

PART II

Theoretical Foundation

This part presents the theoretical foundation of the research and book. The present part introduces a number of basic concepts for the understanding of product development. The objectives of the part are to clarify and put into perspective the contents and distinctive features of the basic concepts of Network Based Product Development. Each chapter strives to apply such foundation to the present book and also to work as a framework for the research project. Finally, each chapter seeks to reflect on the concepts of network based product development in 2003 and for the time beyond. The objectives of the part is to put forward a theoretical concept of network based product development to elaborate the foundation of a descriptive model for network based high speed product development in a global perspective defined in Chapter 7.

2

Project Method

2.1 Introduction

One of the main demands to a research project is a verification of the scientific foundation on which the research is elaborated – often called state of the art analysis. To answer this question it is necessary to verify the use of scientific view and research methods. A proper interpretation of the above require that this book must contain an account of the reflection of scientific point of view.

Both the scientific point of view and the research method constitute a function of the initial problems and questions. As a consequence, this chapter will be constructed on the basis of the five focus areas of the research:

- Concepts of product development
- Concepts of Network
- Concept of speed and time related to product development
- Concepts of product development models and processes related to high speed product development
- Concepts of enablers to high speed product development

Sections 2.1 and 2.2 focus will discuss thoroughly firstly the scientific view of this book, the scientific ambition and dilemma together with the research methods used.

2.2 Scientific Concept

If one should discuss the question “*What is the scientific view of this research project?*” one has firstly to clarify and verify the concept of science.

Science should be considered a procedure used for answering questions, solving problems, and developing increasingly efficient ways in which to answer questions and solve problems. Thus, it is the process which is regarded as science and not the actual amount of knowledge accumulated by the process.

On the basis of this definition or view on science it can be stated that science can be established via a process of putting questions, answering questions,

solving problems, and developing ever more effective methods and procedures to keep on answering questions and solving problems.

On the strength of the above, the scientific view of this research project will be based.

2.2.1 Scientific View

The scientific view of this research project can be traced back to the French philosopher and mathematician René Descartes (1596–1650). Without breaking with the Catholic church Descartes claimed “the right of Reason to correct the doctrines handed down by the Christian faith”.

Descartes said, that man has a right to trust in the Reason given to us by God even when such reason leads to results which are at variance with the beliefs of the authorities. On the basis of (the concept of Reason in Latin is rational), this philosophical movement was later known as Rationalism.

The methodological treatment of economics is based on rationalism and can be traced back to The Austrian school of thought with among others Carl Mengen and Ludwig von Mises.

The Austrian school of thought departed from the positivism thesis of the method-monoistic point of view which claimed that there is no principal difference between the natural sciences and the social sciences – there is only the scientific method corresponding to the one found in the science of physics. In their argumentation the Austrian school of thought stressed the fact that the objectives of social science are to understand the human acts which originate from certain non-observable concepts.

The rational scientific view is based on two fundamental assumptions.

Firstly, it is the intellect – the researcher’s common sense – which decides the final decision of theory. On the basis of a critical discussion with his colleges the researcher has to develop a list of arguments which support the specific research. This list of arguments must not only be numerous but also of a high quality.

Secondly, the researcher’s choice must be guided on the basis of a function of criteria, which demand the weighting of the above-mentioned arguments.

On the basis of the above, the research presented in this book is fundamentally based on Rationalism.

2.2.2 Scientific Approach

As regards the question of basic scientific research as opposed to application oriented research, such a distinction is founded on two alternative approaches.

The objectives of basic scientific research are to produce new knowledge “for the sake of knowledge itself”.

Consequently, basic scientific researchers disregard the practical efficiency of their research, whereas application oriented researchers are able to describe their science as a subject which implement basic scientific experience in the solution of practical problems.

In Table 2.1 the characteristics of the basic scientific research and the application oriented research are shown.

Table 2.1 Basic scientific research as opposed to practice oriented research

	Basic Scientific Research	Practice Oriented Research
Aim/Motivation	To understand and explain the phenomenon better	To improve out control of the phenomenon
Types of Problem	Scientific problems (guided towards maximum scientific contribution)	Technological problems (guided towards the reaching of a function with instructions for a process)
Paradigm Dependency	Yes, the paradigm of the subject	To a lesser extent. Is multi-paradigmatic in a narrow sense (cross scientific and paradigmatic)
Role	Basic realization of the present time	Communicator across scientific and practical areas
Problem Generator	The researcher society (from the inside)	Practice (without the researcher society)
Criteria for Result Evaluation	Increased insight and scientific durability	Increased efficiency, achievement of function and increase of problem solution preparedness

Source: Bohn, Kim (adapted from Frank Gertsen, 1989).

The objectives of the research presented in this book are to “increase the awareness and knowledge of network based high speed product development and processes”.

2.3 Research Method

At the beginning of the research project several methodical models for the solution of the problem areas were discussed. In this connection, I came to realise the necessity of addressing the four main areas methodically:

- An explorative methodical design
- A new way of doing research in cooperation with the industry

- Reflection on what – why – when – how
- An ambition to reach a triangulation in the methodological design of the research

2.3.1 An Explorative Methodical Design

Inspiration from Literature on Product Innovation

The novel nature of the project encouraged the researcher to use explorative and Delhi-like methods in the initial research phase on the concept of network based product development to clarify the problem area and the analysis framework.

Existing literature on product development refers to this method especially in the case of product innovation assignments in unstructured areas or in areas where no or very little knowledge exist (Wind, 1975) as shown in Table 2.2.

Furthermore, this method is recommended in cases where we desire the development of new models or at least new ways to approach the area in order to produce something innovative. Thus, Wind (1975) suggests the following Table 2.2 as a solution to the problem area outlined above:

Table 2.2 Structured and unstructured PD tasks

Consumer-Based		Expert-Based	
Unstructured	Structured	Unstructured	Structured
Individual in-depth interviews a) non directive b) semi-structured/ focus individual analysis	Ned/benefit segmentation	Brain storming	Problem/opportunity analysis
Motivation research	Problem detection studies	Synetics	Morphological analysis
Focus group interviews	Market structure analysis/gap analysis	Suggestion box	Growth opportunity analysis
Consumption system analysis	Product deficiency analysis	Independent inventors and licensors	Environmental trends analysis
Consumer complaints			Analysis of competitive products
Projective analysis			Search of patents and other sources of new ideas
Observations			

Source: Adapted from Wind, Yoram J. (1975).

The researcher chose to regard his research assignment as a product development assignment equivalent to those set in industrial life where they fall into the category “rather radical product development”. This means that the market was known (Balachandra, 2000), the technology was rather familiar (Balachandra, 2000), whereas the innovation degree was rather unfamiliar (Balachandra, 2000). In this particular research area the market – the business-to-business industry was known, the technology – the product development models and processes – were fairly well known but the innovation degree – the pressure and impact on NB PD as a consequence of a pressure on higher speed in product development was unfamiliar and not known before. Furthermore, the enablers to high speed were unknown and not verified.

However, the choice of an explorative design of research methods gave rise to major considerations about generalisation, validity and reliability which will be discussed later in this chapter. Furthermore, the explorative design and the chosen research method differed from the general research ambition and policy on the CIP centre. The analysis of the research object and challenge forced me into another design of the research method compared to the general CIP research tradition from 2000–2003.

Consequently, an explorative design was set out as a profound preliminary study of existing literature followed by a thorough series of interviews with experts and chosen players in the research area in question. Such experts and players included:

- Representatives of the product development management of the industry
- Representatives of national and international research environments focusing on product development

In this way, the methodical demand for a wide-ranging board of experts was met.

