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Abstract

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Keywords: New product development, Performance measurement, Product life cycle

The essential investments in new product development (NPD) made by industrial companies entail effective management of NPD activities. In this context, performance measurement is one of the means that can be employed in the pursuit of effectiveness.

The primary aim of the study is to structure and analyze the concept of product life cycle in the context of new product development. This objective includes answering the question of what elements comprise product life cycle and identifying the different types of life cycles relevant to NPD performance measurement. The secondary objective is to identify and evaluate the present state of performance measurement in Finnish industrial new product development. Interests in this broad issue include the perceived objectives for NPD, the measures employed and the satisfaction associated with the present state of measurement.

The study is founded on three main elements. First, an extensive literature study on performance measurement and product life cycle has been made for conducting a conceptual analysis covering and synthesizing these two issues. On the basis of this, a conceptual framework comprising the idea of "life cycle conscious" NPD performance measurement is constructed. Second, one half of the empirical base of the study relies on a case study of six industrial companies. This case study was carried out to provide empirical evidence on the product life cycles and their distinct phases in different industrial settings. Third, the other half of the empirical data has been collected through a mail survey. The survey was focused on the present practices of Finnish industrial companies regarding NPD performance measurement.

The primary contribution of the study should be divided into two elements. First, the constructed conceptual framework for the comprehensive performance measurement of product development with a particular emphasis on life cycle requirements is a contribution as such – both in practical and theoretical sense. Life cycle oriented performance measurement of NPD reported in the literature has been something of immature, and the novel approach presented in this study provides the doctrine with at least incremental improvement to this. Second, the analysis of the present state of the NPD performance measurement in Finnish industry provides us with new information regarding the development potential in this domain. Respectively, the identification of the present state enables the discussion on the gap that exists between the needs and practices of the management of product development activities.

On the basis of the discussion of this study, a couple of potential research questions can be formulated for future studies. First, proper testing of the constructed framework entails real life cases that would employ the ideas presented in this study for the performance measurement of their product development activities. Second, quantitative evidence on the product life cycles in metal industry should be collected. This can be done either by survey research or by in-depth case studies.

Acknowledgements

Lauri Viita has nicely encapsulated the essence of individuality and personality: ”Before you call anyone idiosyncratic, visit with him the place he came from.” While it is unlikely that any research report can take the reader along the complete path trodden by the researcher, and show the researcher’s background and development from the vague past right up to the present moment, Viita’s idea can be regarded as a sound pointer also for anyone carrying out research. One of the most important aims also of this research report is to provide the reader with some sort of reasonable idea of the development path that I myself have followed since my introduction to this theme.

About six years ago a friend and I were laughing and saying that of course any person worth being taken seriously, who set themself the ambition of earning a doctorate, could fulfill that ambition before the age of thirty. At the back of our minds was the feeling that to do so would not leave us hard pressed. On becoming thirty in February 2004, it appears no longer a joking matter. On the other hand, carrying out research has taught me that time and time-bound aims are not everything. The main thing, one could perhaps say, is that learning should generally take place.

Irrespective of the research topic, learning how to carry out research is a long process. It is so long that very few dare to maintain that they have fully gone through it or have completed their learning. Neither do I, although I do have my rash moments. I can say, however, that practically all the instruction and wherewithal for carrying out research that I possess was obtained by me while working at the Cost Management Center (CMC) of Tampere University of Technology (TUT). As the outcome of various chance occurrences, I began the work for my M.Sc. thesis at CMC in 1998. Since then I have experienced and learned much in the company of skillful and knowledgeable colleagues. Many projects and interim stages, including the completion of my M.Sc. thesis in 1999 and my Licentiate thesis in 2001, have taught me so much that it is impossible to separate many aspects of the process from others. I want to thank all those enterprises and the personnel of enterprises with whom I have had the opportunity to work during these years in connection with both this present research work and other CMC projects: Metso Minerals, Gardner Denver, GNT Finland, Timberjack, Patria Vehicles, Coherent Tutcore, Perkinelmer Wallac, Sandvik Tamrock, and Halton. Concerning product development and its measurement, I want to offer very special thanks to Metso Paper and Vice President (technology) Ilkka Jokioinen in Pansio.

In addition to the above-mentioned enterprises, TEKES and the Ministry of Labor have financed this research quite substantially. Also the foundation Tekniikan Edistämissäätiö, the City of Tampere, the Foundation for Economic Education**,** and the foundation of Kemira corporation have taken part in the financing. To all of these financers I want to express my warm thanks.

Innumerable people contributed to the genesis of the present research work. I wish to thank sincerely first and foremost Jari Paranko. In my view, Jari has conducted the work at CMC as an exemplary pacemaker. Jari’s contribution to me has been most significant both in terms of procuring financing and of my learning process, and he has never shrunk from providing criticism whenever required. This has been extremely valuable. I owe a great debt of gratitude also to all my other colleagues at CMC. Jouni (my special thanks for dialog on methodology), Marko, Matti, and Tommi have all helped in many ways along the road. A former colleague at CMC, current controller of Patria corporation Miikka Jämsen, did much valuable work as part of his M.Sc. thesis which has also furthered the aims of this research work. My humblest thanks are deserved also as a matter of course by Professor Erkki Uusi-Rauva. His sharply perceptive comments and questions have frequently obliged the young researcher to ponder upon profound matters. Erkki's comments have provided genial nourishment for the development of my thought. It is also worthy of acknowledgement that earlier on Erkki had great influence in getting me, as an uninformed student of engineering, to interest myself in management accounting.

The pre-examiners of the work, Professor Hannu Rantanen and Professor Matti Kleimola (Group Vice President of Wärtsilä) have helped significantly in developing the manuscript. To both of them I tender my warm thanks. In addition, Professor Saku Mäkinen, who "has been there and done that" well before me, also provided some valuable help in the last phases of the project. I really appreciate that he shared his own experiences with me.

If of all important people only one had to be named, it would be easy. Tiina is irreplaceable for me. Without Tiina, combining work as a researcher with the process of completing one doctoral thesis, leading a full life, two series of pipe renovations at home, and four other apartment renovations would have been a sheer impossibility. Tiina has endured me even when, during the process, I have been completely unendurable. Which is not rare.

Finally, I want to thank my mother Riitta as well as my late father Matti and my sister Hanna for everything they have done to the good of our family. It is a great privilege to be surrounded by such people.

Saarikylät, Finland
27th February 2004

Petri Suomala

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1 Introduction

New product development (NPD) is a complex and challenging activity. The challenge of managing NPD can be illustrated by addressing a number of difficult – and yet most essential – questions: How to anticipate future events in markets? How to foresee competitors' strategies and actions? How to understand the logic of potential customers in evaluating competing products and services? How to deal with the uncertainties of all the factors affecting the success of the new products being developed?

Edward De Bono (1991) states that our traditional way of thinking has proven its capacity in producing various technical innovations and developments, but he criticizes the effectiveness of our logic in social situations, in human interaction. He provides an example that describes well one of the strengths of ours: the utilization of routine models (De Bono 1991).

> *Consider a normal routine such as dressing up in the morning. If a person intended to wear 11 pieces of clothing he or she would have – theoretically – ca. 39 million different order options to put the cloths on. Of course, not all the options are feasible, like shoes before the socks etc. However, if the person judged each option even for one second it would take years to get the cloths on. Fortunately, it is not necessary for us to consciously do that kind of judging. We are able to utilize the models our brains have once created.*

In the light of De Bono's example, it is a relief to notice that the human mind is capable of constructing different kinds of applications helping us to resolve many practical challenges that we face on a daily basis. However, there are many complex problems that necessitate tools and equipment also other than the human mind. The context of this study, industrial new product development, is argued to be among them. The dressing up –problem addressed the notion that in order to be properly conducted, even the simplest tasks require certain tools.

1.1 Pursuit of Successful Product Development

Industrial research and development (R&D) utilizes science and technology to construct new or improved products or processes for profit-seeking companies (IRI 2000). New product development, which is an essential part of R&D, can be seen as an activity that is expected to improve a company's competitive advantage and future success in terms, for example, of profitability and market share (see for example Morbey and Reithner 1990; Zif and McCarthy 1997; Poh et al. 2001; Osawa and Murakami 2002). Based on the hope and trust that tangible returns will be greater than expenditure, considerable sums of money are invested in R&D (Batty 1988). According to IRI, in US companies alone, representing over one-third of the entire world's allocation in R&D, 185.9 billion USD was invested in industrial research and development in 1999 (IRI 2000). For comparison, US R&D expenditure in 1950 was 2.5 billion USD (Jackson and Spurlock 1966).

Industrial R&D can be seen as a continuum that starts from basic or applied research and ends with the development and design of a commercial product. It is unlikely that a project will straightforwardly pass all the phases of the continuum; rather, a company is typically able to maintain a certain amount of applied research, concept development[1], and product development activities/projects. Each type of R&D can be seen as a pool of knowledge; only the most potential ideas of each pool can be further developed – often through many syntheses or even co-incidences – into commercial products.

When striving for effective new product development, R&D management faces several challenges, including project selection[2], communication, team/individual performance evaluation, benchmarking, etc. In this context, performance measurement can be seen simply as a tool that is supposed to help in grasping "the big picture" and in making good decisions. It is noted that performance measurements drive behavior and they are needed and useful for fostering the prioritization of effort (Schumann et al. 1995). Thus, whatever the purpose (for example project selection, communication, etc.), measurement nevertheless may contribute to the way R&D efforts are managed.

Measurement can be seen as a systematic means for obtaining information and understanding concerning a phenomenon or issue that is rather complicated or broad in its nature, thereby hindering the possibility to manage it only by "gut feeling". The question then is what should be measured in the R&D and NPD context. The challenge of product development management[3] and measurement has received both academic and practical attention. In the practical – industrial – sense, it is highly relevant for companies striving for effective and efficient R&D investments to seek operational tools for better management. Academia, on the other hand, has identified several potential research topics around the subject. Some writers (McGrath and Romeri 1994; Szakonyi 1994; Szakonyi 1994; Chiesa and Masella 1996; Kerssens-van Drongelen and Bilderbeek 1999) have established holistic approaches for the assessment of R&D effectiveness, while others have concentrated on the project level (Ormala 1986; Rouhiainen 1997). There are advocates for continuous or in-process monitoring of development as well as for end-of-process evaluation (Schumann et al. 1995). There is a variety of methods available for R&D project selection (Cooper

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[1] A product concept is an approximate description of the technology, working principles, and form of the product. It is a concise description of how the product will satisfy the customers' needs (Ulrich and Eppinger 1995).

[2] As far as a company's management is concerned, a major dilemma in the management of research and development is that the number of potential research, development, and design projects is greater than it is possible to carry out. The limited resources and skills compel managers to select projects from those proposed. A comprehensive description of different selection methods is presented (for example) by Martino (1995).

[3] Doctoral dissertations that concern product development management conducted in Finland include: (Kulvik 1977, "Uusien tuotteiden onnistumiseen tai epäonnistumiseen vaikuttavat tekijät"), (Ormala 1986, "Analysing and Supporting R&D Project Evaluation: An Applied Systems Analytic Approach"), (Rouhiainen 1997, "Managing New Product Development Project Implementation in Metal Industry"), (Lindman 1997, "Managing Industrial New Products in the Long Run"), (Mäkinen 1999, "A strategic framework for business impact analysis and its usage in new product development"), (Berg 1999 "Appraisal for the technology programmes : development and verification of a new assessment model in some national technology programmes of the construction industry in Finland")

1985; Hollander 2000), performance evaluation for managerial purposes, customer perspective (Hirons et al. 1998; Nixon 1998), and benchmarking. Many creditable reports that describe the state of the art of R&D measurement have been published (EIRMA 1985; EIRMA 1995; Griffin 1997; Werner and Souder 1997; Werner and Souder 1997; Brown and Svenson 1998).

Success in product development can be considered a general aim for any R&D activity. Unfortunately, success is very multidimensional. It is not only the viewpoint of a stakeholder but also the temporal orientation for product development that affects the definition of success. Despite this difficulty, the question of which dimensions of success one should include and how one can measure these dimensions is an essential question that must be resolved within R&D management (Hultink and Robben 1995). However, relatively little discussion has focused on the resolution of this question. Yet, as Hart (1993) puts it:

> *"Clearly, the way in which NPD success is defined influences the findings which describe the factors contributing to NPD success."*

Griffin and Page recognize that success is elusive, multifaceted and difficult to measure. Still, companies and academics use over 75 measures of success in product development. (Griffin and Page 1996) Basically, hand in hand with determining and selecting R&D performance measures for a company, one should also consider the concept of success. What is the form of success that is primarily pursued? Are there any other success dimensions that would be important for us? Knowing the type of success pursued would likely be helpful in choosing the appropriate set of R&D metrics. Further, the elusive nature of NPD success is not only due to the fact that the term *success* is multifaceted. It is evident that the term *new product* is also a challenging one to define succinctly and soundly. Depending on the degree of newness related to the product being developed, the nature of NPD might vary a lot.

As a general requirement, at least two kinds of objectives should be set for the utilization of performance measurement (PM) in new product development. First, the measures should convey essential information on the present state of activities. On the other hand, the measures should provide some guidance for long-term improvements. In contrast with this, it has been pointed out that the measures of NPD in many companies suffer from short-termism and an overemphasis on single projects (Meyer et al. 1997). Indeed, considering the importance of effective new product development, it seems that NPD performance measurement is not as developed as one might expect (see for example Hertenstein and Platt 2000; Hyland et al. 2002).

At a general level, this study addresses the issue of the long-term focus of performance measurement in new product development. By reviewing the body of literature on product life cycle (PLC) theory and on NPD performance measurement, a conceptual analysis focusing on the synergy of these two broad themes is conducted. Further, empirical evidence on product life cycles gathered from six case companies and the evidence on NPD performance measurement practices gathered through a mail survey is reflected against this conceptual framework.

From the performance measurement point of view, the concept of life cycle is multifaceted. The traditional marketing view that implies life cycle phases such as development, growth, maturity, and decline, focusing mainly on the sales volume, is only a narrow one. Life cycle can be generally defined as the period of time that begins when a system is conceived and ends when the system is no longer available for use. Analogously, the life cycle of an individual product begins with the acquisition of raw materials and includes processing of bulk materials, production of engineering materials, manufacture, use, retirement, disassembly, and disposal of residuals that might have resulted in each stage of the life cycle. Furthermore, from the business point of view, the management of product life cycle should not be restricted to the life cycle of an individual product, but rather should also include issues such as after sales impacts, product upgrades, and an assessment of their perceived potential, or life cycle assessment of production systems all of which are – either directly or indirectly – associated with the life cycle of the actual product.

Hence, life cycle analysis has the potential to provide the companies with a framework that depicts virtually all the circumstances and the stakeholders that are relevant for a product. Also, it could be employed as a basis that helps to evaluate the cumulative impacts of new products. As noted by Bauer and Fischer (2000), product life cycle theory is an enduring framework in business. Among many other things, it can be beneficial in analyzing the long-term economic and non-economic effects of NPD activities.

1.2 Research Questions

This study is founded on three broad research questions. Together, the questions cover the idea of life cycle consciousness in NPD, the organization of performance measurement on the basis of the concept of product life cycle, and the consideration of the gap between the present state of NPD performance measurement and life cycle -conscious NPD performance measurement. These questions are:

> *A. Multifaceted performance measurement and the concept of product life cycle -conscious new product development: What would be the potential role of product life cycle in new product development performance measurement and management?*
>
> *B. How would it be possible and expedient to organize the measurement of (new) product development performance while taking into account the challenges and requirements that arise from the product life cycle and its discrete phases?*
>
> *C. What is the difference between this idea of new product development performance measurement and the present state of NPD performance measurement in the Finnish industrial context?*

Question A is founded on the issue pointed out by the literature that there has been a very limited amount of discussion concerning the possible solutions for NPD performance measurement that is both multifaceted and has a long-term orientation. The question addresses the possibility that the concept of product life cycle could be engaged in new product development performance measurement.

On the basis of this, the second question – question B – is interested in the specific nature of the measurement framework that is founded on the combination of product life cycle and NPD performance measurement. The literature includes some examples of the life cycle -oriented NPD performance measurement, but overall, the utilization of the concept of PLC in NPD measurement seems to be far from mature. Importantly, the concept of product life cycle has to be fully analyzed in order to be able to use it as a foundation for NPD performance measurement. Also for establishing a foundation for the framework, the requirements and challenges of NPD performance measurement in general have to be discussed.

Question C addresses the issue that the present state of NPD performance measurement is likely to be something different from the ideas presented within the concept of life cycle -conscious NPD PM. Thus, it would be important to identify the present state of the industrial NPD performance measurement and to discuss the possible gap between the present state and life cycle -conscious NPD performance measurement.

1.3 Objectives

To be able to respond to the challenges posed by the research questions, a number of more specific research objectives have been formulated. The primary aim of the study is:

I. To structure and analyze the concept of product life cycle in the context of new product development. This objective includes answering the question of what elements comprise product life cycle and identifying the different types of life cycles relevant to NPD performance measurement.

II. To analyze the concept of life cycle -conscious NPD performance measurement. This includes identifying the various requirements for performance measurement that are founded on the characteristics of life cycle.

III. To build a conceptual model that connects the product life cycle to new product development performance measurement. The construct should take into account the different stakeholders of the product and the interpretations regarding the product life cycle. As a result, the conceptual model should provide a multifaceted framework for measuring NPD performance.

The secondary objective is:

IV. To identify and evaluate the present state of performance measurement in Finnish industrial new product development. Interests in this broad issue include the perceived objectives for NPD, the measures employed and the satisfaction associated with the present state of measurement.

V. To establish a "development path" or a trajectory from the present state of the performance measurement of Finnish industrial product development towards a state of more multifaceted performance measurement of development activities.

Answering question A entails reaching objectives I and II, while objective III aims to produce answers mainly for question B. Reaching objectives IV and V is seen as a prerequisite for answering question C. When pursuing these objectives and answers for the questions, the study relies on three main sources of data: a case study, a survey, and an extensive literature study. The methods will be more fully discussed in the succeeding sections. The association between the research questions, objectives, and the sources of data is presented in Table 1.

Table 1. Research questions and objectives

Question	Objective	Data source
A: The potential role of PLC in NPD PM	I, II	Case study, Literature review
B: Organizing the PM on the basis of PLC and its phases	III	Case study, Literature review
C: Gap analysis between the present state and the introduced framework	IV, V	Survey

1.4 Scope

The overall intent of the study can be described as to produce an overall blueprint for multifacetedly measuring the performance of product development. The main focus is not on the individual measures or on the detailed description of a measurement system; rather, the study aims to produce fresh and well-founded ideas regarding the overall scheme of NPD performance measurement. In other words, the scope is on the analysis of the relationship between the performance measurement and the environment within which it is applied (Neely et al. 1995, p. 81). Long-term orientation and the consideration of various NPD stakeholders comprise the core idea of this scheme.

The definition of the concept of product affects the scope of this study to some extent. Although the definition of product is not intended to be strictly understood, all the products explicitly discussed within this study represent examples of industrial investment goods. The products referred to are either stand-alone industrial products or physical components or materials associated with investment goods. In other words, no consumer products are included in the study. Due to this restriction, the applicability of the study and its findings with respect to consumer products and markets cannot be discussed on the basis of this study. Above all, it is not the characteristics of the life cycle of a specific product but the overall applicability of the concept of product life cycle regarding a specific product that largely determines the applicability of the discussion and the findings in various market settings. If the PLC concept is feasible, the concept of the life cycle -conscious NPD performance measurement will be reasonably feasible as well.

The scope of the study is not very sensitive with respect to a specific industrial sector. Most of the studied cases represent the metal industry and machine manufacturing but there is also a representation of companies operating in the electronics industry. Further, the companies that responded to the mail survey are industrial companies that represent a number of industries. Again, the characteristics of a specific market – no matter how special they are – are not considered to be an obstacle for the applicability of the concept as such if the concept of life cycle seems feasible.

The primary scope of the study is the class of middle-sized or large companies that are active in product development. This statement is founded on the fact that the case companies, as well as the surveyed companies, are middle-sized if not large. In spite of this limitation, the discussion presented in this study might also be relevant for smaller companies if they practice active and systematic product development.

The temporal nature of business is one of the key issues regarding the scope of the study. The proposed framework is founded on the idea that products have various impacts (operational or directly monetary) on the operation of the company, on society, and on the customer over a period of time. The responsibility of the company pertaining to the product – either implicitly or explicitly – very often extends from development, manufacturing, and delivery to the end of life and, for instance, to the possible recycling. In addition, the issue of after sales service comprises a temporal aspect of its own for the manufacturing company. Especially in the case of an industrial product, the customer utilizes the product for several years and during this period, the product is expected to maintain its ability to produce value for the customer. Furthermore, society often has concerns regarding the life cycle impacts of products including, for instance, environmental hazards and pollution. As a result, if no temporal aspects seem to be feasible in a particular environment, the applicability of the proposed framework would be compromised in those settings.

Finally, the phase of the R&D cycle of interest is an important issue. This study, when discussing performance measurement, concentrates on new product development, which is interpreted as the development of commercial products. Talking about the R&D continuum, product development – contrary to basic or applied research – is seen as an activity that takes place near the market and that is focused on a specific product. Thus, the restrictions, requirements, and objectives of product development differ essentially from those of research (see for example Brown and Svenson 1998). Considering these vast differences between the R(esearch) and D(evelopment) in R&D, this would be an important distinction to make.

1.5 Outline of the Dissertation

The body of the research report relies on three main cornerstones: 1) the literature review on performance measurement (in NPD and in an industrial company in general) and on the concept of product life cycle, 2) the case study conducted in six industrial companies, and 3) the survey of Finnish industrial enterprises focusing on NPD performance measurement. The report consists of seven main chapters, which are organized according to the grand scheme presented in Figure 1.

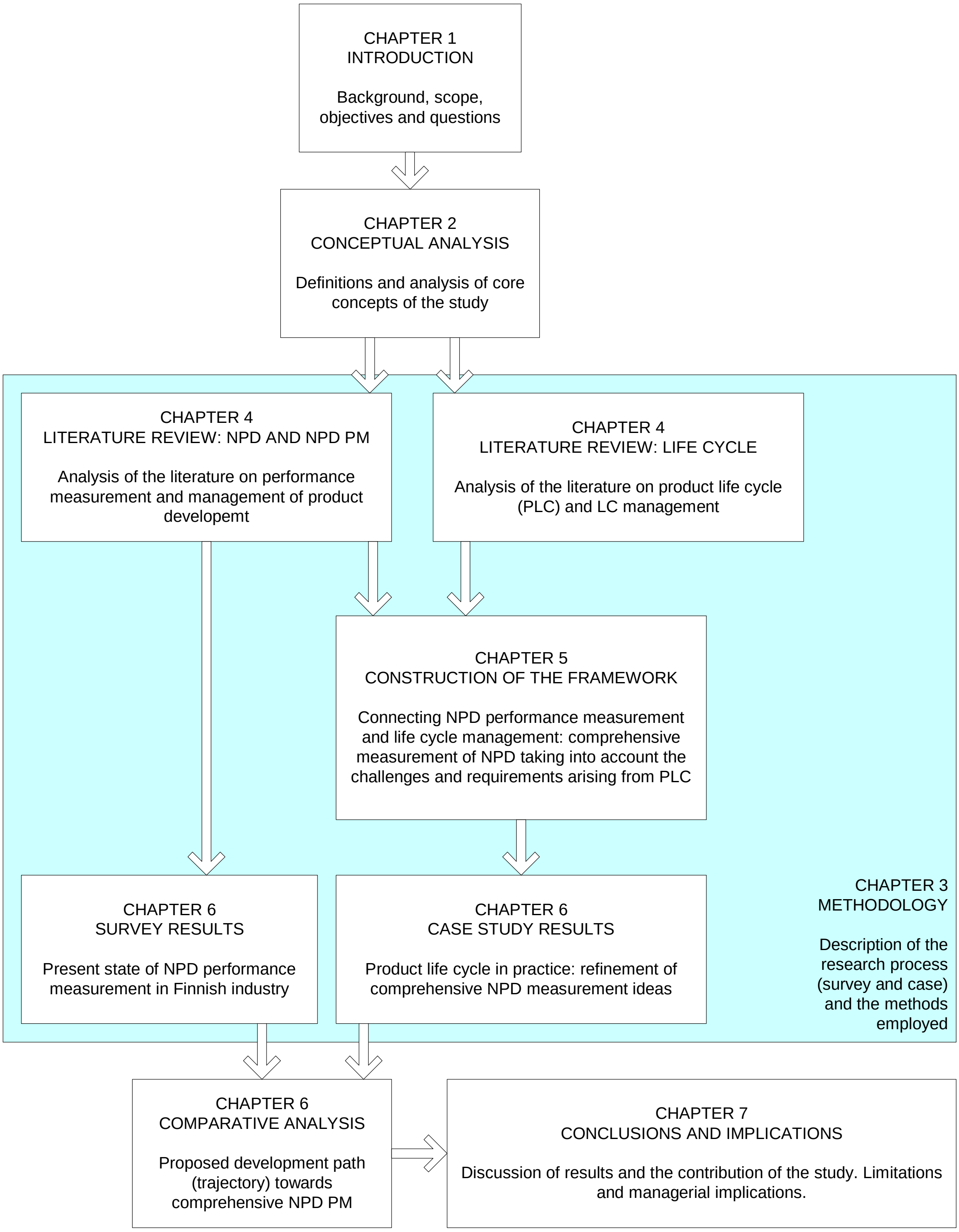


Figure 1. Outline of the study

Following the introduction, the definition of the core concepts, and methodological discussion, the literature study is reported in Chapter 4. The proposed framework is introduced in Chapter 5 on the basis of the literature study. Then, after presenting the empirical findings in Chapter 6, the issues addressed by the proposed framework and the empirical findings are put together and discussed at the end of Chapter 6 and in Chapter 7.

2 Conceptual Analysis

"Rose by any other name would smell just as sweet" - William Shakespeare

Despite the apt remark by Shakespeare that a thing is what it is rather than what it is called, it can be argued that a piece of conceptual research without a proper concept definition would be a paradox. Hence, it is necessary to briefly discuss and define the key concepts of this study.

The primary locus of this study is performance measurement and thus also, in a wider sense, management accounting (Riistama and Jyrkkiö 1991; Neilimo and Uusi-Rauva 1999). Further, the particular context in which the performance measurement is discussed in this study is new product development and – as the boundary between new and old products is sometimes rather ambiguous – product development more generally. Importantly, the study introduces the inclusion of the concept of life cycle in this context for multifacetedly measuring the performance of product development.

Respectively, the key concepts of this study include performance and its measurement. Also the concepts of product and product development are important. In addition, understanding the concept of life cycle is essential in order to be able to address the research interests. On this account, these key concepts are briefly discussed in the following section prior to actual literature review and analysis. This section ends with a brief synthesis of the core concepts employed in this study.

2.1 Performance

Grönfors reminds that there are many definitions of performance that are founded on different paradigms and assumptions: The mechanistic view implies that performance is the difference between input and output (a measure of efficiency or productivity[4]). On the other hand, performance could also be seen as a function of effort, ability, and conditions. (Grönfors 1996, pp. 42-44)

Otley (1999) argues that performance is an ambiguous term. For instance, it does not inherently specify to whom the organization is delivering its performance. This notion leads Otley to recognize and to define that an organization is performing well if it is attaining its objectives or effectively implementing its appropriate strategy. Also Coccia (2001) argues that performance is the *result* of the organization in carrying out activities over a period of time. Further, Otley recognizes the importance of organizational stakeholders for defining the content of the term "performance". (Otley 1999)

Laitinen gives a definition according to which performance can be defined as the ability of the company to gain output in the preferred dimensions (see for example Kaplan and Norton 1992; Lynch and Cross 1995) in relation to objectives and targets set. (Laitinen 1998) This definition seems very compact and yet rather generic: performance is mainly related to the outputs and it can be assessed within various

[4] (see for example Hannula and Suomala 1997; Hannula 1999)

dimensions. That is, there is not only one dimension of performance. In addition, it is an important remark that performance is closely connected to the objectives set. It is only the existence of objectives and targets – they can be either explicit or implicit – that actually define the performance in any given situation.

Flapper et al. (1996) suggest that performance is something that is very important for an organization: the success and continuity of an organization depend on its performance. According to Flapper, performance may be defined as the way the organization carries its objectives into effect. Good performance is also about consistency: "it requires that all noses are pointing in the same direction". However, despite its practical appeal, the requirement of consistency seems to some extent questionable. Rather than coherence and consistency, good performance may also require versatile views and even differences in opinions. Furthermore, the fact that performance has a number of dimensions and that it is a relative concept to some extent implies that good performance is not solely founded on consistency.

If there are a number of dimensions that define the comprehensive performance, there also seems to be hierarchical levels of performance. According to Rummler and Brache (1995), the three levels of performance include:

- organization,
- process, and
- job/performer (see also Eloranta and Räisänen 1986, pp. 45-46).

Organization-level performance emphasizes the relationship between the organization and the market and the variables that affect performance at this level are strategies, organization-wide goals and measures, and organization structure. If the organization structure represents a skeleton of an organization, the cross-functional processes comprise the musculature. To manage the performance at the process level, one must make sure that the processes are designed to meet customer needs and that the process goals are founded on the customers' and organization's requirements. Finally, processes are managed and performed by individuals. Thus, the overall performance of an organization is the result of the performance achieved at three interdependent levels. (Rummler and Brache 1995) Importantly, when emphasizing the role of measurement in management, Rummler and Brache equate the concept of performance with the concept of output. That is, performance measurement should be focused on the output at three levels: organization, process, and job/performer. (Rummler and Brache 1995, pp. 134-137)

In the product development context, a more specific interpretation of the concept of performance has been presented by Ulrich and Eppinger (1995). Five dimensions that relate to profit achieved by (new products) can be used to assess the *performance* of a product development effort (adapted from Ulrich and Eppinger 1995, pp. 2-3):

1. Product quality: goodness of the product as interpreted by different stakeholders, the ability to satisfy customers' needs, robustness, and reliability.
2. Product cost: manufacturing cost including spending on capital equipment, indirect cost caused by the product.

3. Development time: the time frame of the product development effort (determines how quickly the organization receives the economic returns from the efforts).
4. Development cost: the amount of money invested in product development.
5. Development capability: have the product development effort and experiences associated with it enhanced the abilities of the development team to develop future products (development capability is an important asset the organization can use)?

It is noteworthy that the first, the second, and the fifth point in this list clearly relate to the outputs or outcomes of product development. In that sense, the performance of product development is to a large extent based on the achievements and results of product development activities. However, the third and the fourth point suggest that the performance of product development is not only determined by the outcomes but also by the process itself. Within certain settings, development time and cost may be very critical elements to product development success. Therefore, it seems feasible to regard them as components of product development performance.

2.2 Performance Measurement

Performance measurement is a topic that is often discussed but rarely defined (Neely et al. 1995). Of course, Neely's argument was made in 1995 and since then, the situation seems to have changed to a certain degree. Perhaps it can be said that performance measurement is both discussed and defined often but proper definitions are still hard to find. Nevertheless, according to Neely (1995), performance measurement is defined as:

> *"the process of quantifying the efficiency and effectiveness of action."*

In this context, measurement represents the process of quantification and action is something that leads to performance. In addition, being well in line with the definition by Neely, Hyland specifies that performance measurement is considered to be a process of data collection and analysis that provides information about the efficiency and effectiveness of ongoing activities (Hyland et al. 2002). On the other hand, quantification is not the only way to define measurement. Grönfors (1996) argues that if one wants to measure performance from a holistic point of view, instead of a mechanistic one, it is not possible to quantify all the variables. Rather, one has to rely on at least some subjective assessments. (Grönfors 1996, p. 47)

Andersin et al. (1994) argue that the concept of performance measurement emerged in the literature at the end of the 1980's. A major driver for this had been the critics – for example (Johnson and Kaplan 1987) among the others – targeted at traditional financial control and management of organizations based on short-term historical data. Indeed, 1990's witnessed a trend of performance measurement literature. However, it was already some 20 years earlier when (Ijiri 1975) stated that:

> *"Performance measurement is an evaluation of the performance of an organizational unit or corporate unit: hence not only the emotional but also the economic interest of the unit is tied to the measurement. As a result, there*

is likely to be more pressure to bias performance measures than other more neutral measures. For this reason, we cannot look at performance measures as merely additional information useful for some decisions. The measurement has to be more carefully constructed in order to protect it from such pressures."

Management control systems, according to Otley, are systems or "packages" that are intended to provide managers with information that is perceived as important in developing and maintaining viable patterns of behavior (Otley 1999). If performance measures are defined and implemented properly, they will facilitate the implementation of change (Laakso 1997, p. 77): measures are facilitators. The facilitating role of performance measurement underscores the importance of a well-defined focus of measurement. In addition, measures can be regarded as motivators. The purpose of performance measurement is to *motivate* behavior leading to continuous improvement in customer satisfaction, flexibility, and productivity (Lynch and Cross 1995). Hence, it is crucially important to clarify what sort of changes or status quo is being facilitated by the measures. It has been said that the purpose of measurement has to be defined before designing a PM system and identifying the measures (Ojanen et al. 1998).

Performance measurement can also be placed into a larger context: Performance measurement can be interpreted as a part of a performance control process (Kerssens-van Drongelen and Cook 1997), or measurement can be seen as a foundation for process management and for managing organizations as systems (Rummler and Brache 1995, pp. 134-137). It comprises at least information gathering, recording and processing. Hence, acquisition and analysis of information regarding the actual attainment of organizational objectives and plans are included in performance measurement. Further, according to Kerssens-van Drongelen and Cook (1997), performance measurement should also gather and analyze information that relates to factors that may contribute to goal attainment. A performance measurement system is interpreted as a set of tools and procedures that can be utilized to support the information gathering. (Kerssens-van Drongelen and Cook 1997, p. 347)

Bourne et al. (2000) proposed that the development of performance measurement systems consists of three main phases. These are similar to the three phases presented by IMA (1998) for implementing an integrated performance measurement system:

1. The design of the performance measures: this is principally a cognitive exercise, translating customer views and other stakeholder needs into business objectives and appropriate performance measures. A growing literature base is considering this domain of performance measurement.
2. The implementation of the performance measures: this is basically a mechanistic exercise and should be susceptible to being managed by classic project management tools. An early involvement of IT specialists is encouraged to increase the speed of progress.
3. The use of performance measures. This domain is lightly researched and few tools and techniques are available. The solutions in this area require more than simple application of project management techniques.

This scope of this study is on the first point. Due to the novelty of the idea of connecting product life cycle with NPD performance measurement, discussion on the implementation or the use of measures would not be feasible at this point.

According to Hyland (2002), performance measurement can be further divided into active and passive performance measurement. Passive PM is perceived as, for instance, evaluating performance or determining suitable rewards. In contrast, active measurement is characterized by motivating and encouraging desirable behavior or action. (Hyland et al. 2002) As regards the distinction between active and passive performance measurement, it remains somewhat unclear and ambiguous. Performance measurement seems to be a concept that is quite difficult to separate from the context of decision-making – it always has some kind of a connection to active behavior. For instance, it is noted that PM is intended to be a helpful tool in making good decisions and also, it is widely acknowledged that performance measurement affects the people that are in its realm. Therefore, a notion that there could be such an aspect as passive measurement seems arbitrary. In fact, Kerssens-van Drongelen and Bilderbeek (1999) have provided a more appropriate internal typology of performance measurement: As a part of performance control, performance measurement relates to two different aspects of control, namely feed forward and feedback control. In the research and development context, feed forward control is intended to ensure that the right resources and organizational conditions are employed at the right time to promote good performance. Auditing or benchmarking, for instance, can be utilized to improve the alignment of the resources and conditions to increase the probability of success or good performance. On the other hand, the role of feedback control is to consider the actual attainment of goals in respect to the objectives set for the activities – such as new product development – in the first place. Also, the feedback control should comprise the comparison of expected and actual internal and external conditions affecting the performance.

It has been reminded that the terms “objectives” and “measures” are sometimes used as synonyms for each other. However, an objective is actually an abstract representation of quantity while a measure can be considered as a gauge that produces results or measurement values on that quantity. (Fogelholm and Karjalainen 2001) Consistently, a performance measure can be defined as the metric used to quantify the efficiency and/or effectiveness of an action (Neely et al. 1995). This study discussed performance measurement primarily on the level of objectives and performance measurement systems. Individual measures are very context-specific issues, which means that the selection of measures cannot be accurately and thoroughly discussed at a general level.

Performance measures are indicators of the work performed and the results achieved in an activity, process, or organizational unit. The measures may be both financial and nonfinancial. (Player and Lacerda 1999, p. 258) More generally, according to Ijiri (1975, p. 40), the primary purpose of measures is to communicate the state of something else. This purpose is similar to that of, for instance, a language. Figures that are produced as an output of measurement are of no interest as such. Thus, performance measures can be perceived as surrogates – things or phenomena that are used to convey information about the state of something else – and the subjects of performance measurement can be perceived as principals – things that are primarily concerned and represented by surrogates.

