSTRATE AND ACCOMODATE FOR FLEXIBILITY

An intensive and long term cooperation project requires flexibility of the partners involved. For example, the contract should accommodate for enough flexibility, so that changed circumstances (e.g. market conditions or strategic considerations) can be met by the

appropriate actions. Examples are provided by Eye-Tech (Case 2), which terminated an advanced development project when a profitable market was found to be nonexistent, and Medlab (Case 16), which terminated a collaboration project as soon as the partner in question was expected to be unable to supply additional relevant information.

APPENDIX E. CRITICAL ISSUES TO BE CONSIDERED WHEN INVOLVING POTENTIAL USERS AND VARIOUS THIRD PARTIES IN PRODUCT DEVELOPMENT PROCESSES

1. IDEA STAGE

1A. DEFINING A NEW PRODUCT IDEA

A new product idea may be actively generated by the firm through

- establishing and maintaining contact with innovative users,
- periodically scanning technological developments at leading universities,
- periodically interviewing selected distributors and
- establishing and maintaining good relationships with leading figures in the field (e.g. retired physicians, industry experts, gurus).

1B. SCREENING NEW PRODUCT IDEAS

At this early stage, both new product ideas generated by the firm and new product ideas suggested by users or third parties undergo their first evaluation by being checked against a limited number of criteria. Although the evaluation involves only a tentative decision to proceed to the next stage, a representative user, distributor, university or industry expert with whom the firm maintains a good relationship may be employed to comment on the value of the new product idea.

2. PRELIMINARY ASSESSMENT STAGE

2A. PRELIMINARY MARKET ASSESSMENT

The preliminary market assessment, undertaken to determine user requirements and estimate market potential, can be conducted by interviewing

- major potential users (who may provide information about user requirements),
- distributors (who possess a relatively broad view of the market (segment)) and
- industry experts (who possess information about general trends regarding developments in the market).

The critical decisions to be made at this stage relate to

- the types of cooperation partners to involve,
- the number of cooperation partners to involve,
- the criteria to use in selecting cooperation partners and
- the general extension of undertaking the preliminary market assessment (depending on the uncertainties and risks involved, as related, for instance to the newness of the product, the information available, etcetera).

2B. PRELIMINARY TECHNICAL ASSESSMENT

As a complement to the preliminary market assessment, the manufacturer may undertake a preliminary technical assessment to cover the technical aspects of the innovation. Contributions to this stage may be made by

- research institutes (which possess information regarding both the latest and future technological developments),
- competitors (who have first hand information about products and production techniques),
- industry experts (who possess information about general technological trends) and
- sister organizations, subsidiaries and holding companies (which may possess specialized technical knowledge or may be able to provide critical product components or manpower at a competitive price).

3. CONCEPT STAGE

3A. CONCEPT IDENTIFICATION

The various parties mentioned under 2A and 2B may also be involved in identifying, developing and testing the concept. Therefore we will only point out some special potential problems.

In identifying, and also in testing the product concept, the manufacturer must beware of the classic mistake of solely relying on the information provided by innovative users. While these users are typically very interested and willing to cooperate, their wishes and demands may not be representative of the market in general. The information provided by them should therefore be checked against a broader group of users.

Sometimes, (e.g. to obtain very objective information) it may be desirable to question users who have a good relationship with one of the major competitors. These users should be asked about their

needs and expectations, without disclosing the nature of the product concept.

3B. CONCEPT DEVELOPMENT

All kinds of organizations (potential users, distributors, sister organizations, competitors, research institutes, inspection agencies, industry experts, etcetera) may provide input to this stage. The manufacturer should exercise caution in his selection of partners and ensure the confidentiality of information.

3C. CONCEPT TEST

The product concept should be tested with a representative group of potential users. As the manufacturer is now forced to disclose the exact nature of the new product, he may follow three strategies in keeping the concept a secret:

- skipping this concept test and trusting the information acquired earlier,
- having the concept tested exclusively by users with whom he has a good relationship or
- maintaining confidentiality by having all users sign a contract.

4. DEVELOPMENT STAGE

4A. DEVELOPMENT OF PROTOTYPE

Potential users and research institutes can, in particular, contribute to the actual development of the prototype. Users possess the necessary application knowledge, while research institutes may have highly specialized technological know-how. Suppliers may contribute to the development stage by developing a (key) component of the product. In all cases, the manufacturer must

- select the cooperation partner (quality, image),
- define the contribution of both parties (demarcation of tasks) and
- formulate detailed agreements (responsibilities, deadlines, quality levels).