Inspiration from International Research Partners at Centre for Industrial Production

The network formed at the Centre for Industrial Production brought a major work of research carried out at the University of Brighton, England to the attention of the research group. This work of research applies a research method as outlined in Figure 2.1.

The basic idea of this method is to encourage researchers to take their starting point in problems specific to the industry and thus to focus on problems known to exist in industrial life.

Subsequently, our research intends to clarify and analyse the known problem in cooperation with representatives of the industry. Finally, the joint

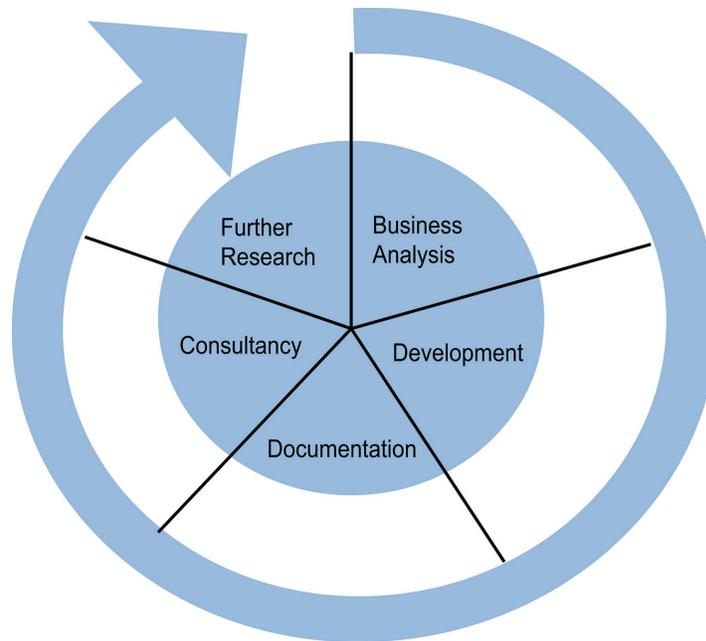


Figure 2.1 Benneth's research model.

Source: Based on model presented by John Bessant, (2000) University of Brighton.

work is substantiated in a combined writing process taking place between the industry and the research institution. In this way, we ensure that the research combines practical relevance and obedience to our chosen research focus with theoretic validity and reliability.

According to the models, the results of such research will be subsequently handed over to other interested parties, including e.g. consultancies, to be further exploited and used by other lines of businesses. Thus, the contents and contribution of the research can be spread to a much wider industrial audience and to a much wider environment than would have been possible if such an assignment had been undertaken solely by the university.

This method of doing research has proven particularly popular at several European universities, whereas American universities have chosen to carry on the classic research tradition and method. The type of research described above has been successfully used during recent years in particular by a series of British research environments in cooperation with small and medium-sized businesses in South and Central England.

The cooperation between Centre for Industrial Production and universities abroad is one of the first results of and contributions to mutual inspiration and use of new research methods and models for cooperation between industry and research environment.

2.3.2 New Way of Doing Research in Cooperation with Industry

On the basis of the above-mentioned overall discussions and considerations of the research design I was highly inspired to try a new way to do research in cooperation with the industry.

The actual methodical framework of the research project in hand was therefore worked out as indicated in Figure 2.2.

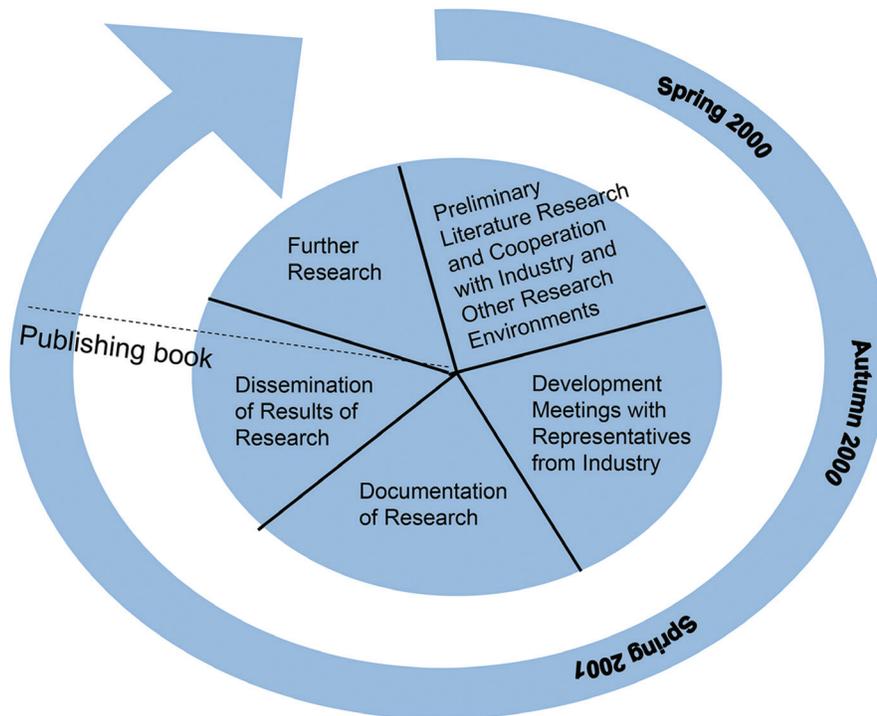


Figure 2.2 Actual research model.

In the following paragraph I will comment on the different phases of the research.

Methodical Framework Phases of Research

The present research project has been divided into six central phases:

- Determination of the methodological ambition of the research
- Preliminary search for literature and cooperation with the industry and other research environments
- Developing meetings with representatives from the industry
- Substantiation of the research work
- Dissemination of the Results of the Research
- Further research

Determination of the Methodological Ambition of the Research

The final determination of the methodological ambition of the research will be commented on in a separate paragraph at the end of this chapter. I will now explain the general considerations of the methodology of the research.

Initially, when I began to do research on NB HS NPD I realised that I was dealing with an area which had not been researched upon before and which seemed to me to be a radical product development task. Therefore, I began to search for a methodological way or framework that could help me to plan the research. As a consequence, I came up with the idea that as I was dealing with product development I should focus on how product development literature and real life deal with such a radical product development task. I therefore put the first initial methodological question to my self

How would a product development manager or a product development team handle a product development task which could be characterised as rather radical?

Looking through the literature of product development I found that the explorative approach is what Wind (1975) and Aaker and Day (1983) propose when researchers and businesses deal with product development and marketing research tasks that are radical and new to the market area. Bearing this in mind I decided first to organise my research methodology in an explorative way but still to develop an architecture that could secure a structured research process that did not let the research and research object slip out of my hand.

I therefore once again investigated the possible structure models for my research. Once again I turned to the product development literature to find a model that would secure this task. The choice fell on Cooper's stage-gate model as a framework model recommended both by researchers and industry as a best practice example of a product development model.

As in a product development project running according to the stage-gate model, each main phase of this research project was therefore divided into various development phases and processes. Such phases and processes have contained the development pertaining to the phases and to the subsequent screening phase in which the development of the preceding phase has been evaluated. During this phase, the objectives of the subsequent phase have been determined.

As in a modern product development process it has been possible in this research project to develop certain areas in parallel and simultaneously. This has particularly been the case during the last part of the research project, but also during the initial phase it has been possible to carry out parallel and simultaneous work.