The inherent surrogate character of performance measures is also founded on the difficulty to directly measure the actual phenomenon or variable that is of interest. Consider, for example, the ability of an organization to measure a very typical performance dimension such as customer satisfaction (see Thomson (1995) and Ellis and Curtis (1995) for more information regarding measuring customer satisfaction[5]). First, individual customer satisfaction cannot really be known without explicitly inquiring it. However, for an organization that serves thousands of customers, it would likely be too resource intensive to carry out such an inquiry in the first place (Thomson 1995). Second, if the inquiry could and would be done, the act of inquiry itself would likely affect the result. Third, despite the previously mentioned problems, imagine that the opinion of each customer had been asked successfully without any bias. What do the results depict? They do not actually represent customer satisfaction but they illustrate the explicit comments of the customers when their satisfaction was inquired. Fourth, if the problems with direct evaluation of customer satisfaction lead to an adoption of clearly indirect measures, such as the number of reclamations, the surrogate nature of measurement is even more evident. Therefore, the notion by Sharman (1995) on the fundamental goal of performance measurement is a very important one. According to him, performance measurement frameworks are to provide an information infrastructure to *motivate and encourage* the organization and its members to attain its goals. Although it may be very difficult to accurately measure all the variables that affect the goal attainment, a well-structured performance measurement framework can nevertheless effectively communicate the assumptions on the causes and on the inter-relations of factors affecting the organizational goals.

It seems undisputable as such that performance measures are merely surrogates of real life phenomena that lack an independent utility. However, to fully understand the surrogate nature of measurement one has to distinguish the *process of developing the measures* from the process of *using the performance measures*. Clearly, using (calculating and communicating) the measures can be perceived as a surrogate activity that has no meaning unless it contributes to some meaningful purposes. In contrast, the process of developing the measures should not be seen merely as a surrogate of something else. This process includes elements that are essential in terms of the purpose and the essence of an organization. For instance, the priorization of objectives or discussion concerning the adopted strategies and methods that are all included in the process of developing the performance measures cannot be regarded as surrogate activities.

Considering the above, many requirements can be identified for performance measures. To some extent generic requirements for measures include (Kaplan and Norton 1996; Olve et al. 1999; Malmi et al. 2002):

- When taken together, the measures should cover all the relevant aspects of business.
- The measures that represent different viewpoints or perspectives should be connected with each other.

[5] Ellis and Curtis (1995) divide customers into three subcategories: consumers/end users, distribution chain customers, and downstream internal operations within the company.

- Measures should be useful for setting goals, which are seen as realistic by those responsible for achieving them.

Importantly, the concept of performance measurement should be interpreted more widely than the concept of a performance measure. As Aaltonen et al. (1996, pp. 35-36) point out, measures comprise the visible and explicit part of a performance measurement system but the theories on the target of measurement and the theories on the measurement as such are equally important parts of a PM system. In other words, performance measures are *things* that are employed in the realization of performance measurement, but performance measurement can also take place without explicit measures. For instance, the sketching or the tentative defining of performance measures, the constructing of a PM system, or target and objective setting can be regarded as parts of performance measurement even with the absence of the very act of measurement and implemented measures.

In the context of product development, it is important to understand that there is a delay between the actual work and its outcome. Because many dimensions of product development performance are related to the outcomes, the measurement of product development performance is a longitudinal task. It is not possible to get comprehensive quantitative or even qualitative data on the performance of a product before it has been in the market, delivered through the supply chain, and used by customers for a while. On the other hand, it is possible in the product development phase to set objectives for the basis of measures and design the measures that could be applied when the data on the performance becomes available. Assuming that product development is a continuous process in an organization and that the organization consistently produces new products, the performance measurement of product development is also a continuous process: it is not possible now to quantify the performance of products being developed at the moment but it is possible to do that for the products that have been developed in the past. Thus overall, the measurement of product development performance takes place continuously with a delay that is context and industry specific.

The different practices of accounting can be seen as a supplement for performance measurement or vice versa. It is even justified to claim that performance measurement and accounting are disciplines that have much in common in terms of objectives, purposes, and even methods. The differences identified between these two are rather based on a different emphasis than on a fundamental distinction. Ijiri (1975, p. 29), for instance, refers to a definition of accounting by the AICPA Accounting Principles Board: "Accounting is a service activity. Its function is to provide quantitative information, primarily financial in nature, about economic entities that is intended to be useful in making economic decisions – in making reasoned choices among alternative courses of action."

An evaluation of the main conditions of the definition of accounting (quantitative, financial, useful in making economic decisions) reveals no significant difference between the concept of accounting and performance measurement. First, both methods are essentially quantitative in nature, relying mostly on both quantitative inputs and producing, above all, quantitative outputs. Second, although performance measurement includes also non-financial elements, the financial aspect of measurement is very clearly acknowledged as well. Finally, the primary motivation of the use of both accounting and performance measurement is based on the support they are able to provide in making good economic decisions.

Indeed, if management accounting (MA) comprises a part of accounting, performance measurement comprises a part of management accounting. Uusi-Rauva (1996) points out that many kinds of typologies can be presented to structure the field of management accounting. According to Uusi-Rauva, there are at least four distinct domains that comprise the management accounting discipline:

1. accounting for different kinds of responsibility centers (cost center, revenue center, profit center, investment center (see for example (Barfield et al. 1994))),
2. accounting for *performance measurement* and management of various activities,
3. product-specific costing,
4. various distinct financial analyses.

In this typology, performance measurement mainly belongs to the second domain. According to Uusi-Rauva, PM is characterized by the fact that not only financial measurement[6] but also non-financial indicators are accepted and utilized. Also typically, the measurement is not strictly connected to the fiscal year or its constant portions.

2.3 Product and New Product

A product is not only a physical artifact but rather also a "bundle of utilities" including the image associated with it, sales services, warranties and after sales services. In the context of product development, product could be seen as a representation of everything that the customer pays for. (Jaakkola and Tunkelo 1987, p. 11) Quite consistently, according to Ulrich and Eppinger, product is something sold by an organization to its customers (Ulrich and Eppinger 1995, p. 2). Naturally, these definitions are rather broad by their nature but they nevertheless depict the extent of challenge that is related to product management in an organization.

If product is other than only a physical artifact, product development should also include other issues than only those that relate to the physical product. The whole "package", including services and various direct and indirect issues or effects associated with the product, should be also addressed within product development. These elements that constitute a comprehensive product can be categorized as follows (Berg et al. 2001):

1. Physical product with its features and performance
2. Package including the brand, price, quality, and design
3. Product support including warranty, instructions for use, service, and maintenance

[6] The classification of financial measures has been traditionally based on three cornerstones: profitability, solvency, and liquidity (see for example Laitinen 1992).

New product is a relative concept. Some companies regard products introduced less than three years earlier as new, whereas others use a respective figure of four or five. In certain markets however, a product's newness lasts no longer than a couple of weeks (fashion clothes, for example). Among other things, at least the maturity of the technologies applied and the characteristics of markets pursued affect the definition of newness. Indeed, it can be concluded that one figure ("a product is new if it has been introduced within the last three years") is not appropriate for all situations. (Griffin and Page 1996) It goes without saying that industries are different in terms of new product introduction pace and the length of product life cycle. Hence, the definition of "new product" has to be adapted to correspond to the characteristics of the industry.

In addition, in terms of the true nature of new product, the time of introduction tells very little. The concept of *new product* is a challenging one to define succinctly and soundly at a very general level: the concept seems to be relative to the context within which it is applied. Further, depending on the degree of newness related to the product being developed, the nature of NPD might vary a lot. A classification that depicts the wide spectrum of new products is presented by, for example, (Green et al. 1995; Moorman 1995):

- An *inventive product* is created in the inception of a product category for example the computer in 1946.
- An *innovative product* is a product with a major functional change for example each generation of floppy disks: 8 inch.,51/4,3½ or compact disks.
- An *incremental product* refers to a product with some modification.

As there are many different types of new products, there are also many interpretations for the concept of success in NPD. For example, an inventive product might be regarded as successful if it ever reaches the market in the first place. That would not be, however, a very remarkable achievement if the product was merely incremental.

Despite their degree of newness, new products often include elements of innovation. The definition of innovation has sometimes been connected with the resources of an organization. It has been said that innovations reconfigure the firm's resources. Yet, it does not mean that the new product and innovations should happen "by accident" or lack a connection to the strategy of an organization. (Dougherty 1990) It has been argued that inconsistencies regarding the definitions of innovations[7] and the operationalization of the concept have essentially contributed to the lack of academic advancements concerning the R&D process of various types of innovations (Garcia and Calantone 2002). Within the academia, the different types of innovations are identified mostly on an ad hoc basis, which has caused a certain "research myopia" in this field. According to Garcia and Calantone, innovation includes not only technology and product development but also marketing, production, and product adaptation. These characteristics distinguish innovation from simple invention, which does not necessarily ever proceed into production or marketing. An innovation, according to Garcia: "differs from an invention in that it provides economic value and is diffused to other parties beyond the discoverers". (Garcia and Calantone 2002) On

[7] Innovation: the introduction of something new, a new idea, method, or device (Merriam-Webster and OnLine 2002) or new idea, method, or device; the act of creating a new product or process. The act includes invention as well as the work required to bring an idea or concept into final form (PDMA 2002).

the basis of a synthesis of innovation literature, Garcia and Calantone propose an operationalization of the concept of innovation. According to them (see also Pessemier 1966), product innovativeness has to be evaluated by utilizing two dimensions (Garcia and Calantone 2002):

1. Micro/macro level (can be interpreted as newness to firm/newness to industry)
2. Marketing/technology discontinuity.

Also, a classification by Cooper (Cooper 1997) points out that the newness of the product is a relative concept to some extent. According to Cooper product novelty can take several forms, including:

- new product for suppliers and markets,
- new product family of the company,
- new product for the company but known and old to the markets,
- improvement of an existing product,
- old product introduced to new markets,
- price discount of the product: lower cost in manufacturing and selling.

Song and Montoya-Weiss (1998) remind that at the firm level, a scarcity of resources typically exists in new product development. In these circumstances, it would be beneficial to know, for instance, whether the new product development process for really new products should be managed differently than for incremental products. Song and Montoya-Weiss argue that the degree of product innovativeness is likely to moderate the relative effect of development activities on new product performance (Song and Montoya-Weiss 1998, p. 125) As one may observe from the above notion, Song and Montoya-Weiss have relied on a dichotomous categorization of new products and their innovativeness. In doing so, they have mainly built on the Ansoff's matrix[8] of growth opportunities. Incremental products are perceived as products that are targeted to existing markets with existing technologies. In contrast, really new products are produced by growth strategies that pursue new markets with new products and technologies. The detailed definition of a really new product by Song and Montoya-Weiss includes three conditions (Song and Montoya-Weiss 1998, p. 126). A really new product is one that:

- is based on technology never employed in the industry before,
- has a significant impact on the whole industry,
- is the first of its kind and, thus, totally new to the market.

It goes without saying that really new products that fulfill these requirements are very rare. Conversely to a really new product, an incremental product does not involve new technology or is not targeted to new markets as the first of its kind. Rather, it involves "adaptation, refinement, and enhancement of existing products and/or production and delivery systems" (Song and Montoya-Weiss 1998, p. 126). Thus, even an existing product that is marketed through a new delivery system can be regarded as an incremental new product on the basis of the previous definition. In that sense, actual

[8] The matrix comprises of two dimensions: market and products/technologies. Different growth strategies are based on combinations of new or old markets and new or old products/technologies employed.

new product development would not necessarily take place in the process of introducing incremental products.

2.4 Product Development

According to Nihtilä, it is a challenge to define the concepts of product development and new product development. The development of a new product may range from minor modifications to an existing product carried out by a single individual to several years' full-time effort from hundreds of people (Nihtilä 1996). For the purposes of this study, no distinction is made between *product development* and *new product development*. Product development, either connected with the prefix new or not, aims to create products that are new to some extent. Naturally, as discussed earlier, the newness of products may vary a lot from one product to another but this is not a phenomenon that would be subjected to closer examination. The framework or blueprint for NPD performance measurement, as such, is intended to be applicable within a variety of settings. It is only the detailed realization of measurement and the individual measures that are expected to be sensitive to the environment (including the newness of products, for example).

Clark and Fujimoto place product development into the spectrum between basic research and production. According to their interpretation, product development is a part of R&D that can be distinguished from basic research (Clark and Fujimoto 1991, p. 169). It could also be said that product development is the bridge that aims to fill the gap between basic research and production. This interpretation is aptly depicted by the definition made by Ulrich and Eppinger:

> *"Product development is the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product." (Ulrich and Eppinger 1995, p. 2)*

According to Clark and Fujimoto (1991), new product development can be considered essentially a process during which the production phase and the consumption phase of the product life cycle are somehow simulated. In this respect, product development is intended to create information assets that are anticipated to represent the elements of the future consumption process. In this information creation context, according to Clark and Fujimoto, the ability of the product development team to simulate the target customers and their requirements is critical to the effectiveness of a product development effort. Clark and Fujimoto describe effective product development at a general level as follows (Clark and Fujimoto 1991, p. 25):

> *"…effective product development simulates future consumer experience accurately at a detailed level."*

Hertenstein and Platt (2000) argue that NPD overlaps partly with R&D. However, the authors remark that NPD is different from R&D as various functional departments – also other than R&D – collaborate to design and develop new products for the markets. Hence, the authors consider R&D as a functional department whereas NPD would rather be an activity or a set of activities.

It would be possible to discuss the nuances of the definition basically forever. However, it is far more important to understand the role of product development in terms of its importance for the firm’s financial success potential. Product development is an activity that largely determines the amount of costs that will be associated with a product. Traditionally, it has been claimed that up to 80 – 90 percent of the product cost are determined during product and production development (see for example Raffish 1991; Ax and Ask 1995, p. 134; Asiedu and Gu 1998; Uusi-Rauva and Paranko 1998). In addition, it is a given fact that in many industries the selling prices of the products cannot be affected by the firm. Hence, it is the success of product development that largely determines not only the product cost but also the firm profitability for the future.

Product development is an interdisciplinary activity that includes at least three major functions: marketing, design, and manufacturing (see for example Ulrich and Eppinger 1995). When analyzing the stakeholders of new product development, it is important to acknowledge the role of research and development in respect to other departments of an organization. Overall, it can be said that a research and development organization or department provides services to other parties within the same organization (Hirons et al. 1998). Overall, collaboration with both internal and external stakeholders should be considered for product development. Hence, R&D can be seen as an open system that is involved in product innovation. Consistently with this, Nixon argues that there is very little completely objective or concrete about either the inputs or the outputs associated with research and development activities. (Nixon 1998, p. 334)

A generic product development process includes five distinct (but partially overlapping) phases (see for example Nihtilä 1996): concept development, system-level design, detail design, testing and refinement, and production ramp-up. (Ulrich and Eppinger 1995) Also, it is important to recognize that product development (and its performance measurement), which can be divided into several more homogenous subsections, does not concern only a small portion of an enterprise but rather the whole organization.

From the perspective of product development management, in practice, seeking and developing successful new products might be challenging, seeing that prospects of success likely vary from phase to phase in the R&D process. The model presented in Figure 2 (Matthews 1991) can be adopted as a basis that describes the fundamental processes of research and product development. In Matthews' model, R&D is a process that consists of three main phases. It starts with technology development and ends with actual product development that results in a marketable product. Two essential dimensions are established: 1) technological uncertainty and 2) the amount of allocated resources. If the R&D process proceeds, it is assumed that the technological uncertainty will decrease – that is the prospects of new product success should be improved. Typically, as the product gets closer to the market more resources are allocated to the development project. According to Matthews, completing the whole R&D process requires answering five generic questions: 1) Is it possible, 2) is it attractive, 3) is it practical, 4) is it desirable and, finally, 5) how do we do it?

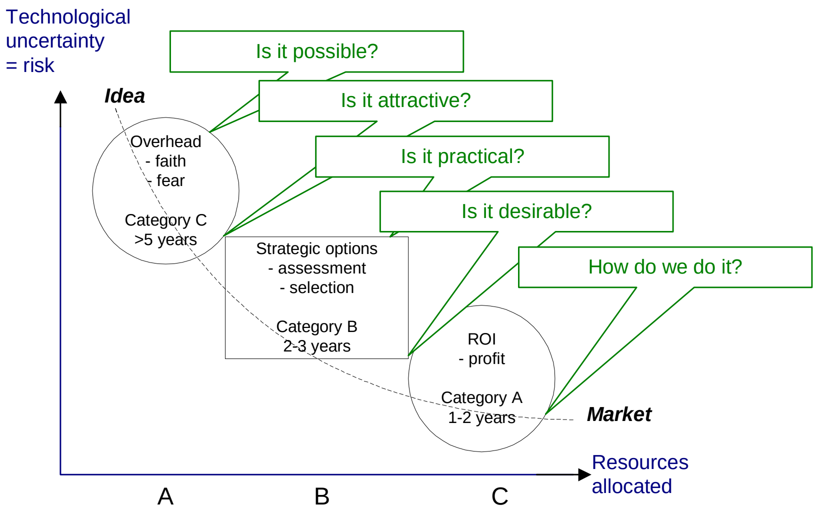


Figure 2. Matthews' model of new product development (Matthews 1991)

The challenges of R&D are likely to differ from phase to phase. Projects belonging to category C have to be managed differently than projects belonging, for instance, to category A. This is because research projects (category C) typically have somewhat different goals, objectives, and restrictions than a specific product (category A) or concept development projects (category B). Research projects may often deal with technological issues that cannot yet be attached to certain industrial and marketable products – they are mainly serving as a "breeding ground for promising tadpoles". Only time will tell whether these technologies will lead to commercial products – that is, technological uncertainty is rather high. According to Matthews, the costs of these types of projects are typically seen as "overheads", and the projects are allowed to yield results over a rather long time scale, if ever. On the other hand, the technological uncertainty of product development projects (category A) should be significantly lower, but at the same time the objectives of the projects should have more concrete goals, including the financial ones, than research projects. As Matthews puts it: "short-term development (in a typical company) is seen as investment". The most problematic area, however, is the gap between "overhead" and "investment". These category B projects may often fail to show sufficient justification for funding, since they neither represent a pure "breeding ground" anymore, nor have they yet reached the status of "investments" that could be assessed using sound financial measures. These projects can be seen as "strategic options" and the challenge is to identify the most promising and practical ones that have the potential to proceed to actual product development.

Matthews' work provides one valuable insight into the classification of new product development projects or activities, but there are other classifications and analyses that can be discussed as well. Batty, for example, has provided a traditional definition of R&D by recognizing three elements: 1) basic research, 2) applied research and 3) product development (Batty 1988). McLeod adds a fourth element – design, which starts after development (McLeod 1988). A slightly different categorization is proposed by Jackson et al. They have identified fundamental research, applied research, and developmental research (Jackson and Spurlock 1966). Furthermore, six sets of general new product development activities are presented by Song and

Montoya-Weiss (1998, p. 126). These include strategic planning, idea development and screening, business and market opportunity analysis, technical development, product testing, and product commercialization. Song and Montoya-Weiss have, however, found that while these activities describe the fundamental process of new product development, there is an essential variance across projects in terms of the details that are related to each set of activities. In this study, research is excluded from the definition of product development if it does not aim to produce commercial products. On the other hand, design is regarded not as a distinct phase of R&D but as one element of product development.

The process of research and new product development – from ideas to economic outcomes – can be depicted also as a system that consists of a number of subsystems (see Figure 3). The inputs include people, ideas, different facilities, and funds. The processing system is the research and development itself, which turns the inputs into outputs including patents, new products, new processes, facts, or new knowledge. The receiving system comprises the consumers – both internal and external – of development outputs. Outcomes are those accomplishments of research and development that have value to the organization, including issues like sales volume of new products, cost reductions, market share, or preferable customer feedback concerning the products or services. (Brown and Svenson 1998)

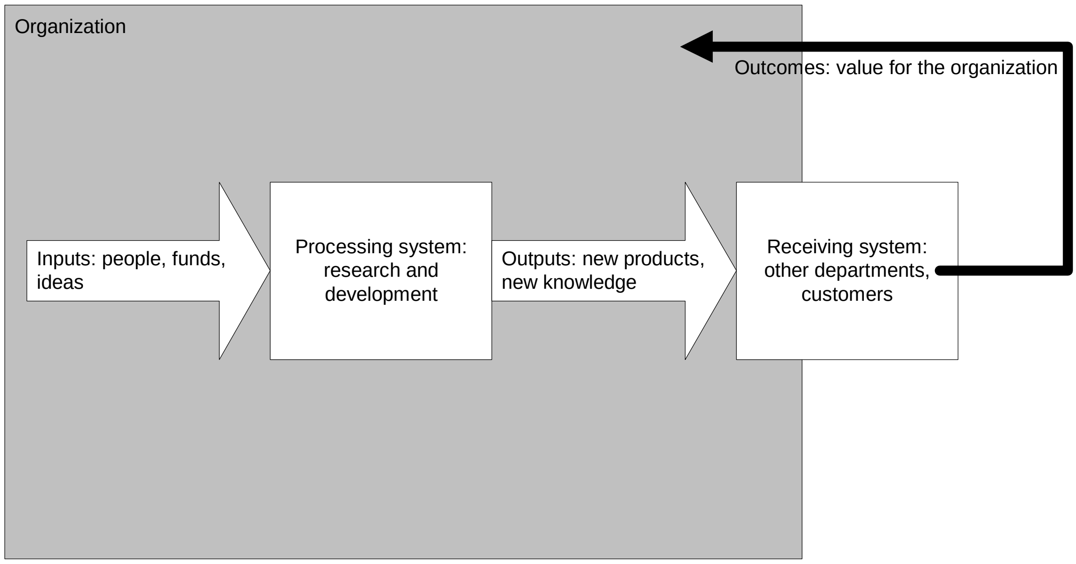


Figure 3. System view of product development (adapted from Brown and Svenson 1998)

Batson (1987) depicts research and development as an information conversion process in which the organization attempts to proceed from uncertainty regarding the technology and requirements towards certainty. For R&D, the main reason for being is to produce innovations. This process relies on three broad stages: idea formulation, problem solving, and realization. The scope of idea formulation is on technologies and concepts, and the stage is characterized by unknown odds to succeed and an uncertain perception of the actions that should be undertaken. In the problem solving phase, the focus is on specifications of design and process and during this stage the actions are already identified. The final stage, realization, is dealing with the physical realization of the product that is developed as a response to the identified needs.

The essence of effective product development process has been a popular topic in scientific literature (Repenning 2001). Ulrich and Eppinger (1995) and Cooper (1996), (1997), for instance, have paid attention to defining a rigorous NPD process. Practice has proven, however, that many organizations have found it difficult to follow the defined processes. Repenning cites felicitously one engineer, when he describes his experiences with a newly implemented development process (Repenning 2001, p. 285):

> *"The (new process) is a good one. Some day I'd like to work on a project that actually uses that."*

One reason for this is a phenomenon called fire-fighting: an unplanned allocation of resources to solve problems that occur in late stages of the development cycle (Repenning 2001). In practice, the process of innovation is often iterative. The iterative nature of innovation and product development means not only that certain problems have to be solved again and again but also that the emphasis of product development is dependable on the stage of the product's life cycle. During its life cycle, a product is likely to be subject to many types of innovations. In other words, innovations do not take place only in the product development phase. For instance at the beginning of the life cycle, the initial emphasis of the development may be on the product's general performance. Later, the main focus may be shifted to standardization or cost efficiency[9]. The iterative nature of innovation results in a variety of different innovation types. The term "radical innovation" is typically associated with products at the early stages of their life cycle. In contrast, the term "incremental innovation" typically refers to a product that represents a more advanced stage of the life cycle (Garcia and Calantone 2002). Although the border between incremental and innovative product development is not easy to draw, it can be said that the majority of industrial R&D investments are targeted to incremental product development activities. In terms of total money invested in product development, truly new products and new businesses are less emphasized (Jaakkola and Tunkelo 1987). Therefore in the R&D spectrum, the domain of incremental product development is at least financially a most important unit of analysis and an essential part of R&D.

Finally, regarding the definition of product development, the fundamental role of new product development may vary a lot from firm to firm. For instance, by constructing a hierarchical cluster analysis, Firth and Narayanan have presented a typology that outlines five archetypes of new product development strategies (Firth and Narayanan 1996, p. 342):

- Innovators: This cluster consists of firms that rely on new product strategies characterized by a relatively high level of innovativeness with respect to the marketplace. Furthermore, these firms are primarily building on their existing technological cores. Hence, the product development of these organizations is mainly carried out by using the existing resources.

[9] The logic of varying the type of innovation on the basis of the life cycle phase has been identified also at the level of industries. Filson and Narayanan (2002) note, regarding the life cycle of automobile industry, that: "The rate of quality improvement is highest early on, the rate of cost improvement is higher later on and firms obtain lower variable costs and higher fixed costs over time."

- Investors in technology: The firms in this cluster seek to extend their technological base. In other words, they tend to embed relatively new technologies into their new products resulting in products that can be considered moderately innovative in the marketplace. Quite often, according to Firth and Narayanan, the extension of the knowledge base for these firms is based on external acquisitions.
- Searching for new markets: The new product strategies of the firms in this cluster tend to focus on searching for new market applications. In terms of market innovativeness, the products seem not to represent the very cutting edge or state of the art. Altogether, product development is typically directed toward more unfamiliar markets by introducing products that are relatively close to existing products.
- Business as usual: The new product strategies are characterized by reliance on existing technologies and markets. New products are often quite closely aligned with the present product portfolio. Hence, the products are not considered as very innovative in the market.
- Middle-of-the-road: The new product strategies of the companies in this cluster relate to product introductions that are characterized by low or moderate newness of embodied technology and market application. Also in terms of market innovativeness, these firms do not represent the cutting edge. Altogether, relative to other firms, these organizations do not show any particular focus with their new product strategies.

2.5 Life Cycle

Life cycle orientation is to some extent a built-in characteristic of product development. However, to be able to fully understand the potential of the concept of life cycle for NPD management and measurement, different interpretations and perspectives of life cycle have to be discussed.

Dalén and Bolmsjö (1996), for example, point out that different components of a production system may have different life cycles. As a result, the estimation of life cycle costs of a product requires that a number of different life cycles can be identified. For instance, the employment cycle varies between employees and different machines differ in respect to the length of their life cycles. Also, the components of a product may have different life cycles from the product itself.

According to one definition, product life cycle is the period that starts with the initial product specification and ends with the withdrawal of the product from the marketplace. The life cycle is also characterized by a number of stages including research, development, introduction, maturity, decline, and abandonment. (Player and Lacerda 1999, p. 258) For the purposes of this study, this definition is, however, rather limited as it predominantly reflects the viewpoint of the producer. Seen from the perspectives of user, customer or society, it is hardly relevant to associate the withdrawal and end of life with each other. Especially regarding industrial goods with long life cycles, it is very likely that a product may continue its life even after the actual withdrawal.

The history of the concept of product life cycle dates back to the 1950's. However, the 1960's and 1970's witnessed the most impressive contributions regarding the definition and the utilization of the concept (Mercer 1993). Perhaps the best-known critical review of the concept was published in 1976 (Dhalla and Yuspeh 1976). Despite the general criticism targeted to the concept of PLC (see for example Grantham 1997), inclusion of the concept of product life cycle provides additional dimensions for NPD performance measurement. According to Bauer and Fischer (2000, p. 704):

> *"Product life cycle theory, although suffering from a lack of generalization, is still an enduring framework in business. If this instrument is applied correctly and adapted to the specific empirical data set, it offers a large potential for analyzing the long-term economic performance of R&D activities."*

It is suggested that the PLC concept, which was originally discussed in marketing theory and later utilized in analyzing and managing the environmental impacts of products, can also be useful in product development management and measurement. A part of this usefulness relates to the recognition of potential differences in product requirements that arise from different phases of PLC. From the NPD point of view this could be interpreted as indicating that the development work should rather focus on *new product life cycles* than on new products as such (Asiedu and Gu 1998; Grossman 2002).

A very important notice regards the dynamics of product life cycle. The traditional marketing view seems to imply that the PLC of a product is somehow a given period of time. However, this is often not the case. Grantham (1997) points out that if PLC is considered as given, it may result in self-fulfilling prophecy (that may also lead to overemphasis on new product development (Massey 1999)). Therefore, product life cycle should not be considered as a passive phenomenon; rather, the PLC of virtually any product can be managed and affected. Also as suggested by Rink et al., it is worth acknowledging that PLC does not just happen with the passage of time; rather it is the result of the interaction between several companies' internal and external variables (Rink et al. 1999). As an example of an internal variable, Stadler (1991) addresses the issue of R&D dynamics in the product life cycle. He argues that it is possible to identify a generic pattern of R&D expenditure variations during the product life cycle for a successful entrepreneur (Stadler 1991). Regarding the total effects of product development, it is important to recognize that products are developed not for a single moment of time but rather for a – shorter or longer – period, depending upon the specific industry and the type of product.

Marketing theory typically considers the life cycle curve that describes sales volume between product introduction and decline (see for example Rink et al. 1999) or (Magnan et al. 1999): the product life cycle depicts the sales of either product class, product form, or brand over its life. Environmental life cycle models have discussed phases that occur before, after, and during the period over which a customer applies the product (see for example Kane et al. 2000; Price and Coy 2001). In R&D environment, a practical aim would be to identify the type of life cycle (including characteristic phases and corresponding product requirements) that is relevant in that particular environment. Several at least partly overlapping types of life cycles can be discussed that are associated with a new product or a product in general: first, there is product life cycle as seen and experienced by the customer; second, one can discuss product life cycle as perceived by the producer; third, life cycles of materials and components associated with the product can be analyzed separately. Further, each type of life cycle may consist of discrete phases that implicate different requirements for the product.

According to Dalén and Bolmsjö (1996), four phases comprise the life cycle for a production system. The first is called the concept and definition phase, the second is the acquisition phase, the third is labeled as the operation phase, and the fourth is the disposal phase. The end of the life cycle is defined as the moment of time when the costs of repair and maintenance increase to a level that is no longer profitable. Hence, by interpreting the view of Dalén and Bolmsjö (1996), one could conclude that life cycle is defined as some kind of an "era of profitability". This seems to be consistent with the statement by Ryan and Riggs (1996) that a product should be marketed as long as it provides a return that minimizes opportunity costs. For a more comprehensive discussion concerning product deletion, see for example Harness (1998).

In the case of investment goods, the customer often utilizes the product for several years, which represents a substantial life cycle. Further, the period of interaction between the product and the customer can be divided into different phases that involve various requirements for the product. From the customer point of view, a product is tested for the first time when the customer is implementing it. General requirements associated with this might be, for instance, easiness of implementation, good instructions, or a logical interface. Another test – possibly the longest and the most significant one – is the phase of active use. General requirements associated with this phase include low maintenance and operations cost, product quality, and well-functioning customer support for the product. The final test might be the disposal of the product. During the last phase, quite different requirements, such as recyclability, may arise.

Product life cycle as seen by the producer is typically structured according to the development of sales. The generic PLC model implies the following successive life cycle phases: development, introduction, growth, maturity, and decline (Prasad 1997; Magnan et al. 1999; Massey 1999). Rink et al. (1999) depict product life cycle as a generalized model that describes the sales trend of a *narrowly defined* product from its market introduction to its removal. Furthermore, according to Rink et al, most products follow some kind of a life cycle curve. It is noted, however, that in some cases the seasonal patterns may override the PLC behavior of a product, resulting in a sales pattern that is different from the bell-shaped or S-curve presented in marketing textbooks. Overall, the requirements that arise from different life cycle phases may differ from each other. For instance in the introduction phase, it may be very important for the product to be able to awaken the interest of potential buyers by providing for example convincing technical specifications or industrial design. In the growth stage, the consistency between the product and the supply chain may be one of the most crucial issues, which would ensure a steady supply to the markets.

As one may conclude from the previous definitions, at the general level, the concept seems to be reasonably understandable and logically coherent. The concept of life cycle covers the various stages of the life of an entity representing its entire existence both as a whole (assembled, constructed) entity or as divided into parts that either will constitute or have constituted the very entity. However, depending on the perspective, PLC receives a number of meanings that differ from each other. Consistently, Prasad (1997), EPA (1993) and Mercer (1993) point out that the literature uses the term of life cycle rather loosely. One has to distinguish at least three different dimensions to look at the life cycle of a product:

1) Product life cycle from the developer point of view
   a) Level of individual product item: Provides a framework for the period and phases during which an individual product will be visible to its producer or developer. This view of PLC may imply life cycle phases such as development, production, sales, delivery, after sales (consisting of maintenance and spare part sales), disposal, or secondary use. *For example, a cruise ship produced by a shipyard would be a fruitful subject to a life cycle analysis at this level. The ship is first designed as a response to individual customer needs and on the basis of an established concept of such a ship. After the ship is finished and delivered, the possible after sales business associated with the particular ship may constitute an additional phase to the life cycle. In addition, after the primary customer, the ship may be sold to a secondary owner.*
   b) Level of one product design: This is a typical aggregate marketing view that implies life cycle phases such as development, growth, maturity, and decline. The main focus of assessment may be on selling volume or cumulative profit impact. Depending on the purpose of the life cycle assessment, this view may also include life cycle phases analogous to 1a. *For example, a certain cruise ship architecture representing a particular cruise ship concept would be a suitable unit of analysis in this respect. After its introduction, a particular architecture will live through an era during which it is capable of providing a competitive platform for individual customizations of marketable individual products. But gradually, due to, for instance, changing customer needs, increased competition, or renewed legislation the basic concept or architecture has to be changed.*
2) Product life cycle from the user point of view
   a) Level of individual product item: An individual product would be the most likely basis for a user or for a customer to explore the life cycle of the product. This type of life cycle begins with the purchasing phase, after which the customer experiences some kind of a delivery and implementation phase. A learning process that is associated with an unfamiliar product may well constitute a phase of its own, after which the customer/user is likely to face a more stable stage of the life cycle, when the product is being utilized according to its primary purpose. This mature phase may be followed by a phase that is characterized by an increased need for maintenance and renovation, and finally, the life of the product will end in a disposal of some kind. *Basically any consumer product will follow an analogous life cycle, consider, for example, a pair of shoes or a car from the consumer point of view. Further, industrial products, such as paper machines or harvesters, would not make an exception.*
   b) Level of one product design: The phases of the life cycle are quite similar to those assessed from the producer perspective. However, in this case, the life cycle normally begins with the product introduction, not with the design or

development. Also, the user is not likely to emphasize the aggregate measures of life cycle such as the selling volume within a market. From the user point of view, the relative length of the individual product life cycle in respect to that of product design is far more interesting than the sales curve the product draws. *Consider, for example, a set of china. The life cycle of individual item, as you know, may be rather unpredictable. An accidental dropping of a plate or bowl from a table may end the life of a product item. On the other hand, it may well be that the complete set of china survives a couple of generations in the family. Given the fragility of the product item, it is obvious that a long life cycle of the product design is perceived as valuable.*

3) Product life cycle from the environment/society point of view. This view covers the aspects that are related to the environmental and social impacts of a product. Also within this dimension, it would be appropriate to distinguish the levels of individual product and the product design. *For instance, tobacco would be a beneficial example for a subject of environmental life cycle analysis. From the growing of tobacco plants to the increased risk for lung cancer (concerning both smokers and non-smokers), and further including harvesting the leafs, production and supply of the end product, the life cycle of tobacco covers a wide spectrum of issues both in terms of the time frame and the domains of effects related to the product.*

2.6 Brief Synthesis of Core Concepts

Within the context of this study, *new product development performance measurement* is interpreted as the setting and articulating of the objectives for product development, the measurement of the outcomes of NPD, and the measurement of the variables associated with those outcomes that are present in a particular organizational environment. *Product development* (with or without the prefix new) is regarded as an activity that aims to develop and introduce products to the marketplace. *Products* – physical products and various services adjacent to them – represent the core outcomes of NPD through which a certain level of performance or certain objectives can be achieved. *Performance measurement* is interpreted here as the design of measurement frameworks and ideas as well as the construction of individual measures employed for these purposes.

No categorical distinction has been made between incremental or innovative products in terms of measuring the performance of their development. Inevitably, a developing company would be more familiar with the incremental products, which would enable better-grounded analyses regarding, for example, the requirements and life cycle of these products. However, the overall blueprint for measuring NPD performance is supposed to be applicable across a variety of settings.

Life cycle, or more specifically *product life cycle,* provides NPD performance measurement with a temporal frame that can be used for identifying and analyzing the requirements and goals that are associated with the developed products. The holistic view of product life cycle adopted for this study consists of the perspectives of producer/developer, customer/user, and society. Further, product life cycle can be identified – at least – on the levels of product class, product form, brand, design, and individual product item.