4B. DEVELOPMENT OF MARKETING PLAN

During the development stage, a marketing plan should be developed in addition to a prototype. The marketing plan is usually formulated by the manufacturer, except for those cases where the manufacturing firm employs an outside organization (such as an OEM or a distributor) to perform the marketing function. The marketing plan should address issues such as

- identification of the target customers,
- organization of the internal communication (informing and instructing the sales representatives),
- date of market introduction,
- how the new product will be launched (e.g. by means of a trade show),
- identification of the (groups of) people to be reached within the buying organizations,
- communication channels to be used,
- selling propositions to be employed,
- price level and strategy to be followed,
- expected reactions from competitors and suggested ways to prevent them, or react to them and
- provision of information, instructions, training and promotional material to distributors.

5. **TESTING STAGE**

5A. IN-HOUSE TESTS

Although the in-house tests are undertaken by the manufacturer to test the technical functioning of the prototype, users or third parties may be indirectly involved.

- For example, users may be consulted to build a testing system that matches real-life conditions as closely as possible.
- Alternatively, research institutes may be called in to devise ingenious testing systems for testing prototypes under extreme conditions.

5B. TEST WITH USERS

When employing potential users to test a newly developed prototype the firm's most critical decisions relate to

- the time during the product development process when the tests will be performed (timing),
- the number of potential users to be testing the prototype,
- the criteria to be used in selecting potential users,
- the formulation of the test objectives,
- the instruction of potential users regarding the operation of the prototype and the performance of the tests,
- the execution of the test,
- the support and control provided by the firm,

- the registration of the test results (comprehensive evaluation protocols versus oral inquiry) and
- the evaluation of the test results.

The potential users who have tested the prototype may be employed during the launch stage to facilitate market acceptance (and thus diffusion) of the innovation. The pursuit of this strategy should be reflected in the criteria employed in selecting the potential users to test the prototype.

6. TRIAL STAGE

6A. FINALIZATION OF DESIGN / PILOT PRODUCTION

After finalization of the design, pilot production is generally undertaken by the manufacturer himself. Interaction at this stage may only occur if a supplier manufactures a strategic component. However, this can be handled, as with any other supplier by agreements on quality control, rejects, delivery schedules, price discounts, etcetera.

6B. FINALIZATION OF MARKETING PLAN / TEST MARKET

At this stage, the final marketing plan is formulated. This plan contains a detailed market introduction strategy based on the more general marketing plan and addresses all issues in detail. Most of the promotional material to be used during market introduction should be ready about this time. Test markets are usually not feasible for complex industrial products.

6C. PRE-COMMERCIALIZATION BUSINESS ANALYSIS

The pre-commercialization business analysis has also been found not to fit the situation of complex industrial innovations too well. For small firms, in particular, this activity is unrealistic at this point in the process.

7. LAUNCH STAGE

7A. FULL PRODUCTION

Apart maybe from some components, the manufacturer will see to production. With its suppliers, the manufacturer has to make agreements about such issues as

- quality levels,
- delivery schedules,
- handling of rejects,
- prices and

- guaranteed future delivery.

7B. MARKET LAUNCH

Both potential users and external research organizations, who tested the prototype, may be employed during the launch stage to accelerate market acceptance of the innovation. Involvement may take the form of

- using the names, reputations and test results during sales presentations,
- using the names, reputations and test results in promotional material,
- having the persons involved in the testing write scientific publications about the results and
- having the users demonstrate the innovation to prospective buyers.

APPENDIX F. STRUCTURED MODEL FOR CONDUCTING CASE RESEARCH

In this appendix we describe a conceptual model for conducting case research, which is based on the experience gained through in-depth study of twenty-two cases. At the outset of the follow-up investigation, a sketchy method for conducting case studies was present, based on the experiences acquired in the course of the preliminary investigation (that is, the detailed study of five cases; Chapter 5). The method consisted mostly of superficially formulated guidelines, such as "contact the customers through the manufacturer so as not to disturb any existing relationships". However, through investigating seventeen additional cases of industrial new product development (Chapter 7), the superficially formulated method was improved upon and the accumulated experiences suggested a detailed model for conducting case research that was found to be both effective and efficient. The model consists of fourteen steps and is structured in such a way as to minimize the limitations of case research mentioned in Chapter 8. It should be stressed here that the theoretical model developed during the course of the investigation and was therefore not followed in every case. Furthermore, as mentioned in Chapter 7, the limited time available to managers sometimes necessitated slight deviations from the theoretical model. Although the model is patterned on an investigation of cooperation between organizations in developing innovations for industrial markets, the description offers suggestions and guidelines for researchers wanting to use case research to investigate similar markets and/or situations.