However, it has also been necessary to attend a rather flexible design of the research with a strong focus on a research architecture that offered the possibility to maximise flexibility. The research architecture focused on the central research questions whereas the research activities opened up for different research method observations, case research, focus group interviews, surveys and some kind of action research. This rather flexible design enabled me to reach an ambition of trying to achieve a triangulation in the final research result. This subject will be commented on later in this chapter.

Each separate phase is described below, and a drawing of the research process is shown in the overall research model below. This model has both a vertical and a horizontal process which is shown in Figure 2.3 and Figure 2.4.

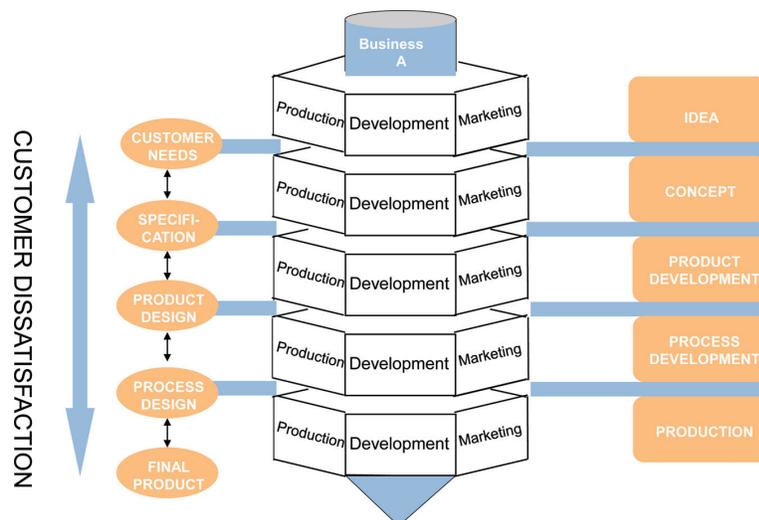


Figure 2.3 Research idea stage.

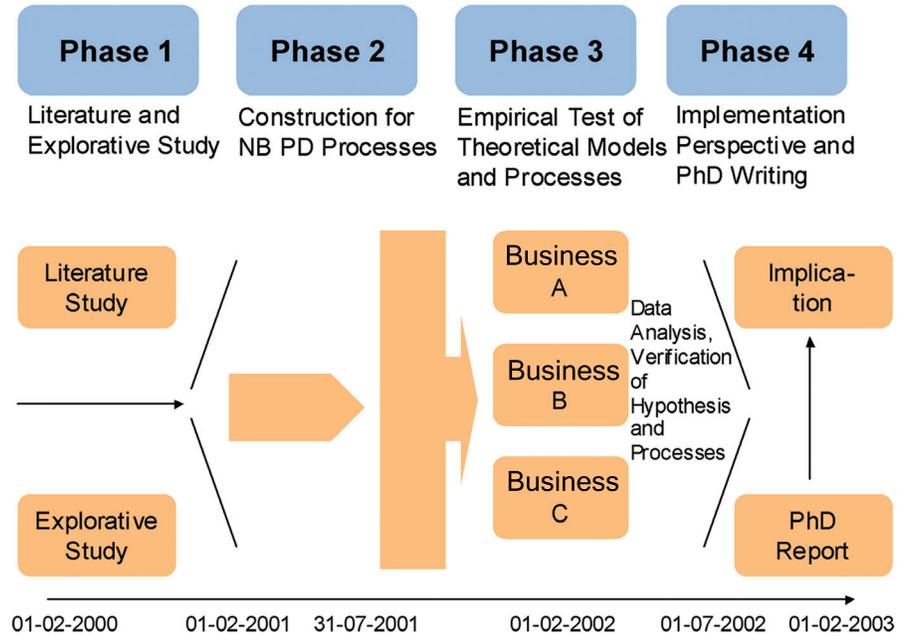


Figure 2.4 Horizontal research process.

The process and the thoughts about what has been going on in the research process will now be described.

The Vertical Research Process

The vertical research process consists of stages and gates:

I defined the vertical research process as the research process stages and gates which I had to consider and go through during the research time period. The vertical research process can be planned beforehand but as will be demonstrated at a later point I could not adhere to some of the stages and gates as the research turned out to have the same characteristics as a practical product development project in the industry. Often in this book I will demonstrate that the industry has to develop informal stages and gates and informal processes outside and simultaneously with “the formal stage-gate model”. Therefore, the final – and actual – research model and process often turns out to be different from what was initially planned. The “product of the

research process” turns out to be influenced by the research environment and continuously developed and improved through the research process until the “encapsulation of the PhD project” is decided upon. Hereafter, the research process will continue as I will comment on later in this chapter.

The vertical research process initially looked as illustrated in Figure 2.3.

Research Idea Stage

The research idea was initiated by the Center for Industrial Production and the thesis was formulated as

Network based high speed product development models and processes

From this general, overall idea I recognized and generated an explorative approach to the research object and task. This process was divided into three generations; one on the research view, one on the research approach and one on the research methods.

The research view considers various points of view such as the business economic view, the technical view, the customer view etc. The research approach considers the approach which a researcher can take on network based high speed product development – the action research approach, the case research approach etc. Finally, the research method considers different methods e.g. the explorative method, the semi-structured method and the structured research method.

These considerations were all possible ways “to handle” the research task. This process generated the first ideas to the research design. In this process I discussed and interfered with several internal and external network partners and for the first time I had to depart from my research development model because I joined and participated in informal product development processes outside my own research process to find ideas to solving my research task.

Research Idea Gate

The different “research ideas” and the different possibilities were considered and evaluated in the research idea gate. The ideas turned out to be decided upon and planned as an explorative research approach.

At first I decided on a multidimensional view on the research objective with an overall focus on a business economical optimal view as the optimal point of entry. This view was chosen because of my business economical background, because the research was carried out for and to the industry and because the research was done together with industrial businesses who focus on the business economical optimal point of entry.

Secondly, I chose a multitude of research methods, however, mainly with a focus on case methods and focus group and survey research methods. This choice was made on the basis of and very much inspired by the product development literature (Wind 1975) which claims that when a business faces a radical product development task, a multitude of development methods are appropriate for the generation of the product idea and concept. Furthermore, an ambition for trying to generate and reach a generalisation on the research object via a triangulation approach was also a main decision criteria. I will later comment on the ambition of triangulation for which I was very much inspired and supported by Professor Mariano Corso and my stay at Polytechnico di Milano. During my stay at Polytechnico di Milano I really understood what I was doing in my research and suddenly I could put words to the research approach.

Concept Stage

After having determined which research idea I was follow and focus on, my research turned into a kind of conceptualisation and break down of the original research idea. This work was fairly easy because the architecture and the focus of the research formulated at the idea stage was very clear and narrowly defined. The conceptualisation phase resulted in a research concept plan.

In this concept generation I was very much helped by my research colleagues and industrial businesses via discussion and inspirations to concepts to the research plan.

Concept Gate

The concept of the research was evaluated and only minor corrections to the final research plan were added. I hereafter began to develop the research.

Research Development Stage

The research development stage turned out to involve simultaneous research activities and it was therefore possible to do carry out these research activities

at one time. This of course put pressure on the research architecture and on the management.

Research Development Gate

The research development gate was a very brief phase and much of the research development was carried out as a kind of “on the market” development or as a direct process development. The reason to this was simply that there was a high time pressure on the research. I will later in Chapter 15 comment on the sources to faults in the research when the research is under such a time pressure. Initially, however, I can already state that I tried to diminish faults in this area by sticking very strictly to the previously elaborated research architecture and also by continuously evaluating and continuously improving the research development process.