3 Methodology

Perhaps the most obvious lesson I have learned during my post-graduate studies is that one who pursues new scientific information or knowledge – say a researcher – may and *ought to* choose between a number of alternative scientific methods. In fact, most of the discussion that I have experienced, for instance, in TUT post-graduate courses have not concerned substances, nor research process in practice, but scientific methods. It seems to be generally accepted that *science is progress*[10] and creditable progress cannot happen without a scientific method. Indeed, Huotari (2002) remarks that while there are several alternative methods to choose from, it is not regarded as an alternative not to choose a method at all. In practice, when choosing a method, a young researcher such as myself tends to look at the literature – that is method guides – on scientific methods. Huotari (2002) remarks that the method guides can be seen as messages from those that have once or twice experienced the road to knowledge and then decided to leave signs for successors to assist their journey; however, according to Huotari, one should ask whether there is a definitive road to knowledge at all. It could be possible the road only leads to the point where the previous researcher has drifted to. This researcher could have concluded that this is the final destination and left signs for successors in order to make sure that they would confirm this conclusion by their arrival at the same destination. (Huotari 2002, p. 2) It is not the purpose of this study to go any deeper into these challenges with the scientific method; however, the intention is to address the necessary methodological issues associated with this study by critically looking at the methods of business economics (by reviewing a number of method guides) for positioning this study as properly as possible.

3.1 Research Methods

3.1.1 Choosing a research method

The selection of methods and criteria for evaluating the quality of a piece of research, such as this, could be founded on the ideals and norms of the particular scientific discipline. In the case of this study, the discipline to look at would primarily be management accounting. Interestingly however, the ideals of this discipline seem to be fairly ambiguous. The ambiguousness becomes apparent, for instance, when analyzing the debate initiated by the literature review by Ittner and Larcker (2001). Ittner and Larcker reviewed empirical research in management accounting. They applied the value-based management (VBM) approach to structure the body of literature in this field. The VBM framework emphasizes shareholder value as a primary objective of an organization, and the process of attaining this objective consists of six broad phases: choosing the internal organizational objectives that lead to better shareholder value, selecting the strategies and organizational designs that are aligned with the objectives, identifying the value drivers that create value within a particular organizational context, developing action plans and selecting the appropriate performance measures, evaluating the success of the action plans and measuring the organizational performance, and finally, assessing the validity of the organizational regime built in the previous phases (and possibly revising it if

[10] A phrase by Coldplay in *The Scientist (2002).*

necessary). It can be argued that contingency theories behind management accounting advocate both the decision-making process and the development of performance measures that drive the employees' behavior and actions towards a desired mode. In line with this, the fourth phase of value-based management emphasizes the development of action plans on the basis of value driver analysis. Yet, it has been claimed that the choice of specific action plans has received virtually no attention in the management accounting literature (Ittner and Larcker 2001, p. 376).

Inspired by the Ittner and Larcker's review, Zimmerman (2001) criticizes the state of management accounting research. According to him, the management accounting literature has not matured enough. It has not proceeded beyond describing practice to developing and testing theories explaining the observed practice. In this spirit, Zimmerman proposes a number of conjectures regarding the present state of empirical management accounting research and proceeds to advocate, among other things, something of a monolithic utilization of economics-based frameworks and additional emphasis on the control aspect (contrary to decision-making) in management accounting research.

However, the contributions of Ittner and Larcker (2001) and Zimmerman (2001) together triggered a rather vivid discussion on the nature, achievements, and ideals of management accounting research. Hopwood (2002) has found weaknesses from both papers. First, according to him, the approach of Ittner and Larcker that relies on the VBM framework suffers from the very same "faddish" character that was referred to in IL's paper as a shortcoming in management accounting research. On the other hand, Hopwood criticizes the stance of Zimmerman paper, which relies strongly on a positivistic approach and stresses the emphasis on economics-based theories. Hopwood points out that the kind of *monolithic approach* Zimmerman proposes is likely to harmfully increase the conformity of research in the field, leading to a situation where new papers only produce minimal additions to the present body of knowledge. Hopwood also cites Dye (2001), who observed unfortunate phenomena in the management accounting "mainstream" research:

> *"First, much of the literature has become computational rather than conceptual. That is, rather than articulating some new idea, much of the research has pursued the detailed working out of some known concept. (Dye 2001, pp. 230-231)"*

Well in line with this, Salmi and Järvenpää state that the fundamental objective of business economics is to understand business and the logic or relations that underlie companies and their interrelations. *In addition*, the objective is to construct concepts and tools that are to be used in business management. (Salmi and Järvenpää 2000, p. 265) Ittner and Larcker (2002), for one, underscore the importance of describing practices. They remark that to be able to build knowledge within an applied discipline such as management accounting, it is imperative to carry out detailed examinations on actual practices. They stress that:

> *"A primary goal of managerial accounting research should be determining which (and under what circumstances) existing or emerging managerial accounting techniques actually work in practice."*

Further, the authors question Zimmerman's notion that the research on management accounting does not test theories and hypotheses derived from theoretical models. The same notion is reinforced by the argumentation by Luft and Shields (2002). They stress that it is possible to argue that the theories tested might be sometimes inappropriate or incomplete but it is contentious to argue that theories and theory testing do not exist. Luft and Shields also point out that, contrary to Zimmerman's conjecture, management accounting research indeed clearly emphasizes control in addition to decision-making. Furthermore, Lukka and Mouritsen (2002) add to the discussion that whilst a monolithic paradigm (like that based on economics as proposed by Zimmerman) may increase efficiency within a scientific discipline, it also restricts the window *"to the world and creates areas of 'non-discussables'."* Above all, contrary to the stance of Zimmerman, Lukka and Mouritsen advocate and invite heterogeneity in management accounting research.

The above discussion seems to point out that neither the concept of the true character and the state of the art of management accounting nor its identified ideals are shared with the researchers even within the discipline. In spite of this, it would not be justified to claim that the field is in an actual state of dissolution. Rather, it could be interpreted that the criteria for "good" or "acceptable" research depend on the specific regime within the discipline. In other words, a number of competing regimes can be identified within the discipline. It seems to be possible for a researcher to choose between alternative regimes within which the quality of the study will be evaluated. Accordingly, the following section includes the explicit selection of and discussion on the regimes (methods, research approaches, or design) that are applicable regarding this study.

3.1.2 Models and empirical science

Empirical management accounting research virtually always includes some kinds of models. These models may be either completely explicit or sometimes partially implicit. Nevertheless, models are important tools for grasping the reality being studied. Models can provide an important medium for systematizing or organizing empirical reality or they may be useful for structuring an ideal state of affairs. Accordingly, two main types of models can be identified: *Normative models* represent real-world phenomena, as they ought to exist if certain goals are to be achieved. In contrast, *descriptive models* represent real-world phenomena, as they exist (Ijiri 1975, p. 5).

> *"The distinction between descriptive models and normative models may not be clear-cut in every empirical situation. A descriptive model cannot represent all existing accounting phenomena; hence, there are likely to be some empirical observations which may contradict the model that is in a sense a "purified" version of the empirical system. Only a very few descriptive models in empirical science are perfectly descriptive. On the other hand, a normative model can be a representation of some empirical phenomena, if the idea formulated in the model has already been applied in practice. Therefore, a normative model need not be counter-empirical. In fact, a descriptive model and a normative model may coincide if the existing system is considered to be optimum.*

Nevertheless, the distinction between the two is important in terms of selecting methods of defence. A defence of a descriptive model consists of showing that the model essentially represents what it is supposed to represent. A normative model, by contrast, is developed deductively and may not have any counterpart in the empirical world. Thus, its defence is primarily concerned with demonstrating that the consequences of using the model will lead to a better state, judged from the set of goals given in the model. (Ijiri 1975, pp. 6-7)"

According to Ijiri, the intention of empirical science is not limited to passively observing the behavior of the empirical system – in other words the behavior of the real world. The scientists also attempt to control the systems of the real world so that their behavior would be more beneficial to human beings. Normative models are developed to improve the empirical system closer to the norms or goals that the scientist has perceived. However, normative models are not similar to policies. While normative models have policy implications, they do not involve a commitment to goals, nor are they based on value judgments or opinions (Ijiri 1975, pp. 6, 9-10).

In this study, both model concepts are employed. Product life cycle modeling in case companies represents descriptive modeling. On the other hand, the main concept of the study, life cycle -conscious NPD performance measurement, mostly represents normative thinking. It is suggested that taking into account the life cycle of a product when evaluating the performance of product development would improve the practices of performance measurement and management in the product development context.

3.1.3 Available methods and paradigms

Scientific research in the field of industrial management belongs to applied sciences (Olkkonen 1994). Within applied sciences, the practical relevancy of the research topic is emphasized more than the research method used. Since the applied sciences mostly focus on solving problems practical to managers, it might be a challenge to consider the acceptance criteria of scientific results (Näsi, 1980b, p. 14) that, on the other hand, are strongly connected to the prevailing scientific paradigm. According to Näsi, scientists have traditionally been interested in the ultimate truth, while in the applied sciences the objectives are completely different. According to him, the results of applied studies are evaluated more, for example, on the basis of applicability, usefulness, feasibility, or functionality. One additional problem is that the usability of results in applied sciences should be explained already in advance (Näsi, 1980b, p. 19), which naturally is not easy.

The results of the studies in applied sciences are typically different types of recommendations or norms. Sometimes however, especially in the case of basic research, it is argued that science and scientific research is independent of values; in other words, scientific work is perceived as value-free activity. This perception is, however, problematic: If the "free of value" –requirement was taken literally, applied sciences would not exist at all (Näsi, 1980b, p. 27). Virkkunen (1961, p. 22) has suggested an interesting solution to the problem. According to him, the responsibility of applied sciences is to search for the best ways to reach the desired goals of the enterprise. The company management or other stakeholders have set these real-life goals, and the scientist does not need to have any kind of opinion about the values related to these objectives. When the goals and policies of the company have been established, it is possible to search for the best ways to achieve them using scientific methods. Also Näsi (1980, p. 39) admits that despite the problematics related to values in applied sciences, science in general should still be used for the advancing of businesses. Olkkonen (1994) states that applied research is virtually always connected with a number of values, including broad issues such as efficiency, effectiveness, sustainability, or equality. These universal values may be so inherent within a scientific discipline (they may have become generally accepted "truths") that the researcher has difficulties to distinguish between the "truths" and the actual value selections associated with a particular piece of research. Despite this difficulty, it cannot be convincingly argued that applied research is totally value-free. It is already the selection of the research topic that represents a value selection of some kind. In fact, Kettunen (1974) points out that especially in management sciences objectives and values cannot be left unstudied because values, objectives, and means often become so merged that they are difficult – if not impossible – to distinguish from each other. Furthermore, Arnaud remarks that in the constructivist paradigm, ontological reality is virtually unthinkable: the observer or researcher, as a conscious subject, has access only to representations of reality expressing his or her experience of the world. In other words, everything is a construction of the mind. In this context, it is important to understand that researchers' theoretical background and socio-cultural references influence both the observations and different decisions made during the research process. (Arnaud 2002)

Hermeneutic research (see for example Olkkonen 1994, pp. 26-34) is often perceived as opposite to positivistic research. Whereas positivistic research builds on objective truths that are definitely known and can be observed and rejects issues that are based on personal or subjective interpretations, perceptions, or assumptions, hermeneutic research is all about interpretation and search of meaning. The formula of hermeneutic research can be summarized as follows (Olkkonen 1994, pp. 33-34): First, describe the issue or the phenomenon of interest as accurately and profoundly as possible. The description is made on the basis of some examples or cases that represent the evolution of the issues, its causes, and the circumstances associated with the issue. Second, on the basis of the researcher's understanding, find possible explanations for the described phenomenon or issue within the selected cases and within the scope of the study. Third, look at the present theory to find support or counter-views for the presented explanations. Fourth, develop a theory, model, or construction that serves as an answer to the research question or as an explanation for the issue of interest. Fifth, evaluate the results obtained in the fourth phase in terms of reliability and generalizability.

Although it is possible to distinguish between hermeneutic and positivistic research, some research methods, such as constructive research (Kasanen et al. 1991; Kasanen and Lukka 1993; Lukka 2000) and conceptual research (Näsi 1980; Näsi 1983; Uusitalo 1995), which are applied within the business economics discipline combine the positivistic and hermeneutic approach (good examples of this include Lahikainen et al. 2003; Lyly-Yrjänäinen 2003). Furthermore, as Olkkonen (1994) points out, it is inherent in industrial engineering and management (IEM) research that various approaches, methods, and explanation strategies are applied simultaneously. This is because IEM research has traditionally been substance and relevance based rather that method-based (Olkkonen 1994, p. 59).

According to Olkkonen (1994, p. 59), several different types of research methods can be used in business economics, depending on the problem at hand, the quality and amount of information at the starting point, the availability of information in general, and the desired results. Thus, there are several research methods, all of which have ideal application situations of their own. Neilimo and Näsi (1980, p. 67) have presented one of the most famous classifications of research methods in Finland (see for example Olkkonen 1994, p. 60). Neilimo and Näsi identified four different research approaches: nomothetical, decision oriented, action oriented, and conceptual. Kasanen et al. (1991) have later classified the four methodologies according to whether they are theoretical or empirical on one hand and descriptive or normative on the other. They have also added the constructive research approach to the classification. The positions of the five research approaches based on the classification are illustrated in Figure 4.

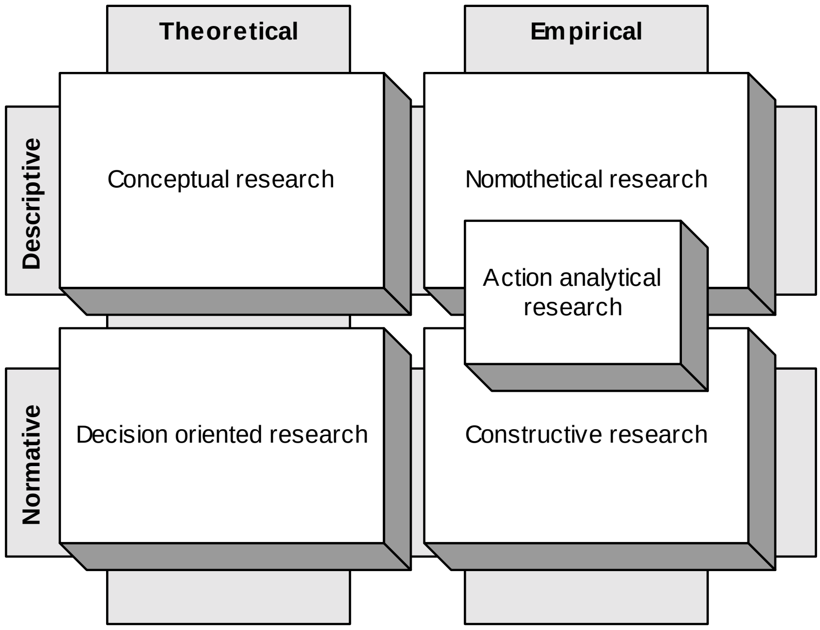


Figure 4. Typology of typical research approaches in management accounting (Kasanen et al. 1991)

Conceptual research aims at the creation of new concepts or entire concept systems, or simply seeks to analyze and organize the existing ones (Näsi, 1980a, pp. 9-11). In their classification, Kasanen et al. describe this form of research as theoretical and descriptive even though some empirical data could be included in the analysis and some normative recommendations could be made as well. Conceptual research becomes normative if the recommendations regarding how different types of concepts should be used form the key issue of the study. Furthermore, Näsi (1983, p. 38) has also discussed whether conceptual research should be a separate method at all because the analysis of the concepts used, that is the frame of reference, plays a significant role in all the other research methods as well. According to Näsi, this research approach has its roots in philosophy, and therefore it is at a higher level compared to the other approaches shown in Figure 4. On the other hand, it is very difficult to determine at which level a research approach generally lies, because the research approaches can be applied very differently depending on the researcher and on the problem at hand.

Decision-oriented research is mainly used for developing different types of mathematical models that can be of assistance in decision-making, and the approach is highly theoretical. The models are deduced logically from the existing theory even though they can also be tested in real-life situations. (Olkkonen 1994, p. 70) The research method seems to be quite close to the ”theory and application” approach, which seems to be very popular, for example, among published journal articles (see for example Bjørnenak and Mitchell 2002). An interesting question, however, is where the boundary between conceptual and decision-oriented research lies. If a decision-oriented study results in a theoretical model that has not been seriously tested in practice, how is it different from conceptual research? Normativity is hardly the only explaining factor because of the partly normative nature of the conceptual research stated above. Thus, one might be justified in considering the mathematical nature and the ideals of planning sciences as the most significant differences between decision-oriented and conceptual research. (Lyly-Yrjänäinen 2003) Further, the results of decision-oriented studies are typically more specific in terms of the application area than the results produced by conceptual studies.

Besides the decision-oriented research approach, another method with positivistic roots is nomothetical research (Näsi, 1983, p. 40), which in practice often means survey studies. Such studies aim at identifying statistical causalities from the research data and explaining the reasons for the causalities found. These studies are descriptive and empirical data is given by means of extensive samples, which – on the other hand – may lack depth. The hypotheses to be tested should be deduced from the existing theory and the role of the theory is also critical when constructing the questionnaire. Unless the researcher is able to ask the right questions, the sample data is useless from the research point of view. It is important to understand that surveys are not actually able to provide data on real-life “things” but rather they provide data on perceptions regarding those “things”. Overall, conceptual research forms a critical part of nomothetical research, especially when constructing the questionnaire and forming the hypotheses that are to be tested.

Action-analytical research has been clearly placed on the empirical side, but the descriptive-normative dimension for the research approach is much more complicated. The research approach has its roots in hermeneutics and the objective is to understand the phenomenon studied on one hand and to give some recommendations on the other. However, Näsi (1983, p. 41) sees action-analytical research as a higher-level concept, which includes various different types of research approaches, such as action research, clinical method, comparative analysis, and historical research. Typical of the action-analytical research is the strong interaction between the researcher and the research subject and the interpretations based on the understanding of the researcher. The strong interaction means that there is a vast mutual difference in the nature of data collected by action-analytical and nomothetical research. In action-analytical research, the researcher has the possibility to directly observe real-life phenomena and, in addition to others' perceptions, also collect first-hand information about the subject.

Especially the characteristics of action research and action-analytical research are easily confused, and sometimes they are even used as synonyms. Without going much further, it seems reasonable to argue that action research is one of the means to practice action-analytical research. In action research the researcher becomes a part of the organization that is the research subject (see for example Eskola and Suoranta 2001, p. 127), and sometimes the researcher is even referred to as an active change agent. Action-analytical research, as such, does not necessarily *require* an active role for the researcher. According to Kaplan (1998), action research engages the researcher in an explicit program to develop new solutions that alter the existing practice and then test the feasibility and properties of the innovation. Kaplan himself introduces a slight variation of action research, which he names innovation action research. The idea of the method is to document a major limitation in contemporary practice, identify a new concept to overcome the limitation, and continue to apply and improve the concept through publication, teaching, and active intervention in companies (Kaplan 1998). The phasing of the innovative action research presented by Kaplan does not highlight the creation of a new construction, but rather the identification of already existing ones used in some organizations, their further development, implementation in new environments, and learning from the implementation efforts (Balanced Scorecard and Activity-based costing are good examples of this procedure).

The line between the constructive research approach and action-analytical research is to some extent ambiguous (see Lyly-Yrjänäinen 2003). The constructive research approach emphasizes the creation of some kind of construction, such as a new costing method, for example, in the organization that is the research subject. However, a most significant difference between action-analytical research and constructive research is that in the former the researcher takes part in the organizational development or creation of a construction and the greatest interest is in the analysis of the development process itself. In constructive research, the researcher, in particular, creates the construction that meets the needs of the case company – sometimes using the assistance of the case company employees. Further, the idea of the market test in constructive research, which implicates that the solution would ideally have some "markets", distinguishes these two approaches from each other.

Further, it should be noted that also the line between constructive and conceptual research – the opposite corners of the classification – might be sometimes unclear. It is possible that conceptual research produces conceptual frameworks or systems that are rather analogous to constructs developed with constructive research. The similarity of these two approaches is even more highlighted by the fact that it is not only constructive research but also conceptual research that may be engaged in empirical evidence. Hence, it is perhaps only the market test requirement of constructive research and the commitment of the researcher to the subject organization that makes somekind of a clear difference between these two approaches. Besides the market test requirement, it can be argued that all conceptual research is more or less constructive, but that not necessarily all constructive research is conceptual.

Tamminen in (Manninen 1997) has proposed a research approach that is rather similar to constructive research called “development research” (*kehittämistutkimus* in Finnish). The basic idea of development research is that it is (also scientifically) enough if one is able to construct a “best possible” solution to a problem or to an issue perceived in one case (company). According to Tamminen, it is just the concept of “best possible” that gives the scientific justification to development research. Thus, in contrast with constructive research, development research does not seek to generalize or to generate solutions that are directly generalizable but seeks to develop solutions for distinct observed problems. The advocates of development research argue that this research approach is able to indirectly produce ingredients for generalizations by providing the scientific community with interesting and relevant research topics for further studies. However, despite their differences, constructive and development research share one fundamental objective: they are both intended to find innovative new solutions for practical problems.

The classification presented in Figure 4 gives some guidelines for understanding the major differences between the research methods, but it no longer is completely unambiguous. First, is it possible to make the classification so rigorous, since individual studies typically embody characteristics of several different research methods (see for example Neilimo and Näsi 1980, p. 8; Olkkonen 1994, p. 62)? As already mentioned, conceptual research is present in practically all research methods. Second, because theory is needed in every research method, it could be better to classify the research methods based on whether they are empirical or not. Then again, all approaches may greatly benefit from empirical data. Third, the descriptive-normative relationship is also somewhat problematic. Conceptual research and nomothetical research can sometimes be at least partly normative, if the particular findings made in the studies facilitate the establishment of norms. Overall, the definitions of the research methods have been left loose enough to allow many of the research approaches to be placed on either side. (Lyly-Yrjänäinen 2003) Indeed, to provide the methodological discussion with some sparks, it is proposed that the five typical research approaches can be structured also quite differently (Figure 5).

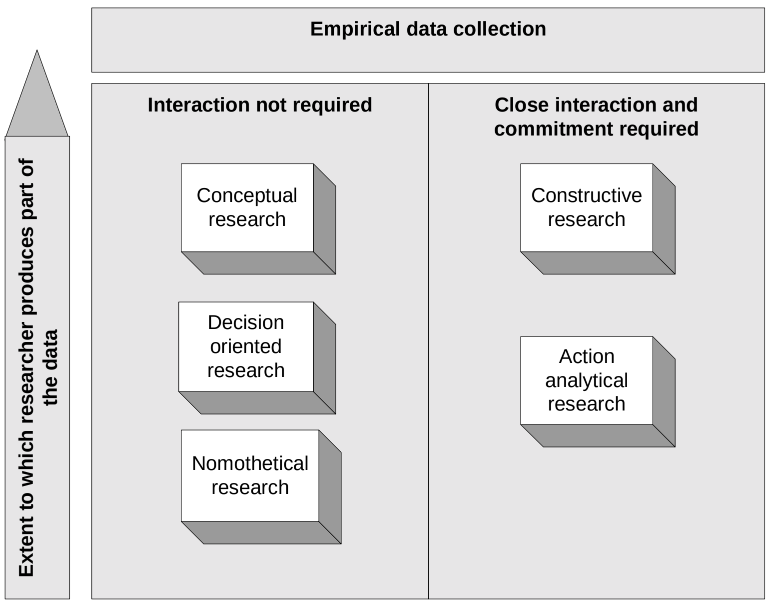


Figure 5. Traditional classification revisited

Since the empirical data can be important in all approaches, the nature of the data collection process could better distinguish the approaches from each other than the presence of empirical data per se. First, the collection of data can be based on a close interaction between the researcher and the research subject or environment (company, organization, society). In this sense, constructive and action-analytical research constitutes a rather clear category. To be able to conduct this type of research, close interaction is required. Consistently with this, case studies are typically applied in constructive and action-analytical studies. Second, the empirical data can also be obtained with less commitment despite the fact that the role of empiria can be very important. Thus, conceptual, decision-oriented and, especially, nomothetical research constitute another category in this dimension. Importantly, regarding these approaches, close interaction may exist but it is not required.

What constitutes the data in each approach? Data can be perceived as the material the analysis of which is the foundation of study. Within this question, the role of the researcher is an interesting issue. At least in constructive and conceptual research, the researcher himself/herself produces a great portion of the key material analyzed: in constructive research this may happen mainly through empirical work (building the construct) and in conceptual research the process is likely to be primarily a mental one (building the conceptual framework). In decision-oriented research, the contribution of the researcher on the decision model, for instance, may be considerable. This means that also in the case of decision-oriented research the researcher may partly produce the analyzed data. Regarding action-analytical research and especially nomothetical research, the data are not primarily produced but rather collected through researcher. Finally, regarding all these research approaches, it is reminded that a large portion of data that underlies the research (for instance in the form of literature) exists before the research and is not created by the researcher.

3.2 Research Approaches Employed

The initial point in selecting a research approach is the research problem at hand and the objectives of the study. Yin (1994, p. 7) emphasizes the importance of the research question formulation for the success of the study itself even if the selected research approach will still contribute to the research question formulation. The availability of research material will set some limitations in selecting the research method and it might be wise to ponder philosophical issues such as truth and relevancy as well as the required evidence and the ways to obtain them. (Olkkonen 1994, pp. 81-82) The existence of antecedent knowledge is also a factor, which has a significant impact on the selection the of research method. Furthermore, the personal characteristics of the researcher and the topics of interest to him or her should not be forgotten either (Olkkonen 1994, pp. 92-93). In addition, individual studies typically include many different types of methods and that is the situation in this study as well.

Table 2. Research design

<table>
<tr><th>Phase</th><th>Connecting NPD performance measurement and product life cycle. Constructing a multifaceted measurement framework.</th><th>The identification of present practices of NPD performance measurement in Finnish companies</th><th>The gap analysis: the difference between the ideas presented with the framework and the practices of performance measurement</th></tr>
<tr><td rowspan="3">Evidence/ data</td><td>Literature review: performance measurement</td><td>Empirical evidence on performance measurement practices in new product development</td><td rowspan="3">Previous phases, Literature</td></tr>
<tr><td>Literature review: product life cycle</td><td rowspan="2">Literature: performance measurement in NPD</td></tr>
<tr><td>Empirical evidence from six case companies</td></tr>
<tr><td>Methods</td><td>Conceptual research, Case study</td><td>Survey</td><td>Conceptual research, synthesis</td></tr>
</table>

The primary approaches or methods applied in this study are qualitative by their nature. The foundation of the study relies on conceptual research and a case study. Within these, also more quantitative approaches, such as survey research, are also employed. The overall design of the study is presented in Table 2.

3.2.1 Conceptual research

The overall purpose of conceptual research is to construct conceptual frameworks or systems. Concepts can be perceived as key elements in any theories and Eisenhardt (1989) argues that theory development – that is closely connected with empirical reality – is a key activity in organizational research. Conceptual frameworks are needed, for instance, for describing new phenomena or for classifying or organizing information. On the other hand, conceptual frameworks may also be needed as a basis for larger systems or frameworks. The fundamental conceptual work that is needed for capturing the idea of "life cycle -conscious" NPD performance measurement forms the main part of the study. However, it is important to observe that a conceptual framework does not have value as such, but rather it should serve as a solution for some need or purpose. This study aims to show that the concept of life cycle would serve as a solid foundation for NPD performance measurement.

In conceptual research, the developed conceptual framework may be either totally new or improved from a prior version. NPD performance measurement as such is a topic that has been widely and profoundly discussed; however, with some exceptions (see for example Patterson 1983; Foster et al. 1985; Krogh et al. 1988; Brown and Svenson 1998), product life cycle has not been seriously taken into account in NPD performance measurement solutions (Meyer et al. 1997, Appendix A). Hence, the concept of product life cycle would provide fruitful ground for conceptual analysis that could enrich present measurement ideas regarding new product development.

It is important to observe that a conceptual framework does not have value as such; rather it should serve as a solution for some need or purpose. The methods typically applied in conceptual research are – simply put – thinking and analytical comparisons with existing knowledge. The testing of results is made by critically evaluating the applicability of the constructed conceptual framework in different settings and cases within the scope of the study. In this process, the aim is to establish evidence to support the implication that the conceptual framework that has been developed indeed represents a step towards "true progress" or "truth". The role of hypotheses in conceptual research is minor; they are typically not used at the beginning of the research process. Instead, the developed conceptual framework can be perceived as a hypothesis until it has been sufficiently tested. The phases or elements that comprise the conceptual research process, according to Näsi (1980) and Olkkonen (1994), are presented in Figure 6.

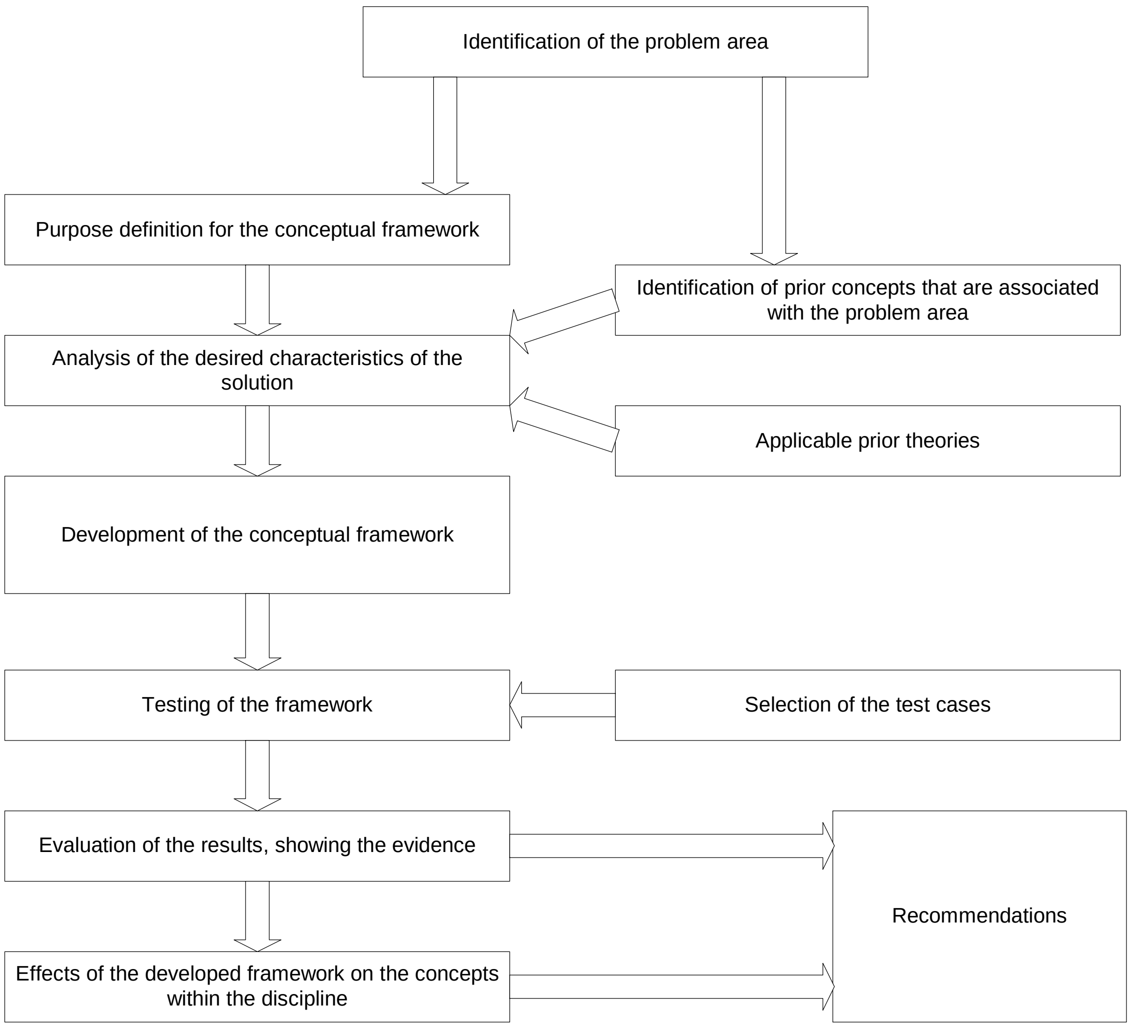


Figure 6. Conceptual research process (adapted from Olkkonen 1994, p. 67)

As discussed earlier, in their widely cited typology (Kasanen et al. 1991) place conceptual research into the theoretical-descriptive corner. (see Figure 4). Also Uusitalo (1991) argues that conceptual research is typically theoretical. Despite this, the role of empirical evidence in conceptual research may be very essential. The need for a new or an improved conceptual framework can be strongly connected to empirical findings and the development of the conceptual framework can be done on the basis of empirical support. It is also possible that there are many practical applications associated with the results of conceptual studies. Therefore, it seems contentious to argue that conceptual research would be purely theoretical. In addition, the descriptive nature of conceptual research is not self-evident either. It is very likely that conceptual research produces not only purely descriptive results but also normative implications. Conceptual research should be regarded as normative, for instance, if it is able to argue that the developed conceptual frameworks or systems are more applicable or represent higher quality than the previous ones within the given settings.

The design of the conceptual part (see Table 2: constructing a multifaceted measurement framework) of this study follows the logic of conceptual research. The typical elements of conceptual research and the issues regarding this study can be associated as follows:

- **Identification of the problem area:** This phase of the research comprises a long process in the mind of the researcher. Most of the aspects related to problem area identification are not explicitly discussed within the research report. But the very existence of the report focusing on this particular subject (NPD performance measurement) can be seen as a representation of this phase.
- **Purpose definition for the conceptual framework:** The purpose for the framework created in this study is defined mainly by the formulation of research questions and objectives. In line with this, the literature review and analysis conducted reveal the purposes for the framework.
- **Identification of prior concepts that are associated with the problem:** Prior concepts that are highly relevant include “product”, “new product”, “performance”, “performance measurement”, “product life cycle”, and “product development”. These concepts are discussed within the first chapters of the report.
- **Analysis of the desired characteristics of the solution:** Desired characteristics of the solution are founded on the requirements identified in the literature regarding NPD performance measurement. These include outcome orientation, objectivity, versatility, and feasibility. These are discussed within the synthesis of the relevant literature.
- **Development of the conceptual framework:** On the basis of literature and case studies, the conceptual framework is defined and refined. The initial idea regarding the framework is based on the literature study, while the cases provide evidence to further develop and refine the initial framework.
- **Selection of the test cases and the testing of the framework:** Six case studies conducted serve both as the sources of empirical data for constructing the framework and as test cases. The selection criteria are discussed in more detail later in this report.

- **Evaluation of the results, showing the evidence:** After the framework has been constructed, the applicability and feasibility of the ideas are discussed. This will be done by comparing the framework and the cornerstones of the literature.
- **The effect of the developed framework on the concepts within the discipline and recommendations:** The later parts of the study, including the comparison of the present state of PM in Finnish NPD and the multifaceted performance measurement reflected by the framework, comprise these issues.

3.2.2 Case study

3.2.2.1 Introduction

On the basis of an extensive review and meta-analysis of the literature on antecedents of new product success (47 surveys), Montoya-Weiss and Calantone conclude that:

> *"Case studies must play a new role in the future…Case studies can contribute to the field [of new product performance] in terms of identifying new factors or developing new methodological approaches… Also, new branches of new product performance research are primary candidates for case study." (Montoya-Weiss and Calantone 1994, p. 413)*

What is a case study? The classification of Neilimo and Näsi and of Kasanen et al. both exclude the concept of case study, which seems to be rather popular within management accounting or business economics research. For example, the descriptive case study (see for example Yin 1994, p. 3) can be seen to belong to the same group as the nomothetical research approach because it certainly is descriptive and uses empirical data. The nomothetical research approach, however, can be seen as a complete contrast to the case study method because of the differences in the scope of the empirical data used (see Figure 5). Research approaches, which are complete counterpoints to one another probably should not belong to the same class in a successful classification. However, the classification of the case study method as such is not that simple either.

According to (Yin 1993; Yin 1994), case study is a research strategy or a research approach that could be selected when the phenomenon under investigation is not readily distinguishable from its context. As (Eisenhardt 1989) summarizes, case study focuses on understanding the dynamics within single settings. Hence, the inclusion of the context is seen as a major task in a case study. The above is in line with the notion that case study typically addresses a situation in which the boundaries between the issue or phenomenon under study and the context are not very evident (Yin 1993, p. 59). Yin (1994) points out that case study has a distinct advantage over other research strategies when a "how" or "why" question is being asked about a contemporary set of events over which the investigator has little or no control.

The conducted case study (see Table 2: constructing a multifaceted measurement framework) includes six cases – six companies – that represent three different industries. However, the sample[11] for the study is reasonably homogeneous inasmuch as all the case companies are manufacturers of physical investment goods. The empirical data have been obtained mainly by using semi-structured interviews (n=13). A product development manager or director was interviewed in each case; in addition, representatives from purchasing, after sales, manufacturing, sales, and marketing were interviewed in one case company. Also, observations and other data sources such as direct observations (in two companies), company presentations (in all companies), and archival data (in one company) have been employed.

The questions that were employed in the interviews focused on the following main issues (see Appendix A):

- The nature of product development in the case company
- The general importance of a new product for the business of the case company
- The length of product life cycles
- The distinct phases of product life cycles and their typical features: a picture of a good process/product as interpreted at different stages of the life cycle
- Product life cycle phases seen from the perspective of different corporate functions

The interviewing process followed the traditions of qualitative research in conducting in-depth interviews (see for example Marshall and Rossman 1999). No predetermined response categories were given, and the interviewer basically let the interviewees structure their responses as they wanted. Naturally, the interviewer asked some specifying questions if needed.