STEP 1. DEFINITION OF THE SCOPE OF THE INVESTIGATION

The first step entails defining such critical issues as (a) the problem to be investigated, (b) the (kind of) firms to take part in the investigation, (c) the sources of information to be employed and (d) the kind of people to be interviewed.

STEP 2. FORMULATING THE FRAMEWORK

Conducting case research properly, requires the formulation of a general framework before the individual cases are investigated. It structures the investigation and allows for later

analysis of the findings. The framework may be based on (a) existing literature, (b) a preliminary investigation or (c) a combination of both.

After this, a number of individual case studies is investigated according to Step 3, up to and including Step 13. The individual cases may be investigated subsequently or simultaneously.

STEP 3. SELECTION OF A MANUFACTURER

First, a manufacturer of complex innovations for industrial customers in general or customers belonging to a specific market segment or industry is selected. The selection criteria are derived from the purpose and nature of the investigation.

STEP 4. IDENTIFICATION OF THE RIGHT PERSON

Next, identification of the right person to interview is of the utmost importance. In all cases, the person most closely involved with the selected development process was interviewed. Identification of the right person can be achieved in three different ways:

a. through references made by industry experts or competitors,
b. enquiring by telephone for the person most closely involved in developing medical equipment, explaining the objective and nature of the investigation and assessing whether he is indeed the person most appropriate to provide information about a recent development project, and
c. enquiring by telephone for the director of product development, making an appointment and using the interview to get some general information about the firm and its products and identify the right person to interview about a specific development project.

STEP 5. ESTABLISHING THE FIRST CONTACT

The first telephone conversation with a manager at the manufacturing firm is very critical. It aims to (a) introduce the researcher, (b) explain about the investigation, (c) arouse the manager's interest, (d) assure the manager that the information will be kept confidential, (e) obtain the manager's cooperation and (f) make an appointment for a first visit.

STEP 6. CONDUCTING THE FIRST INTERVIEW

The first interview is primarily used to establish rapport with the manager. Therefore no questions were asked about a