Research Development Process Stage

The research development process stage is very much identical to what I will describe in the horizontal research process in the paragraph below. However, the process was actually similar to the “production process” of all the empirical data which formed the basis of this research project.

Horizontal Research Process

The horizontal research process of the research project is as illustrated in Figure 2.4. Each separate phase will be described in the following.

Phase A – Preliminary Search for Literature and Cooperation with Industry and Other Research Environments

Taking his starting point in the above methodological framework the researcher began a major search for literature by means of books, databases of academic papers, newsgroups etc. in order to uncover the framework of network based high speed product development (Please see reference list in Chapter 1).

Such a search for literature also served to provide the researcher with a definition of concepts, a historical view of existing literature on product development as well as a preliminary model for the academic framework of the project.

Historically, the research project takes its starting point in a collection of models developed during the 1960s. Subsequently, the researcher has analyzed

and mapped out the theoretical and practical work of models from the 1960s and until 2003.

The study of literature has been directed towards the prevailing literature on product development during this time, ranging from the stage-gate models, the functional models, the department models and to process oriented product development models and product development models based on simultaneousness and flexibility. Further the study of literature has been directed towards the prevailing literature on network during this time, ranging from literature on physical internal and external network to digital computer network to virtual network.

In terms of method, it can be argued that the initial research into product development focused on finding a theoretical framework model to be tested in the industry. The framework model was based on a hypothetical model which had not been tested in the industry.

The main focus of the product development model was to map out the separate phases of a product development sequence – the stage and gate models – in order to determine which phases the course of product development ought to comprise (Wind, 1973) (Cooper, 1986) (Myrup & Hein, 1985) (Eppinger, 1996) (Hart, 2000). As researchers in the United States focused on theoretical studies and on developing theoretical product development during this time, European researchers concentrated their efforts on studying and interpreting the implementation of the results and models of product development.

At a later point in time, a wider selection of researchers such as e.g. Cooper and Eppinger tried to test theoretical models in real, industrial product development life. Consequently, a need arose to look into which functions ought to be taken care of in each separate phase of product development. The result of this was a shift in research in terms of method; researchers and industries approached each other and the functional and departmental models came into existence (Hart, 2000).

Later, concurrently with the methodical approach of research towards the industry especially at the beginning of the 1980s, the parallel and simultaneous models gained a footing (Myrup and Hein, 1985) (Eppinger, 1993) and others. Among other things, this was due to a growing awareness of the apparent inability of previous theoretical as well as practical product development models to explain the product development processes sufficiently. Furthermore, it became apparent that the classic stage-gate models (Wind, 1975) (Cooper, 1986) were too slow compared to new market and technology demands.

At this point in time, however, in terms of method, research was still characterized by having the industry as its object and researchers as mere observers.

Up to 2003 there had been a shift in the methodical character of research. Thus, the application of the action research method particularly among European researchers had become popular (MacLoughland, 1998). Among other things, this brought about a close cooperation between a growing number of researchers and the industry.

This cooperation meant a growing recognition of the fact that the old product development models were not capable of explaining all product development processes in the industry. Action researchers fully realized that this research method influences the processes and the models according to which the industry attacked the complex of product development problems.

The action research method was chosen as the overall research method and framework of research method at the Centre for Industrial Production. The practice of the action research method can be compared to other practices as is shown in Table 2.3.

The present research project did not offer me the opportunity to carry out research as dictated by the pure action research method. In practice. The present research was carried out as a mix between the committed method and the action research method; however, with the greatest importance attached to the committed practice.

Consequently, the research project cannot be considered an action research project but rather an initial explorative study of literature and business cases based on a combination of theoretical literature cases, real explorative confrontation with select businesses, and a subsequent survey containing descriptive and analytical comprehension of the problem area.

At a later point in time, it was expected that it would be possible to carry through actual action research in the industry on the basis of this project.

In terms of models, the project had attempted to advance a hypothesis model for this research project. Such a model were elaborated to represent a combination of the stage/gate models and the department/functional models as an overall framework. The argument for this choice can be seen in Chapter 8.

The research project focused its efforts on the initial processes of the preliminary stage and gate models and on the models and processes used in NB HS NPD. Such an approach produces the overall analytical framework shown in Figure 2.5.

Table 2.3 Research methodology

	The Relevant Method	The Committed Method	The Action Researcher
Choice of Problem Method	Prior to data collection	In relation to field of research	In relation to field of research
Starting Point for Research	Positivist Theoretic categories and hypotheses	Interpreting Met-theoretic guidelines	Interpreting Meta-theoretic guidelines
Research Strategy and Analysis Unit	In terms of quantity	In terms of quality	In terms of quality
Empiric Collection Methods	The field is examined independently of context	Phenomena are studied in relation to context	Phenomena are studied in relation to context
Interaction with Actors in the Field	Disassociated relationship	Interact without intending to bring about changes	Active participation in the field intending to bring about changes
Pitfalls	Ignorant, <i>a priori</i> , unknown conditions	Risk of getting lost in details	Risk of getting lost in details
Completion of Study	Sufficiently representative	When inner understanding suffices for an outer understanding	When inner understanding has been reached and the problem solved
Method of Presentation	Normative and explanatory	Descriptive and understanding	Descriptive and understanding

Source: Translated from Pernille Kræmmergård – Centre for Industrial Production, 2001.

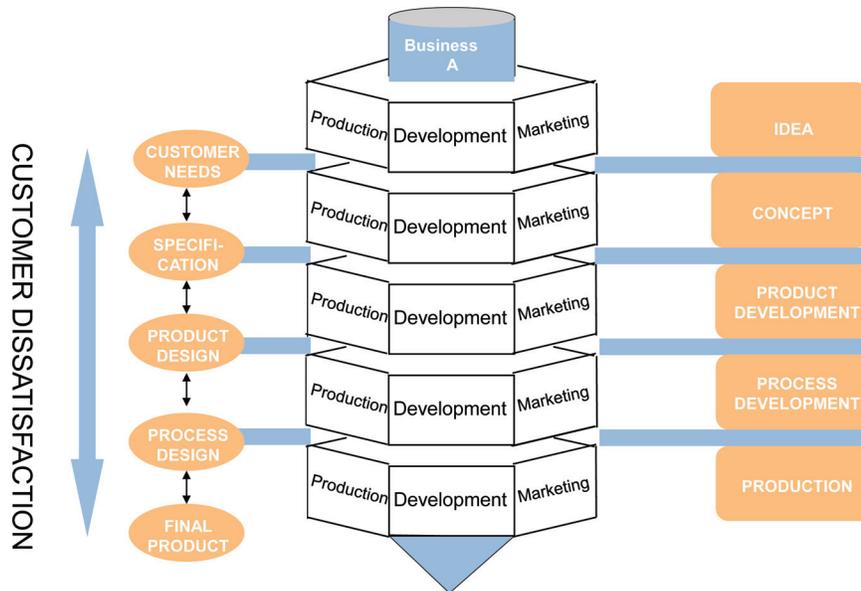


Figure 2.5 Analysis model for network product development.

Source: Bohn & Lindgren, 2000.

During my preliminary study of literature I examined a series of business cases described in literature (Please see the collection of cases). The cases were all selected on the basis of the literature search where it was found that some businesses and researchers claim that some businesses were developing at high speed and in networks.

The results of my case study were a collection of 71 cases which all represent one or more high speed enablers to network based high speed product development. Methodically, each case has been registered and at a later point analysed in relation to i.a. product development models, product development type, and identification of the main phenomena which govern high speed product development.