3.2.2.2 Types of case studies

Easton (1992) points out that it is important to distinguish between the use of the term “case study” in the research and learning contexts. In the learning context, which is not of primary interest here, a case study comprises a description of an occurrence or a series of occurrences seen in retrospect. However, in the research context, a case study is an attempt to test or develop theory on the basis of experience gained from a real-life phenomenon.

In the research context, Yin (1994, pp. 3-4) proposes three different types of case studies: explorative, descriptive, and explanatory case studies, all of which are used for different purposes. Yin (1994, p. 6) has also suggested a framework for analysing different research methods. In his framework, Yin has included five different types of research approaches: the experiment, the survey, archival analysis, history, and the case study. Yin’s framework is presented in
Table 3.

[11] According to Yin (1994), it is not totally appropriate to use the term “sample” in case studies as the purpose of the case study is not to produce statistical generalizations.

Table 3. Different types of research methods with research questions characteristic of them (Yin, 1994, p. 6)

Strategy	Form of research question	Requires control over behavioral events?	Focuses on contemporary events?
Experiment	How, why	Yes	Yes
Survey	Who, what, where How many, how much	No	Yes
Archival analysis	Who, what, where How many, how much	No	Yes/no
History	How, why	No	No
Case study	How, why	No	Yes

Yin's framework relies heavily on the research question formulation and the research questions determine which research method would be the most suitable one. Considering the present study, the greatest interest is on the "how" types of questions. In the framework, three research methods answering that type of question can be found: experiment, history and case study. Of these three, history focuses on the past, which leaves only experiment and case study as options. The third classification criterion of Yin's is control over behavioral events. According to him, the experiment requires control over behavioral events, while the case study method, in contrast, does not. That could be interpreted to mean that with the case study method the primary aim is to describe and to understand, but not to affect, the functioning or behavior of an organization. That, on the other hand, would distinguish the case study from action-analytical and action research, and especially from constructive research.

Salmi (2000) (see also Yin 1994) argue that case study cannot be considered a distinct research approach but it should rather be seen as a versatile framework that is comprised of many alternative types of strategies to conduct research. Salmi and Järvenpää give three examples of case studies that, according to the authors, meet scientific criteria and standards. These are:

1. Analytic review of a case for constructing a new theoretical framework or for testing an existing framework.
2. Simultaneous assessment of a case or cases using a number of alternative perspectives that supplement each other. Triangulation is applied as a methodological foundation.
3. Theoretical generalization.

It is rather obvious that the first alternative is well in line with the interest of this study. In addition, although many case studies – such as this one – include descriptive elements, Salmi and Järvenpää have excluded purely descriptive case studies from the previous list. According to their interpretation, descriptive case studies may be very useful in the data gathering phase of the research but they should not be seen as actual scientific studies or as sources of scientific contribution.

It is interesting, however, that contrary to the impression given by the presentation of Salmi and Järvenpää (2000), the three approaches proposed may not be regarded as discrete approaches for conducting case studies; rather, all the three elements are likely to be present in most case studies that aim to meet scientific standards. In that sense, the three points presented should not be seen as a typology but rather as overall criteria for good case studies. First, as suggested by Yin (1994), Eisenhardt (1989), and Stake (1995), the role of theory in case studies is essential. Hence, one would not expect to find case studies that do not either test theories or construct them. Second, virtually as inherent as the theory connection in case studies is the simultaneous use of versatile approaches for analyzing cases. Further, the application of triangulation – as important and effective method as it might be – does not constitute a research approach of its own. Finally, theoretical generalization – the use of cases to find support for theories or their rival theories – should be an objective shared with all scientific case studies. Thus, case studies that apply theoretical generalization strategies do not comprise a case study category of their own.

For comparison, Eisenhardt (1989) also proposes three purposes for case studies. They can provide descriptions, test theories, or generate new theories. However, it is likely that all of these three elements proposed by Eisenhardt may well be observed even within a single study. Nevertheless, the three purposes provide a parsimonious but representative enough classification for generic case studies. In this study, the aim is to both provide descriptions and generate refined if not totally new theories.

A basic typology of different case study designs can be presented on the basis of selections made between single and multiple cases and between single or multiple units of analyses (Table 4) (see Yin 1994, p. 39). Clearly, since this study utilizes several cases (six companies) and multiple units of analyses (product life cycles and individual life cycle stages), the study at hand represents the lower right corner of the portfolio (Type 4). Yin (1994) argues that a single-case design is appropriate under three main circumstances: the case is critical in terms of testing a well-formulated theory, the case is unique (the phenomenon is not likely to be present in several cases), or the case is revelatory (the phenomenon has previously been inaccessible). Since neither of these circumstances is present in this study, the multiple-case design is likely to be the most appropriate. On the other hand, a holistic approach would be advantageous when no logical sub-units of analyses can be determined. However, in this study, the entire life cycle and the discrete phases are hierarchically logical (virtually self evident) and consistent units of analyses. Hence, embedded design would be more fruitful and appropriate.

Table 4. Types of designs for case studies (adapted from Yin 1994, p. 39)

	Single case design	**Multiple case design**
Holistic, single unit of analysis	TYPE 1	TYPE 2
Embedded, multiple units of analyses	TYPE 3	TYPE 4

While Yin’s classification is a rather mechanical one that relies on two factors associated with research design (the number of cases and the number of units of analyses), a more practical and purpose-oriented classification is made by Stake. According to him, two main types of case studies include (Stake 1995): 1) Intrinsic case study, which is characterized by an intrinsic interest in the case (medical cases, for example). 2) Instrumental case study, in which case study is regarded as an instrument to accomplish something other than understanding a particular case. Regarding this study, intrinsic purposes are virtually negligible and the study clearly underscores instrumental interests: the main purpose of the case studies is to test the applicability of the concepts developed in the conceptual research process. However, as trivial as this may seem, this distinction is important to make since the methods applied in intrinsic and instrumental case studies will differ from each other.

> *"The more the intrinsic interest in the case, the more we will restrain our curiosities and special interests and the more we will try to discern and pursue issues critical to case." (Stake 1995)*

Finally, Aaltio-Marjosola (1999) presents four types of case studies depending on the number of cases (one or more) and on the nature of data (longitudinal or non-longitudinal). According to Aaltio-Marjosola, each approach has its own potential and strength. The approach adopted in this study, non-longitudinal and multiple cases, is mainly about the comparison between the cases along the selected dimensions (or units of analyses (Yin 1994)).

3.2.2.3 Selection of cases

Aaltio-Marjosola (1999) reminds that in case studies it is important to connect the whole research setting with the previous theoretical foundation. The nature of case analysis is often inductive and the purpose of the researcher is to reveal aspects and issues that are to some extent unexpected. It is less important to test theory and hypotheses than to describe the data comprehensively and in detail. In line with this, the target group should be selected purposefully instead of randomly. Also Eskola and Suoranta (2001) propose that the selection of cases should be made on the basis of their theoretical representativeness or coverage. Thus, in qualitative research, sample may not be the most suitable term to describe the studied cases because the term "sample" implies somewhat random selection, which is not appropriate in qualitative research. The selection of cases in qualitative research is strongly based on the theoretical foundation of the study: theory should provide guidance for case selection.

Paradoxically, since case studies seek to produce in-depth understanding of studied environments they often require a level of commitment and involvement that far exceeds the level required, for instance, in mail surveys. Due to this, it can be very challenging for a researcher to obtain access to a vast number of companies that fulfill the characteristics and requirements derived from the theory. This may lead to a situation in which the researcher ends up with studying the cases he or she is able to, rather than studying the cases that would be ideal considering the theoretical foundation and the research questions defined:

> *"It is not unusual for the choice of case to be no 'choice' at all". (Stake 1995)*

Whether the studied cases are actually selected or not, the use of multiple cases allows the researcher to follow replication logic in case studies. That is, multiple cases can be used to improve the possibility to generalize from case studies. In replication, the theory[12] or the theoretical framework applied would predict under which circumstances a phenomenon is likely to be found and under which conditions a particular phenomenon is not likely to be found. Hence, two forms of replication can be utilized in case studies. Literal replication happens when the different cases represent similar results. Theoretical replication occurs when different cases represent different results. Each case in a case study should be selected to represent either literal or theoretical replication; furthermore, preferably both forms of replication are present in a case study. (Yin 1994) Also Salmi and Järvenpää (2000) advocate case selection that enables theoretical replication. They put forth that if multiple cases are selected for a case study, it would be fruitful to include cases that are opposite for each other (for example cases that represent successful ABC implementations and cases that represent unsuccessful implementations). This way it is possible to more comprehensively capture the true nature of the phenomenon being studied. (Salmi and Järvenpää 2000, p. 271)

Theoretical sampling is especially important in theory-building case studies. According to Eisenhardt, the selection of (a limited number of) cases could be made so that the cases represent somewhat extreme situations and polar types. In other words, the goal of theoretical sampling of cases is to choose cases that are able to replicate or extend the emergent theory. (Eisenhardt 1989) Olkkonen (1994, p. 107), for one, seems to be somewhat of attached to the positivistic paradigm when discussing the case selection for case studies. He has associated the cases with a "population" and identified three different types of case companies that can be selected:

- Cases that can be considered typical of the population
- Cases that represent the different types of companies identified by conceptual research and that can be considered typical of each company type
- Special cases that do not fulfill the definition of the population, but will give interesting and revealing information from the point of view of the research objectives

In the design of a case study, one of the interesting questions is the suitable number of cases. The answer could be founded on the idea of saturation. Basically, when a new case is not able to produce essential new information regarding the research questions, the saturation has been achieved. Regarding the appropriate number of cases in case study, Eisenhardt refers to the concept of theoretical saturation, which is interpreted as the point at which incremental learning is minimal due to the fact that the researcher is observing phenomena seen before. (Eisenhardt 1989) In practice, however, it is sometimes very difficult to determine when the point of saturation has been reached (Eskola and Suoranta 2001). As a result, the term "saturation" may be sometimes used rather as a synonym for the laziness or tiredness of the researcher.

[12] Theory is defined as a set of statements that define the concepts and their interrelations. Concept, for one, is seen as a surrogate for phenomena, occurrences, or "things" applied in scientific research. (Kettunen 1974, pp. 58-63)

A case study with multiple cases has, as the discussion points out, several advantages. However, it is also a feasible option to rely on a single case. Stake (1995, p. 85) suggests that single cases do not provide as strong a base for generalizing to a population of cases as other research designs. However, it is possible to learn much that is general from single cases. People learn from single cases partly because they are familiar with other cases and they add a new one, thus making a slightly new group from which to generalize. This process is about producing naturalistic generalizations, which are conclusions "arrived at through personal engagement in life's affairs or by vicarious experience so well constructed that the person feels as if it happened to themselves." In reporting case studies, Stake offers a list of seven issues to assist in the validation of naturalistic generalization (Stake 1995, p. 87). These include, for instance, availability of adequate raw data, practical description of methods, and information about the researcher.

As pointed out earlier, this study includes multiple cases. The study seeks to produce insights into product life cycles in different companies (common and uncommon issues across companies) and thus in this context, multiple cases are primarily selected for enabling either literal or theoretical replication of observations. The selection of cases is purposeful in a sense that all the cases are reasonably homogenous: they all are middle-sized or large manufacturers of industrial investment goods. Also the concept of product life cycle was expected to be relevant one way or another in each case: especially in machine construction, the life cycles of products are relatively long including an after sales phase. Being the main unit of analysis, the relevance of life cycle is certainly necessary. On the other hand, the cases were selected in such a way that within the specified boundaries the cases would also differ in terms of size, products, and environment. Finally, the selection was naturally also partially founded on the fact that these cases – based on previous contacts and cooperation – were feasible and accessible for the researcher.

3.2.2.4 Appropriate procedure

Goffin provides a good example of research design that is supposed to ensure a rigorous case study. He has reported a case study based on five industrial cases that connect customer support and new product development. The research design consists of four stages (Goffin and New 2001, p. 283):

1. **Preliminary contacts with the cases.** The agreements to participate in the study were obtained and suitable contact persons (informants, interviewees) were identified. Also, the aims of the research were preliminarily clarified and the date for the company visit was agreed upon.
2. **Case study visit**. Semi-structured interviews were conducted during the visits. During the visits, the researcher also had the opportunity to inspect other material such as company documentation.
3. **Data analysis and post-visit contacts**. The preliminary data analysis was conducted after each visit, and finally after all the visits, cross-case analysis was carried out. During this stage, the case companies had an active role in checking case descriptions and discussing the results with the researcher.
4. **Workshop with participating companies**. The workshop was arranged to provide the participants with an opportunity to discuss the results of the cross-

case analysis and to share possible best practices across different companies. The workshop also provided extensive feedback for the researchers.

In this study, the interviewing process in all the cases followed a four-phase procedure (quite analogously to the procedure proposed by Goffin and New 2001, p. 283): agreement on the interviews, conducting the actual interviews, writing a preliminary manuscript from the interview, and the feedback round.

The agreements were made by phone, but the interviews were conducted person-to-person. In each case, after the researcher had finished the manuscript on the basis of the interview (within a couple of days after the company visit), the manuscript was sent to the company for a check-up and refinement. The feedback round enabled the inclusion of a variety of opinions from the company (other than that of the interviewee) because the interviewee was instructed to circulate the interview manuscript among the key persons of the company to test the ideas and to reach a reasonable degree of consensus. In fact, at least some feedback was obtained from all the cases. After this feedback round, the analysis of the cases, including both within-case and cross-case analysis (see for example Eisenhardt 1989), was performed.

3.2.2.5 Data collection and analysis

Regarding data collection, case studies may apply rather versatile approaches. According to Eisenhardt (1989), suitable data collection methods include archive studies, interviews, questionnaires, and observations. Further, there is no need to purely rely on qualitative information but rather a collection of quantitative data may also be appropriate. When collecting data in case studies, Eisenhardt (1989) emphasizes the importance of well-defined focus and research questions. Without an appropriate focus, the researcher is likely to become overwhelmed by the volume of potential data. Also a priori specification of constructs is seen as important, because it facilitates a more accurate measurement of the constructs that are of interest. Most importantly, Eisenhardt stresses that theory-building research should be begun as close as possible to the ideal of “no theory under consideration and no hypotheses to test”. While it may be impossible to actually reach the ideal, it is still worth attempting because strong propositions may bias and limit the findings of a theory-building case study (Eisenhardt 1989, p. 536).

In analyzing the data obtained from case studies, it may be appropriate to proceed stepwise. First, each case should be analyzed as a closed entity. This is mainly done in order to become intimately familiar with each case. The within-case analysis facilitates the unique patterns of each case to emerge before it is pushed to generalized patterns across cases. Second, after within-case analysis, the researcher is advised to conduct cross-case analysis in order to find patterns that apply over single cases. The idea of cross-case analysis is to find accurate and reliable theory that would fit as closely as possible with the data obtained from several cases. It is also suggested that an essential element of theory-building from cases is the comparison of the findings (whether they are concepts, theories, or hypotheses) with extant literature. This involves identifying the similarities and differences between the findings and literature as well as identifying possible explanations for these. If the researcher ignores conflicting findings, readers may judge the findings to be incorrect (questionable internal validity) or idiosyncratic to a specific case, which would be a challenge to the external validity of the study. (Eisenhardt 1989)

Huber and Van de Ven (1995, p. xiii) suggest that due to the information overload typically present in case studies, establishing rigorous inferential links between theory and data requires methods "that go beyond subjective eyeballing" of raw data. In contrast with this need of methods, the applied data-analyzing methods are rarely reported in case studies in detail. As a result, it is often very difficult to follow how the researcher has actually gotten from the field observations to the final conclusions.

To overcome the problems associated with relying only on subjective eyeballing of raw qualitative data in case studies, Van de Ven and Poole (1990) suggest that researchers could follow a four-stage sequence in measuring an organizational phenomenon in a case study. These four stages can help the researcher to quantify the obtained data and thereby to improve the possibilities to fully analyze the richness of the data. First, the qualitative datum is defined as an incident and the raw data collected from the field is organized into a qualitative incident data file. Second, the validity and reliability of classifying the collected raw data into incidents is evaluated by achieving consensus and consistent interpretations of decision rules between at least two researchers that perform the task and by asking organizational participants or representatives to review the chronological list of incidents that occurred in their organization. Third, each incident is coded in terms of presence or absence of theoretical event constructs. This coding is added into the incident data file. (For a more detailed description on this, see Van de Ven and Poole (1990)) Finally, the reliability and validity of the coding should be evaluated by following the conventional procedures associated with construct validity.

When theories are drawn on the basis of case studies, a number of challenges are at hand. According to Eisenhardt (1989), two typical weaknesses of theory building from cases include: First, the theory becomes overly complex caused by a high volume of rich data (researcher tries to capture everything and in doing so, compromises parsimoniousness). Second, the theory becomes narrow or idiosyncratic and does not comprise a "grand" theory in any sense. Theories that are built on case studies are seldom generic but rather tend to be theories about specific phenomena.

Theory building can be considered one of the aims of this study. In other words, the concept of life cycle -conscious NPD performance measurement can be seen as a theory of some kind. Thus, the arguments made for example by Eisenhardt are at least partially applicable. The analysis of data in this study, in the spirit of Eisenhardt, began with no explicit or implicit hypotheses. The actual analysis was initiated with within-case analyses after which cross-case analyses were conducted. The coding of qualitative data was partially applied: life cycle phases and their characteristics were coded for the purposes of cross-case analyses. Finally, the main result, the measurement framework, was left at a high level, which would help avoiding idiosyncrasy and complexity typical of theory-building case studies. Also, a high-level blueprint would likely be more general and applicable in different settings.

3.2.3 Survey

Although survey has been used as a research instrument (see Table 2: present state of performance measurement), this study cannot be regarded as nomothetical (see for example Neilimo and Näsi 1980). This is mainly because the mail survey was carried out to collect primarily qualitative and descriptive data on *the present state of* measurement practices rather than to collect quantitative data enabling identification of cause-effect chains and statistical generalizations. In other words, survey has been employed as a research instrument to support and complement the conceptual analyses and cases conducted in this study. As a whole, this study should be considered as qualitative and hermeneutic.

The survey part of the research was initiated in 2001 with a literature review of the field of NPD and R&D performance measurement. In the spring, that year, the research questions were sufficiently clarified for the design of the questionnaire. (see Appendix B) After a few iterations regarding the design of the survey, the questionnaire was pre-tested with the assistance of three R&D managers. These R&D managers were asked to fill in the questionnaire and to evaluate the applicability and understandability of the questions. The pre-testing brought out only minor development needs in the questionnaire. After some modifications, the questionnaire was sent to respondents in September, 2001. Replying to the questionnaire was made possible through the Internet (Web questionnaire) and by mail.

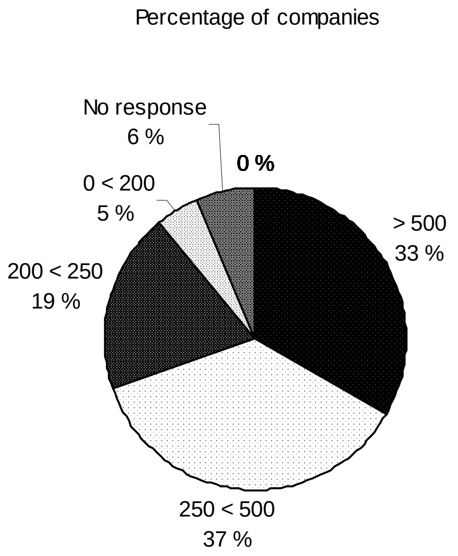
The questionnaire was sent to 340 R&D managers of Finnish industrial companies that mostly employed more than 200 employees. The contact addresses of the companies were queried from the Sales Leads database software. According to the database used, those 340 companies covered the whole population of Finnish industrial companies that employed more than 200 employees.

Responses were obtained from 82 companies. That corresponded to a response rate of 24.12 %. According to the responses, 19 companies did not have R&D activity at all. These companies were left out of the scope of this study and hence the final sample of this study consisted of 63 companies. (see Table 5) Only three of the respondents represented staff other than the company's R&D management staff. Those represented either general management or marketing management.

Table 5. Response pattern of the study

	Number of companies	Percentage
Population	340	100.0 %
Sent questionnaires	340	100.0 %
Total responses	82	24.1 %
Excluded from the sample	19	5.6 %
Usable responses	63	18.5 %

The most represented lines of industry in the sample were machine construction (13 responses), electronics and optical instruments (12 responses), and pulp and paper (9 responses). The companies of this study employed on the average 1033 persons, which was due to a few very large global corporations. Approximately 56 percent of the sample consists of companies that employ more than 200 but less than 500 persons. The profile of the sample in terms of the size and industry of the companies is depicted in Figure 7.



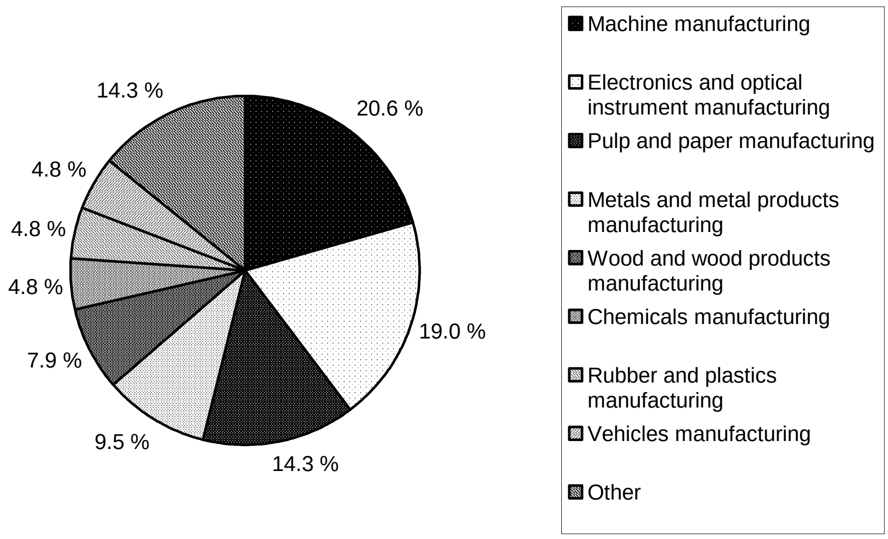


Figure 7. Distribution of the size and industrial sector of the surveyed companies

Both versions of the questionnaire (Web form and mailed papers) were identical as regards the substance and order of appearance of the questions. Only the visual formatting of the versions were somewhat of different. The questionnaire consisted of

11 open-ended and 10 closed-ended questions. The questionnaire was 8 pages long (paper version) and it was outlined into four main sections.

The first section dealt with background issues of the respondents and the companies. The second part of the questionnaire included questions about a company's NPD and R&D. Especially the objectives of product development, which were perceived as important ones by respondents, were emphasized. The third section of the questionnaire was reserved for the R&D managers' opinions about the validity of their company's performance measurement practices in general. The key matters of this research were underlined in the fourth section of the questionnaire. These matters were the performance metrics of the NPD used, the purpose of measures, and the R&D managers' opinions about the quality of the NPD performance metrics used.

The data were analyzed both quantitatively and qualitatively. Answers for the closed-ended questions were given with nominal and order scales. For instance, the opinions of the R&D managers were clarified with different kinds of arguments. The respondents were asked to indicate the level of agreement or disagreement using five portal scales. The data, which were gathered with the order scale types of questions or arguments, were analyzed using arithmetic average and median computations.

However, the majority of the data were obtained by open-ended questions. These were for example the important objectives of product development, the metrics the of product development used, and the purpose of measures. The data gained with open-ended questions were quite many-sided as written down by the respondents and therefore required interpretations that undeniably have some influence on the reliability of the results. The open-ended data were put into statistical mode by subjectively classifying them into similar kinds of categories. This unavoidably to some extent obscures the chain of evidence of this study, but it was necessary, given the large variety and amount of data obtained.

3.3 Generalizability and Validation of Results

Applied sciences face a number of problems both at the beginning and at the end of the research process (Näsi, 1980b, p. 41). According to Näsi, the studies seldom resemble the realistic planning and decision-making situations (see also Kerssens-van Drongelen 2001) and, in addition, significant questions arise when verifying and validating the research results. Qualitative research emphasizes deep understanding and explaining in the local context, as Alasuutari (1999, p. 55) portrays it. In a case study, the goal is not to generalize; rather the real business of a case study is particularization (Stake 1995, p. 8). According to Stake (1995), Yin (1994) and Alasuutari (1999), actual (statistical) generalizations are completely the reserve of traditional survey studies.

By applying the principles of qualitative research, the problem of generalizability can be approached and solved at least to some degree. Qualitative research denies the dominance of statistical generalizations; yet qualitative methods are widely used, especially in social sciences. Qualitative research is applied to phenomena whose existence and therefore also the generalizability of the phenomena themselves cannot be questioned (Alasuutari 1999, p. 237). If the principles of qualitative research are applied to conceptual research, the ability to define the population in which the developed conceptual framework would work becomes crucial. In other words, the researcher must be able to define the characteristics of an environment in which the framework would work. This is the foundation of contextual generalization (Lukka and Kasanen 1995). Statistical generalization, such as that the framework would work in 70 percent of Finnish companies, is not required and not even expected to be given. The definition of the population, however, must be sufficiently exact so that the construction will work in every environment fulfilling the set preconditions. If this is not the case, the definition of the population needs to be changed. Furthermore, it has to be noticed that the researcher defines the population and therefore it is not necessarily related, for example, to a certain business.

Defining the population is closely related to the idea presented within the constructive research approach that the framework most likely should work in a "similar organization" (see for example Kasanen et al. 1991 and Lyly-Yrjänäinen 2003). The problem of the researcher is to define exactly what that "similar organization" is. Traditionally, this has been done by describing the operating environment of the case company at a detailed level, but the generalizability itself has rarely been commented on. The definition of population can be seen as a more advanced analysis compared to the description of the operating environment, and it will give at least some sort of understanding regarding the generalizability of the results.

Also according to Aaltio-Marjosola (1999), case study does not seek to generalize like survey research does (statistical or empirical generalization). However, in trying to gain understanding and to profoundly interpret particular cases within their real-life contexts, case study actually tries to identify the internal mechanisms and to organize the cause-effect –relationships of the cases in such a way that is rather similar to the traditional perception on generalization. In this respect, the amount of data is not crucial; rather, it is the soundness and sustainability of the inference that counts. Furthermore, Eskola and Suoranta (2001) suggest that instead of generalizability, qualitative research focuses on transferability of the findings: whether this inference can also be applied to different settings. Importantly, Aaltio-Marjosola (1999) suggests that the generalization cannot be the one and only purpose for scientific work. Sometimes, when issues are discussed in a very general level the actual content of the discussion gets very thin. The phenomenon becomes so general that it loses its contact with reality[13]. Also Stake (1995) suggests that, first and foremost, a case study aims to catch "the complexity of a single case". Cases are not primarily studied for the purpose of understanding other cases. In general, two essential characteristics of qualitative research include orientation away from cause and effect explanation and holistic treatment of issues (Stake 1995). Case study can be used as a feasible research instrument in this context.

In summary, the problem of generalizability can be solved fairly well using the arguments of qualitative research. However, validation and verification of the constructed framework may constitute another challenge. For example, in the case of constructive research, Hannula (1999, p. 142) states that there is no straightforward test for validity in the literature. In the case of measurements, reliability refers to the exactness of the measurements, and validity, on the other hand, refers to the ability of

[13] In Finnish, Aaltio-Marjosola (1999) uses expression: "ilmiö ikään kuin hajoaa yleisyyteensä".

the measure to measure the phenomena it is supposed to be measuring (see for example Niiniluoto 1997, p. 187). However, according to McKinnon (1988), validity and reliability may be described at a broader level in respect to their applicability to research in general. According to her, validity is concerned with the question of whether the researcher is studying exactly the phenomenon he or she is claiming to study, neither more nor less, while reliability is concerned with whether the gathered data can be trusted.

According to Yin, reliability is concerned with the repeatability of the research. If someone else had gathered the data or formed the conclusions from the same information, he or she should have ended up with the same conclusions as well. To ensure validity[14] in case studies, Yin (1994, p. 33) proposes a number of tactics associated with construct, internal, and external validity. In short, construct validity is promoted by using multiple sources of evidence, by establishing a chain of evidence, and by having the key informants to review the draft case study report. Internal validity is built by doing pattern matching, explanation building, and by conducting a time-series analysis whenever possible. External validity can be improved by conducting several case studies, that is, by following replication logic in case studies. The different tactics presented by Yin are listed in Table 6. Furthermore, Montoya-Weiss and Calantone (1994, pp. 398-399) refer to the priority order of threats to the validity for applied research as follows: 1) internal validity, 2) external validity and 3) construct validity. In other words, according to the author, internal validity seems to be the primary concern.

Table 6. Different tactics to improve the validity and reliability of a case study

Tests	Case study tactic	Phase of research in which tactic occurs
Construct validity	Use multiple sources of evidence Establish chain of evidence Have key informants review draft case study report	Data collection Data collection Composition
Internal validity	Do pattern matching Do explanation building Do time-series analysis	Data analysis Data analysis Data analysis
External validity	Use replication logic in multiple-case studies	Research design
Reliability	Use case study protocol Develop case study database	No

In the conceptual research approach, construct validity could be seen to mean that the conceptual framework and its internal elements suit well the application in mind (very analogously to constructive research, see for example Lyly-Yrjänäinen 2003). The tactics for improving the construct validity presented by Yin seem to be usable also in the conceptual research approach. The information required in forming the framework should be gathered from different sources and it is worth the trouble to allow a number of experts to comment on the framework and the ideas behind it. Careful and detailed description of the process will give the reader access to the logic in the creation process of the framework, thus maintaining the chain of evidence. Equally

[14] Emory (1985) defines validity in general as: “The extent to which differences found with a measuring tool reflect true differences among those being tested.”

important when considering the chain of evidence is the preservation of the original documents created during the research process.

The purpose of internal validity is to rule out different types of disturbing factors affecting the research results. In that context, pattern matching means that empirical results are compared to the estimate or forecast created on the basis of theory. This has been done in this study as well, although internal validity is mainly a concern of causal studies (Yin 1994). The researcher, however, must be aware of the four general threats to validity and reliability in a field study (McKinnon 1988): observer-caused effects, observer bias, data access limitations, and the complexities and limitations of the human mind. The threats to internal validity of new product performance studies are mainly caused by the fact that it is difficult to develop rigorous experimental controls for the studies due to the fact that the researcher has to infer the relationship between a determinant of success and the performance either by using subjective interpretation or by relying on self-reported respondent information (Montoya-Weiss and Calantone 1994).

When trying to increase the external validity, that is generalizability, the implementation of the conceptual framework in a number of settings is naturally a key question. However, it is not always possible to test the constructed framework in a number of companies, which also supports the significance of defining the population and the boundaries for applicability with regard to the generalizability of the framework. Table 7 refers to the issues or problems addressed by Leonard-Barton (1990) concerning retrospective case studies. Since these issues are relevant in this study also, each of the issues is briefly reviewed or discussed in terms of the purpose and realization of this study (see Table 8)

Table 7. Issues in multiple site retrospective case studies (adapted from Leonard-Barton 1990)

Research activities	Issue
1. Data gathering	
Efficiency	Relatively high; focused data gathering
Objectivity	Danger of unconsciously accepting respondent bias
Pattern recognition	Recognition of overall patterns in the process
2. Establishing validity	
External validity	Relatively high generalizability; variety of situations
Internal validity	Lower than with single in-depth cases; potential confusion about cause and effect
Construct validity	Opportunity to validate the stability of the construct across situations

Table 8. Discussion on the issues addressed by Leonard-Barton (1990) regarding this study

Research activities	Issue
1. Data gathering	
Efficiency	Semi-structured interview platform. The structure of the interviews was communicated to the respondents in advance.
Objectivity	Data triangulation whenever possible: multiple interviewees, company documentation, feedback round.
Pattern recognition	Information on product life cycles and their distinct phases cumulated along the interviews: this enabled a gradual recognition of issues regarding PLC.
2. Establishing validity	
External validity	External validity is promoted by the definition of population or target group in which the results (the constructed framework) are applicable. Generalizability, as such, is not regarded as a primary aim of this study.
Internal validity	Cause-effect relationships are not of primary interest here. Pattern matching as a method of analysis is still applied to some extent. (Internal validity is a concern only for causal studies (Yin 1994)).
Construct validity	The use of multiple sources of evidence and multiple cases are the core means to secure construct validity. Also the feedback round with the interview manuscript was intended to improve the validity of the findings.

When evaluating the role of the different dimensions of validity with regard this study, it seems clear that the external validity has only a limited importance – as discussed above – in a case study such as this. Second, construct validity, which refers to the operationalization of the construct of interest, seems always important in a study. The use of multiple sources of evidence whenever possible has been the main instrument for improving the construct validity of the study. However, internal validity constitutes some kind of a dilemma regarding this study. As Yin (1994) points out, internal validity is mainly a concern of causal case studies. This study is not regarded as a causal study. For example, the study does not seek to produce explanations for the observed product life cycles in case studies. On the other hand, it could be argued that reaching a good internal validity even in a non-causal study could be able to improve the construct validity of the study. This would be possible because good internal validity would better facilitate for example the evaluation of the internal relationships between the concepts utilized in the study. In a multiple case study, this would improve the consistency of the constructs across the cases.

4 Literature Review

Literature review is one of the main sources of data in conceptual research. The following sections comprise the core findings made within three branches of literature: performance measurement, new product development and its management and measurement, and product life cycle. On the basis of this, the initial framework and blueprint for multifaceted NPD performance measurement is constructed.

4.1 Performance Measurement

Progress, growth, and improvement are issues, which are generally accepted as worth pursuing. In the business context, certain tools are needed to support the pursuit. Among them, performance measurement can be utilized for illustrating the progress achieved during a period of time in respect to the goals of an organization specified by the measures (Ijiri 1975). An organization without well-defined performance criteria, through which the performance of individuals and the organization may be evaluated, would find it hard to plan and control the operation as well as motivate the employees (Globerson 1985).

4.1.1 Relevance of the discussion concerning performance measurement

Overall, performance measurement is not a fundamentally new topic. In fact, it is a topic that has been widely discussed both by researchers and practitioners. In that sense, it could be assumed that any further discussion on this topic would have little value for anybody. Indeed, Neely (1999) has remarked:

> *"Given that the 'basic management techniques' have been used for so long and that business performance measurement is undoubtedly one of these techniques, then surely most organisations should have had well developed performance measurement systems in place for many years by now."*

Hence, all the problems and challenges associated with performance measurement would be solved? Even the briefest examination of the academic literature and practitioners' experience would confirm that this is not the case. There is a considerable interest around the issues related to good performance measurement (Examples include Maisel 1992; Nanni and Dixon 1992; Ellis and Curtis 1995; Lynch and Cross 1995; Euske et al. 1998; Laitinen 1998; Bourne et al. 2000; Kald and Nilsson 2000; Kaplan and Norton 2001; Suomala and Kulmala 2001; Tenhunen and Ukko 2003).

One of the most fundamental issues of good measurement is presented by Ijiri (1975): normally performance measurement is not able to indicate whether this progress has been a result of a set of good decisions or just produced by *good luck* (Ijiri 1975, pp. 179-189). The influence of good (or bad) luck on performance measures is certainly inconvenient as measurement is not only a passive representation of real life phenomena but it is also an active agent that affects real life through its influence on the decision-maker. Although performance measurement has traditionally illustrated the consequences of the decisions of the entity but not necessarily the causes that led to these consequences, it is very important for a performance measurement system to be able to show the essential cause-effect relationships within the measured phenomena. Especially in the case of output measures, it is at least an imperative to discuss the variety of factors that might have an effect on the measure. Otherwise, the decision-maker is likely to make distorted judgments on the basis of performance measurement.

Unfortunately, despite the fact that the cause-effect relationships have received more attention lately, many actual effects of performance measurement still remain open. This is the case with, for instance, the balanced scorecard (see Kaplan and Norton 1996). Although BSC includes the idea of cause-effect identification and measurement, it is a fact, as Ittner and Larcker (2001) remark, that despite the widespread adoption of the BSC, there is little hard evidence that a company's performance can be improved by its use. Due to this, essential value could be produced by conducting more work to explore the possible effects of measurement practices.

Because some of the fundamental issues regarding performance measurement have been identified already some 30 years ago, the question remains, as Neely puts it, why now? Why have so many people become so interested in business performance measurement so recently? The reasons have been classified into seven domains, including (Neely 1999):

- The changing nature of work: the portion of direct labor cost from the total cost of goods sold seems to be less than before due to the heavy automation investment in many industries. Therefore, cost allocation on the basis of the distribution of direct cost is not feasible.
- Increasing competition: In the pressure of often global or at least international competition, organizations seek to differentiate in terms of quality of service, flexibility, customization, or innovation. Competing on the basis of non-financial factors means that organizations need information on how well they are performing across a range of dimensions.
- Specific improvement initiatives: As a response to increased competition, many organizations have built on different improvement initiatives. TQM, as one example, relies heavily on performance measurement. Before an organization is able to improve its operations, before it is capable of focusing on continuous improvement actions, it has to establish where and why its current performance is unacceptable. Hence there is a need for performance measures.
- The following are also discussed:
    - National and international awards
    - Changing organizational roles
    - Changing external demands
    - The power of information technology

At least one issue can be added to this list. Vivid academic and practical discussion around the topic has certainly acted as an autocatalysis: discussion has encouraged more discussion, which in turn has triggered even more discussion. Perhaps the performance measurement boom cannot be totally explained using rational arguments.