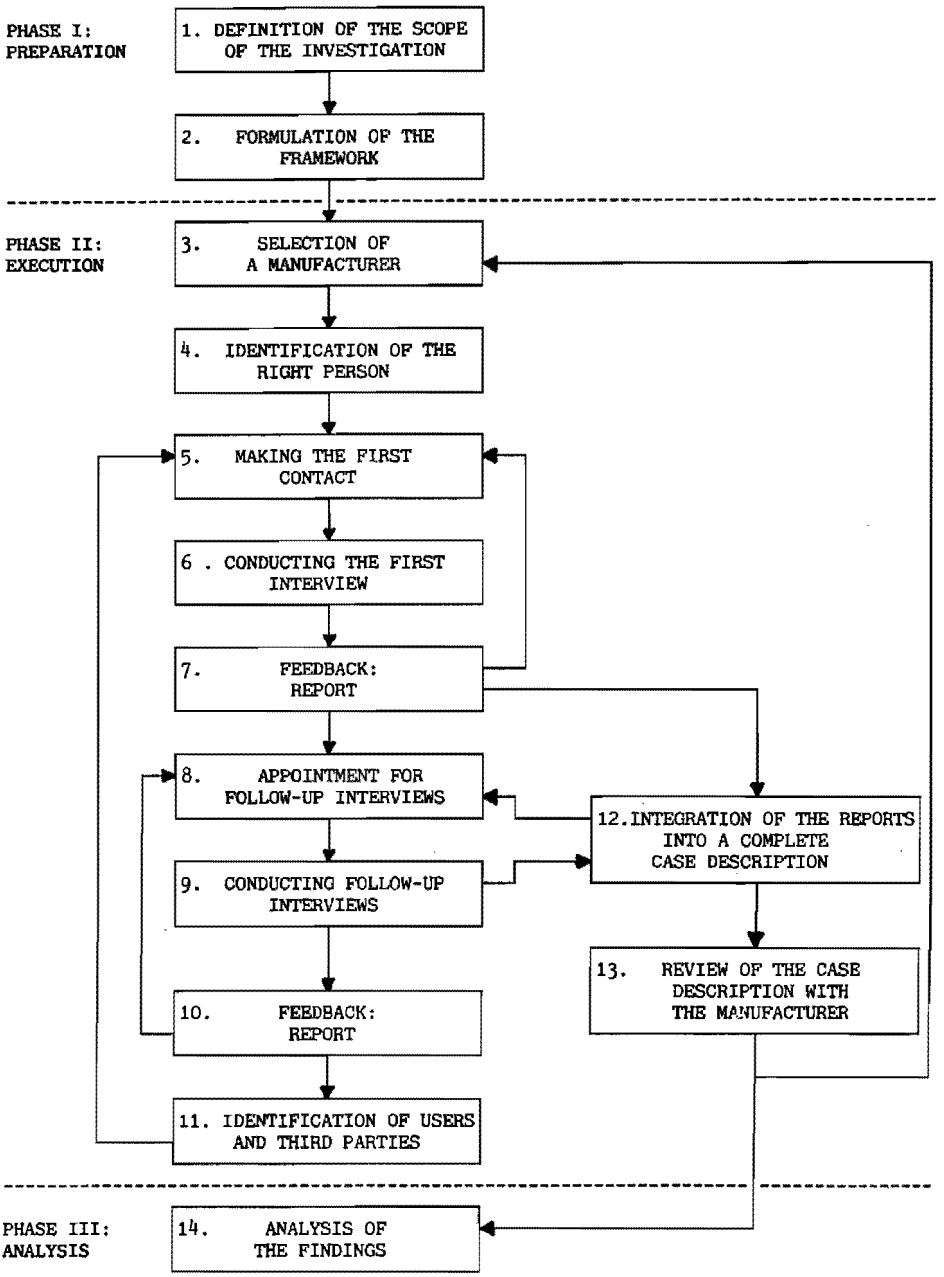


Figure F.1 A conceptual model for conducting case research.

specific innovation project. Instead, information was obtained regarding such non-confidential matters as the structure and size of the firm, its products, the customers served, its general product development strategy and the competitive situation. At the end of the interview the manager is asked to tell something about the firm's most recent innovation projects and the most suitable project would be selected for further investigation. Agreements are made about the next visit(s), handling of the information and the feedback to be provided.

STEP 7. FEEDBACK IN THE FORM OF A CONCISE REPORT

Next, the written notes are converted into a concise report, which is sent by mail to the interviewee with the request to verify the information, supply additional information where necessary and send it back. Writing the report structures the information already gathered, but may also result in new questions to be asked during a follow-up interview.

STEP 8. MAKING AN APPOINTMENT FOR A FOLLOW-UP INTERVIEW

Ideally, an appointment for the next interview is made at the end of the previous visit. Otherwise, the receipt of the report reviewed by the manager can be used as a pretext for contacting the manager again and making an appointment for a follow-up interview.

STEP 9: CONDUCTING A FOLLOW-UP INTERVIEW

While the first interview typically lasts only about two hours, follow-up interviews may take from two to four hours. The enthusiasm of the manager telling about 'his project' allows the researcher to conduct these extended interviews. The manager is encouraged to tell 'his own story in his own words', while the questionnaire is used to structure the interview and check whether all the issues are being covered. While a follow-up interview mainly aims (a) at obtaining information about subjects not covered before, it may also serve (b) to clear up issues from the last session, (c) to ask additional questions about subjects already covered and (d) to clarify encountered inconsistencies.

STEP 10. FEEDBACK IN THE FORM OF A CONCISE REPORT

This step is identical to Step 7.

Steps 8, 9 and 10 may be reiterated a number of times. In some cases a manager was interviewed as many as five or six times. This reiterative process ends when all subjects have been covered and an additional interview is not expected to supply any significant extra information.

STEP 11. IDENTIFICATION AND SUBSEQUENT INTERVIEWING OF USERS AND THIRD PARTIES INVOLVED IN THE DEVELOPMENT PROCESS

During the interview conducted with the manufacturer, users and third parties that contributed significantly to the development process are identified. With permission of the manufacturer, these organizations are contacted and interviewed (a) to obtain additional information and (b) cross-check the information supplied by the manufacturer. The manager at the manufacturer provides the names of the people to be interviewed and can be used as a reference (sometimes he/she may even introduce the investigator). Thus, the other parties were contacted and interviewed, that is to say, the Steps 5, 6 and 7 were completed again. In these cases, one interview lasting from one to three hours was found to be sufficient.