The analysis of these cases was performed as follows. By way of introduction the high speed enabler of each case was exploratively registered. Subsequently, crosswise of the cases, the frequency of the occurrence of the enablers was registered. This has been elaborated on in Chapter 5 of this thesis.

Next, the analysis was applied in the project as a help in putting forward the hypotheses of the research focus of the project. A description of all cases can be found in the Collection of Cases.

During the initial round of thorough interviews the researcher visited five case businesses. The researcher selected these particular businesses because the case businesses in focus had already been working with the focus area of his research project. The objective was to get an explorative view of NB HS NPD.

Representatives from the case businesses described and characterized their own businesses product development models and methods. As representatives from the businesses, managers connected to the product development function of the business were chosen (see Chapter 9).

The interviews can be characterized as semi-structured, direct interviews. On the basis of my study of literature and of my survey of business cases, the interviewer had prepared a semi-structured questioning framework, according to which the representative of the business was allowed to respond to the questions and the areas of my questionnaire with the least restrictions.

All my interviews were committed to minutes of the meetings and were subsequently used to contribute to further discussion and reflection on the modelling of hypothesis models and on the identification and confirmation of the HS enablers in my efforts to understand product development at high speed. Appendix 1 outlines my preparation of interview questions and NB HS PD hypothesis models.

Representatives from national and international research environments and projects have been actively involved in this research project. Thus, several different methods have been employed as shown in Table 2.4:

Table 2.4 Research activities and empirical activities

Research Activities	Activity	Referred to in Chapters	Publication	Appendix
Scenarios	Discussion with Professor John Bessant, Professor Marianno Corso, Professor Roberto Verganti, Professor Spina, Professor Harry Boer, Professor John Johansen, Professor Jens Riis, Professor Richard Leifers, Professor Mogens Myrup, Associated Professor Poul Dreisler	Several Chapters		(Appendix 2)
Conferences	Eiasm Conference Anti Polis CiNET – Aalborg CiNET – Helsinki	More Chapters	Right speed in NB HS NPD	(Appendix 3)

Table 2.4 Continued

Focus Group Discussions	PUIN Group DISPU Group	Chapter 10	Product development in Network	(Appendix 4)
Survey – internet based	PUIN DISPU	Chapter 11		(Appendix 5)
Meetings with experts on specific areas	Development director Preben Meyer TDC Internet,	Chapter 12		(Appendix 6)
Participation in various lectures and seminars relevant to the project	PhD Summer school in COMO	Chapter 12		(Appendix 7)
Action research laboratory project – TIP Project	Aarhus School of Business Economics; School of Danish Architecture in Aarhus; and School of Engineer Århus	Chapter 12	Network based High speed product development ISBN	(Appendix 8)
Participation in other research groups	(SMER, Loknit, Pitnit, Dispu, PUIN, RESME, SALSA, The TOM Project)	Chapter 12	SMER Loknit, Pitnit Case Book	(Appendix 9)
Participation in national and international projects	www.bestcom.dk www.viborg.dk www.loknit.dk www.smer.dk	Chapter 12	Process report 1, 2 and 3 Bestcom toolbox, case book and theory collection	(Appendix 10)

In connection with the first explorative examination of the problem area, a cooperation with Syddansk Universitet and DTU was initiated with a view to discussing the problem sphere and possible solutions to the assignment.

Thus, the researcher employed both telephone and direct focus group meeting techniques during his cooperation with Syddansk Universitet on specific sources of inspiration from a parallel research project on small and medium sized businesses in the southern part of Denmark.

Furthermore, the researcher took the opportunity of presenting and discussing with a major research group the relevance of and the approach to the problem sphere at the annual Fuglsø seminar in which DTU and Aalborg University both participate. In this context the product development groups of DTU headed by professor Myrup had been of interest and central importance in my efforts to define the problem sphere and as a guide in my study of literature.

In addition, certain parts of the project had been discussed by the research group PITNIT, who had been particularly interested in discussing the

complexity of network and the HS enabler of e-development (www.loknit.dk) and book from the PITNIT project.

In connection with the PITNIT project it had been possible for the researcher during the initial phases to discuss the complex of problems with other small and medium-sized businesses when meeting for the LOKNIT arrangements. During this research project LOKNIT had provided the PITNIT researchers with the opportunity of discussing the research results with the industry.

Finally, internal seminars and meetings at the CIP and at the institute for production enabled me to discuss the problem sphere with other researchers working at the CIP. Such meetings had involved me in particular discussions on the learning organization and on main enablers for high speed product development to which discussions Professor Jens Riis and John Bessant had been contributing. Questions on speed, time, and logistics had been discussed with Professor John Johanssen. Continuous improvement and learning had been discussed with Professor Harry Boer and with Associate Professor Frank Gertsen. On the subject of product modulation and product modelling, Associate Professor Poul Kyvsgård Hansen had been consulted. In addition, the actual composition of models as well as the marketing related aspects of product development had been discussed with Associate Professor Kim Bohn.

Associate Professor Poul Dreisler from the Århus School of Business had discussed the processes of network based product development under high speed in a student project called the TIP project (Århus School of Business, Arkitektskolen and Ingeniørskolen in Århus and Herning (www.tipprojektet.dk)).

Phase B – Development Meetings with Representatives from Industry

Subsequent to the initial search for literature, to the initial analysis, to the preliminary visits to selected industrial businesses, and to the development cooperation with other research environments, I decided to institute Phase B – Development Meetings with Representatives from the Industry. This phase entailed a series of more thorough focus group meetings in which a wider circle of industrial businesses took part. These businesses included:

- B&O
- NEG Micon
- Linco Trading
- Lyngsø Industri

- SCANIO
- AKV Langholt
- Ansager Møbelfabrik
- Tele Danmark Internet
- Grundfos
- Danfoss
- Dansk Teknologisk Institut
- GSI Lumonics (invited)

Our meetings took place from Autumn 2000 and until Autumn 2002 approximately once a month. Consequently, ten meetings were held. The meetings lasted between four and five hours and aimed to present and discuss details of the product development models of the selected businesses. At the same time, we aimed to approach the processes which the businesses passed through in the course of their product NB HS PD models. (See Appendix 4 + minutes of the meetings).

In addition, observations and their consequential hypotheses could be tested and discussed with a view to trimming the immediate validity of the hypothesis models.

All participating industrial businesses were offered the opportunity to present their formal and informal product development models as well as the processes attached to their model. Each meeting was assigned a main and unifying theme. Previous to each meeting, the participants had received the papers prepared by the researchers together with selected articles which could support and put into perspective the unifying principle of the meeting (Appendix 4 and Chapter 10).

The selection of industrial businesses was drawn from a wide range of businesses in terms of size and line of business as can be seen from the list of participants. This was a conscious and disciplined decision on the part of the researchers and should serve the purpose of having as many different product development situations and aspects represented as possible.

Phase C – Substantiation

Already before the development meetings were completed, Phase C – Documentation could be initiated. Methodically speaking, such an act was an explorative attempt at getting researchers and representatives of the industry to write together. These efforts resulted in the book “Product development in network, 2001” and the articles Network based product development a question of right speed not high speed.

Methodically, it was of the utmost importance to the researcher to attempt to analyse, describe, and develop a research area in a new way. Accordingly, it was significant to me to attempt a closer working relationship with representatives from the industry, among other things by writing directly in cooperation with participants from the industry.