In spite of this, as Neely (1999) remarks, there are many background issues regarding performance measurement that are very topical at the moment. On the other hand, there are issues that seem to be topical across decades. For example, nearly 20 years ago Uusi-Rauva (1986) stated that in the firm level, the accounting function should more effectively than before focus on the management of various activities of the operating processes instead of being interested primarily in the control of the financial process. Further, Ijiri (1975) pointed out that:

> *”Accounting measurement may then be characterized as primarily economic performance measurement, although in the future this field may be extended to include the performance measurement of social goals or even engineering goals.”*

These remarks are still relevant. Studies on performance measurement practices have shown that financial measures still seem to dominate the measurement culture although non-financial issues are also regarded as important. For example, Andersin et al. (1994) and Laakso (1997) conducted a survey of performance measurement practices. The survey was carried out back to 1992 and the focus was on Finnish metal industry firms. The response rate remained somewhat low: 123 responses out of 1350 sent questionnaires (9.1%). Anyhow, the analysis of the survey results showed that short-term financial measures are dominant. On the opposite end, employee- or supply-chain related measures are quite rare. The most common measures, according to the studies were, respectively:

1. General financial measures (ca. 24 percent of all reported measures)
2. Efficiency/effectiveness, productivity (ca. 21 percent)
3. Ability to deliver (ca. 11 percent)
4. Quality (ca. 11 percent)
5. Sales (ca. 10 percent)
6. Inventories (ca. 8 percent)
7. Customers (ca. 7 percent)

In contrast, Ittner and Larcker (2001) surveyed 148 firms to clarify the managerial perceptions regarding to what extent different performance categories (both financial and non-financial ones) are important drivers for the organization’s long-term success. The five most important performance categories were, in the order of the perceived average importance: customer, quality, operational, employee, and finance. Ittner and Larcker further remark that the non-financial categories were highly correlated, meaning that the respondents regard these domains of performance as substitutes.

The quality of present performance measurement solutions seems to be a concern. Ittner and Larcker (2001) found that the body of research and literature generally maintains that the selection of performance measures is a function of three aspects: organization’s competitive environment, strategy, and organizational design. However, according to authors, the performance effects of these choices remain rather uncertain despite the research efforts. Further, a major limitation identified by Ittner and Larcker relates to the unsatisfactory quality of performance measurement. The authors compared the practitioners' ratings on the importance of different performance dimensions with the ratings on quality (scale of 1 to 7, where 1 = not important/poor quality, and 7 = very important/high quality). As a result, they showed that there are vast differences between the perceived importance and the quality of the performance measures. For instance, in customer related measures the average rating for importance was as high as 5.5 whereas the average rating for the measurement quality was about 3.8. (Ittner and Larcker 2001)

As a conclusion, versatile and multidimensional measurement is certainly not a "done deal". On the other hand, Otley reminds that it is not realistic to assume that the research on performance measurement would result in a totally coherent outline of a rational set of control mechanisms well suited to the purposes for which they are intended. This is because individual measures or components of control systems may approach this degree of rationality but it is unlikely that the total package of control measures that are in place at any point in time will possess such a degree of coherence. (Otley 1999) Nevertheless, ideas concerning effective measurement practices, measurement frameworks and systems, and even individual measures should be further developed. In addition, more evidence is needed regarding the bottom-line effects of PM. The modern business environment calls for good performance measurement for supporting good performance. As Neely, suggests there are four fundamental questions that research regarding business performance seeks to address (Neely 1999):

1. What are the determinants of business performance?
2. How can business performance be measured?
3. How to decide which performance measures to adopt?
4. How can the performance measurement system be managed?

As far as the present state of performance measurement literature is concerned, no single question is fully resolved. Within one application area – NPD – the foundation of this study relies on question two above. This study seeks to contribute to the question of how performance can be measured in product development.

4.1.2 Requirements for good performance measurement

Performance measurement (PM) is most typically seen as a process that is intended to track the goal attainment of an organization (Gooderham 2001). Hence at a general level, the focus of performance measurement lies on the effectiveness and efficiency of the operations. As there seems to exist a general agreement on the main purpose of performance measurement, many authors have collected lessons or advice that have been perceived as important in terms of achieving the objectives set for PM. Good performance measurement is a multidimensional question. Consistently, a wide range of different criteria and frameworks are presented in the literature (Neely et al. 1995). Gooderham (2001), for example, emphasizes the importance of an established link between the strategy of the organization and the measures (to provide means to identify the high-priority actions). Also Lingle and Schiemann (1994) argue (quite analogously to, for instance, (Kaplan and Norton 1993-1996), (Keegan et al. 1991), (Grady 1991), (Brown 1995), (Wisner and Fawcett 1991), and (McMann and Nanni

1994)) that the measures should be strategically anchored. In other words, measurement should be closely linked with business the strategy of the organization being evaluated. Lingle and Schiemann (1994) also propose a test of validity for the measures in terms of this principle: one should be able to determine the business strategy of the organization on the basis of the measures it applies.

Slater et al. (1997), similarly to many others, argue that performance measurement should be based on the strategy of the organization. However, they present a framework for strategy-based PM by relying on three generic strategies (presented by Treacy and Wiersema 1993; Treacy and Wiersema 1995), which are further supplemented by a fourth "generic" strategy. These four strategic options – product leadership, operational excellence, customer intimacy and brand champion – are associated with a particular set of performance measures that are seen as the most relevant in each setting. Also the contingency theory of management accounting suggests that the choice of appropriate control techniques depends on the circumstances surrounding a specific organization. Key contingent variables include the strategy and objectives an organization chooses to pursue. That is, different strategy and different organizational plans are likely to cause different control system configurations (Otley 1999).

Understanding cause-and-effect relationships seems to be equally important to strategy connection. Although those cannot be predicted with utmost accuracy, it is still important to reveal the *assumptions* about the relationships (Gooderham 2001). Specifically, it has been argued that good measures should exhibit a direct cause-effect relationship instead of correlation relationships (Fry and Cox 1989) (see Anderson and Fornell 1994, for comparison). As an example of this, Fry and Cox (1989) found that firms that actually achieved high customer satisfaction also enjoyed superior economic returns (see also Ittner and Larcker 1998). An annual one-point increase in customer satisfaction had a net present value of $7.48 million over five years for a typical firm in Sweden. Given the average net income ($65 million) of the study's sample, this represented a cumulative increase of 11.5%.

According to Gooderham (2001), discussions regarding the priorities are also vital. In practice, assigning weights for measures means discussing priorities, which is a substantially important – and subjective – step in creating PM systems since measures with low weights may be very important in terms of overall goal attainment but would not receive sufficient attention until it is too late. Kennerlay and Neely (2002) refer to a number of criteria that are attributable to effective performance measurement, including – in addition to the previously mentioned – the ability to reflect the company's external environment, customer requirements, and internal objectives that are perceived as important. At the level of individual measures, the PM system design can be analyzed by stating questions such as (Neely et al. 1995):

- What performance measures are used?
- What are they used for?
- How much do they cost?
- What benefit do they provide?

At the next higher level, a number of issues are raised. These include:

- Have all the appropriate elements been covered?
- Have measures, which relate to both long-term and short-term objectives of the business been introduced?
- Have the measures been integrated both vertically and horizontally?
- Are there any conflicts between the different measures?

At the highest level, the PM system analysis concerns:

- Whether the measures reinforce the firm's strategies
- Whether the measures match the organization's culture
- Whether some measures focus on customer satisfaction

In addition to these, Globerson (1985) proposes that performance criteria or measures have to fulfil the following conditions: First, they have to be derived from the company's objectives so that they are well aligned with the overall objectives and intent of the firm. Overall, it is important to make sure that the purpose of the criteria and the measures are clear for everyone. Second, the measures should facilitate benchmarking; they should enable the comparison of organizations in the same business. Third, the measures and criteria should be determined through discussions with the people involved and they should be under the control of the evaluated organizational unit.

> *"For any performance measurement system to work, the measures must be reported back to those that have the ability to affect them." (Frigo and Krumwiede 1998, p. 2)*

Further, Globerson (1985) suggested that it is important to have the data collection and calculating methods as clear as possible. Finally, ratios are preferred to absolute numbers and objective measures are preferred to subjective measures. (Globerson 1985) In line with the objectivity requirement, it has been suggested that the measures should reflect the outcomes rather than the activities themselves (Gooderham 2001) (In contrast, see for example Keegan et al. 1991). At least when the number of feasible measures is very limited, one should concentrate on the results rather than on the doing. On the other hand, if one only measures outcomes, measurement is likely to produce little information on the case-effect relationships present in that environment.

The demand for consistency in PM systems is among the most important requirements. Performance measurement stimulates action towards certain directions (see Chenhall 1997). It has been argued that the consistency of measures and the measurement framework is therefore important: as Neely (1995) cites Mintzberg (1978):

> *"…it is only through the consistency action that strategies are realized."*

Keegan et al. (1991) underscore that performance measures should comprise an integrated set. Comprehensive utilization of performance indicators has been discussed quite early also in Finland (see for example Uusi-Rauva 1986; Uusi-Rauva 1996). One famous example of this is the Balanced scorecard, which seems to be the most extensively discussed performance measurement construct of the 1990's. Since the introduction of the concept in 1992 (Kaplan and Norton), an extensive number of authors and organizations (see for example Wahlström 1998) have applied the Balanced scorecard approach for performance measurement (see for example Maisel 1992; Constantinides and Shank 1994; Hoffeecker and Goldenberg 1994; McWilliams 1996). Analogously to the balanced scorecard approach, Provost and Leddick (1993) propose that by taking into account the various stakeholders of an organization – owners, employees, customers, and communities – when measuring performance, an organization is able to avoid too narrow a focus that would result from the reliance on a single perspective. Also Schneiderman (1996; 1996) underscores that good measures should be linked with stakeholder satisfaction.

Epstein and Manzoni (1997) remind that French companies have been using a tool analogous to the Balanced scorecard for over 50 years (starting as early as in the 1940's) – called "Tableau de bord" (TDB). The logic behind TDB is quite similar to that of BSC. First, the strategy of an organization forms the basis for the measurement system. Second, on the basis of strategy formulation, a number of critical success factors are derived from the strategy. Third, performance indicators are developed to respond to the identified critical success factors. Both BSC and TDB recognize that non-financial and financial indicators of performance are needed, and they are regarded as substitutes for each other. On the other hand, according to Epstein and Manzoni (1997), many applications of TDB have somewhat failed to sufficiently emphasize non-financial indicators and measures that are derived from the company's external environment, including customer-based measures. Furthermore, Epstein and Manzoni (1997) suggest that the Balanced scorecard may have succeeded better in initializing communication and discussion within the organization in which it has been applied. However, it remains open whether this observed difference is due to the nature of the tools or caused by the different cultures of the organizations that apply the tools.

The concepts of the Balanced scorecard and its "relatives" underscore the view that performance measurement of an organization should take into account a number of perspectives or viewpoints. Performance can be comprehensively measured when it is assessed simultaneously from several directions. (Kaplan and Norton 1992; Kaplan and Norton 1993; Kaplan and Norton 1996; Kaplan 1996; Pillai et al. 2002, p. 168)

Quite analogously, it has been pointed out that focusing only on cost and efficiency when evaluating an organization's performance is not enough. Too many performance measurement systems have narrow or uni-dimensional focus. Also Fry and Cox (1989) stressed that local measures should be used with extreme caution. However, the authors do not advocate the elimination of local performance measures but they recommend analyzing the impact of the local measures on the more important global measures such as long-run profit and market share. They also recommend synchronizing the measures from supplier to customer and from short term to long term. In other words, according to Fry and Cox, measurement should be both multi-dimensional and consistent as a whole. As a reflection of this, Flapper et al established a concept of "consistent performance management system" (PMS) (Flapper et al. 1996). By that they mean a system that is able to cover all aspects of performance that are relevant for the existence of an organization as a whole. As a solution, the authors propose a method for the construction of performance measures or indicators consisting of three steps (Flapper et al. 1996): Step 1, defining performance indicators, a preliminary list of indicator candidates for each function of an organization; Step 2, defining relationships between performance indicators. To assist this phase, classifications of indicators are proposed as practical means; Step 3, setting target values, values that trigger different actions on the basis of performance measurement. In addition to these, Lingle and Schiemann (1994) stress the importance of creating a counter-balance between the selected measures (supported also, for instance, by Brown (1995)). This is because improvements in other areas may result in degradation in others. Increased sales, for example, may in some occasions reflect decreasing profitability or product quality.

In addition to good results, Kim and Mauborgne (1998) stress the importance of a fair process. Even when the outcome of the process is desirable, a fair processing has been found important in terms of accepting the result and of overall satisfaction. This “fairness” theme is certainly relevant in the context of constructing performance measures as well: if the performance measures are not regarded as fair enough, one cannot expect to reach full benefits from the utilization of the measures. In creating a fair process, Kim and Mauborgne (1998) underscore the importance of three issues: engagement, explanation, and expectation clarity. In the performance measurement context, engagement can be translated as involving those individuals in the performance measures’ creation process whose performance will be tracked or who will utilize the final measurement system in their work. Explanation means that those involved will understand why the decisions are made the way they are. Expectation clarity refers to a state when everyone knows what the standards to be met are (as demanding as the standards may be). Performance objectives may be very challenging to reach but it is still important to communicate the common objectives in a homogenous way for everyone.

As one synthesis of the literature, Neely et al. provide a list of recommendations for the design of performance measures. The list consists of 22 points, including remarks such as (Neely et al. 1995):

- Measures should be simple to understand (see also Ittner and Larcker 1998)
- PM should reflect the business process, that is both the supplier and customer should be involved in the definition of the measure
- Performance measures should relate to specific goals and targets (see also McMann and Nanni 1994)
- PM should be relevant

Neely et al. presented a framework that can be used to design and audit performance measures (Neely et al. 1997). The framework is comprised of a construct called “performance record sheet” that includes titles that compel to address necessary issues or elements during the PM design process. The elements included are: 1) Measure, the title of the measure should be clear and self-explanatory and not include functionally specific jargon; 2) Purpose, the rationale underlying the measure should be specified; 3) Relates to what, if the measure being considered does not relate to any of the objectives or targets then one should question whether the measure should be introduced at all; 4) Target, specifies the level of performance to be achieved; 5) Formula, one of the most important and challenging issues because formula – the way performance is measured – affects how people behave; 6) Frequency, a function of the importance of the measure and the volume of data available; 7) Who measures; 8)

Source of data; 9) Who acts on the data; 10) What they do, probably the most important element that "closes the necessary management loop". It is not possible to detail the action that should be taken, since that is often context-specific. However, it is possible to define in general the management process that will be followed, should performance appear to be either acceptable or unacceptable.

Importantly, Flapper et al note that in order to have a consistent performance management system, more is required than a (consistent) performance measurement system (see also Kerssens-van Drongelen and Cook 1997). As this is clearly the case, it is unfortunate that the authors do not provide any further comments that would specify the nature or form of that "more".

In addition to all the previous issues, modern performance measurement should also facilitate learning and help to anticipate potential success and failure well in advance to prevent unnecessary drain of resources. According to Otley, performance measurement is a major mechanism that can be used to explicate the set of means-end relationships that the organization has developed to attain its strategic intent. Performance measurement should not only facilitate single-loop learning on the basis of feedback it provides but also double-loop learning to improve the system in such a way that prevents the same dysfunctional behavior to occur again and again (Otley 1999). Pillai et al. (2002, p. 168) summarize that PM should provide help for continuously revalidating those assumptions that are made in the past. This should be done in the light of the knowledge gained from the present projects. The idea is to learn and to consider the requirements for future success. Hence, the importance of an integrated approach that links various phases of the project life cycle is underlined. Lingle and Schiemann (1994) point out that it is important to secure responsiveness to change. The longer the lag between acts and consequences, the more difficult it is to manage the situation. This is why organizations need to consider leading indicators that are able to – if not predict – but at least demonstrate the effect of potential future events.

An important point made by Lingle and Schiemann (1994) is that the measurement system should achieve a strong signal-to-noise relationship. That is, the validity of measures should be one of the principal concerns. The true message of a measure should not be interfered with "background noise" that would make the information communicated by the measure more difficult to interpret. In line with this, Brown (1995) stresses the importance of minimizing extraneous information that is not representative.

An optimal realization of performance measurement seems to depend, among other things, on culture. Namely, it has been found out that the national culture affects the choices of desired performance measures. For instance, cultural differences have been experienced in respect to individual or team performance measure preferences. (Awasthi et al. 1998). Firm size has also been mentioned as a contingency variable of performance measurement system design: On the basis of analyzing both the Balanced scorecard system (Kaplan and Norton 1992) and the performance pyramid model (Lynch and Cross 1995), Laitinen (1996) proposes his own model for integrated performance measurement, especially for small businesses. Laitinen underscores causal links between measures and a sufficient number of perspectives to ensure a comprehensive view of performance. Performance measurement applications for small businesses have also been discussed by Chow et al. (1997).

4.1.3 Inappropriate performance measurement

As Johnson and Kaplan (1987) argue, good management accounting systems cannot assure success, and poor management accounting systems do not lead to automatic failure. However, an efficient and effective system does contribute to the survival of an organization. A number of factors have been associated with poor PM.

The main reasons or the primary sources of inappropriateness of performance measurement are: short-termism, the lack of strategic focus, and local optimization (Neely et al. 1995). Further, another typical shortcoming is that the measures encourage minimization of variance rather than continuous improvement (see for example Johnson and Kaplan 1987; Lynch and Cross 1995; Bourne et al. 2000)). In addition, to be appropriate the measures should not be totally internal but also externally focused (for example Kaplan and Norton 1992). Consistently, too narrow a focus has been considered as a major limitation of many financial and non-financial performance measurement studies. Performance seen as a consequence of something is associated with a number of antecedents that are also interdependent. Thus, a rather comprehensive stance is needed to attain the goal of identifying the regime of performance. Only by studying a single factor or an antecedent it may not be possible to disclose the most essential characteristics of processes related to good performance. Ittner and Larcker (2001, p. 373), for example, remarked that the value of many studies on non-financial performance measurement is limited due to the fact that these studies examine only one of many potential non-financial value drivers. As a result, misleading inferences are somewhat inherent in these studies if non-financial measures are highly correlated or if different non-financial value drivers are substitutes or complements for each other.

Santos et al. (2002) propose that one reason for failing performance measurement - observed in many organizations - is the lack of understanding concerning the relationships between specific performance measures. Santos et al note that both the identification of appropriate measures and the consideration of potential trade-offs between measures can be supported if the relationships between the measures are discussed and understood. Some conceptual tools for this purpose have been proposed in the literature, including strategy maps. (see for example Kaplan and Norton 1996) However, Santos et al suggest that quantitative simulation (supplementing qualitative modeling) can produce value for the assessment of relationships between measures.

Ijiri speaks for unambiguous performance measurement. He notes that a number of measures that would be ideal from the standpoint of accurately reflecting the degree of achievement toward the goals of an organization have to be ruled out because they are impractical. He suggests that there are three main ingredients for hard measures – measures that are constructed in such a way that it is difficult for people to disagree – including (Ijiri 1975): First, the measurement process has to begin with verifiable facts. If the measurement is based on fiction, opinions, or hypotheses, it will invite disagreement. Especially, Argyris points out that performance evaluation on the individual level is one of the things that may initiate defensive reasoning within an organization, thus creating a powerful obstacle to learning. Performance evaluation at this level represents a situation when professionals are forced to assess their performance and behavior against some formal standard. Thus, especially when the evaluation produces unsatisfactory ratings, professionals tend to rely on defensive reasoning that focuses on the claimed shortcomings of the evaluation rather than their own behavior that might provide relevant explanations for the ratings. (Argyris 1991)

Second, according to Ijiri (1975), the measurement process has to be well specified in such a way that it enables all the stakeholders of measurement to judge if the measurement rules used for transforming the input into actual figures are justified or not. Third, the number of measurement rules applicable for a given situation should be restricted. This is necessary in order to be able to secure the consistency of the measurement system.

The ingredients presented by Ijiri (1975) seem to be well grounded and logical. However, regarding the first one, hypotheses or opinions cannot be totally avoided in measurement situations that are focused on future events. For instance in product development, measurement may employ sensitivity analyses and scenarios that are based on assumptions, opinions, and anticipations. In spite of the fact that they can be disagreed on, they can still be very useful for structuring and analyzing the potential impacts and effects of new products. If nothing more, even measures that are not founded on hard facts could be able to provide the organization with a common framework and language that helps to more effectively organize the activity being measured. In addition, even though the measurement may *begin* with assumptions it can proceed into facts. Again in the case of product development, the assumptions made at the initial stages can be verified later in the life cycle when more evidence regarding product performance, markets, and customers is available.

Ittner and Larcker (2001, p.377) argue that the selection of performance measures should be made on the basis of value driver analysis. However, contrary to this need, many of the empirical studies in the field somewhat ignore the analysis of value drivers. According to the literature review by Ittner and Larcker (2001), many studies proceed directly from the organizational design, strategy, or technology choices to appropriate performance measures. A failure in identifying the core issues – such as value drivers – may lead to too large a number of performance measures, which in turn might constitute an organizational problem. First, management may find it difficult to effectively employ and benefit from information if its supply becomes too extensive. Second, information is a resource and all resources are associated with costs (Upchurch 2002). Therefore, rather than a large amount of information as such, the high quality and appropriateness of information should be considered the primary objective.

4.1.4 Dynamics associated with performance measurement

Palmer and Parker (2001) discuss the deterministic assumptions about the world on which, according to the authors, dominant performance measurement models are largely based. The authors argue that the physical world has a fundamental uncertainty – grounded in two properties: sensitive dependence on initial conditions ("butterfly effect") and the impossibility to measure without participation (measurement always affects the system) – at its core. Palmer and Parker (2001) address the question of what lessons can be drawn from this notion in terms of management and performance measurement systems. They argue that aggregation of measures – concentration on "significant few" – is more useful than the attempts to measure at an individual or detailed level.

Also Ittner and Larcker (1998) underscore that a very diverse set of performance measures is likely to cause managers to spread their efforts over too many objectives, which would reduce the overall effectiveness of the performance measurement system due to an "information overload" and a lack of focus. This phenomenon is reported as a typical shortcoming in many balanced scorecard implementations (Ittner and Larcker 1998, pp. 226-227).

Palmer and Parker (2001) put forward that rather than trying to correlate inputs with certain outputs, it is more useful to aggregate individual elements to help to determine which inputs are linked to many more elements within an organization. Furthermore, according to the authors, such a focus on critical few can initiate spontaneous and valuable self-organization that will result in the system being better aligned with the environment.

In many cases, however, self-organization of measures would be too optimistic an assumption. For instance, Vaivio (1999) discussed the emergence of non-financial performance measures. Among other things, he showed how the non-financial measures became embedded into management processes. The study illustrated that the systemization and evolution of non-financial performance measurement at the firm level can be a disciplined and intended effort indeed. In Vaivio's study, the systemization process did not organize itself but it was driven by a key actor. In addition, it required collaboration that provided the sufficient functional expertise. Vaivio (1999) pointed out the role of non-financial measures as a vehicle for focused interactive control. With the assistance of measures, the search for relevant knowledge and the emergence of new solutions were kept within and forced into tolerable limits.

Also Kennerlay and Neely (2002) point out that performance measurement should be a dynamic phenomenon: the measures and the measurement system have to be modified as the circumstances change. However, as a number of drivers of change can be identified (that cause the change to be necessary), one may observe that also a number of barriers for the change exist. According to Kennerlay and Neely (2002), the effective management of a PM evolution requires considering the following lessons: the active use of PM system is a prerequisite for evolution, three interrelated elements of a PM system – individual measures, the set of measures, and the enabling infrastructure – should all be considered during the evolution process, and four stages of evolution that form a continuous cycle exist: use, reflect, modify, and deploy.

4.1.5 Financial vs. nonfinancial measurement

Eccles (1991) points out that ever since double-entry bookkeeping was invented in the fifteenth century, accountants have developed financial performance evaluation methods. As a result, these methods are relatively developed at the moment. Still, supplementing the argument made by Eccles (1991), a word of caution is necessary: despite the fact that the financial performance evaluation *methods* are rather well-developed, financial evaluation *practices* at a firm level are often unsatisfactory and sometimes unreliable and misleading.

Nevertheless, in contrast with the substantial efforts to measure financial performance, efforts to measure, for example, the innovation activity have been relatively modest. According to Eccles (1991), significant resources are needed to be able to place new non-financial measures on an equal footing with financial data measures. Because many critical success factors cannot be measured by using financial measures, companies have adopted non-financial performance measures to supplement the financial measures (see for example Fisher 1992). Non-financial measures may include, for instance, measures of customer satisfaction, quality, innovation, flexibility, efficiency, and effectiveness (Brinker 1997).

Overall, it could be argued that performance measurement should basically incorporate any financial or non-financial measure that is able to provide incremental information on the managerial effort (Ittner and Larcker 1998). This, however, should be done subject to its cost. Among many other relevant issues in this domain, the balance between financial and non-financial performance measurement is one of the topics that has received substantial attention in the literature. It is argued, for instance, that the heavy emphasis placed on financial measures is not consistent with their relative importance (Ittner and Larcker 1998, pp. 206-207). Despite the relative emphasis on different types of measures, the perceived importance of performance measurement nevertheless seems to be increasing over time (see for example Ittner and Larcker 1998, p. 207).

Taking into account that an organization applying non-financial measures would still simultaneously apply also financial measures, the question of the interpretation of figures produced by indicators is interesting. As McNair (1990) asks: do financial and non-financial measures have to agree? According to the authors, the answer is twofold. If permanent changes have occurred, either in terms of capacity, methods, or costs, all the measures should be synchronized. If, on the other hand, the differences between financial and non-financial figures represent volume-based effects or phenomena that will smooth over longer run, a balance between measures is not necessary. McNair (2000) also argues that interpreting the financial and non-financial signals of the business is primarily a management issue instead of an accounting concern. This argument seems to be in line with the idea that performance measurement and management accounting are tools that should be utilized responsibly. Any tools can be used ineffectively or hazardously if necessary caution is not practiced.

Consistently, Drucker (1994) suggests that financial accounting, profit-loss statements, and balance sheets are an X-ray of an organization's skeleton. But he also argues that much as the diseases people most commonly die from, such as heart disease or cancer, cannot be avoided by X-ray diagnostics, an organizational failure does not register in the accountant's figures until the damage has been done. Hence, according to Drucker, organizations need various leading and lagging indicators to point out the directions in which the environment and the organization is likely to proceed.

The claim that non-financial performance measures are the leading indicators of a firm's financial performance is problematic at least to some extent. Namely, it is a typical challenge with non-financial performance measures to show that the financial consequences of initiatives related to non-financial issues actually impact financial performance. (see for example Ittner and Larcker 1998, pp. 218-220) Well in line with this, the adopters of the Balanced scorecard approach tend to place a substantial emphasis on the financial measures (56 percent of weight, compared to 15 percent to customer measures and 12 percent to internal process measures) (Ittner and Larcker 1998, p. 221). As regards the fundamental effects of PM, Ittner and Larcker (1998) recognize that performance consequences that can be observed in performance measurement applications may represent merely a Hawthorne[15] effect and specific measures may only have marginal importance.

Non-financial performance measurement tends to focus on issues that are easy to measure, despite their importance. Important issues are rarely measured if the measurement is perceived as very challenging (Stivers et al. 1998). There are also aspects of performance that are not measured, although they are perceived as important, because the measurement would distort the process being measured (Otley 1999). Due to the reason that there are many intangible factors that affect the success of an organization but that are very difficult to explicitly and quantitatively measure, Rangone (1997) proposes a fuzzy linguistic framework for assessing and modeling the imprecision related to these factors. The fuzzy framework, according to (Rangone 1997), allows a proper handling of uncertainty and ambiguity associated with intangible success factors.

As a branch of non-financial measurement, environmental performance measurement has been advocated, for instance, by arguing that business has an ecological and social impact in addition to an economic one. It is also reminded that the environmental management of a corporation is often good business. (see for example (Eckel et al. 1992), (Lawrence and Cerf 1995)). Environmental performance measures would include both the measures of inputs and outputs. Suggested input measures include expenditures on environmental matters and the existence of recycling programs or employee education. Output measures would include, for instance, the volume of materials processed by internal and waste recycling programs, the volume of waste material generated, and monetary value of damages to the natural and social environment. (Eckel et al. 1992)

[15] The Hawthorne effect (known also as the reactivity effect) refers to the phenomenon that subjects in an experiment behave differently when they know they are being observed. This can threaten the external validity of an experiment. The phenomenon is called the Hawthorne effect because of a study conducted in the Western Electric Company's Hawthorne plant in Illinois in the late 1930s. This study was conducted to measure the effects of certain factors such as lighting on worker's productivity. The researchers varied the conditions at the Hawthorne plant and compared that plant's productivity with another plant. (see for example http://www.ugrad.cs.ubc.ca/~cs444/revised-gloss-stud.shtml or http://www.sociologyessentials-2nded.nelson.com/glossary3.html)

4.1.6 How to analyze measurement frameworks?

Otley proposes a framework or a template for describing and analyzing management accounting practices and control systems. The framework consists of five elements that represent five critical questions to be addressed when analyzing management control systems. These are (Otley 1999, pp. 365-366):

1. What are the key objectives that are central to the organization's overall future success, and how does it go about evaluating its achievement for each of these objectives?
2. What strategies and plans has the organization adopted and what are the processes and activities that it has decided will be required for it to successfully implement these? How does it assess and measure the performance of these activities?
3. What level of performance does the organization need to achieve in each of the areas defined in the above two questions, and how does it go about setting appropriate performance targets for them?
4. What rewards will managers and other employees gain by achieving these performance targets (or, conversely, what penalties will they suffer by failing to achieve them)?
5. What are the information flows (feedback and feed-forward loops) that are necessary to enable the organization to learn from its experience, and to adapt its current behavior in the light of these experiences?

According to Otley, a comprehensive control system involves at least implicit answers for each of the five elements identified. The elements should be addressed both individually and in combination. The framework proposed by Otley (1999) is to some degree applicable also in this study.

4.1.7 Summary

Given the extensiveness of the literature on performance measurement, it would not be feasible to summarize all the key findings only by using a few bullet points. However, the following list comprises the themes that seem to be repeated by many studies and concerning these, a reasonable consensus seems to exist.

- Measures and measurement systems should be constructed from top down: from the strategies and objectives to ensure consistency
- Internal coherence of measurement is important
- Measurement should facilitate learning, learning from past mistakes
- Measurement should provide means for anticipating some future effects
- Measures should focus on outcomes, results, and achievements
- Comprehensiveness and multidimensionality: external orientation and the inclusion of several stakeholders is recommended
- Cause-effect relationships should be identified

4.2 New Product Development Management

Networking and supply chain integration have affected the role of product development in a value chain. Development is – even if actually carried out by one firm – not necessarily only the concern of a single firm within a value chain. When the effects of product development extend over the boundaries of a single firm, also the role of product development carried out by a single actor may change substantially: A modern view of research and development includes a perception according to which the customers think of the supplier's research as theirs (Miller 1995). Also, the success of a company developing new products depends on the success of the entire value chain the company is part of. This is an especially important notion for the companies that develop and produce industrial products – that is products that can be regarded as investment goods. Hence, the objective to help to increase the performance of the customer companies is one of the most important ones for industrial NPD (Kärkkäinen et al. 2001). As a result, the challenges of product development seem to be even more versatile than before. For generating profits through product development, the need to understand the process of customer value creation, for example, is underscored in product development management.

Further, Lichtenberg (1990) advocated that to make appropriate R&D expenditure decisions, firms need reliable data on research and development. Indeed, according to Morbey (1988), statistical analysis of data on the sales growth, R&D spending, and profit growth of U.S. companies covering a ten-year period from 1976 to 1985 showed that there is a strong association between sales growth and spending on research and development. However, Morbey (1988) acknowledges that R&D spending – though very important – is only one of the factors that affect the sales growth. The effect can also vary from one market to another (Hall and Bagchi-Sen 2002). Furthermore, no significant relationship was found between R&D intensity and profitability. Quite to the contrary, at an aggregate level (including the data of all industries) a negative association was found between these two variables. In other words, when profitability declined, R&D intensity increased. Overall, the findings made by Morbey (1988) seem to suggest that to maintain its competitiveness, an organization has to invest in R&D in order to maintain or increase the sales volume. But for maintaining its profitability, however, a high R&D spending *per se* is not enough. Rather, the organization has to simultaneously master a variety of other disciplines as well.

4.2.1 Need and role of NPD performance measurement

On a general level, the importance of R&D performance measurement seems obvious. It has been pointed out that the role of performance measurement in ensuring the success of a new product development project and in securing the project's usefulness to the organization is important. It has also been shown that performance measurement and the specific metrics utilized actually affect the performance achieved by NPD. (Pillai et al. 2002) Overall, the potential contribution of management accounting to new product development is quite well acknowledged and demonstrated. (see for example Uusi-Rauva and Paranko 1998) In many cases, however, practice shows that many industrial companies have not been able to fully utilize the potential of management accounting to promote successful and cost effective product development. For instance, studying the role and the contribution of accountants in new product development has revealed that accounting is consistently ranked as the least important functional team member in cross-functional product development teams (Rabino 2001). According to the evidence presented by Rabino (2001), accounting was the most likely member of the team to be disregarded. In his survey, 66 percent of respondents did not include accountants as product development team members at all. However, it is not clear to what extent the reluctance is based on an interpretation according to which accounting and bookkeeping are more or less the same thing. In other words, it could be possible that the reluctance is rather due to the notorious reputation of the accounting function than doubts regarding the usefulness of accounting or measurement information per se.

Among many other issues, the need for performance measurement is founded on the notion that product development is a function that has to be managed in a well-organized way:

> *"A 'strategy of hope' approach to R&D management has been replaced by a very systematic, disciplined one that emphasizes contribution to shareholder and customer value." (Pearson et al. 2000)*

The more difficult question is then what should be measured in the R&D context. Ellis argues that without objectively measuring the process of innovation[16], one is not able to determine whether expenditures on R&D are beneficial or not. Both the desired outcomes and the inputs and R&D processes that contribute to these outcomes should be measured. (Ellis 1997, p.3) Consistently, McLeod suggests several factors that should be taken into account when selecting R&D projects, including probability of success, time to first sales, profitability, and compatibility with the company's long-term plans (strategy). However, it is argued that there is little point in trying to give the factors any order of priority. According to McLeod, all these factors should be considered as a whole. The construction of numerical indices, struggling with figures, and scoring the projects is not seen as beneficial. (McLeod 1988, p. 254) Indeed, inasmuch as literature is rich with suggestions for measuring NPD, it seems reasonable to argue that performance measurement is no longer excluded from product development activities. Attempts have been made to establish measurement principles, systems, and individual measures for the research and development environment. To a great extent, however, the research focusing on product development performance measurement has not been able to produce effective and powerful practices and support to actually carry out the measurement in product development. For instance, a profound analysis of a proper construction process for NPD performance measures or for an NPD measurement system is virtually absent. (Kerssens-van Drongelen and Bilderbeek 1999) It has also been pointed out that in many cases information needs during the product development process are not matched by the supply of information (Batson 1987). Further, it has been argued that there is a gap between the methods and approaches proposed in the literature, and the

[16] Innovation can be defined as an application of new or different approaches or methods or technologies to meet organizational goals. (Schroeder et al. 1989)

methods that are actually observed in practice. (Kerssens-van Drongelen and Bilderbeek 1999).

Despite the widely acknowledged need for performance measures in NPD, sometimes the act of measurement is thought to restrict and discourage creativity that is seen as a prerequisite for research and development. This kind of view implies that the management of the company should be content with *a faith* that the development actually produces value for the organization. Without measuring the activity, managers are thus expected to *believe* that the development of a new product is an economic investment. It has been stressed that this kind of naïve belief is not appropriate: R&D is not only expected to produce and develop new products and processes but also to show their value to the organization (Brown and Svenson 1998). However, managing R&D strictly by measures can also be misleading if inferences are made too loosely. A promising project does not have to be a major success according to all R&D metrics. Partly because of the uncertainty associated with long-term future events affecting the success criteria of new product development, it sometimes might be necessary also to encourage those projects that are not in line with the selected R&D metrics. Abetti points out that the long-term payoff for R&D might require faith in the value of exploratory research (also), which allows more freedom to create than does applied research or development (Abetti 2002). A multidimensional and structured set of metrics is likely to present the aspects of R&D in a form that enables managers to consider both the long-term and short-term effects of R&D for various stakeholders. Therefore, multidimensional measurement aims at reducing the risk of abandoning or promoting projects on too weak grounds. The findings made by Davis et al. (2001) are in line with this. Davis et al. noted that the probability of commercial success of a project is affected by a number of factors that should be considered when making R&D decisions. Further, the logic of multifaceted measurement is also supported by Cooper and Kleinschmidt (1995), who point out that new product performance is a multidimensional concept. Therefore, a single measure for NPD performance monitoring may not be enough (see also Griffin and Page 1996).