STEP 12. INTEGRATION OF ALL INDIVIDUAL REPORTS INTO ONE COMPREHENSIVE CASE DESCRIPTION

After all the relevant persons at the various organizations have been interviewed and all the desired information obtained, the reports of the individual interviews are integrated into one comprehensive case description. This description is drawn up according to a specified format to allow comparison between case studies at a later stage.

STEP 13. REVIEW OF THE COMPLETE CASE DESCRIPTION WITH THE MANUFACTURER

The process concludes with reviewing the ultimate case description with the manufacturer. This evaluation may lead to additional information and refinement of the conclusions.

STEP 14. ANALYSIS OF THE FINDINGS

As a final step, the findings of the individual cases must be analysed according to the general framework constructed during Step 2. The quantitative data may be analysed by using such well-known statistical tools as frequency distributions, cross-tabulations and chi-square tests. However, the analysis of the qualitative data gathered to generate new theory much

depends not only on the quality of the framework used to structure the investigation but also on the creativity and inventiveness of the researcher.

The model for conducting case research presented above is designed to minimize the limitations of constructing case studies mentioned in Chapter 8. The large amount of time required for the total investigation is reduced by simultaneously studying a limited number of cases, while the experiences thus acquired are employed during the subsequent study of additional cases. The considerable time expected of the manager is perceived as being reduced by breaking up the total investigation into a number of short interviews with relatively long periods in between (generally at least one month). During the intervening periods the researcher can process the acquired information and prepare for the next interview by formulating new questions, while the manager has time to 'recover'. The subjectivity of the information is reduced through a complex reiterative process of cross-checking the information by means of (1) conducting various interviews with the manager, (2) employing additional objective sources, (3) interviewing various persons at the manufacturer and (4) interviewing people from various organizations. This comprehensive system of cross-checking also minimizes the disadvantages of the imperfect memory of the people interviewed. The simplification of reality is largely rectified by conducting flexible semistructured interviews which allow the manager, as far as possible, to tell 'his own story in his own words'. Finally, the difficulty in analysing the final results is largely countered by building a comprehensive framework for the problem to be investigated.

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SAMENVATTING

In deze samenvatting zullen we in het kort het onderzoek en de gevonden resultaten beschrijven. Achtereenvolgens zullen we ingaan op (1) het onderzochte probleem, (2) de gebruikte onderzoekmethode, (3) de belangrijkste resultaten en (4) de implicaties voor het management.

1. DE PROBLEEMSTELLING

Een groot aantal auteurs en onderzoekers heeft zich bezig gehouden met innovaties. Ondanks een grote stroom publikaties ondervinden de meeste bedrijven die produkten aan industriële afnemers verkopen nog steeds problemen met het innovatieproces. Ongeveer een derde deel van de nieuwe industriële produkten die op de markt worden geïntroduceerd worden geen commercieel succes. Daar komt nog bij dat wetenschappers traditioneel het ontwikkelen van innovaties beschouwen vanuit het oogpunt van de fabrikant. In werkelijkheid blijken echter ook potentiële gebruikers en diverse andere organisaties vaak bij te dragen aan het ontwikkelen van complexe innovaties. Zulke innovaties worden dus ontwikkeld binnen een netwerk van samenwerkende organisaties. Deze, en andere in hoofdstuk 1 geschetste overwegingen, leidden tot de constatering dat er behoefte is aan onderzoek dat het ontwikkelen van complexe innovaties voor industriële afnemers bestudeerd vanuit een netwerkperspectief. Dit onderzoek zou met name praktische richtlijnen moeten opleveren voor het management van industriële bedrijven. Ons onderzoek poogt in deze behoefte te voorzien en heeft de nadruk gelegd op de groep van middelgrote bedrijven, gedefinieerd als tussen de 50 en 500 werknemers hebbende.