As a result, the I forced to adapt myself to a new way of writing and under altered conditions. Additionally, the high speed concept had suddenly turned more relevant and had drawn nearer to the research environment as the representatives of the industry have had specific expectations to the performance of the “product” – or rather to the results of the book – to the degree of topicality, and to taking their own complex of problems as the starting point. At the same time, our chosen method had the result of involving the industry to a large extent.

On the other hand, the representatives of the industry had been forced to confront the researchers’ theorizing of i.a. the concepts behind the theme of the project. Such a scenario gave rise to a continuous immersion into and consideration of the application of actual models and processes. As an example, the following statement gave cause to further research and preoccupation:

“The product development models you present are not used in our business at all! – We just do it. We just develop a prototype”
(SCANIO)

“If we ask our employees to slow down during a short span of time, everything stops. Therefore, a product development course must be run at high speed throughout the entire course” (Grundfos)

“Generally speaking, we only perform incremental product development – in 95% of the cases. Advanced models are only used in connection with large, radical product development assignments”
(Danfoss)

These comments were central to the interpretation of the problem and have resulted in among other things the book “Product Development in Networks” (Bohn and Lindgren 2013).

The researchers have written Chapters 1 and 2 of the above-mentioned book by themselves, however, with representatives from the industry as critical reviewers. Chapters 3 to 6 have been written by researchers and industrial representatives in cooperation. A researcher has been attached to the writing

of Chapters 3 and 4, and another researcher to Chapters 5 and 6. Each of these four chapters have had two or more industrial representatives as co-authors.

Such a cooperation was most fruitful to both parties and in terms of process it has been a most exciting method of working.

Phase D – Survey

On the basis of the results of the primary case research and the focus group interview a survey was elaborated. It was not possible to have all results ready from the case and the focus group interviews because the case and the focus group interviews were running simultaneously with the survey. However, most results could be used to elaborate the final survey as the survey was “produced” very late in the research project. In Chapter 11 a more detailed description of the survey and the survey results can be seen.

Phase E – Other Research Activities

Parallel to the formal, planned research activities other research activities which I joined came up (see Chapter 12). I chose to participate in these research activities because I wanted to observe other ways of doing NB HS NPD in other environments.

Phase F – Dissemination of Results of Research

The dissemination of the results of the project has been of a different character. However, the major dissemination took place at the publication of the PhD project. During the PhD project some publications had been developed – a book, conference papers, articles e.g. Furthermore, several presentations and discussions took place with internal colleagues, research network partners, managers of industrial businesses and others.

Phase G – Further Research

A series of new articles on the subject in question was planned after 2003. Such articles have attempted to discuss in detail a number of related subtopics to this research project. Please take a look into my profile at Aarhus University ([http://pure.au.dk/portal/en/persons/id\(244bfceb-2a4c-4ef0-8c5a-34ad8238b5eb\).html](http://pure.au.dk/portal/en/persons/id(244bfceb-2a4c-4ef0-8c5a-34ad8238b5eb).html))

Furthermore, the research project provided the research environment with the possibility of involving several international researchers.

Finally, the group behind the research project decided to carry on their network cooperation in a number of small or large groups with the object of discussing and exchanging experience and activities related to the subject.

Our research project also initiated a series of students' projects at the study of MSc Engineering at the Institute for Production at Aalborg University.

2.3.3 Reflection on What – Why – When – How

One of the most important scientific discussions today is the paradigm discussion. The paradigm discussion concerns the analytical object, the theoretical foundation and the theories along with the scientific method. The paradigm discussion was firstly introduced by Thomas Kuhn (1962) who claimed that the paradigm provided models from which particular coherent traditions of scientific research are developed.

Kuhn explains how paradigms are generated and how paradigms vanish. Kuhn claims that in a time when a particular line of science seems to evolve with stableness with verifications of findings, analyses of findings, and development of normative guidelines, the scientific work and activity take place.

The stable time is characterised by Kuhn as normal scientific time phases and in this time phase some anomalies – some unexpected and unexplainable differences may turn up. As the anomalies become more and more expressed and increase, the researchers begins to loose faith in the paradigm, and the scientific area enters a time of crisis. In the time of crisis more competing paradigms can evolve and the paradigm which best explains the new phenomenon turns out to be the dominant paradigm. This time is called the revolutionary time. After this time, science moves into a new stable era of normal scientific time, where focus shifts from development of core scientific definitions to detail development of models and methods in the new, dominant paradigm.

The picture of the above-mentioned process is shown in Figure 2.6.

The paradigm is an overall definition in the development of science. Abnor and Bjerke (1977) have elaborated further on Kuhn's work. They talk about a working paradigm which breaks down the dominant overall paradigm and focus on an actual specific research area. The overall paradigm is relatively stable over time whereas the working paradigm is continuously changing in relation to the characteristics of the specific focus areas, to the evolving methods etc.

Abnor and Bjarke claim that the philosophic and scientific statements can be gathered in a methodological view where the working paradigm builds a

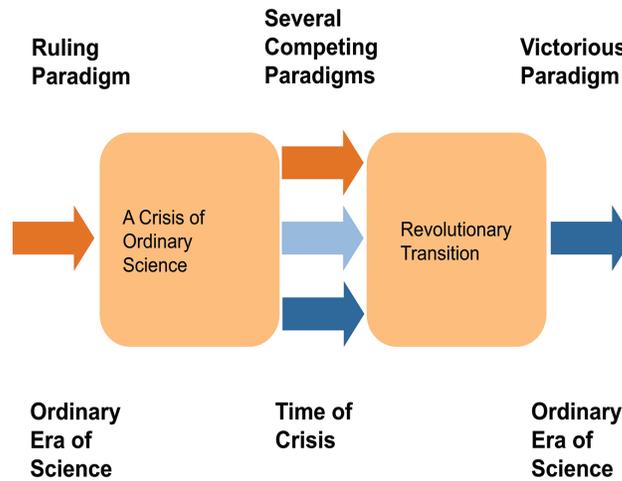


Figure 2.6 Kuhn's theory of paradigm.

bridge or a connection between the methodological view, the methodological learning and the focus area. A model of the above-mentioned is shown in Figure 2.7.

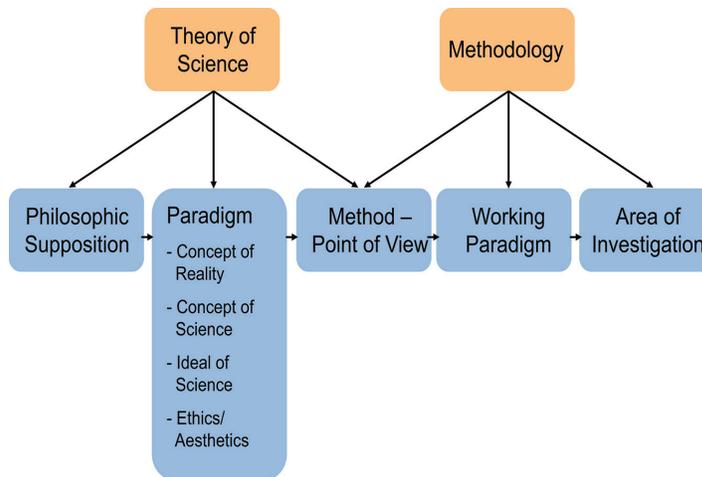


Figure 2.7 Working paradigm of scientific area.

It is the responsibility of the individual researchers to formulate the working paradigm to establish consensus between the methodological view, the methodological learning and the research area as shown in Figure 2.7.