4.2.2 What is pursued: the essence of NPD success and performance?

If an outcome-oriented definition of performance is adopted, the success and performance of new products can be perceived virtually as synonyms. NPD performance and success are multidimensional concepts that have received a number of different interpretations and definitions. The following summarizes both the explicit and implicit ones presented in the literature.

First, according to a very general definition, success is the degree to which the product met the firm's profit objectives for this product (Song and Montoya-Weiss 1998). Second, Brown and Eisenhardt have collected and synthesized a wide body of new product development literature. They have identified three main streams of research: "rational plan" built on the studies by Myers and Marquis (1969), "communication web" originated by Allen (1971, 1977) at MIT, and finally, problem-solving by Imai and colleagues (1985). In each stream, the conception of new product development success seems to be slightly different. As the rational stream interprets success mainly as financial success consisting of, for example, profits, sales, and market share, the communication stream deals with success that is mostly perceptual by its nature: success is defined by a subjective team and management ratings. The problem solving stream concentrates on the operational success concerning more specific issues such as speed or productivity. (Brown and Eisenhardt 1995)

Gomes et al. (2003) explored the relationship between functional intra-organizational integration and new product performance under different conditions of new product project uncertainty. However, the definition of new product performance employed in their survey was a rather narrow one (but a very common one, too). The performance was measured by three budget-type measures:

- Time for development: launched before or after the anticipated time
- Cost: project cost less or more than budgeted
- Quality of end product: lower or higher quality than expected

Taking into account that the authors used survey as their research instrument, the selected measures of success raise a number of questions. First, on the basis of mail survey it is very challenging to obtain reliable information about the real goals employed in respect to time, cost, and quality. Second, relying on the relative measures of success causes difficulties to determine whether a project had actually succeeded or had only attained the goals set for its development but nevertheless failed in the market. Finally, other end product-related aspects than perceived quality were not inquired. In effect, the success of the actual outcomes of NPD is left almost totally unexplored.

Also according to Terwiesch et al., generally discussed NPD performance dimensions have been illustrated through three perspectives (Terwiesch et al. 1998): development time, cost, and quality. Further, some studies such as the one by Brown and Eisenhardt (1995), have added a suggestion that relevant performance dimensions for product development cannot be generalized across different industries, that is, market contexts. Nevertheless, Terwiesch et al. made an interesting observation that *the effect of development performance on the business success was the most significant in slow-growth markets and in markets with long PLC's.* Also, the results showed that NPD performance has a more important role for explaining the profitability of dominant firms than that of firms with low market shares. (Terwiesch et al. 1998). In their study, product development performance was assessed by using five measures (Terwiesch et al. 1998):

- Market leadership: the percentage of significant product innovations that were first to market in the reported period
- Technical product performance: self-assessed technical performance of the product related to competition
- Product line freshness: percentage of sales from the products introduced within the previous three years
- Innovation rate: product life cycle in years multiplied by the number of essential product line changes within the previous three years, further normalized as the relative deviation from the industry mean value
- Development intensity: the number of development personnel for the product group in question divided by respective revenues

Above all, NPD success seems to be a relative concept: Dougherty studied interpretative barriers to successful product innovation in large firms. Her study covered four successful cases, seven uncertain cases, and six cases that failed. Successful products were those that met or exceeded the expectations after their introduction. In contrast, failed products were those that were introduced but subsequently canceled. In the midst of these, uncertain products were not canceled but they did not quite meet the expectations. (Dougherty 1990; Dougherty 1992) Griffin has analyzed product development cycle times of business-to-business products using absolute numbers. Among other things, she has investigated the relationship between the cycle times and product success. Griffin employed seven success measures – including, for instance, new product sales as a percentage of total sales and new product profits as a percentage of total profits – that covered three distinct success dimensions: overall success compared to competitors, success compared to the organization’s objectives, and market or financial success. (Griffin 2002)

Shenhar et al. (2002) et al. have established three success dimensions in their study, including 1) meeting design goals, 2) benefits to customers and 3) commercial success and future potential. These dimensions contain altogether 13 measures of success. However, the authors note that their study yielded a major insight that the list of project success factors is far from universal. In another study concentrating on the role of launch in NPD success, the concept of “success” was measured with relative market share, total sales, months to break even, and the size of the served market. In this study, Oakley found that in order to reach the full benefits of NPD, companies should set ambitious objectives for the product launch and place emphasis on the early introduction into foreign markets (Oakley 1996).

Further, Cooper (1996) and Cooper and Kleinschmidt (1995) have identified 10 different measures, including the percentage of sales by new products, success rates, impact on the firm, and the overall profitability of the business’s total new product efforts. In fact, provided that it is challenging to define the term success in the first place, it is interesting that the literature is full of more or less anecdotal statements regarding the probability of success. For instance, “about 60 percent of developed products actually will become a commercial success” (Cooper 1985, p. 34).

In addition, the concept of product success can be extended over the primary product: Goffin remarks that among the many things a product’s design influences, one of great importance is the issue of customer support requirements. Product support or after-sales service is important for many manufactures not only because it serves as a means to achieve financial benefits through lifetime support revenues that may be essentially higher than the initial product revenue, but also because it is vital for achieving customer satisfaction and competitive advantage. (Goffin and New 2001) Also, Lele (1986) notes that product design is a key factor that affects the efficiency and economics of customer support. Thus, there seems to be a need to also consider customer support during the NPD process. Goffin suggests that ignoring service issues – including for instance installation times, fault diagnosis times, field access times, repair costs, or user training times – in the development process might lead to products being difficult to repair, products which have high warranty and service costs. (Goffin and New 2001)

Further complicating the concept of success, the objectives of different stakeholders for the new product may occasionally be contradictory. For instance, Goffin and New (2001) has found that the primary objective of the manufacturing department may be to reduce assembly costs, which could be seen as an opposing objective for that of the after sales department. This is due to the perception that a product that is easy to manufacture might be difficult to repair at customers' sites.

O'Donnel and Duffy also point out that there is a substantial lack of consistency in defining the concept of performance in the literature. They have summarized some eleven different references that have defined either the concept of performance, dimensions of performance, or performance measurement both in the product development context and at a general level (O'Donnel and Duffy 2002). O'Donnel and Duffy conclude that efficiency and effectiveness are the key terms that emerge from the definitions of performance. These terms are not, however, typically used as a basis for defining performance but rather employed in some parts of the definitions. Also, the relationship between these two elements is not adequately discussed. O'Donnel and Duffy define the relationship between performance, efficiency, and effectiveness on the basis of an activity model that relies on four elements: Goals, resources, input, and output (see Figure 8). Design and development activities are seen essentially as processing knowledge so that knowledge evolves during the development process. The design activity employs resources to transform input to output and in doing so, a number of goals and constraints are directing the activity.

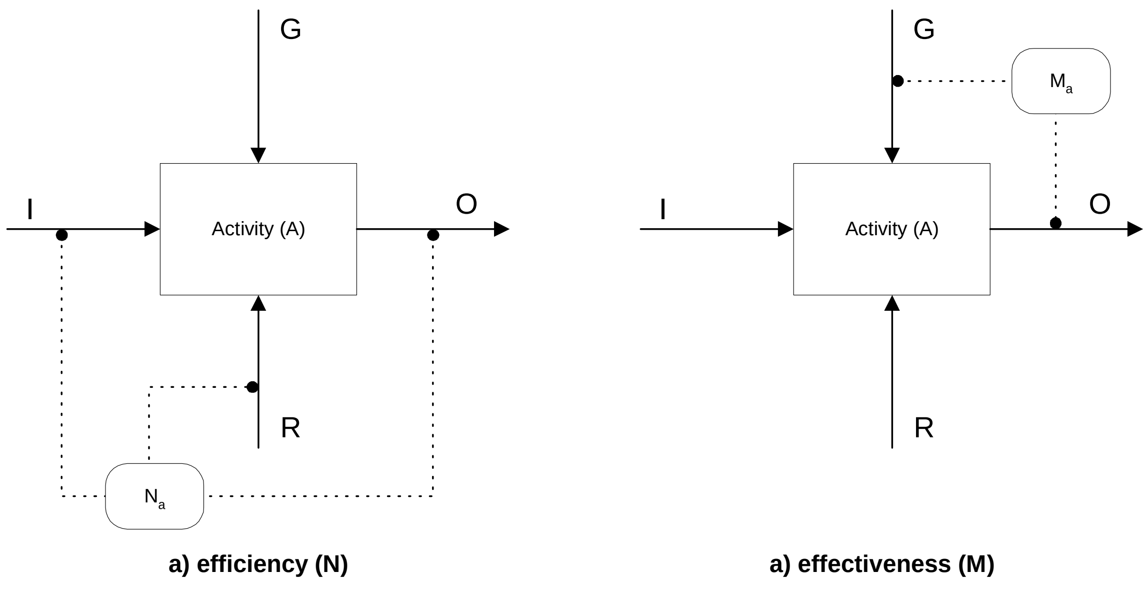


Figure 8. Efficiency and effectiveness (adopted from O'Donnel and Duffy 2002)

The definitions of the elements presented in the model can be summarized as follows (O'Donnel and Duffy 2002, p. 1205):

- Knowledge input (I) is the knowledge present prior to the activity
- Knowledge output (O) is the knowledge present as a result of the activity
- Knowledge goal (G) is the knowledge directing and constraining the activity

- Knowledge resource (R) is the knowledge acting as the input to produce the output

On the basis of conceptualizing the elements of activity, efficiency, effectiveness, and performance (O'Donnel and Duffy 2002) argue three axioms of performance:

- Axiom 1, activity performance. Activities are not only the basic building blocks for processes but they are also considered fundamental means to create performance. No other aspect that is related to performance but the activity itself creates it. These other aspects may affect the type, definition, and behavior of an activity, but the activity itself realizes the performance.
- Axiom 2, efficiency and effectiveness. In all circumstances, performance can be measured by efficiency and/or effectiveness. In other words, all indicators of performance – no matter how general or specific – will indicate either an efficiency or effectiveness measure.
- Axiom 3, activity and management. Activities and their management cannot be totally separated. Every time an activity is carried out, an element of management is involved. That is, even an activity at an individual cognitive level will involve its management. Performance measurement needs to ensure that correct metrics are being used both for the activity itself and its management. Otherwise, conflicts or misdirected efforts will arise.

Foster et al. (1985) have provided a feasible approach to structure R&D performance. The authors distinguish between R&D return (the ratio of profits and investments), R&D productivity (the ratio of technical progress and R&D investment), and R&D yield (the ratio of profits and technical progress). It has been argued that productivity and yield may be rather independent. For example, a positive R&D productivity illustrates that technical progress is possible but for instance due to poor cost efficiency or overcapacity within the industry, the R&D yield may be negative. Quite similarly, according to Ernst and Ross (1993), the profit from R&D is a function of two variables: 1) R&D productivity, which relates to technical progress made for a given level of investment. 2) R&D yield, which is interpreted as the amount of profit made from the achieved technological progress. On the basis of this distinction, it can be pointed out that a company may have high R&D productivity but zero R&D yield, for instance, due to technology development that is not able to currently produce value for the customer. Using this framework for R&D performance, one may observe that R&D performance cannot be comprehensively evaluated on the basis of one variable but the evaluation should cover (at least) both the aspects of productivity and yield.

4.2.3 Drivers of success and performance

It is of interest to both practitioners and academics to pursuit drivers of good new product development performance. Given the rather significant spending on NPD activities across industries and research institutions, some indications concerning the drivers of successful product development would be necessary. Consistently, a rather extensive body of literature has focused on the drivers of NPD performance. Regarding this literature, it is important to recognize that models that are intended for selecting and screening product development projects include at least an implicit premise or assumption that successful projects can be identified in the development stage. That is, these models are based on a belief that a desirable profile for a project actually exists and that the profile is also reasonably capable of predicting the project's outcome (see for example Cooper 1985, p.37).

A good fit between the product and user need is one of the most fundamental issues facilitating success. Dougherty reminds that successful innovators – from the commercial point of view – understand the user needs better than their failed counterparts (Dougherty 1990). It is an imperative that new products are relevant to the needs of the end user (Hirons et al. 1998). In the same spirit Cooper (1996) advocates the facilitators of success: 1) A high-quality new product process that is characterized by: up-front homework on predevelopment work, sharp and early product definition before the development actually started, based on the strong focus on the customer ("voice of the customer") throughout. 2) A clear and well-communicated new product strategy for the business unit that sets the objectives and describes the contribution of NPD to the overall corporate goal. Also recognizes the long-term nature of new product activities. 3) Adequate resources for NPD: sufficient budget and the necessary people available.

Even more comprehensive a list was published three years later. Cooper identifies eight denominators of successful NPD. Levers, as Cooper calls them, that one can pull to heighten one's odds of success are (Cooper 1999):

1. Up-front homework before proceeding further from the idea stage
2. Building in the voice of the customer
3. Seeking differentiated and superior products
4. Early and stable product definition before actual development
5. Strong market launch
6. Tough go/kill decision points
7. Organizing around cross-functional project teams
8. Building an international orientation into NPD process

In addition to the previous list, Cooper and Kleinschmidt have also stressed the importance of a well-defined new product strategy, adequate resources (needed people), and spending on NPD in an earlier study (Cooper and Kleinschmidt 1996). Furthermore, Ottum and Moore have investigated the role of market information in new product success or failure in their study. They have shown that there is a strong relationship between market information processing and new product success. Ottum and Moore stress that effective market information processing requires not only good quality information gathering but also good effort in sharing and using that information. (Ottum and Moore 1997) However, to the extent of customer involvement in NPD there is also somewhat different evidence available. Namely, it is argued that there is no automatic short-term commercial benefit associated with customer partnering when compared to in-house development. Possible explanations for this – as the authors put it, "surprising lack of impact of partnering on new product performance" – may be that the risk-level or complexity differ between in-house and partnering projects or that the quality of collaboration happened to be poor in the sample partnerships. The authors also remind that in the long term, partnering may be important to gain access to customers or to elicit learning (Campbell and Cooper 1999).

Zirger and Maidique conducted a study that analyzed the success or failure of 172 electronics products. Success was measured by financial terms: the more the product contributed to profitability, the more successful it was considered. They found five major issues that affect the success of a new product (Zirger and Maidique 1990):

1. Managerial excellence: Products are likely to succeed if they are planned and implemented well. This includes good coordination, proper monitoring, and efficient product champions that are able to nurture the project through development.
2. New products should provide significant value to the customer: Value can take several forms. It can be related to superior technical performance, to lower price due to a cost efficient design, or it can be associated with a set of unique features.
3. Strategic focus: Products that are based on the company's existing technological, marketing, or organizational competences should be preferred. However, without any ventures in new directions, the company will soon exhaust the potential of its present product lines.
4. Management commitment: Without support from the management, the necessary resources for the development are not likely to be approved. To secure the support, it is suggested that the new product team should be able to clearly demonstrate the market need for the new product.
5. Market environment: Products that are first to the market and experience little competition are likely to be successful.

Poolton and Barclay (1998) have collected a number of factors that are associated with the development success of new products. They have organized them into two classes: tactical and strategic. Tactical factors include, for instance, good communication (internal and external), innovation as a corporate-wide activity, high quality of management, key individuals, understanding user needs, and good after-sales service for the products. Strategic factors include, for instance, management support for innovation, long-term strategy with a focus on innovation, long-term commitment to major projects, and acceptance of risk. Davis et al propose five factors of technical probability of success for R&D projects including: proprietary position, competencies and skills, complexity, access to external technology, and manufacturing capability. Further, they introduce six factors of commercial probability for success including: customer and market need; market and brand recognition; distribution channels; customer strength; raw materials supply; and environment, health and safety. (Davis et al. 2001) Pinto and Slevin have identified ten factors that are critical to and predictive of success for R&D projects including project mission, top management support, client consultation, personnel, client acceptance, monitoring and feedback, and communication. The order of importance of these factors is further depending on the stage of the NPD project life cycle. The life cycle of the project is organized around four stages: conceptual, planning, execution, and termination. (Pinto and Slevin 1989) In addition, to further extend the list of success factors, the following factors having a statistically significant impact on the R&D success of related new products at 3M have been identified (Krogh et al. 1988):

- The competitive position of the business unit developing the product

- The firm's product performance in relation to competition
- Degree to which the technology being developed is related to the existing technical base of the firm
- Degree to which the market of the product being developed is related to the existing business base of the firm

In addition, provided that the success of a product is a temporal variable, also the factors affecting success have a temporal dimension. Clark and Fujimoto point out that inasmuch as many industrial products have long life cycles and companies' development actions can be considered a continuous process that results in products over a long period of time, customer satisfaction must extend over the long term. Clark and Fujimoto distinguish three factors that affect the ability of the product to satisfy customers (Clark and Fujimoto 1991, p. 68-):

1. Total product quality (TPQ). The extent to which the product satisfies customer requirements. TPQ is built on both objective attributes such as, taking an example from the car industry, acceleration and fuel efficiency and subjective elements such as aesthetics, styling, or driving experience.
2. Product development lead time. A measure of how quickly a company is able to move from concept to market. Lead time affects both the execution of the development and the acceptance of the design in the market.
3. Productivity. The level of resources required to take the product development project from the concept phase to a commercial product. Productivity has at least a twofold effect on the performance. First, it has a direct (but sometimes relatively small) effect on the unit cost of the product. Second, it affects the firm ability to conduct a number of product development projects at a given level of development resources.

The effect of these three factors on competitiveness and customer satisfaction is seen as somewhat hierarchical (see Figure 9). Long-term competitiveness is suggested as a function of total product quality and contributions that originate from other functions. Further, total product quality is connected to product development performance represented by lead time and productivity.

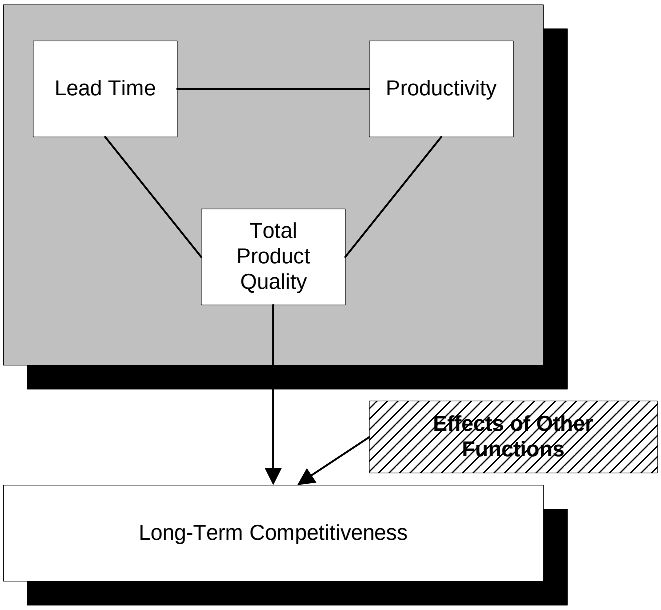


Figure 9. Factors associated with the product development performance (Clark and Fujimoto 1991)

Montoya-Weiss and Calantone (1994) studied 47 articles on new product success. All of these included commercial[17] measures of performance as a dependent variable describing new product performance. Only four studies were found to include technical success measures. Regarding the antecedents of success, eighteen factors were identified within the literature. These factors relate to four categories: market environment, new product strategy, development process execution, and organization. (see Table 9) Montoya-Weiss and Calantone (1994) remind that while there is some consistency as to which factors (determinants) are included in analyses, the typical set of factors employed within one study is too narrow.

[17] Both financial success measures and market share attainment measures were considered as commercial measures of performance.

Table 9. Determinants of success employed in studies on new product performance (Montoya-Weiss and Calantone 1994)

Category	Factor
Strategic	Product advantage
	Technological synergy
	Company resources
	Strategy
	Marketing synergy
Development process	Proficiency of technical activities
	Proficiency of marketing activities
	Protocol
	Top management support
	Proficiency of pre-development activities
	Speed to market
	Financial business analysis
	Costs
Market environment	Market potential
	Market competitiveness
	Environment
Organizational	Internal/external relationships
	Organizational factors

Analyzing unsuccessful projects may also reveal important lessons regarding factors that drive good performance. Whittaker studied information technology projects carried out in leading organizations in Canada. She found out that the most common reasons for a failing project were (Whittaker 1999): Poor project planning in terms of inadequate planning and risk analysis, a weak business case in which organizational goals were not well aligned with the project, and the lack of support from the top management. Management support is an issue that is often referred to and it was found to be important also in this study. Furthermore, Whittaker noted that 60 percent of the failed projects were planned to take less than a year to complete. It indicates that especially in the short projects the risks and requirements associated with the project are too easily underestimated. (Whittaker 1999)

As one may observe from the above, the findings of many studies on new product development performance read like a "fishing expedition". There are sometimes even too many variables associated with the success. Especially in the rational stream – that looks at NPD as an activity that is supposed to be based on rational planning and execution – it is common for a study to report 10 to 20 or more factors that contribute to success. Also, the research streams suffer from retrospective "sense making" of complex past processes that includes a host of different kinds of biases, myopia, and memory lapses. This is partly due to frequent use of single informants in those studies. (Brown and Eisenhardt 1995)

In contrast, there are also studies, which try to elaborate the mechanisms that are either connected to successful product development or actually lead to successful innovations. These studies often discuss a limited number of issues at a time but in doing so have the possibility to provide more in-depth understanding of cause-effect relationships present in product development. For instance, for successful innovation activity, Dougherty suggests that attention has to be paid on the effects of thought worlds – “a community of persons engaged in a certain domain of activity who have shared understanding about that activity” – and organizational routines. According to Dougherty, two aspects of thought worlds are relevant to product innovation: their “fund of knowledge” – what they know, and their “systems of meaning” – how they know. (Dougherty 1992) In new product development, departmental thought worlds could selectively filter information and ideas. Due to specialization, a certain thought world is likely to best understand some issues, but also to ignore information that might also be essential to the task. Therefore, thought worlds may disable an important link between the technological possibilities of a product and the market possibilities. thus limiting the comprehensive understanding. As Dougherty demonstrates, innovation is an interpretative process. The management of innovation must involve the management of interpretative schemes that shape how people make sense of their work. Collective action is required in the innovation process. To be able to overcome the possible interpretative barriers, three processes are suggested (Dougherty 1992):

1. Use the unique insights of each thought world: all must actively contribute to the design, and actively challenge each other.
2. Develop collaborative mechanisms: interdisciplinary responsibility for focus groups, market research plans, and visits with users should, for instance, enhance collaboration.
3. Develop an organizational context for collective actions: interactions should be based on appreciation and joint development; product definitions should be based on collective and first-order customer knowledge.

Indeed, there are many studies that emphasize the role of good internal communication and effective cross-functional cooperation in successful new product development (Elias et al. 2002). This notion has been reinforced by the study of Song et al. (1997) by stating that cooperation as an antecedent of NPD success is seen quite consistently within different functional departments such as marketing, R&D, and manufacturing.

> *“All critical organizational parties should take part in the NPD process from the beginning of the process”. (Song et al. 1997)*

Also the role of top management is seen as very important in NPD. This is due to, among many other things, its significant control over the culture of cooperation. (Song et al. 1997) However, the top management is not the only group that is of importance. It has been found that R&D and product development should not only concern and satisfy the needs of customers but also respond to the requirements of different stakeholders: such as employees, owners, suppliers, dealers and alliances (Miller 1995). Identifying the stakeholders[18] of an R&D or a new product

[18] The concept of “stakeholder” dates back to 1963 in management literature. According to Elias et al, the concept appeared in a memorandum at the Stanford Research Institute. According to that definition, stakeholders were seen as groups whose support is elemental for the existence of an organization. In other words, a firm is not likely to survive without the support of the stakeholders. (Elias et al. 2002)

development project and analyzing[19] their interests supports better management of the projects. A systematic management of the stakeholder interests is underlined because of the rather generally acknowledged difficulty in R&D management to communicate the value of the development to sponsors and to other stakeholders who make decisions regarding the funding. (Elias et al. 2002)

Despite the belief that the effects of cooperation are generally positive, cooperation does not seem to be equally important in all settings. Gomes et al. (2003), for instance, conclude that the degree of product innovativeness is one of the contingent variables explaining the nature of the relationship between intra-organizational collaboration and new product performance. According to Gomes et al. (2003), collaboration is the most relevant and effective in the case of high product innovativeness. In addition, Ancona and Caldwell provide more contingent variables regarding the benefits of collaboration. They have investigated the effect of the composition of the new product team on the performance. Performance has been interpreted as, for example, team efficiency, quality of technical innovations, ability to resolve conflicts, adherence to schedules, and adherence to budgets. They found that, although literature predicts that team diversity – in general – will have an impact on performance, certain distinct effects can be identified depending upon the type of diversity: The more heterogeneous the team in terms of tenure, the greater the clarity of the group's goals and priorities. This is, for one, associated with high team ratings of overall performance. On the other hand, rich external communication is associated with great functional diversity. The more external communication the team members have with other teams, the higher the managerial ratings concerning team innovation. (Ancona and Caldwell 1992) Further, it has been found that the product development team's stability increases the probability of product success in stable environments. However, in turbulent conditions, when reducing or eliminating pre-existing knowledge is sometimes needed for the sake of removing potential barriers to learning, team stability does not play such an important role. These findings have been made on the basis of defining success as meeting or exceeding expectations regarding sales volume, profits, market share, and some subjective criteria. (Akgün and Lynn 2002)

Further depicting the role of cooperation, Kessler et al found that external sourcing – using external ideas to prompt learning – within the product development process has significant effects on the speed of innovation and on the creation of competitive advantage. Further, these impacts were found to be contingent on the stage of the product development process. In contrast with externally generated ideas, internal sourcing – when it takes place at the early stage of the innovation process – provides the development team members with a good basis to work together in a committed way to secure the successful completion of the project. In addition, outsourcing seems

[19] Three levels of stakeholder analysis include rational, process, and transactional (Elias et al. 2002):

- rational level: an understanding regarding who the stakeholders are and what their perceived stakes are
- process level: an understanding of how the organization either implicitly or explicitly manages its relationship with the stakeholders
- transactional level: understanding the set of transactions and bargains between the organization and its stakeholders

to increase the completion times of projects, especially when it takes place in the technology development phase. (Kessler et al. 2000)

There are some attempts to connect the NPD success with the way to organize the new product development project (Larson and Gobeli 1988). Larson and Gobeli found that there is no single best way to organize an NPD project. Project team, project matrix, and balanced matrix demonstrated roughly equal success rates[20]. However, functional matrix and functional organization are suggested to be less effective than the other forms.

Time is one of the contingent variables that are regarded as important for new product development success (see for example Anthony and McKay 1992). At the same time, it seems to be a rather common misconception that a short new product cycle time is strongly connected to good new product success. Griffin demonstrated the lack of such a connection in a study that employed seven success measures, including financial ones. She notes, however, that the short development time might be otherwise beneficial to an organization, for instance, by providing the firm with a possibility to reduce development costs or by providing the personnel with an opportunity to participate in more new product projects during their career with the firm. (Griffin 2002) In contrast, a study by Lynn et al. has illustrated a positive correlation between development speed and new product success. However, they had not employed absolute measures either concerning the speed or the success. Speed had been measured by asking about the perceptions of management regarding, for instance, the timeliness of launch, the overall time-to-market, and the performance compared to an industrial norm. The concept of success was also a multi-item construct relying on managerial perceptions. (Lynn et al. 1999) Further, to comprehensively understand the effect of NPD cycle time on product success, one should also consider the issue of market growth. For instance, Lynch and Cross (1995, p. 108), cite an analysis of McKinsey & Co showing that late commercialization has a significant impact on the life cycle profit of the product. In summary, similar to the behavior of several other factors in new product development, speed or cycle time – faster product development – alone is not able to secure high performance and success (Ittner and Larcker 1997). It has also been pointed out that the impact of speed to market on new product performance has not been studied extensively enough (Montoya-Weiss and Calantone 1994).

Clark and Fujimoto argue that *integrity* is the factor that differentiates successful innovators from those that tend to fail. As a measure of integrity concerning industrial customers, it is proposed that new products should mesh with existing components in a system or production process. More specifically, Clark and Fujimoto divide the integrity into two components: internal and external. Internal integrity refers to the consistency between a product’s function and its structure. As a means to achieve internal consistency, they advocate cross-functional coordination within the company and with the suppliers. In contrast, external integrity is interpreted as the consistency between a product’s performance and the customers’ expectations. (Clark and Fujimoto 1990)

[20] See Larson and Gobeli (1988, pp. 181-182) for detailed descriptions of the different project structures.

Inventions (new products) can also be viewed as results from the combination of components, either physical things or ideas, in new and useful ways (Fleming and Sorensen 2001). Rather interesting findings can be made at this level. By drawing on the data of the U.S. Patent Office covering over 200 years of innovation history, Fleming and Sorenson have concluded that even though using interdependent components – in contrast to modular designs – in product designs makes innovation much more uncertain and difficult, it often results in breakthrough products. They put forth that highly modular designs make product development more predictable indeed, but many companies use modularization techniques to an extent where they actually undermine the innovation process by unnecessarily reducing the opportunities for more radical advances. (Fleming and Sorensen 2001) To some degree consistently, Firth and Narayanan studied 459 new product introductions during a five-year period in altogether 18 large firms. They found out that firms emphasizing market innovativeness in their new products achieved higher returns (operationalized by using measures such as ROI, return on investment) compared to those of less innovative firms. Surprisingly, the innovative organizations gained the advantage without a simultaneous rise in the risk level. (Firth and Narayanan 1996) In contrast, the analysis of a number of successful and unsuccessful R&D programs at 3M has revealed that the programs that are related to “maintenance of existing business” have the highest odds to succeed, whereas the programs that pertain to the creation of totally new business are the most likely to fail. (Krogh et al. 1988) Regarding the totally new products, the uniqueness or newness to the world of the developed product and the firm’s competitive position in the closest industry have been identified as having the most significant effect on the success (Krogh et al. 1988). Between these two, the probability of the success of programs focusing on new products that are well connected to the existing business of the firm depends on the target of the program: success is achieved more often with those programs that pursue high sales targets than with those that are aimed at smaller ones. (Krogh et al. 1988) Further, Hultink et al. have studied the new product selling performance as one dimension of success. The main focus was on the determinants of success and, indeed, a number of factors positively correlated with the selling performance were identified including, for instance, an experienced sales force responsible for selling the product, market familiarity, and product familiarity. “New to the firm” and “new to the market” products were found to be negatively correlated with new product selling performance. (Hultink et al. 2000)

Overall, it seems clear that no single recipe for success can be given. Success depends on the nature of the market, individual customer preferences, the maturity of the technology, or the degree of innovativeness, for example. As regards the product development practices, “one size does not fit all”. Too generic approaches for product development management and measurement are restricting the possibilities for practitioners to implement them into action. According to Poolton and Barclay, it is more appropriate to adjust the product development practices on the basis of the type of product than to suggest a generic approach. (Poolton and Barclay 1998) Well in line with this, the performance measures could be attached specifically to the product being developed: the product would be the focal point when NPD measures are being developed. In practice, this would require the systematic and comprehensive assessment of the anticipated product life cycle and its phases.

The success factors of new product development may also be contingent upon the firm size. For instance, Ledwith (2000) has found that small firms have somewhat different success factors than large firms. Souder and Jenssen, for one, have studied successful new product development practices on a cross-cultural basis between Scandinavia and the U.S. As a conclusion, they implicate that some core NPD management principles may be common to all cultures, whereas others have to be adjusted to cultural variations. (Souder and Jenssen 1999) It should be noted, however, that in the process of linking antecedents and outcomes (NPD success or failure) Souder and Jenssen have interpreted NPD success only as the commercial success of the outcome. Further, Hultink et al. have concentrated on one of the antecedents, namely product launch decisions and the launch support program, to understand new product success. (Hultink et al. 1999) However, in their study it also remains unclear to some extent what is actually meant by "success" and "failure". Further, the study by Song and Montoya-Weiss underscores clear differences in the determinants of success for really new and incremental products. The authors note that there might exist a basic skeleton of a new product development process that is mainly applicable across different development conditions, but the process is to be applied differently depending on the product innovativeness and type. The findings of the study produce several interesting insights. (Song and Montoya-Weiss 1998) First, insufficient emphasis seems to be placed on product commercialization activities. This holds true for both really new and incremental products. The findings, however, suggest that proficient execution of product commercialization activities is an equally important requirement for the success of both types of new products. Second, a significant gap has been found between current and best practices regarding the relative emphasis on strategic planning activities. The level of proficiency in strategic planning activities is relatively low for really new products. In contrast, for incremental products the mean level of proficiency in this domain seems to be relatively high. Yet this seems to be exactly the opposite order to what is really needed for success. Really new products would benefit from greater emphasis on strategic planning. This planning would be able to give some boundary guidelines that help to cope with the uncertainty associated with the development of totally new products. In contrast, incremental products are merely hurt by excessive efforts in strategic planning. Regarding these products, strategic planning could be simplified by drawing on previous insights and successes.

> *"For really new products, customer needs are often not well-defined and competitor capabilities are often not clearly established. As a result, detailed market studies are not of great value and can be exorbitantly costly. Really new products will likely involve extensive consumer education and iterative learning from the market as customer requirements and technological capabilities co-evolve." (Song and Montoya-Weiss 1998, p. 132)*

The evidence by Song and Montoya-Weiss supports the finding that really new products consistently achieve higher levels of success compared with incremental products. (Song and Montoya-Weiss 1998, p. 132)

Whilst several decades of R&D studies have produced a good deal of data with respect to variables associated with the success and failure of new products, the research has not been able to resolve a practical problem: how should R&D be actually managed to promote high new product success rates? Poolton and Barclay conclude that managers are still relying on gut feeling regarding "best practice" in new product development. Analogously, research has tended to be theory-driven instead of being applications-based. (Poolton and Barclay 1998) Driva et al. conclude that in most cases companies do not measure the R&D activity very well but they are striving to find out how to do it effectively (Driva et al. 2000). In this respect, it seems fair to claim that a good deal of work to improve the efficiency of the interface between industrial R&D management and academic R&D research is still needed.

The nature of the management control system seems to be an important issue also in a sense that it itself affects the performance. When the new product performance is defined on the basis of subjective, self-reported measures, it is shown that the use of different measurement information (including cost-, time- and product design-related) is significantly related to performance. More specifically, better cost and product design information is positively associated with the performance but time information has a negative effect. Thus, a management control system's design is, as such, related to performance. (Davila 2000) This notion highlights the importance of paying proper attention to the design, composition, and use of any control system. Indeed, there is evidence available that the most successful organizations tend to use performance measurement in new product development more extensively than the firms whose performance is inferior (Griffin 1997):

- 75.6 percent of the firms develop formal financial objectives against which the performance could be evaluated
- The portion of best firms that employ formal financial criteria is slightly bigger than the respective portion of inferior firms. However, the difference between these two is not statistically significant.
- 63.2 percent of the best firms actually monitored the actual NPD performance against the formal criteria
- Only 48 percent of inferior firms monitored the actual NPD performance against the formal criteria

In addition, higher targets lead to better outcomes: according to the PDMA best practice study by Griffin, the best firms typically have higher expectations for the future new product development performance than the rest of the firms (Griffin 1997).

Finally, it seems appropriate to conclude this section with a remark that deals with the importance of an overall pattern in contrast with the importance of details. After studying the car industry and the product development performance of a number of car manufacturing companies in the United States, in Japan, and in Europe in the 1980's Clark and Fujimoto conclude that a prerequisite for high-performance development seems to be consistency in the overall pattern of product development (Clark and Fujimoto 1991, p. 306):

> *"No single capability, no one structural characteristic, no particular strategy, no specific process made the difference… Only when a company developed a consistent pattern across many variables in all areas did it achieve superior performance. It appears that to be effective in product development, an organization must do many things well in a consistent way, rather than do a few key things exceptionally well."*

Quite consistently, it has been argued that achieving success requires a firm to have control over a number of disciplines simultaneously. Griffin (1997), for instance, reminds that benchmarking the best practices of new product development has revealed that the best-performing firms do not succeed by utilizing one NPD practice better than the others, but by using a number of practices and methods more effectively.

4.2.4 Performance measurement applications

4.2.4.1 Guidelines for measurement

Werner and Souder have studied the state of the art of measuring R&D performance. By conducting an extensive literature survey, they have structured the present measurement techniques into three main categories on the basis of two dimensions (Werner and Souder 1997): First, measures can be either qualitative or quantitative and secondly, the measures are either based on objective information or on subjective judgments. Thus, quantitative-objective, quantitative-subjective, and qualitative-subjective classes of research and development performance measures are established. A qualitative-objective measure is regarded as a paradox, which is excluded from the analysis. In addition, integrated measures that combine the subjective and objective elements constitute a class of measures of their own. Indeed, according to Werner and Souder, some degree of integration between subjective and objective elements would produce the most effective measures for research and development. This is because the integration is likely to reduce biases and capable of taking advantage of multiple dimensions of excellence. Hence, to be able to capture the nature of a number of different research and development processes, integrated measures are often needed. Furthermore, taking into account the wide spectrum of issues that relate to different stages of the R&D cycle, different methods are preferred depending on the stage and its requirements. This idea is depicted in Figure 10.