Terwijl hoofdstuk 1 de probleemdefinitie beschrijft, komen in hoofdstuk 2 enkele algemene aspecten met betrekking tot innovaties aan de orde en wordt de term zorgvuldig gedefinieerd. Hoofdstuk 3 behandelt produktontwikkelings-, adoptie- en diffusieprocessen. Het geeft met name een uitvoerig overzicht van verschillende modellen van het ontwikkelingsproces die allen hun specifieke voor- en nadelen bezitten. Met inachtneming van de doelstelling en de aard van het onderzoek wordt uiteindelijk het meest geschikte model gekozen dat zal dienen als raamwerk om het onderzoek te structureren. Hoofdstuk 4, tenslotte,

geeft aan hoe de theorie zich heeft ontwikkeld van een nadruk op interactie tussen fabrikant en gebruiker naar het beschouwen van netwerken. Deze netwerken bestaan uit een aantal organisaties die met elkaar zijn verbonden door interactieve relaties.

2. DE ONDERZOEKMETHODE

Gezien de doelstelling en de aard van het onderzoek, leek 'case research' de meest geschikte onderzoekmethode. Case research is het onderzoeken van een aantal individuele praktijkgevallen ('cases' of 'case studies'), die vervolgens met elkaar worden vergeleken om tot conclusies te komen.

Het totale onderzoek bestaat uit twee delen. Het eerste verkennende onderzoek is uitgevoerd door vijf praktijkgevallen uit diverse sectoren van de Nederlandse industrie gedetailleerd te bestuderen. Op basis van deze verkenning zijn enkele conclusies getrokken die hebben geleid tot een vervolgonderzoek in de Nederlandse markt voor medische technologie. Dit bestond uit het bestuderen van zeventien praktijkgevallen van het ontwikkelen van nieuwe medische apparatuur.

Voor beide onderzoeken is gebruik gemaakt van persoonlijke halfgestructureerde interviews die zijn afgenomen met de fabrikant van de innovatie, met potentiële gebruikers en met diverse andere organisaties (zoals distributeurs en universiteiten) die bij het ontwikkelingsproces betrokken waren. Bij de fabrikant zijn veelal diverse personen geïnterviewd, waarvan het merendeel meer dan eens is ondervraagd. Op deze manier is gepoogd een zo waarheidsgetrouw mogelijk beeld te krijgen van hetgeen zich heeft afgespeeld.

Hoofdstuk 1 geeft een verantwoording van de keuze van de onderzoekmethode, terwijl deze in hoofdstuk 5 in detail wordt beschreven. Hoofdstuk 8 evalueert de onderzoekmethode in termen van voor- en nadelen en presenteert een conceptueel model voor het uitvoeren van case research.

3. DE RESULTATEN

De vijf cases die zijn bestudeerd in het kader van het verkennende onderzoek (hoofdstuk 5) hebben geleid tot de volgende conclusies.

a. De verschillende fasen van het produktontwikkelingsproces zijn in de praktijk niet altijd nauwkeurig te scheiden.
b. In het algemeen zijn er grote verschillen tussen het testen van consumentenprodukten en industriële produkten door potentiële gebruikers.

c. In sommige specifieke gevallen is het aspect 'afgeleide vraag' met betrekking tot industriële produkten van invloed op het testen van prototypes door potentiële gebruikers.
d. Product champions spelen vaak een cruciale rol tijdens het ontwikkelen en/of aanschaffen van innovaties.
e. Industriële innovaties worden veelal ontwikkeld binnen netwerken.
f. De marketing van complexe industriële innovaties omvat ook de marketing van kennis.
g. Veel problemen worden veroorzaakt door het slecht uitvoeren van de externe testen (testen van prototypes door gebruikers).

De gevonden resultaten leidden tot de beslissing een vervolgonderzoek uit te voeren in de medische technologie. Hoofdstuk 6 geeft een korte inleiding over medische technologie en de Nederlandse situatie. Hoofdstuk 7 beschrijft de resultaten van de diepgaande studie van zeventien praktijkgevallen. Deze worden hieronder kort beschreven.

a. Theoretische concepten
   - Interactie heeft betrekking op de tweezijdige ruil van waarden. Deze waarden kunnen produkten of diensten, informatie, financiële middelen of sociale gebeurtenissen zijn.
   - Interactieve relaties kunnen worden gekenmerkt door het type, het doel, de intensiteit, de duur en de formalisatiegraad van de interactie.
   - Interactieve relaties kunnen worden onderscheiden in enkelvoudige en samengestelde relaties.
   - Netwerken kunnen worden gekarakteriseerd aan de hand van de complexiteit, de aard van de belangrijkste partners en de omgeving van de interactieve relaties.