2.3.4 Relating Theory and Method

To clarify the working paradigm of this research project, the following three areas should be described:

1. The normal scientific view of the project
2. Network based high speed product development as a new research area
3. The scientific view and scientific ideal of the focus areas

Normal Scientific View of Project

The normal scientific view of the research project is related to the business economic scientific area, in particular the product development research area. The focus of the area is development and implementation of new products to the market in an business economically efficient way. As an independent research area it is a relatively new research area which came into being in the 1960s with the American effort to develop a spacecraft that could reach the moon before the Russians. There was major focus on product development and how to do product development in an effective way.

In the mid 1970s a few teaching and learning books were published (Wind 1973) and in the early 1980s a stable academic discipline was introduced.

The normal scientific discipline was very much divided between a purely technical and production view to product development and a sales view to product development. The conflict between the technical/production view and the sales view was very much in focus at this time. The focus was primarily based on an internal view and primarily focused on stages and gates. Please see later for a more detailed description in Chapter 3.

In the late 1980s the normal scientific view of product development was developed further in detail (Abnor & Bjerke, 2009). However, the view experienced a crisis (Kuhn, 1962) because marketing and increased focus on customer needs and demands entered the discussion of product development. To a large extent, the discussion was concentrated on the conflict between market needs and wants and the technical and production competences and capacity of the businesses.

In the middle of the 1990s new research came up related to the process view of product development and the need of continuous improvement in product development. Increased focus on time and speed in product development came up, however, mainly focused on internal improvement and internal diminishing of time to market. In the late 1990s and early 2000 the continuous innovation and the network view came up related to product development along with the theory of learning in product development. These new trends

came up with the increasing acknowledge of the need to develop a new theory on the product development area concerning:

1. The need to see the business in a new way – e.g. a network business
2. The need to manage the product development of the businesses in a new way
3. The need to do product development in network.
4. The need to do product development faster and more customized
5. The need to evaluate the product development process

The development on the product development area has given rise to new scientific areas:

- continuous improvement
- innovation theory
- learning theory
- network theory related to product development

The focus in this research project is on network based product development with special emphasis on speed.

Network Based High Speed Product Development as a New Research Area

Network based high speed product development must be said to be a new research area from 2000–2003. Many researchers had carried out important research in network and product development. However, it was new to science to combine network and product development. Furthermore, it was also new to combine speed and high speed related to network based product development.

The Center of industrial production at the University of Aalborg decided in 2000 to focus on this scientific area as one important research area and strategy of the centre. This was due partly to a huge interest in gaining more knowledge on this specific area, partly to the desire of businesses related to the centre to gain more knowledge about NB HS NPD.

Scientific View and Scientific Ideal of Focus Area

The Scientific work follows two essential but different goals:

- The first goal is to find new knowledge to increase the amount of available knowledge on the scientific area – basic science
- The second goal is to give clearness and systematic to the scientific area – applied science

This project can be classified in the area of applied research which goal was to develop new theory that explains and supports specific practical goals. Therefore, the project is strongly related to businesses and their product development models and processes.

2.3.5 Reliability, Validity and Generalisation

A discussion of Validity, reliability and generalisation is always important and relevant to all academic research. They are even inevitable when analyses, verifications, conclusions and recommendations are based on empirical data which include many personal interviews, registrations of group discussions, survey results, observations from group interaction etc.

The validity assessment concerns the planned phase of the research method and is focused on the interview, focus group discussion, survey and observation phase that created the data. The reliability assessment focuses on the data collection and the data analysis that precedes the final analysis, development of conclusions and recommendations.

Validity

Validity in any research or evaluation means that

“the research instrument measures what the individual using the instrument wishes to measure” (Philips, 1996)

Even though this definition is simple, the concept of validity may include the four different aspects shown in Figure 2.8.

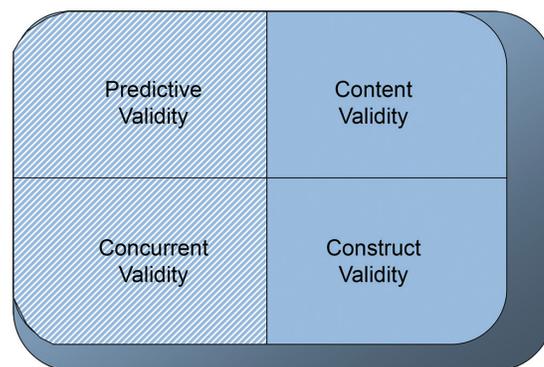


Figure 2.8 Four aspects of validity.

A validity discussion in relation to NB HS PD is not considered relevant to all four validity aspects.

Predictive validity which evaluates the ability of a research instrument or method to predict the future, is not considered relevant, since the purpose of the research on NB HS NPD was to grasp the present status of businesses involved and to paint a picture of NB HS NPD in up to 2003.

Concurrent validity refers to the extent to which the results of an analysis correspond to results of similar analyses made at approximately the same time. For NB HS NPD, no standard of reference exists. Some researchers have elaborated important results on product development and to some extent on product development in network. However, until now nobody has focused on NB HS NPD.

Another argument for the irrelevance of concurrent validity is that NB HS NPD is dynamic, and results from later research – observations, interviews, focus group discussions etc. – would necessarily be carried out differently in e.g. another business focus group or another TIP student group. However, I claimed that the generic results and research findings will be the same. On the basis of the research architecture which seeks to meet the demands of a triangulation research method I claim therefore that the generic results would be the same if the same analysis was carried out at the same time.

Content validity is important for the management of the research on NB HS NPD, since it refers to the extent to which the analysis is representative. An analysis which is not considered representative has a low content validity whereas a high content validity means a good balance between analysis and reality. With regard to the research on NB HS NPD, the content validity is only to some extent obtained.

The case interviews were carried out in five businesses with a general and a specific case analysis in each business. In most case businesses the case research was carried out with an interview with two or more persons responsible for or involved in the business product development activities. Of course it would have been better to have all actors involved in the product development activity presented in the interview but due to time limits, this was not possible. Furthermore, it would also have been better to follow a case from beginning to end but there is a danger that the memory of the respondents can be under the influence of time, policy or other components. However, I had no such impressions that this was the case when speaking to the respondents.

Obviously the case interviews can only be representative within the single business but combined with other cases a stronger representation can be obtained. Of course it would have been better to carry out more than five case researches but this was not possibly within the time given.

The focus group interviews were carried out with people responsible for product development in ten different businesses. The selection of businesses was carried out carefully with a view to business-to-business businesses and a view to different lines of business. The latter criterion was selected because it was essential to the research in an explorative perspective to get as many aspects of NB HS NPD as possible. Major differences in lines of business turned out to result in many aspects of NB HS NPD which surely could not have been obtained if all businesses had been in the same line of business.

The survey was sent out to a representative amount of SMEs on the business-to-business market. However, as will be verified later in this project, the amount of answering businesses was not large but it still allowed me to form an explorative picture of how NB HS NPD was carried out in SMEs in 2003. However, it was not possible to make general conclusions on specific lines of business.

Other research activities have been carried out on the subject NB HS NPD. None of these activities can be said to match the criteria of representativeness. However, neither was this the intention. Instead it was the intention to find add-on information to NB HS NPD and to support findings in some of the other research activities. Furthermore, especially the TIP project offered the possibility of coming closer to NB HS NPD and to make close observations on the process of NB HS NPD.

The visit to Italy added new dimensions to NB HS NPD although this could not be characterised as representative add-on to the research.