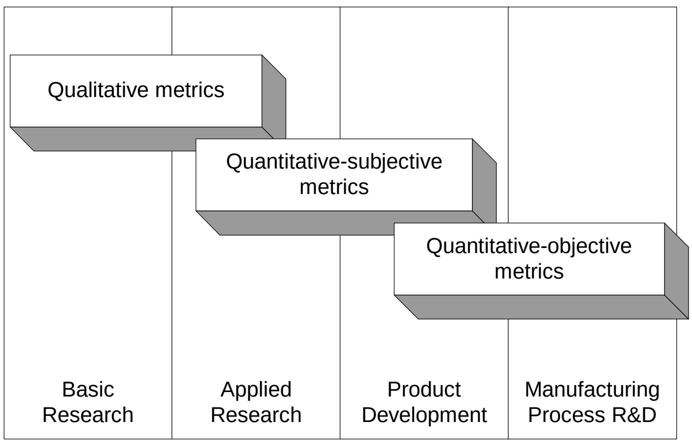


Figure 10. Preferred approaches for R&D measurement in each stage of the R&D cycle (adopted from Werner and Souder 1997, p. 40)

Further, Nixon has identified three main limitations of the literature on research and development performance measurement (Nixon 1998). First, according to Nixon, behavioral and more qualitative factors that may influence the design and operation of performance measurement systems have not received enough attention. These factors include issues like styles of evaluation, organizational culture and climate, strategic management styles, cognitive styles of decision-makers, and belief systems. Second, the literature on the evaluation and measurement of development has to some extent neglected the management process of simultaneous new product development and the modern practices that organizations are being compelled to adopt to reduce costs, risks, or time-to-market. For instance, many companies are striving to guide product innovation and development so as to find a balance between the company's cash flow or profitability requirements and customers' purchase price and ownership cost needs. These challenges should receive more attention in the performance measurement literature. Third, the definitions of research and development (what activities are included, what are the inputs and outputs) leave an enormous scope for different judgments about these activities. As a result, it is a big challenge to define quantifiable measures for research and development or to allocate/assign costs to these activities. Considering the limitations in the literature, Nixon proposes that management accounting techniques could be applied to enhance and develop R&D performance measurement. (Nixon 1998)

One of the most important problems related to new product development success measurement is the issue of multidimensionality of product development outcomes (Griffin and Page 1996, p.479). At least three general dimensions can be presented (Griffin and Page 1996, p.479): consumer-based, financial, and technical. Griffin and Page argue that these dimensions are independent of each other: "Achieving success with consumers is unrelated to whether a product produces profit for a firm". This seems to be, however, only partly true: one could achieve customer-based success without producing profits to the organization but is not very likely in a competitive market to be able to produce financial results without simultaneously succeeding with respect to the customer perspective. Nevertheless, as Griffin and Page point out, firms often have to settle with some kinds of compromises between these three success dimensions. A sacrifice in one level might be required in order to be able to reach success in another. Griffin and Page found that the most appropriate measures for new product success depend on the new product and business strategy of the organization (Griffin and Page 1996). On the basis of simulated strategy scenarios that were assessed by new product professionals in order to identify the measures that would be the most appropriate for each strategy option, the authors concluded that for *new-to-the-world* products, customer satisfaction and customer acceptance were the most useful measures, in addition, meeting profit goals and internal rate of return and competitive advantage were seen as the most appropriate measures. The success of *new-to-the-company* products would be the most relevant to assess by using measures like profits, market share goals, competitive advantage, and customer satisfaction. For *product improvements* customer satisfaction, profits, and competitive advantage were regarded as the most appropriate measures of success. Regarding *cost reduction projects*, the measures of meeting profit margin goals and, once again, customer satisfaction, were seen as important. Utilizing four generic business strategy types originally presented by Miles and Snow (1978) (see for example Slater and Narver 1993), namely prospector, analyzer, defender, and reactor, Griffin and Page identified that in addition to the new product strategy, the business strategy also affects the appropriate performance measures of new product success. Further, a particular set of measures always varies from company to company (Tipping 1995). This is due to, for instance, different requirements in different industries and differences between competitive strategies between firms within a particular industry. Tipping et al. argue that one thing is still common to all measurement situations in R&D: to be able to comprehensively measure the performance, one has to adopt a holistic view. (Tipping 1995)

The need for multidimensional and multifaceted (including both financial and non-financial measures) measurement of NPD leads to an idea to employ some kind of balanced scorecard system for measurement. In fact, the Balanced scorecard has been identified as a suitable method for the performance analysis of new product development. According to Sandström, at least three benefits are associated with the utilization of the Balanced scorecard in product development: its future orientation, its clearness, and the ability of the BSC to capture multiple perspectives of performance. A prerequisite for the successful implementation of the BSC is the involvement of the designers (users, more generally) during the process of developing the measurement system. (Sandström and Toivanen 2002) Generally speaking, the involvement seems to be important since the R&D measurement should be consistent with the way the development is organized and planned. Hence, emphasis has to be put on the alignment of performance measures and the decision-making process. (Pearson et al. 2000) Measures should not come "out of the blue", so to speak. Further, the alignment between the measurement system and decision-making process is a result of many issues. Five major parameters for research and development performance measurement systems and their design are identified by (Kerssens-van Drongelen and Cook 1997). These include (see also Uusi-Rauva 1996):

- The metrics or measures of performance themselves and the structure along which the measures are organized
- The norms and standards against which the performance is determined
- The techniques and methods employed in the measurement
- The frequency and timing of reporting and measurement
- The reporting format

Besides the choices regarding the five basic parameters, a number of contingency factors are likely to influence the performance system design. For instance, the organizational level is affecting the measurement. Also, the nature of R&D – i. e. the position of the subject of measurement in the continuum from basic research to product development – and the type of industry are factors that affect the design of a performance measurement system (Kerssens-van Drongelen and Cook 1997). However, although the contingency factors seem reasonable and valid as such, it is to some extent in doubt whether the contingency factors actually directly affect the performance measurement design or whether the factors just affect the choices made regarding the five basic parameters. Nevertheless, a number of issues shape the performance measurement system and its requirements. Interestingly, the authors found that the selection of measures was not as criticalan aspect of performance system design as it was anticipated to be. The least and most effective measurement systems included roughly the same set of indicators, which implies that the other design parameters are far more important than the metrics for the effective design of an NPD performance measurement system. (Kerssens-van Drongelen and Bilderbeek 1999)

One of the possible explanations relates to organizational climate: Krogh et al have recognized the importance of the right atmosphere and attitudes for the success of R&D evaluation and assessment. They have argued that a constructive approach is most likely to truly support the R&D units being evaluated. Also, Krogh et al support a practice that the recommendations that can be derived from the performance evaluations do not automatically lead to certain actions. In other words, although the performance of an R&D project or program would be evaluated as questionable, that would not result in automatic termination of the project. Hence, the primary aim of the R&D evaluation is not a straightforward screening of efforts, but rather the evaluation is targeted to support the planning and allocation of resources. (Krogh et al. 1988) This view is underscored by the fact that in many cases NPD performance measurement has to be conducted on the basis of subjective assessments. If this is the case, one of the problems that have to be solved is the standardization of subjective opinions or responses. Davis et al suggest anchored scales for the assessment of R&D efforts (Davis et al. 2001). According to them, an anchored scales -system is able to standardize the responses when multiple evaluators are conducting subjective assessment. An anchored scales –system consists of ordinal numeric indicators, each of which is associated with a set of words or phrases that help the evaluators to anchor their opinions. As an example, consider the assessment of raw material or key components supply related to a new product (Table 10).

Table 10. Example of using anchored scales for NPD assessment (Davis et al. 2001)

Anchored scale for raw material or key components supply	
Anchor point	Anchor point description
5	Multiple suppliers; vendor relationships, with acceptable pricing, easily negotiated
4	Single, reliable source with stable contact
3	Currently producing, single supplier identified, but no commitment to supply
2	Supplier identified, willing to manufacture but currently is not
1	No known suppliers

The idea presented by Davis et al conveys the logic that for each factor being assessed, one should determine a set of conditions or scenarios that would represent both the more desirable and undesirable conditions for the new product. Based on this, the project evaluation could be conducted also on a quantitative basis. Quantitative assessment would allow, for instance, numeric weighting of the factors if one has to be emphasized over another.

Theoretically, anchored scales seem like a feasible idea. However, in practice, the method raises a number of questions: First, it is likely to be rather challenging to determine a set of consistent and suitable descriptions for a number of factors. Second, it is nearly impossible to reach any commensurability within and across different factors as different descriptions reflect either more demanding or less demanding criteria for reaching a certain anchor point. Thirdly, even on the basis of written descriptions of the anchor scales, individual evaluators are likely to rely on their own interpretations, which to some extent jeopardize the sort of "pure standardization" that is pursued with this method.

Performance evaluation can be founded on the external customers' opinions. For instance, Hirons et al. (1998) propose external customer satisfaction as a measure of research and development management. On the other hand, Pearson et al identify the "everything should begin with the customer" -thinking as one of the most popular management dogmas that is also well represented in the measurement of development activities, for instance, through an emphasis on customer satisfaction metrics (Pearson et al. 2000). At the same time, there is a consistent pattern in the failure of leading companies to stay on the cutting edge of their industry when a technological or market paradigm shift occurs. Hence, good management of R&D is characterized by the design of an evaluation process that focuses on weeding out the products and the technologies that do not properly address the customer needs. (Pearson et al. 2000)

A word of caution has been added regarding the use of surrogate measures (such as number of patents or new products). A surrogate measure may fail to capture, for instance, the true relationship between technical progress and a number of selected variables (surrogates). Consider, for example, a surrogate measure like "the number of new products" at different stages of the technology life cycle: as technology matures, the rate of progress decreases inevitably. At the same time, however, the rate of new product introductions may remain constant. (Foster et al. 1985) Consistently, it has been argued, that the key performance indicators (KPIs) should reflect the achievement of the goals for the activities being measured rather than their outputs (O'Donnel and Duffy 2002). Simultaneously, it has been argued that most of the measurement effort in recent decades has focused on the *output* of research and development. Hence, the true measurement of development *effectiveness*[21] has been practically absent. (Szakonyi 1994, p. 29) O'Donnel and Duffy give an example (O'Donnel and Duffy 2002, pp. 1207-1208):

> *"… the number of drawings (output) is used to measure the performance of a draughting activity. This then changes the behaviour and output of the activity in order to achieve a seemingly high performance with respect to the metric. However, the goal of the activity is more likely to be to define the product's geometry to such a degree as to enable further analyses or product development. The KPIs should in fact reflect and support the goals of the activities and not their output. A more appropriate performance indicator in this example may be something like drawing usability, appropriateness or completeness. Such measures could be given by downstream activities and fed back to indicate the drawing activity's performance."*

One of the common features of all performance measurement systems is that they include (at least implicit) assumptions concerning causes and effects (see for example Akgün and Lynn 2002). On the other hand, practice has shown that revealing cause and effect assumptions (making them explicit) is very important in clarifying differences of opinion and settling conflicts that arise in discussions about strategy (Gooderham 2001). Given the typically long time period between some causes and

[21] This view of effectiveness is quite interesting when compared with that of, for instance, O'Donnel's (O'Donnel and Duffy 2002) Traditionally, effectiveness is seen as closely connected with output, although output and effectiveness have also essential differences. One of the biggest differences is that effectiveness is a context-specific concept, whereas the concept of output is unrelated to any particular context.

business effects, this is especially important in the R&D context. Further, important cause-effect relationships may be detected also at the level of management and measurement techniques. (Lewis 2001) For instance, according to Lewis' evidence, incremental innovations that are the most often associated with prescriptive project management techniques might increase the risk of restricting strategic resource (skills, knowledge and experiences of the development team) development. The risk is even more highlighted as the effectiveness of R&D is assessed against an arbitrary sense of "normal"[22]. When constructing multidimensional R&D performance measurement, the possibilities to communicate the assumptions behind the metrics, and also behind the structure of the measurement framework, should be carefully considered.

4.2.4.2 Subjects or topics for measures

It has been argued that the diversity of R&D functions, including activities from basic research to product or process improvements, calls for a diverse set of measures to be able to completely cover the measurement need within these activities. In line with this, Brown and Gobeli have suggested a versatile R&D measurement practice. It would be organized around a concept of "top ten R&D productivity indicators" intended to capture the multidimensionality of R&D performance, including measures for (Brown and Gobeli 1992):

- Resources
- Project management
- People management
- Planning
- New technology study and development
- Outputs
- Division results and outcomes

It is likely that no single approach for NPD performance measurement can be established. On the basis of a number of factors, performance measurement should be rather adapted to fit any particular context seen as relevant. It has been pointed out that different objectives require different types of measures (Schumann et al. 1995). As one typology, Schumann et al. propose a matrix the dimensions of which represent the external/internal focus of measurement and the timing (end-of-process versus in-process) of it[23]. Schumann et al suggest that internal end-of-process measurement would be mainly used for performance tracking purposes, and internal in-process measurement for technical productivity improvement purposes. On the other hand, external end-of-process measurement would allow competitor assessment while external end-of-process measurement facilitates the search for best practices. As regards the unit of analysis in performance measurement, Schumann et al. (1995) suggest four levels of aspects (see also Figure 11):

[22] Lewis uses the claim *"this type of project should cost this much"* as a typical example of an "arbitrary sense of normal".

[23] Chiesa and Masella (1996) employs a similar classification but introduces also an additional category for the timing, namely ex-ante measurement that can be utilized when the input resources or the skills of an organization are evaluated.

- People: The professionals working in an organization and their technical vitality constitute the people category. Technical vitality refers to personal responsibility to ensure that the creative talents of individuals are used to promote change or development. It is about carrying out each activity "with excellence".
- Process: Gaining experience in the process can facilitate learning. This logic is related to a belief that when one gains more understanding on the factors associated with the desired outputs, these outputs are more likely to occur. Suggested process measures would result in understanding how the process is actually carried out. Hence, good process measures would act as a feedback mechanism with a certain amount of delay.
- Outputs: The primary output of research and development activities is information, technology, or products. As it is often very challenging to evaluate the value of information (a context-specific issue) Schumann et al propose peer review as a means to overcome the challenge. Overall, when measuring the output, it is underscored that the customers and the competitors are those stakes that best define the quality standards of the output that should be reached.
- Consequences: The consequences can also be referred to as outcomes of research and development activities. In this respect, each stakeholder of R&D would require measures of its own because the outcomes can be evaluated from quite different perspectives. For example, although the needs of external customers may constitute the primary concern during the actual development work, in the pragmatic sense, satisfying the internal customer that provides the funding for the whole activity may be the most immediate need. Naturally, when the interests of different stakeholders do not conflict, balancing the measures of consequences across a number of stakeholders is not very problematic; unfortunately, this is not always the case.

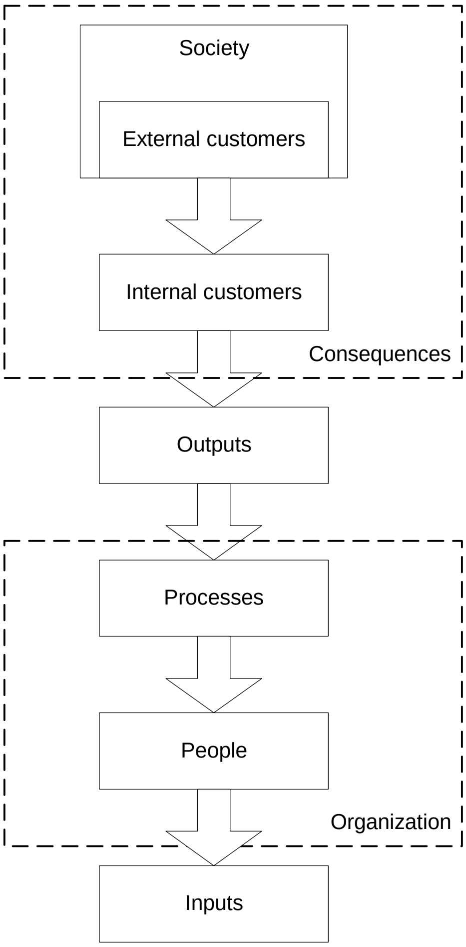


Figure 11. Scheme of market-driven measurement system (Schumann et al. 1995)

Besides this, performance measures for new product development have been organized and classified in many ways. Naturally, one of the most general and typical classifications is based on the distinction between financial and non-financial indicators. Hertenstein and Platt have presented a more specified typology on the basis of this traditional classification for the measurement of design performance. Financial measures constitute one domain including measures such as revenue/sales, product cost, development costs, gross profit of the new product, sales to break-even, or the percentage of new product sales from the total sales. Non-financial measures are further divided into eight subgroups (Hertenstein and Platt 2000):

1. Timing measures
    a. Time to market
    b. Cycle time by phase
2. Design effectiveness measures
    a. Percentage of the first design meeting the needs
    b. Team assessment of design effectiveness
3. Design efficiency measures
    a. Number of design modifications
    b. Frequency of specification changes
4. Customer satisfaction measures
    a. Satisfaction concerning the product
    b. Satisfaction concerning the ease of use

5. Employee-rated measures
    a. Employee morale
    b. Team assessment of individual contributions
6. Strategic measures
    a. Achievement of specific strategic goals
    b. The alignment of design with the company strategy
7. Innovation measures
    a. Number of patents
    b. Number of new products developed
8. Volume measures
    a. Number of products in the pipeline
    b. Number of products started

Many measures in the typology of Hertenstein and Platt (2000) are not very well operationalized. Especially the strategic measures are not really measures at all; rather they represent still somewhat ambiguous ideas regarding what could be measured in terms of strategy in new product development. Also from the new product performance point of view, it seems irrelevant to measure, for instance, employee morale or individual contribution. They may be seen as antecedents for the performance but they do not really indicate performance as such. The typology also includes some shortcomings regarding the hierarchy of the measures; for instance, in the category of customer satisfaction measures, satisfaction concerning the product and the satisfaction concerning the ease of use seem to be overlapping.

Furthermore, Szakonyi has constructed a framework for the evaluation of research and technology effectiveness. Effectiveness is defined as a function of, for instance, good R&D planning, identifying a market need for R&D, competent management of personnel, and good teamwork. The assessment of effectiveness is based on performance evaluation on ten activities, including for instance (Szakonyi 1994):

- Selecting R&D
- Planning and managing projects
- Transferring technology to manufacturing
- Fostering collaboration between R&D and finance
- Linking R&D to business planning
- Coordinating marketing and R&D

In each activity, the evaluation is carried out by utilizing a scale of six pre-determined levels of performance (Szakonyi 1994):

1. Issue not recognized
2. Initial efforts are made towards addressing the issue
3. Right skills are in place
4. Appropriate methods are used
5. Responsibilities are clarified
6. Continuous improvement is underway

One can easily derive from the previous description that the method proposed by Szakonyi is designed primarily for monitoring purposes and for both external and internal benchmarking, not for supporting the practical everyday management of development activities.

Tipping et al. (1995) stress that: “one cannot judge the value of an R&D organization to a corporation simply by looking at the new products it has produced recently, just as one cannot judge the value of a house by looking at the exterior brickwork.” Instead, the authors propose a model called the “Technology value pyramid”, TPV, for assessing this function. TPV aims to communicate that value creation is the primary driver of the overall business returns that can be derived from new products. The basis of TPV relies on a number of beliefs, including (Tipping 1995):

- The R&D effort should defend and develop the value of the corporation
- A linkage has to exist between R&D and corporate strategic aims
- R&D has to sustain its capabilities to be able to produce relevant output in the long term

The authors also propose a number of measures that can be used to operationalize the ideas of TPV. According to Tipping et al., TPV provides a holistic view on R&D and enables both prospective and retrospective measurement. However, the authors note that prospective measures should be used cautiously. The projections concerning the future will only be as good as the assumptions concerning the cause-effect relationships (Tipping 1995).

4.2.4.3 Concrete measures

Pillai et al. (2002) argue that R&D projects are difficult to measure properly due to the fact that they are inherently complex and uncertain. Furthermore, Pillai et al. suggest that to avoid poor overall NPD performance, each phase of product development should not be managed and measured separately but rather the measures of new product development should encompass the entire life cycle of the project. As a solution to this problem, the method or tool, Integrated Performance Index (IPI), that is suggested by Pillai et al., can be regarded as an attempt to link the key factors from each phase of R&D together. However, because IPI integrates several measured factors into one figure, the construct obviously suffers from the lack of ability to directly associate the measure with a real-life phenomenon that has actually affected the measure. Thus, it seems somewhat too complex to be widely adopted by the practitioners. The life cycle of a new product development project, according to Pillai et al., consists of three phases (Pillai et al. 2002):

1. Project selection phase that mainly concerns screening, evaluation and selection of potential projects.
2. Project execution phase that covers technology and product development and, further, performance demonstration.
3. Implementation phase, which is related to the implementation of the project to the production, marketing, and sales.

However, one product development project or one new product is not the only possible unit of analysis in performance measurement. In this sense, it is important to acknowledge that measuring the performance of a single product development project is different from evaluating the performance of a portfolio of projects. This distinction is made, for instance by Nixon (1998), who argues that the differences between these two relate to different risk assessment requirements and a different emphasis on strategic dimensions. On the level of product family, Meyer at al propose two measures for NPD performance (Meyer et al. 1997):

1. Product platform efficiency. It is interpreted as the degree to which a platform provides the possibility for the economic generation of follow-up products. Mathematically, the efficiency is defined as a simple ratio: Platform efficiency (E) = R&D costs for the derivative product/R&D costs for the platform version
2. Product platform effectiveness. It is defined as the degree to which the products relying on the same platform are able to produce revenue for the firm in relation to the costs associated with the development of those products. Mathematically, the effectiveness (L) is given by the ratio: L = cumulative sales of the products associated with a platform/cumulative costs of developing the platform and the products associated with it.

Coccia presents a methodology called *relev* for evaluating R&D performance. The method is based on a number of indices representing the principal activities that are carried out in the organization. Again, the method produces a single figure, a score that is to be used to rank several R&D organizations against each other. Thus, the relev method is mainly beneficial for an external evaluator and it is not primarily targeted at managerial purposes within a single firm. (Coccia 2001) Analogously, McGrath and Romeri propose an aggregate measure for monitoring the overall success of product development called R&D Effectiveness Index (EI) (McGrath and Romeri 1994). The EI index combines the revenue from new products with the overall net profit and R&D investment. It is said to describe whether the returns from new products are greater than the respective costs. However, the authors are not able to demonstrate the actual validity of the measure. Furthermore, their logic contains features that have to be regarded as misleading, such as: “The profitability of new products is a result of how successful the products are in meeting the customer needs compared to competitive products.” (McGrath and Romeri 1994) It is self-evident that meeting the customer needs in respect to competitive products could be a driver of profitability, but a number of other factors, such as the direct manufacturing or material costs, affect the profitability far more directly.

Chiesa and Masella distinguish between performance measures that are to be used before the end of a development project (*t*) and after it. This distinction is made on the basis of a logic that the critical drivers of performance before *t* are intrinsic to R&D, but after *t* the performance is affected also by other functions. The first category, measures before the end-of-project, consists of measures in two domains: technical success measures and efficiency measures. Efficiency measures are further divided into subcategories of productivity and synergy measures, the measures of adherence to scheduling, and risk measures. The measures that focus on the period after project completion are said to concern mainly integration issues. Two broad domains of measures are established (Chiesa and Masella 1996):

- Manufacturing integration
    - Time to market

    - Number of redesigns
    - Design performance
- Marketing integration
    - Number of new products, licenses, patents
    - Percentage of sales and profit from new products
    - Customer satisfaction

Suitable measures have been organized on the basis of the chosen new product strategy of the company. Prospectors who pursue to be the first to the market would utilize measures such as (Griffin and Page 1996):

- Percentage of profits from products < n years old,
- Degree to which today's products lead to future opportunities,
- Percentage of sales from products < n years old.

Analyzers who are seldom first to the market but are able to respond quickly and effectively to produce fairly innovative products are likely to utilize measures like (Griffin and Page 1996):

- Degree to which products fit business strategy,
- Development program ROI,
- Success/failure rate,
- Percentage of profits from products < n years old.

Defenders attempt to maintain or secure a rather stable niche and to provide high quality or superior service. For defenders, the following measures are appropriate (Griffin and Page 1996):

- Development program ROI,
- Degree to which products fit business strategy.

Reactors are less active operators in the markets and tend to respond only if they are forced to do so. For them, the suggested measures are (Griffin and Page 1996):

- Development program ROI,
- Success/failure rate,
- Degree to which products fit business strategy,
- Subjective overall program success.

The strategy-based measures proposed by Griffin and Page (1996) are clearly upper-level measures. They primarily illustrate the overall success of product development but tell little about the success of individual products and causes related to possible successes or failures.

Some, although rare, proposed measures of product development comprise the life cycle dimension of outcomes. For instance, Brown and Svenson (1998), have suggested the net present cash flows during product life cycle to development cost as a measure of product development. Demonstrating a kind of life cycle orientation, Curtis has analyzed the relationship between a product's lifetime revenues and the duration of the development cycle (Curtis 1994). On the basis of his analysis, Curtis suggests that companies should be cautious in compressing their product development cycles. This is because, as Curtis argues, a point will occur at which further development cycle reduction may not add to a product's life cycle revenues due to, for example, an inability to cover the incremental costs of acceleration through higher prices. (Curtis 1994) On the other hand, according to Johnson and Kaplan (1987), traditional accounting methods are not suitable for organizations that are characterized by short product life cycles and high importance of research and development. (Johnson and Kaplan 1987)

Despite the practical problems with accounting measures, regarding the financial objectives of research and new product development, there is a number of different dimensions or perspectives that need to be acknowledged. From the financial and management accounting point of view, Nixon underscores the importance of three different measures (Nixon 1998, pp. 340-341):

1. The total development cost. The total costs include all the costs that can be either directly or indirectly assigned to the development project including consulting, testing, and overheads.
2. Direct costs of the new product/service, that is, what the costs associated with the production of the new product are.
3. Operating costs. These refer to costs that the customer incurs when using the product for its purpose.

Importantly, the interactions between these three types of costs are very complex. Hence, Nixon underscores the importance of close collaboration between engineers, R&D team, manufacturing, component supplier and customer, and financial controller in order to be able to finalize the product development in a way that balances the different cost requirements. Especially the role of the financial controller is very crucial in assisting the designers to evaluate the effect of different design possibilities and alternatives on the cost of producing and operating the product. On the basis of an extensive and longitudinal case study, Nixon summarizes the importance of different cost targets in product development: "Increasingly, producers must look beyond their competitors and focus on the competitive environment of their customers. In the case of CCM Ltd. the purchase price [of the new machine] is far less significant for its customers than the operating cost." (Nixon 1998, p. 343) Furthermore, this finding seems to be consistent across different industries (for example Jokioinen 2003)

The fact that the literature is full of suggestions concerning measures and measurement system designs could indicate that it is possible to identify a suitable set of measures for every setting. This view, however, is misleading. Above all, measures and measurement systems should not be regarded as static constructs; rather, measurement is a dynamic phenomenon that should be adapted to changing conditions and requirements.

> *"Once measures are made they should not be regarded as the answers. Instead, they need to be continually reviewed and refined." (Driva et al. 2000, p. 156)*

For instance, Nixon has found that the process of evolution regarding a product development project is essentially about uncertainty reduction and consensus building within the organization. The better the consensus, the more resources can be assigned to the development. There is typically a "gestation period" before significant resources are committed to development. This is quite consistent with the ideas presented by (Matthews 1991). Hence, when considering the role of performance measurement in new product development, it is necessary to analyze the needs that cover the entire cycle of development. During high uncertainty, the requirements for performance measurement are likely to differ from those that are related to stages of relatively low uncertainty in the later stages of development. (Nixon 1998) In other words, a performance measurement system, in practice, may be an iterative process that cannot be totally separated from the basic nature of the design and development process. Thus, as the information and criteria associated with product development in general evolves from the more soft or general towards the more specific and reliable, the performance measurement system also evolves. In the later stages of development, more objective and explicit data are required. A performance measurement system should then produce information that is more structured and organized and that can be directly used as a decision-making criterion. (Nixon 1998)

4.2.5 Other managerial constructs

A good number of suggestions – that directly or indirectly relate to performance measurement – for managing product development performance and success can be found from the literature. Ransley and Rogers (1994), for example, identified seven best practices of research and development concerning which a consensus seems to exist. These include: 1) A clear technology strategy that relies on a common vocabulary (such as time frame, approach, and risk) and that is understood widely across functions, 2) rigorous program and project management including analytical tools are used in balancing and assessing R&D programs, 3) identified core technologies that are also integrated into long-term development plans, 4) effectiveness meaning that the results are measured against technology and business objectives, 5) external awareness including a systematic process for monitoring external threats and opportunities through a number of stakeholders, 6) technology transfer across functions through, for instance, cross-disciplinary teams and 7) effective and careful personnel recruitment and education. For facilitating these purposes, however not equally focused regarding all these seven mentioned, a number of tools and techniques exist. One of the most well-known R&D management constructs is presented by Cooper (1996): the Stage-gate system. A Third-generation stage-gate system consists of five stages (preliminary investigation, detailed investigation, development, testing and validation, full production, and market launch) and of five gates (go/kill decision points) that control the process.

Delano et al indicate that Quality Function Deployment (QFD) is able to provide many benefits for an organization during the product development process (see also Akao 1990; Pullman et al. 2002). These would include tight focus on the customer and customer requirements, good communication, and effective teamwork across the developing organization (Delano et al. 2000): "Decision making requires the ability to gather and communicate information and to perform different types of analysis" (Delano et al. 2000, p. 606). QFD, among other possible techniques, is able to provide tools to support decision-making in the R&D environment. Further, more generic techniques have also been discussed. Poh et al have compared several R&D evaluation or selection techniques including scoring method, AHP, decision tree technique, economic analysis, and cost-benefit analysis. The comparison was carried out by using the AHP technique. The criteria deployed in the comparison included aspects such as the ability of the method to cope with multiple objectives (typical in the NPD environment), simplicity, data availability, and cost. On the basis of this comparison, the authors conclude that the scoring method would be the most favorable method for evaluating R&D projects. The strength of the scoring method seems to be in its ability to deal with multiple criteria and in its simplicity. (Poh et al. 2001)

In addition to valuing development projects, options-based analysis for R&D projects has been presented as an alternative to more traditional discounted cash flow (DCF) techniques. The justification for options-based approaches is underscored by a view that an R&D project is actually an initial investment that creates future follow-on commercial opportunities. (Herath and Park 1999) On the contrary, traditional DCF methods are seen as unable to correctly value the projects because the total economic value of these investments includes an option value that is associated with the future opportunity to commercialize (Herath and Park 1999, p. 2). Further, risk assessment is closely connected to option-based approaches. Davis argues that a robust product development process should somehow make the risks associated with it understandable and measurable. The risks, as Davis has perceived them, are further divided into market risk, technical risk, and user risk. He proposes a construct called NPVR, which is based on the traditional net present value calculation supplemented with a risk evaluation. The risks are operationalized in the NPV calculations by using market research and questioning and further, heuristically interpreting the information gathered. (Davis 2002)

Cooper has developed the NewProd model for separating probable successful projects from probable losers. He remarks that project selection is pivotal to effective risk reduction in product development. A scoring model could be a valuable tool in screening proposals. According to the NewProd model, product superiority/quality, market need, growth and size, and product scope are the factors that have the strongest impact on the probability of success. (Cooper 1985) Hollander has reported the potential of the Genesis model for project assessment. His study is based on Cooper's NewProd studies. The objective of both of these models is to provide support for the product development team, especially for "go or no go" decisions. The Genesis model is focused on development projects and teams. The question is: Does the team have the necessary resources and skills and how is the product positioned in respect to markets and competitors' products? (Hollander 2000)

Slevin and Pinto (1986) have proposed a framework for estimating or anticipating project management success. The framework is called the project implementation profile (PIP). The authors have identified ten success factors, including for instance project mission, top management support, client consultation, communication, and troubleshooting, which are related to a project’s success. By studying 82 successful projects, Slevin and Pinto have provided a reference score scale for each success factor that enables benchmarking a certain project performance with the success profiles of known successful projects (For instance, regarding the factor of communication, the 0th percentile of 12 points refers to the fact that none of the studied success projects scored less than 12 points, and the 100th percentile of 99 indicates that the full score of 100 was not achieved by any project.). If a project's performance in the case of any factor is below the 50th percentile, one should – according to Slevin and Pinto – devote extra attention to that factor to improve the odds of success.

Kim and Oh have noted that economic compensation or a reward system is a good tool for motivating the personnel working in research and development. However, to be able to employ such a system, the organization has to establish a fair and an effective means to measure the performance of its development activities. From the performance measurement point of view, at least two questions have to be answered properly: 1) Who should measure the performance of R&D workers?, 2) What criteria should be employed to measure the performance? The former question implies that performance measurement is not totally neutral activity in respect to the subject of measurement. Therefore, the one who is responsible for the measurement has to be carefully selected. The latter question suggests – at least implicitly – that attention has to be paid to the resolution of the question: How do we actually define the R&D performance? Kim and Oh put forth four broad sets of criteria that could be utilized in evaluating R&D engineers' and scientists' performance (Kim and Oh 2002):

1. Market-oriented including public relationship building, social activity such as lectures and spreading information, and commercial profit
2. R&D project-specific including technological complexity and the duration of the R&D project
3. R&D researcher's technological attributes including personal technical expertise, the number of publications such as books or papers, and the number of patents
4. R&D researcher's behavioral attributes including mentoring for junior researchers, leadership, the ability to get things done, and efforts for teamwork building

Kim and Oh have shown that there exists a strong correlation between R&D personnel's job satisfaction and their satisfaction with the performance measurement system employed. Thus, it seems important to carefully design and implement the measures that are employed for tracking the employees' performance. In practice, a measurement system that relies on the inputs from the employees themselves, their peer reviewers, and external customers is perceived as more fair and better than one relying only on the inputs from R&D project directors and top executives. Furthermore, the results of the survey indicate that an ideal R&D performance measurement system – according to the R&D workers – would emphasise measures that are based on the behavioral criteria such as teamwork building abilities or leadership for the R&D organization. (Kim and Oh 2002)

Managing costs is an important part of managing the profitability of new products. Costs can be assessed at least from the perspectives of customer and manufacturer. From the customer point of view, it has been suggested that cost of ownership is a key issue in business-to-business markets (Goffin and New 2001), which should be considered in product development. If the product development process lacks rigorous control over product design, many product features may be added to the product specification in response to sub-segment requests without a thorough consideration of the total effects of these additions (Rabino 2001). In line with this, it is suggested that launching a new product to the market on the basis of qualitative market study is very risky in contrast with relying on a more quantitative one. According to Howley, this is because qualitative market research is likely to lead to undesirable bias for the development process. (Howley 1990) As a form of rigorous control, target costing is one of the possible applications (Tanaka 1993; Fisher 1995; Kato and Boer 1995; Ansari et al. 1997; Horvath et al. 1998; IMA 1998; Cooper and Slagmulder 1999; Dutton and Marx 1999). Benefits associated with the practice of target costing during the product development process imply that assigning specific cost targets for product developers should result in favorable financial outcomes. That is, the employment of explicit cost targets during the product development would lead to lower costs of the developed product than, for instance, relying on a general objective to strive for low product cost. This notion has been basically supported by (Everaert and Bruggeman 2002). However, they add that target costing only has a positive effect on the new product when employees can afford to work relaxed. (Everaert and Bruggeman 2002, pp. 1349-1350) This reminds of something that is almost self-evident regarding all managerial tools: it is not only the tool itself but the way it is used that determines the success of the application.

Cost estimation can be regarded as one means to conduct financial assessment within product development. Generally, cost estimation is employed in order to be able to predict costs such as labor or material over time on the basis of some data on cost drivers. Smith and Mason argue that cost estimation is an important activity that relates to a number of decisions concerning, for instance, engineering or business in general (Smith and Mason 1997). The estimation of the costs of a new product is a typical managerial challenge in new product development. At least two appropriate approaches have been introduced that can be employed when estimating new product costs:

1. Using an analogy with other, already existing, products produced either by the firm itself or by competitors
2. Through parametric models, which can relate a representative number of parameters of the product to the cost of the product.

Activity based management (ABM, see e.g ICMS Inc. 1992; Kaplan 1992; Pryor 1998; Ness et al. 2001), that is based mainly on information produced by activity based costing (ABC, see for example Cooper and Kaplan 1988; Cooper 1990; Cooper 1990; Johnson et al. 1991; Hardy and Hubbard 1992; Turney and Stratton 1992; Innes and Mitchell 1995; Mecimore and Bell 1995; Ness and Cuzuzza 1995; Krumwiede 1998; Cokins 1999; Cooper and Slagmulder 1999; Lahikainen and Paranko 2001; Zeller et al. 2001; Jones and Dugdale 2002; Lukka and Granlund 2002) has been mentioned as a methodology that can be applied to research and development activities. According to Maccarrone (1998), ABM would be a helpful tool regarding a number of issues including the evaluation of economic benefits that can be gained through re-design of processes, the evaluation of product life-cycle costs or budgeting and controlling of product development activities. More specifically, Maccarrone (1998) suggests that using the ABM methodology in the cost estimation process of a new product can reinforce, and integrate, both approaches. This is because ABM enables a detailed analysis of differences between the new and the existing products.