b. Bijdrage aan produktontwikkeling
   - Hoewel de fabrikanten meestal bij vrijwel alle fasen van het proces zijn betrokken, besteden ze over het algemeen te weinig aandacht aan de activiteiten die moeten worden uitgevoerd voordat het prototype wordt ontwikkeld.
   - Potentiële gebruikers zijn op veel verschillende manieren betrokken bij het ontwikkelen van nieuwe medische apparatuur. Vaak beperkt de fabrikant zich echter tot het interviewen van een enkele belangrijke klant in plaats van het systematisch analyseren van de behoeften van een representatieve groep gebruikers. Ook wordt het testen van prototypes door potentiële gebruikers niet

altijd even zorgvuldig uitgevoerd. Tenslotte worden gebruikers die het prototype hebben getest slechts in beperkte mate ingezet bij de marktintroduktie van het nieuwe produkt.

- Een groot aantal zeer diverse organisaties, 'derden' genoemd, kan eveneens op de een of andere manier betrokken zijn bij het ontwikkelen van medische apparatuur. Een veel voorkomend voorbeeld is de universiteit die een (deel van het) prototype ontwikkelt. Gespecialiseerde onderzoekinstituten kunnen worden ingeschakeld om specifieke problemen op te lossen.
- Hoewel zowel potentiële gebruikers als verschillende derden door de fabrikant betrokken kunnen worden bij het ontwikkelingsproces, zijn er belangrijke verschillen ten aanzien van de intensiteit van de interactieve relaties.

c. Ontwikkeling binnen netwerken

- Complexe medische apparatuur wordt ontwikkeld binnen netwerken, die variëren in complexiteit. Hoewel het ontwikkelen van innovaties binnen een complex netwerk duidelijke voordelen heeft (specialisatie en correctie van tekortkomingen), zijn er ook nadelen aan verbonden (misverstanden, vertragingen en het dubbel uitvoeren van activiteiten).
- Bij het ontwikkelen van innovaties binnen netwerken schieten fabrikanten vaak op verschillende punten tekort: de integratie van marketing en R&D, het uitvoeren van de eerste fasen van het ontwikkelingsproces, het toewijzen van middelen aan de ontwikkeling van het prototype, het laten testen van het prototype door gebruikers, het moment van marktintroduktie, het inzetten van gebruikers tijdens marktintroduktie en het samenwerken met universiteiten. Kleine ondernemingen hebben hierbij nog enkele specifieke problemen.

D. Adoptie en diffusie

- Ten aanzien van de adoptie hebben zich de laatste jaren enkele belangrijke ontwikkelingen voorgedaan. De medisch specialist heeft aanzienlijk aan invloed verloren, ten gunste van financieel directeuren en medewerkers van de technische dienst of medisch technologen. Hierdoor maken de ziekenhuizen bij het aanschaffen van nieuwe apparatuur een duidelijker afweging tussen de kosten en de baten en begint het koopgedrag van ziekenhuizen het industriële koopgedrag te benaderen.

- Ten aanzien van de diffusie kan weinig concreets worden geconcludeerd. De academische ziekenhuizen lijken echter een belangrijke rol te spelen. Ze zijn veelal betrokken bij het ontwikkelen van nieuwe apparatuur en hebben een positieve uitstraling naar de regionale ziekenhuizen.

4. IMPLICATIES

In hoofdstuk 8 worden uitgebreid de belangrijkste conclusies en hun implicaties voor het management besproken. Hier in de samenvatting ontbreekt het echter aan ruimte om op alle besproken aspecten in te gaan. Samengevat kunnen we echter concluderen dat het totale onderzoek tot belangrijke resultaten heeft geleid. Zo heeft het geresulteerd in een heldere formulering van een aantal centrale concepten met betrekking tot interactie en netwerken en geeft het belangrijke aanzetten in andere richtingen. Van groter belang is echter de waarde voor het management van industriële bedrijven. Zoals uit hoofdstuk 8 blijkt kunnen de diverse conclusies direct worden vertaald in richtlijnen die in de praktijk kunnen worden toegepast. Hierdoor is het gestelde doel bereikt en de waarde van het uitgevoerde onderzoek aangetoond. De vruchtbaarheid van het onderzoek blijkt eveneens uit de concrete aanbevelingen voor verder onderzoek. Hopelijk bieden de gevonden resultaten inspiratie en een leidraad voor andere onderzoekers.