Summarising on the content of validity it could be verified that each individual empirical research activity cannot be said to be representative. Nevertheless, some of the activities had more representativeness than others. However, this was not the intention as the research was carried out in an explorative perspective.

Altogether the research activities try to match a triangulation on the research focus NB HS NPD. In this perspective the general generic findings must be said to be representative.

The construct validity refers to the extent to which the analysis maps the construct that it is intended to map. The construct validity is a complex matter and forms a general idea of something formed in the mind by combining a number of pieces of information. This can be defended by expert opinion.

The expert opinion related to the construct validity of my PhD project came primarily from my supervisors of the research project, from colleagues at the CIP centre and from discussions with professors and seniors at the Polytecnico di Milano. Secondly, it came from the individuals evaluating the research project.

The explorative and semi-structured interview approach is exactly what Wind (1973) and Aaker and Day (1983) propose when researchers and businesses deal with product development and marketing research tasks that are radical and new to the market area.

Reliability

Reliability in any research or evaluation means that

“the research instrument is consistent and the outcome of subsequent measurements produce approximately the same results”.
(Philips 1986)

If there is a significant difference each time a research instrument is used, then the instrument is considered unreliable. Differences or errors can be explained by fluctuation in the mental alertness of participants, variations in conditions under which the instrument is administered, differences in interpreting the results from the research instrument, and random effects caused by the personal motivation of the participants (Philips 1986).

With regard to reliability and instruments used in the research on NB HS NPD, the question is whether or not another research group would have developed a significantly different action plan for researching on NB HS NPD. The argument defending the reliability of the NB HS NPD models and processes of the PhD project are found in:

1. The data collection which included not only a few businesses but nearly 180 individual businesses
2. The strong involvement of businesses, participants, students in case research, focus group interviews, survey interview, student NB HS NPD projects etc.
3. The strong involvement of management of product development in businesses involved in the research project
4. The strong involvement of other researchers in the research project

The data collection included all phases of the product development process though with a strong focus on the upper part of the product development

process. A high degree of verification was attached to e.g. the enablers to high speed product development due to the number of participants involved in the research process.

The strong involvement of businesses is explained by the degree of the actuality of the project and intense discussions in business networks, internal businesses and in research – how to perform high speed within network based product development.

The strong involvement of product development management was important in the discussion of relevance and priority of the suggested hypothetical models and processes to NB HS PD. Since cost, benefit and priority of each suggested model and process to NB HS NPD were discussed or considered in several meetings with the persons responsible of product development and the management, only the significant models and processes survived and were verified.

Therefore, it was not considered likely that a similar research would have given significantly more or different findings and suggestions than the findings concluded in Chapter 15.

All in all, it can be concluded that the research undertaken in the research project NB HS NPD fulfils the aspects regarding validity and reliability, which support the credibility of the research on NB HS NPD and the results obtained.

2.3.6 Ambition of Triangulation on Research on NB HS NPD

Previously I commented on the ambition to do a triangulation on the research on NB HS NPD. As it was argued before I was inspired during my research project to try to fulfil this ambition. The research work was therefore focused on trying to come as high as possible on the generalisation according to Jick's (McGrath et al., 1982) model of the different aims of a research project, see Figure 2.9.

“Ideally, a scientific study should reach all three aims – at least traditional Natural Science studies. However, within the world of management, the three objectives will constrain each other. In McGrath's (1982) interpretation, the model becomes a “three-horned dilemma” in the sense that a researcher can only reach two or three objectives in a study – leaving him or her vulnerable to critique for not reaching the third objective – the third objective (whatever that may be). Thus realism, precision and generalisability are impossible to reach at the same time for researchers.” (Drejer A. et al., 1998)

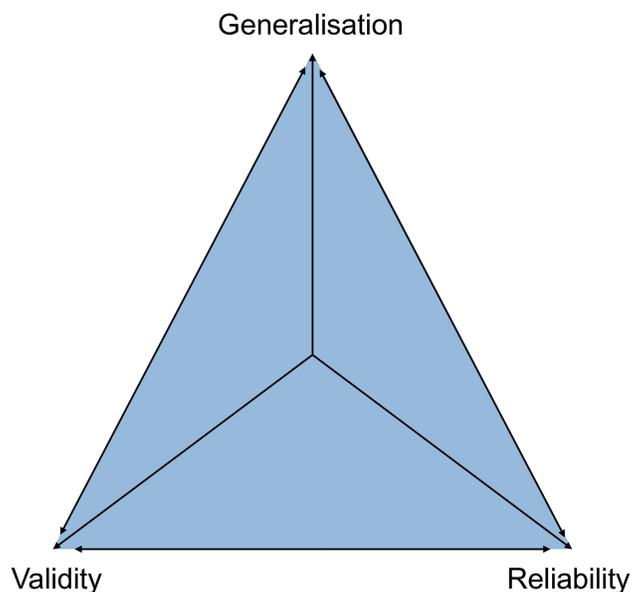


Figure 2.9 Jick's model for trade-offs in doing scientific research.

Source: Based on McGrath et al., 1982+.

With the above-mentioned in mind I was left with a difficult challenge. I chose to go for a maximum of generalisation and reliability. Via the ambition to do a triangulation in the research (case research, focus group interview, survey etc.) my research project had the possibility to reach a high level on both areas whereas the validity area could suffer from this chosen research focus and ambition.

The project differs from other research projects at the CIP Center. Normally, the research projects focused on one or two cases which normally give the researcher a possibility to reach a high level of validity. In this research project I chose to do a multitude of research activities and was very much inspired by the UK tradition of research (Drejer A. et al., 1998). This resulted in a strong empirical content and a combination of more cases, focus group interviews, surveys and other empirical results.

This meant that initially my research project was confronted with the challenge to meet a high level on the arrow of generalisation and realism. On the other hand, this choice resulted in problems in the validity area because it was not possible to perform very thorough research in all case businesses and other research activities. Therefore, I had in 2003 to accept a lower validity to

fulfil my ambition on generalisation and realism. I tried to cover this area as already explained above in the paragraph on validity. In my final conclusion I will comment on how the results of the research turned out seen in the context of validity, reliability and generalisation.

2.4 Summary

The purpose of the present chapter was to map out the scientific and theoretical framework and foundation of the research project. Similarly, the purpose was to determine and explain the methodical focus areas of the research project.

Consequently, it was established that due to the newness and practically non-existing degree of documentation of this problem sphere in 2003, the research project had to apply explorative and Delphi-like methods in order to gain insight into the nature of the existing models, processes, and phenomena of this problem sphere.

As a result, the researcher used a 7-phase analysis frame as his theoretical basis. During the first phase, a) a thorough literature and case study was carried out in combination with b) semi-structured business visits and interviews. The results of such preliminary research were continuously discussed and documented via c) various working papers with national and international research environments and via d) individual meetings, e) focus group meetings and seminars together with f) a survey and g) other research activities.

Special attention must be drawn to the focus group meetings consisting of representatives from the industry and from the research environment at Centre for Industrial Production, Aalborg University. Meetings between the two parties had the purpose of discussing each separate area of the project in detail and of activating the subsequent documentation and writing process between the industry and the research environment. Among other things, the results of our cooperation has been a book on network based product development.

Methodically, my research project has been based on a multitude of research methods with both a business case method and on a combination of engaged and action-like research methods. This choice was mainly due to the need to carry out an explorative research and to the research ambition to try to reach a level of generalisation via triangulation. If this has been achieved and the sources of faults will be commented on and analysed upon in the final conclusion.

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