STELLINGEN

behorende bij het proefschrift

DEVELOPING INNOVATIONS WITHIN NETWORKS
With an application to the Dutch medical equipment industry

van

WIM G. BIEMANS

12 december 1989

1. In de meeste Nederlandse ziekenhuizen is de rol van de medisch specialist bij het aankopen van complexe medische apparatuur sterk aan het veranderen. In plaats van belangrijkste beïnvloeder wordt hij medebeslisser in een aankoopteam.

(Dissertatie, Hoofdstuk 7)

2. Aan de geavanceerde technologische kennis van de Nederlandse fabrikanten van complexe medische apparatuur wordt in veel gevallen afbreuk gedaan door slechts geringe marketingkennis en -vaardigheden.

(Dissertatie, Hoofdstuk 7)

3. Voor kleine ondernemingen kent het produktontwikkelingsproces een kritiek punt. Na dit punt hebben ze niet meer de mogelijkheid een NO GO beslissing te nemen, omdat dat zou overeenkomen met het sluiten van het bedrijf.

(Dissertatie, Hoofdstuk 7)

4. Het is niet mogelijk om het management uitgebreid in detail voor te schrijven hoe het produktontwikkelingsproces moet worden uitgevoerd. Men kan slechts richtlijnen geven, die dienen te worden aangevuld met situationele analyse, creativiteit en ervaring.

5. Door het commerciële succes van de compact disc zal een deel van de consumenten worden gedwongen een innovatie tegen hun zin te adopteren. Daarom zou men wellicht in de theorie over adoptie en diffusie, in aanvulling op (a) de passieve verwerping, (b) de a priori actieve verwerping en (c) de a posteriori actieve verwerping, nog een vierde categorie van verwerping moeten onderscheiden: (d) de niet-effectieve verwerping.

(E.M. Rogers (1983), The Diffusion of Innovations, The Free Press, New York, p. 173; Dissertatie, Hoofdstuk 3)

6. Het door de Canadese hoogleraar Cooper voorgestelde model voor het ontwikkelen van innovaties bestemd voor industriële afnemers is niet zonder meer algemeen geldig.

(R.G. Cooper (1981), A Process Model for Industrial New Product Development, McGill University, Faculty of Management, Montreal, p. 14a; Dissertatie, Hoofdstukken 5 en 7)

7. Het succesvol ontwikkelen van innovaties heeft veel gemeen met het spelen van goede jazz. Beide zijn gebaseerd op creativiteit, samenwerking en improvisatie.

8. De ondergewaardeerde positie die industriële marketing in Nederland inneemt wordt het duidelijkst geïllustreerd door het ontbreken van een eigen leerstoel.

9. Door de ontoereikende aanwezige begeleidingscapaciteit aan universiteiten dreigt het aantal afgestudeerden op het gebied van de marketing kunstmatig te worden beperkt.

10. Nieuw geworven AIO's dienen niet te worden voorzien van een volledig uitgewerkte probleemformulering en de meest geschikte onderzoekmethode. Het structureren, afbakenen en definiëren van het probleem, alsmede het evalueren van verschillende onderzoekmethoden en kiezen van de meest geschikte, vormen wezenlijke onderdelen van het proces en de frustraties die een wetenschapper doormaakt. Beide ervaringen dienen de AIO niet te worden onthouden.

11. Het bewust niet-stemmen tijdens nationale verkiezingen is eveneens het resultaat van een politieke stellingname.

12. In 1989 is ondernemend Nederland overspoeld met informatie over het jaar 1992 en haar gevolgen. Alle gestelde doelen ten spijt dient men zich echter te realiseren dat, net zomin als op 1 januari 1984, ook op 1 januari 1992 de wereld niet plotseling drastisch zal veranderen.

13. Diverse recente promotiecampagnes dragen bij aan de emancipatie door meisjes aan te sporen tot het uitstippelen van een verstandige, overwogen toekomst. De emancipatie zou echter beter zijn gediend wanneer dergelijke promotiecampagnes de mannelijke jongeren niet automatisch buiten de doelgroep zouden houden.

14. "Samenwonen is meer dan samen wonen".
Hoewel deze uitspraak veelal als een open deur zal worden aangemerkt wordt er in de dagelijkse praktijk lang niet altijd naar gehandeld.