The costs of new products can be analyzed as combinations of activities that are carried out in the various processes of a firm. Activities consumed by the products are thus seen as the parameters that affect the cost of the product. Hence, a parametric approach – that relies on analogies between new and existing products – for the cost estimation of new products consists of two main building blocks: 1) On the basis of activity based costing a firm is able to know the unit costs of activities, and 2) On the basis of analogies with and anticipated differences between new and existing products in terms of activity consumption, a firm can assess the amount of activities the product will require. By combining these two pieces of information, a cost estimate for a new product can be established.

4.2.6 Life cycle oriented measurement

In striking contrast with the popularity of the topics of performance measurement and new product development management, product life cycle has been discussed to a very limited extent in the context of new product development performance measurement. For example, the number of journal articles that have explicitly addressed the issue is as low as less than ten. Still, life cycle orientation seems to be to some degree a built-in characteristic of product development. As Tipping (1995) notes, R&D has to be able to sustain its capability to produce useful output over the long term. Furthermore, life cycle concerns in NPD performance measurement should be well aligned with the overall “broadening” trend in project management. As Fangel (1993) argues, the applications of project management have changed substantially during recent decades. One of the identified trends is the shift of focus from the period from contracting until commissioning towards handling the entire life cycle. A product’s performance can be viewed as an aggregate measure that is not established on the basis of a moment of time but rather as a function of time over its entire life cycle. Moreover, field service or after sales service related to – or wrapped around – the physical product is one of the elements that affect the customer’s perception of the product. It is worth noting that – in addition to providing a source of revenue for the manufacturer – the service function also provides the company with a possibility to gather feedback on product performance and information on customer preferences. (Hull and Cox 1994)

Some evidence has been presented implicating that the characteristics of product life cycles have an impact on the relevant design of NPD performance measurement systems. Terwiesch et al. (1998) emphasize the importance of analyzing the characteristics of the industry when designing new product development performance measurement. The authors argue that although a universally valid relationship between new product development performance and business performance (success) may exist, the relevant NPD performance measures seem to depend on the industry in which a firm operates. The market context that can be derived from the industry includes three dimensions: market share, market growth, and external stability that refers to the average length of product life cycle (PLC) in the market.

Also, the relevant measures of NPD performance seem to be time-dependent. For instance, Hultink found that measures perceived as important at the beginning of the product life cycle differ from those seen as the most important later in the PLC. Product performance -related measures were regarded as the most important in the short term; that is, at the beginning of the life cycle, whereas financial aspects and customer-related measures gain importance towards the end of the life cycle. (Hultink and Robben 1995) It was concluded by Griffin and Page (1996) that either the most relevant and useful measures of success change during the product life cycle, or there is a need to obtain different measures at different points of time. As the idea presented by Griffin and Page is merely a hypothesis, it seems consistent to argue that the life cycle stage affects the optimal set of performance measures. Consistently, also Foster et al. (1985) remark that the relevant performance measures vary over time due to changing customer needs. According to Foster et al. (1985) the fact that customer need is a temporal variable is rarely fully acknowledged. The authors argue that the profound understanding of customer needs can be reached on the basis of two analyses. First, it has to be understood what the customer values now. Second, an understanding should be obtained regarding what the customer will likely value in the future.

The overall characteristics of an effective measurement system for product development have received significant attention in the literature (Szakonyi 1994; Schumann et al. 1995; Nixon 1998; Kerssens-van Drongelen and Bilderbeek 1999; Davis et al. 2001). Brown and Svenson (1998), for instance, suggest several issues. First, according to them, the focus should be on external measures rather than on internal measures. Internal measurement might be a valuable quality control tool, but for evaluation purposes external measures are more valid and important. This could be partly seen as implying stakeholder-oriented performance measurement. An important part of developing a feasible and effective PM system for new product development is to identify the stakeholders involved, to understand their needs, and to agree upon them (see for example Tipping 1995). Also, it would be necessary to integrate the stakeholders into the process of developing a new product, because this allows the effective use of both leading and lagging indicators of performance. It should also be noted that different stakeholders have different interests, which means that the important measures for one group of stakeholders would be secondary for another. Furthermore, it is not only the fundamental interests that differ between stakeholders but also the preferred time frame may be different. Therefore, the measurement should allow different stakeholders to address their particular period of interest for measuring the development activity. Despite the possible conflict of interests between stakeholders, Tipping et al. stress the importance of communicating the interconnectedness between the factors measured. (see for example Tipping 1995)

Second, Brown and Svenson (1998) state that outputs and outcomes should be measured instead of behavior. This focus implies that as long as the outcomes are desirable, the individuals should have the possibility to select the most appropriate means to achieve them. Outcomes should be measured along the three basic dimensions: quality, quantity, and cost. Essentially, the two points made are well in line with the idea presented by Foster et al. (1985) that the measures should track the performance as the customer sees it. In other words, the measure ought to relate to benefits that the customer experiences when using the new product (Kerssens-van Drongelen and Bilderbeek 1999). This conclusion regarding the essential measurement focus can also be made from a rather different perspective. Namely, when Kortge and Okonkwo discussed the role of marketing strategy in new product development, they noted that one of the most essential activities of the marketing manager is participating in the development of new products that meet customer demands and attain the objectives of the company. (Kortge and Okonkwo 1992)

Further, Brown and Svenson (1998) argue that only the valuable accomplishments should be measured. Curiosities, even though they might be easy to quantify, should not be of interest. An example of a curiosity could be the number of citations in a technical journal or the number of new products per se. Brown and Svenson (1998) also suggest keeping the measurement system as simple as possible. In addition, they advocate using indices that comprise several aspects of performance rather than separate indices for each dimension of performance. As a rule of thumb, six to eight key indices is recommended. Finally, according to Brown and Svenson (1998), the measurement system should be kept as objective as possible. Quite similarly, Foster et al. (1985) advocate the use of technical measures (such as tensile strength or yield). When it is not possible to totally avoid subjectivity, then it should be at least minimized. For instance, when the impact of a certain development output is in question, the evaluation should be based on an assessment by a stakeholder rather than on an opinion of the R&D manager. Brown and Svenson (1998) have also proposed some measures which explicitly involve the life cycle dimension of outcomes. For instance, they suggested the net present cash flows of the PLC compared to development cost as a measure of product development. On the other hand, Krogh et al. (1988, p. 11) propose an R&D program evaluation that is carried out on the basis of nine wide factors that cover both the technical and business aspects of development. Among the proposed measures, the measure of financial potential, which includes anticipation of future sales and profits associated with the product, represents life cycle -oriented performance measurement. However, Patterson (1983) provides perhaps the most crystallized example of life cycle -oriented PM by reporting the performance evaluation practices at Alcoa Laboratories. The evaluation of R&D at Alcoa relies on projections of future economic benefits produced by new products or innovations. First, different functions of the organization collaborate to establish the magnitude of potential new product -related economic benefits, which can take several forms including cost reduction, sales advantage, capital avoidance, capacity expansion, or knowledge. Second, the series of benefits (within a limited time horizon of 15 years) is converted to a present value by using a discounting factor (corresponding to a standard NPV calculation). Third, to measure the benefit ratio within the organization, the discounted benefits of implemented innovations are proportioned to respective expenditures. Obviously, as Patterson (1983) points out, this ratio varies quite heavily on a temporal basis.

Cordero (1990) presents a framework for the comprehensive evaluation of a firm's innovation performance. (see Figure 12) According to his model (and analogously to the ideas presented by Krogh, 1998), to obtain overall performance evaluation, one has to measure both commercial and technical performance. Moreover, performance could be tracked on the levels of firm, business unit, or function. During the early stages of product life cycle, it is recommended that the performance measures should focus on estimations and help in the evaluation of alternatives. At the later stages, the measurement focus would shift to recording the realized outputs.

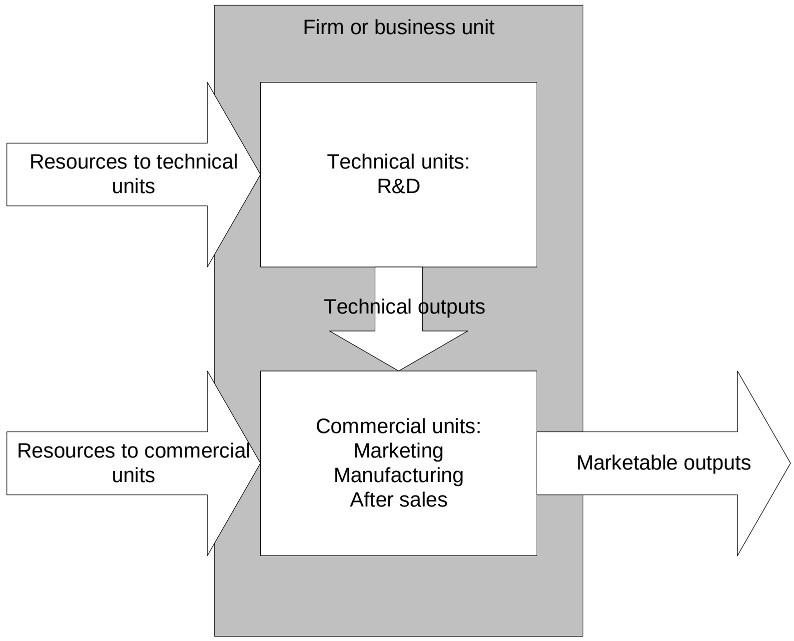


Figure 12. Model of comprehensive innovation performance measurement (adapted from Cordero 1990, p. 186)

Meyer et al. (1997) approach the problem of short-termism in NPD measurement by suggesting measures for product families and platforms as opposed to measures for single projects or products. A successful product platform can be considered a long-term investment as it provides the possibility to launch a number of follow-on products that are based on the same architecture. Further, Osawa et al. (2002) have presented a conceptual model for evaluating industrial R&D projects. In a way, they have also grasped a life cycle dimension of new product development as they have adopted a five-year period for the financial appraisal. The method of Osawa and Murakami is still quite subjective and heuristic, since it relies heavily on the project manager's projections regarding the product. The authors note, however, that the main advantage of the method is that it provides project managers with a platform to discuss and reach consensus with the project's stakeholders. Second, the utilization of the method accumulates quantitative data within the organization that can be exploited when assessing development projects in the future. (Osawa and Murakami 2002)

4.2.7 Use of performance measures and measurement in product development

The overall observation in the literature seems to be that the measurement of product development is not as developed as it probably should be. Compared to many other application areas, such as manufacturing, performance measurement in product development is rather poorly developed (O'Donnel and Duffy 2002, p. 1199). When measuring the effectiveness of research and development, one should aim to demonstrate the organization's performance in this critical dimension of new product development and to point out the means to improve it in the future. Somewhat in contrast with this, the measures of NPD in many companies suffer from short-termism and an overemphasis on single projects or products. A very typical measure of product development assesses the variance between a project's plan and actual outcome along the dimensions of cost and time (Meyer et al. 1997, p. 89).

Driva et al. have conducted a survey on the usage of performance measures in product development both in Europe and the USA. They received some 150 replies from European and American companies. The results show that the five most common performance measures are (Driva et al. 2000, pp. 151-152):

- total cost of the project (71 percent of the companies employed)
- on-time delivery of the development project (60 percent)
- actual project cost compared to budgeted cost (60 percent)
- actual versus target time for the project completion (58 percent)
- lead time to market (57 percent)

Furthermore, 51 percent of the surveyed companies employed some kind of a projected profitability analysis. However, 18 percent of those not employing it at the moment wanted to use it in the future. Overall, it is highly interesting that none of the five most important measures actually concern the outcomes and effects of product development.

According to a survey, 50 percent of companies use performance indicators that are related to product performance including broad aspects such as quality, technical performance, development cost, production cost, and unit cost of the product. (Hyland et al. 2002) According to the same study, approximately 60 percent of the companies monitor the profits generated by the product innovation activity. Hyland et al. also conclude that, apparently, many companies are much more involved in establishing an innovation process than actually trying to improve it. Thus, the potential of performance measures in improving and developing activities or processes is not fully utilized. (Hyland et al. 2002) As a piece of data from 20 years ago, Meyer cites a study by Schainblatt (1982) who found that 59 percent of the studied firms did not measure the R&D activity at all. Further, as little as 20 percent of the studied firms carried out comparisons of R&D costs and commercial outcomes on a quantitative basis. (Meyer et al. 1997, p. 89) More recently according to Kerssens-van Drongelen and Bilderbeek (1999), a survey among Dutch companies revealed that 80 percent of the companies that had some kind of R&D activities measured product development at least in some manner. While it is difficult to list the comprehensive reasons for these observations, Nixon points out one by putting forth that:

> *"The measurement of R&D productivity and effectiveness has received relatively little attention in the management control and accounting literatures". (Nixon 1998, p. 330)*

On the other hand, it has been recognized that management is generally unsatisfied with the present R&D measurement approaches presented in the literature (Pearson et al. 2000, p. 357). Nevertheless, it is a fact that many companies do not utilize explicit measurement of new product development performance at all and that, overall, comprehensive and consistent measures are still in their infancy (Driva et al. 2000, p. 158). However, it has been found that those companies that do useexplicit measurement often deploy both financial and non-financial measurement. Further, according to Hertenstein and Platt, NPD managers are generally not satisfied with the performance measurement of new product development. Also, the link between the measurement and corporate strategy seems to be weak in many cases despite the fact that a number of managers stress the importance of measuring the strategy alignment of product development. (Hertenstein and Platt 2000)

Werner and Souder studied the differences between U.S. and German practices of R&D performance measurement. They found out that both the perceptions on the usefulness of the measures and the fundamental philosophy related to performance measurement in these countries were different from each other (Werner and Souder 1997). German managers did not show any particular trust on performance measures. Particularly output measures were distrusted, whereas input measures were employed more often. U.S. managers, on the other hand, relied mostly on measures like the number of patents, financial measures such as rate-of-return, or quality assessments. The authors underscore, as a lesson from the cross-cultural study, that research and development measures cannot be selected "in a vacuum"; rather, performance measurement needs to be adapted to the organization in a such way that the measures are consistent with the particular organizational culture and philosophy. Hence, the greatest effectiveness through measures is only achieved when they become an integral part of the firm's research and development system. (Werner and Souder 1997)

By using four case studies, Davila has shown the diversity that exists among the use of management control systems in new product development. Depending on the project characteristics, the role of control systems seems to vary. Prototyping, for instance, is likely to partially replace management control systems when technology is the main source of uncertainty. In contrast, when uncertainty is mostly due to the market of the project scope, management control systems are seen as vehicles to reduce uncertainty rather than to monitor and control. Thus, on the basis of this evidence, the information perspective – the role of measures in producing relevant information for the decision-making process – is supported. (Davila 2000) Davila's study also pointed out the relative importance of non-financial measures:

> *"… project managers rely on non-financial performance measurement much more than they do on financial ones. This finding suggests that researching management control systems in new product development cannot be restricted to traditional accounting measures, but needs to encompass a broader set of measures. This is so because managers work with the implicit assumption that good performance in non-financials will drive good financial performance." (Davila 2000)*

Consistently with this, it has also been argued that NPD managers might want to increase the emphasis on non-financial measures and, simultaneously, decrease the emphasis on financial ones. The rationale for this would be the difficulty to separate the financial results of NPD from those of other functions. (Hertenstein and Platt 2000) In other words, non-financial measures are expected to, better than financial ones, capture the specific contribution of NPD to the company objectives.

The lack of measures per se is not a problem. Meyer has found some 75 different measures of research and development in the literature. On the basis of analyzing them, he criticizes the existing performance measures of R&D. He argues that the actual impact of these various measures is questionable due to a number of aspects, including (Meyer et al. 1997):

1. The measures are not able to provide help for the management to understand the long-term dynamics of evolving product lines
2. The measures do not provide understanding concerning the leverage that the underlying product architecture, that is product platform[24], can provide in derivative products (products that can be derived from or based on a platform)

One of the reasons for poor measurement may the one presented by Szakonyi. He points out that the collaboration between R&D and finance is quite underdeveloped. He found that the lack of collaboration between these parties can be regarded as one of the most dramatic shortcomings of R&D effectiveness (Szakonyi 1994, p. 53). According to Szakonyi, an average R&D department has not recognized the benefits associated with the collaboration between R&D and finance. Hence, they lie on the first level A (see Table 11). The column "Points" in the table refers to the scoring used in the evaluation method of R&D effectiveness (Szakonyi 1994). On the other hand, it can be asked whether the non-financial measurement of product development, for example, should be a responsibility of financial department at all.

Table 11. Present state of collaboration between R&D and finance (Szakonyi 1994, p. 53)

Performance level	Description	Points
Level A (Not recognized)	R&D department does not recognize how poor its relations with the finance or accounting department are	0
Level B (Initial efforts)	R&D managers are interested in working better with finance, but lack knowledge about the financial affairs of the company	1
Level C (Skills)	Understands financial matters, but lacks methods for determining the financial benefits of R&D	2
Level D (Methods)	Economic analysts work closely with R&D people, but there are disagreements about involvement and responsibilities	3
Level E (Responsibilities)	A finance person is transferred to R&D to serve as a bridge with finance, but company's accounting procedures short-change benefits of technology	4
Level F (Continuous improvements)	R&D managers have option of discussing with finance managers how economic analyses of technology are conducted if it looks like strategic benefits of technology are neglected.	5

According to Nixon (1998), the exclusion of accountants from the NPD teams can be due to the perception that accounting has traditionally placed on control rather than on constructive planning. On the other hand, the accounting function itself has not traditionally been very keen on participating in product development in the first place,

[24] A product platform is the technological foundation of a product family. "A platform is the physical implementation of a technical design that serves as the base architecture for a series of derivative products." (Meyer et al. 1997, p. 90)

which has resulted in underdeveloped applications of management accounting information in product development.

4.2.8 NPD and learning

The knowledge-based view of the firm is an approach that addresses questions such as "How to understand the learning process of the firm?" or "How to manage the knowledge base of an organization?" (see for example Nonaka 1994; Grant 1996) From the knowledge point of view, the success of the firm depends on how well it is able to (Kessler et al. 2000):

1. Enhance its own knowledge-base by creating or obtaining knowledge from various sources.
2. Integrate the numerous knowledge areas effectively within the firm.
3. Apply the knowledge to develop successful new products or to improve the existing products.

Thus, learning is an essential part of product development. Yet, it has been demonstrated that people do not really know how to learn effectively (Argyris 1991). According to Argyris, many skilled and educated people are quite good at single-loop learning but, in contrast, they fail to properly conduct double-loop learning. In other words, these skilled people tend to succeed in what they normally do – in the things they are educated for. But ironically, since they quite rarely experience a failure they often lack the ability to learn from the mistakes: "their ability to learn shuts down precisely at the moment they need it the most" (Argyris 1991, p. 100). Defensive reasoning has been identified as a major antecedent for the deficiency of the professionals in double-loop learning. Argyris points out that effective double-loop learning necessitates a reflection of how people think. The cognitive rules and reasoning that are employed to design and implement one's actions have to be exposed. By this exposure, defensive reasoning that blocks learning can be identified and perhaps gradually replaced. (Argyris 1991)

Organizational learning can be discussed in the knowledge-creation framework. Perhaps the most well-known authors who have studied the knowledge creation process are Nonaka and Takeuchi, who have, among others, presented a model that describes the knowledge conversion from individual tacit knowledge to organizational knowledge (1995). As seen in the context of knowledge creation, the concept of product development success receives one additional interpretation: R&D activities can be perceived as successful when they enable or generate valuable knowledge building. This seems to be reasonably well in line with Lewis' (Lewis 2001) notion that NPD can be seen as a specific illustration of organizational learning. Lewis has created a model that defines the elements and their basic interaction of organizational competence. According to Lewis' definition:

> *"organisational competencies are those combinations of organisational resources and processes* (including NPD) *that together underpin sustainable competitive advantage for a specific firm competing in a particular product/service market"*

Lewis argues that the interaction between resources and processes is not uni-dimensional: resources create value when they are utilized in processes, which in turn helps to create new or extend existing resources. In NPD this means that skilled resources is not only one of the prerequisites of a good NPD process but the good process itself generates valuable information, knowledge, or experience – that is resources. Another definition is presented by Drejer and Riis (1999) who view competencies as a system of human beings, using technology in an organized way and under the influence of a culture to create output that yields a competitive advantage for the firm. Both of the definitions are essentially similar: both perceive competencies as systems to some extent – action and interaction are strongly present, and both link competencies tightly with the creation of competitive advantage. Competencies are not just any abilities to respond to "random" demands but rather building blocks for the firm's competitive advantage. Lehtonen (2002) has listed several different parties that an organization can utilize when striving to increase or develop its competencies including customers (networking), subcontractors, competitors, and educational institutions. He also postulates that sometimes the only available method for competence building is to invest in the firm's own product development. Interestingly however, Lehtonen has made a notion that in the case environment he studied, competence building has not been a really intentional nor a target-oriented activity. On the basis of this case, Lehtonen suggests that instead of the expression "knowledge is built" one should rather use the more passive expression "knowledge is grown" when the knowledge creation process cannot be examined as an intentional activity. Happonen (2001), for one, concluded that a product development project is not a closed entity, whose results are communicated only after the project completion. In contrast, it is typical that knowledge transfer takes place already during the actual development project.

4.2.9 Summary

New product development management seems to be a popular topic that has attracted both academics and practitioners. Within the overall subject, the performance measurement of product development has also inspired many insights. Regarding this theme, the above section primarily reviewed four streams of literature: 1) One that discusses performance measurement and related applications as such. 2) One that explores the application and utilization of performance measurement in companies. 3) One that discusses on the interpretation of new product success and performance. 4) One that seeks antecedents of success and tries to identify mechanisms associated with successful product development. The following list comprises some of the key findings made on the basis of the literature:

- The changing role of product development: increased investments, networking, R&D cooperation.
- Product development should be founded on a clear understanding of customer value: how the customers create value in their processes.
- The importance of NPD performance measurement has been underscored.
- Measurement should be simultaneously relatively simple and comprehensive.
- Dangers related to too straightforward measurement have been pointed out.
- Need for multifaceted measurement has been identified, but there is a very limited number of practical solutions available.

- The construction process of the PM system needs more support.
- The utilization of performance measurement in practice is not very well developed.
- NPD is one vehicle for organizational learning and measurement should also support learning.
- Success is both stakeholder- and context-specific issue.
- Success is very often assessed in relative terms.
- Success is a temporal variable.
- Many cause-effect –relationships have been established regarding the antecedents and consequences of success.
- Product life cycle is one contingent variable of PM system’s design.
- Life cycle -oriented measurement has been discussed to a very limited extent.
- Life cycle would provide a feasible foundation for PM:
    - Comprehensiveness: different stakeholders, a longer time frame, and different requirements are represented
    - Outcome orientation: the “total effects” of a product

4.3 Product Life Cycle and Life Cycle Management

"What is frequently lacking for management discussion is an adequate set of options about the future, and the means to measure them." (Miller 1995)

4.3.1 Applicability of the concept

Life cycle is an applicable concept regarding many issues. Overall, life cycle models imply that the needs and requirements associated with products and technologies (or even entire industries) have an evolutionary character. In other words, products and technologies are seen as dynamic phenomena whose requirements evolve as a function of time. The requirements that are important in early stages of life cycle become less vital when a product or technology reaches the later stages of its life cycle. Massey (1999) lists a number of different purposes, which have been mentioned to benefit from the PLC concept. It has been proposed in the literature that product life cycle would be a useful framework to determine appropriate business strategies (see for example Anderson and Zeithaml 1984, pp. 21-22; Rink et al. 1999) and it could be applied in some marketing problems – such as marketing planning. Also, it has been suggested that a potential area would be forecasting the sales of new products. For instance, Nelson (1992) has analyzed the product demand of engineered metals such as steel, aluminium and titanium by employing the product life cycle concept.

Magnan et al. (1999) have studied the applicability of the PLC concept for developing or selecting the most appropriate manufacturing strategy or practice for products. A number of different manufacturing practices were analyzed regarding which life cycle phase would be the most appropriate for utilizing a particular manufacturing practice. In fact, on the basis of the survey, a variety of different practices were found suitable for the design, introduction, growth, and maturity stages. However, the respondents did not see many manufacturing practices as relevant within the decline stage. This notion implies that the end of the life cycle still receives little attention from the practitioners. Overall, it was confirmed by this survey that firms with products in different life cycle stages employ different manufacturing practices and emphasize different kinds of strategies. Overall, according to the survey of 500 manufacturing managers by Magnan et al (1999), the PLC concept was used by most firms, although at a somewhat moderate level.

Anderson and Zeithaml (1984) stress the potential of the product life cycle concept in the long-term assessment of business impacts. They note that the decision-makers may, for instance, in many industries face high product development costs and investment requirements when developing and launching new products. If this is the case, according to Anderson and Zeithaml, the business has to determine or project the implications of various operating modes for profits over time. Also, it would be relevant in these circumstances to carefully assess the feasibility and profitability of market share gains through the development activities. Anderson and Zeithaml (1984) describe two main methods to proactively benefit from the product life cycle concept:

1. Especially growth businesses should consider the implications of their perceived objectives and strategies for the later stages of product life cycle. The analysis would be based on projections of anticipated market conditions and, on the other hand, the assessment of competitors' strategies.
2. Business management should evaluate the evolutionary development of the market. This comprises continuous evaluation of the company's position in the market and implementation of strategies that enable proper responses to changing conditions.

General support for the idea that life cycle and its phases can be used to structure different requirements and patterns of action can be found from literature. For instance, a study by Moores and Yuen (2001) adopted a life cycle perspective to study management accounting systems and their formality that organizations employ in different stages of life cycle. According to the study, firms in the growth phase pay particular attention to increasing the formality of their management accounting systems.

Werker (2003) refers to a generally agreed relationship that market performance, innovation, and competition depend on the maturity of markets. The level of maturity can be usually described as a function of competition: new markets are typically associated with competition between several firms, whereas mature markets would be dominated by fewer firms. However, all the real-life situations do not correspond to this definition (consider, for instance, the food industry).

Weisenfeld et al. (2001) discussed the differences between forms of collaboration and, especially, the suitability of a collaboration profile for a particular phase of technology life cycle. According to Weisenfeld et al (2001, p. 99), two collaboration profiles that have validity in high-tech areas are industrial platforms and virtual companies. Industrial platforms should be especially suited for the early phases of technology life cycle since they can be used to promote technology transfer by setting up an infrastructure for technology development. At the commercialization stage, virtual companies are recommended as a means to master the management of competencies and market orientation. These findings are, however, made on the basis of a limited number of interviews, thus limiting the validity of these generalizations.

Among other things, the concept of product life cycle has been employed in cost management (Ansari et al. 1997). Life cycle costing (LCC) is founded on the notion that the majority of costs associated with a product could be other than initial: maintenance, replacement, and finance. For instance, over 60 percent of the total costs of a typical office building consist of maintenance, operations, energy consumption, and replacement (Dell'Isola 1997). Furthermore, life cycle has been adopted as a structure for organizing many organizational issues. For example, Sherman and Olsen (1996) investigated the relationship between various dimensions of organizational climate and performance across the life cycle stages of an R&D project. Van den Ende (2003), for one, has showed that the service product life cycle affects the choice of the governance mode of development projects. His analysis is made on the basis of distinguishing between the mature and fluid phases of life cycle. Hart and Tzokas (2000) analyzed the marketing mix decisions related to product launch over product-market life cycle. In addition to product life cycle, technology life cycles, project life cycles, and industrial life cycles have been discussed. For instance, despite the fact that the recognition of project life cycle phases may be difficult, it has been argued that the description and analysis of life cycle as a collection of discrete phases can help to understand the logic and phenomena related to the project and its life cycle (Vartiainen et al. 1999). However, in spite of the numerous possible applications of the life cycle concept, product life cycle is the main interest of this study.

4.3.2 NPD management and life cycle

So far, it has been made clear that new product development management is a crucial issue for successful business. The life cycle management of a product, on the other hand, seems to be among the issues that should be considered within effective NPD management. For instance, Westkämper et al. (2001) define life cycle management (LCM) as an approach that considers the entire product life cycle in order to optimize the interaction between product design and its life cycle activities. On the other hand, Clifford (1965) identified two functions for LCM, one of them being very different from the function identified by Westkämper et al. (2001). Namely, the second function referred to controlling the *product mix* in terms of life cycle stages represented. Further, it has been reminded that product development should not merely translate an identified need into a description of a product but should rather ensure that the design is compatible with the elements across the product's life cycle including performance, effectiveness, producibility, reliability, maintainability, quality, and cost. (Asiedu and Gu 1998, pp. 884-885)

Profitability can be best nurtured with sound decisions during the early stages of product life cycle (Prasad 1997). It has been pointed out that if careless decisions are made during the early stages of product development, the process is continuously in a fire-fighting mode: all the things cannot be resolved because there is always something urgent going on. Hence, Prasad underscores the importance of careful definition and design phases of product development. Through thorough and rigorous initial development, later redesign phases can be avoided. Prahad gives an example that covers two shipyards (Figure 13): one of them put emphasis on early definition when developing the first vessel for a customer, while the other somewhat neglected the initial phase. As a result, when another similar order was placed, the latter company had to put significant effort into redesigning the initial concept.

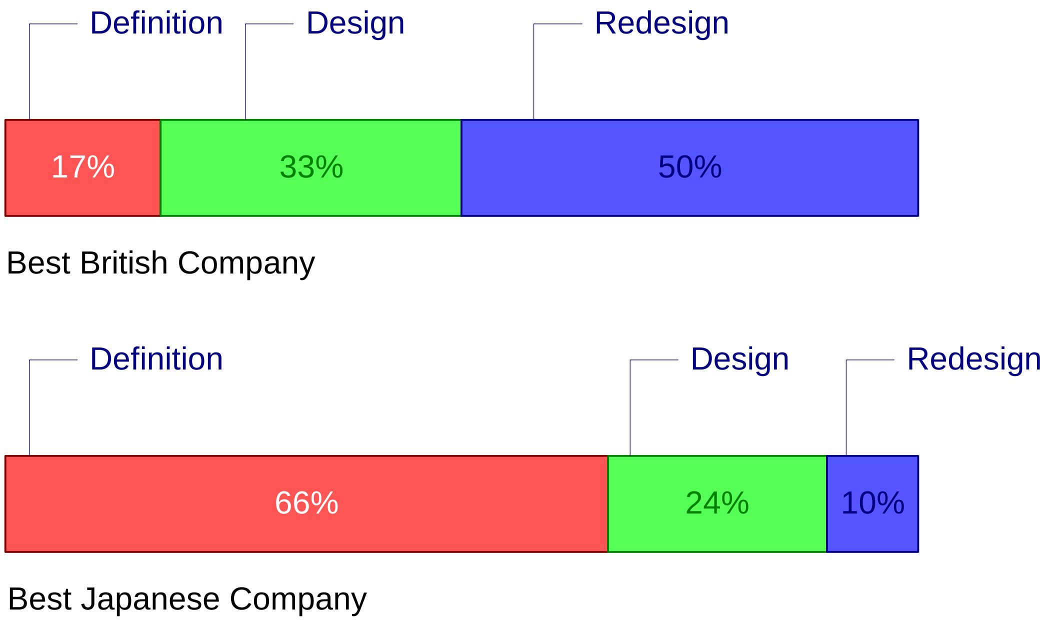


Figure 13. Distribution of product development efforts (Prasad 1997, p. 94)

Wyland (1998) suggests that the capabilities of a product can – and need to – be tracked throughout the supply chain. Furthermore, the tracking can be extended to cover the entire life cycle of a product. Hence, according to Wyland, the full life cycle management of a product is cradle-to-grave management of the product as it progresses through the logistics pipelines. As many different types of data are inherently involved in product life cycle management, some causal data is also likely to be obtained.

At the product level, both the lifetime, the expenditures associated with it, and all the revenues have to be assessed in the LCM process. Bauer and Fischer stress the importance of product life cycle for the long-term profitability of new products (Bauer and Fischer 2000). They have shown that to economically cover the R&D investments of a late-mover pharmaceutical product, the product life cycle needs to reach a sales maximum as early as in the first years after the product launch. This result relies on studied life cycle patterns of pharmaceutical products and the typical R&D costs, marketing expenses, capital costs, and product cost structure associated with them.

Overall, the importance of total life cycle management seems to be increasing as Westkämper et al. (2001, p. 677) point out:

> *"In future times, the designers and manufacturers of manufacturing systems will have an increasing responsibility in developing systems and devices appropriate or adequate to the demands of the whole life cycle. The complete development process is of utmost importance for the future product."*

The first reason for this is pointed out by many authors: product development influences a large portion of the total costs of a product (see for example Asiedu and

Gu 1998; Uusi-Rauva and Paranko 1998). The second reason is the paradigm shift (especially in the industrial context) regarding the essence of "merchandise". Traditionally, producers of investment goods have sold machines or manufacturing lines, for example. Increasingly, however, these manufacturers perceive themselves as "solution providers" or "value/benefit providers". In other words, a manufacturer will not only deliver a system but will also operate and maintain the system. In effect, the manufacturer's responsibility for the product and/or service increases, which leads to the increasing importance of life cycle performance seen from the manufacturer's perspective (Westkämper et al. 2001).

Product life cycle and product development are dynamically inter-connected issues:

> *"The win-win of joint life-cycle planning is that both the company and the suppliers can smoothly move from one product generation to the next. The company is able to optimize time-to-market, while both the company and the supplier benefit from better capacity utilization and reduced total inventories and obsolescence."(Hoover et al. 2001, p. 143)*

Harness et al. (1998) remark that the life cycle management of a product also includes the question of product deletion. As a part of the deletion process, one should be able to identify when a product ceases to fulfil its rationale for existence. To better understand the logic of product deletion, the authors have identified a number of factors that create the need for ending the life of the product. They found that the deletion process may be lead by external, customer-based, strategy-based, or operationally-based factors. Hence, these issues of product deletion add one aspect to the discussion concerning the nature of product life cycle. That is, product life cycle is predominantly a dependable variable that can be *partly* affected by the company and its actions. External factors that may lead to product deletion cannot always be anticipated or affected.

Successful innovations may require close collaboration between suppliers and customers. Collaboration serves not only as a means to identify needs that are communicated by the customers but also as a means to familiarize with the customer's industrial environment. Athaide et al. (1996) stress that the collaboration should not only take place during the development or early commercialization but should rather be a continuous process that goes on also after product installation and implementation. Product development, for instance, works closely with the customer during the customization process. This kind of collaboration requires a clear understanding of the customer's needs, which may not be attained without long-term interaction. Athaide et al. (1996) found that the quality of interactions between product development and customer affect the buyers' satisfaction and future purchase intentions. Also, interaction may facilitate that product development could be able to identify opportunities (such as desired product enhancements that may serve as a foundation for future generations of the product) along the product life cycle as they arise. If the supplier is familiar with the trajectories present in the customer's industry, he will be able to anticipate rising needs via, for instance, modified products.

The performance of a product through its life cycle has been mentioned as a predominantly qualitative measure of R&D productivity (Brown and Gobeli 1992). Also, the economic life cycle of the product is commonly used as a (implicit) basis for economic analysis in product development. In fact, anticipating a product's economic life is a prerequisite for using discounted cash flow techniques, such as net present value (NPV). However, life cycle -based information is often applied in a very straightforward manner, not considering – for instance – the different stages of the life cycle and their characteristics. For example, when testing an option-based approach for R&D project valuation Herath and Park (1999, p. 22) note: "…operations continue at the current level over an economic life of 8 years. We can then obtain the required gross values using the present value formula of an equal payment series". In this example, it is obvious that the life cycle is not more than a numerical parameter for one formula in the value calculation process.

On the other hand, opposite examples can also be found in the literature. There are several authors who have applied the concept of life cycle to various management themes. For instance, the concept of life cycle has provided value when positioning products in the market. Grantham (1997) reports a story of a small software producer that employed the PLC concept when competing against Microsoft. This small producer noticed that its product would be more suitable than that of Microsoft's for the majority of users with older computers unwilling to update their systems. By positioning the product in the later stages of the life cycle, the producer found the niche that was the most suitable for it.

The recognition of important and less important activities and tasks of product development has to be based on the analysis of the product life cycle. Maccarone argues that a number of product development activities may apparently not add value if only the product development process is considered. However, these activities may be of fundamental importance to reach a certain target level of market performance. Hence, the analysis of activities and the identification of value-adding activities has to be made with respect to all the stages of the life cycle of a product. (Maccarrone 1998, p. 150)

Further, especially at successful product introductions, demand exceeds supply. Therefore, preparing for demand is an essential issue in life cycle management. In network relationships, sharing of aggregate volumes (concerning also ramp-up and ramp-down plans) for the whole life cycle is a key activity in joint life cycle management. (Hoover et al. 2001, pp. 143-144) Consistently, Kurawarwala and Matsuo (1998) point out that a total sales estimate covering the entire life cycle of a product and sales estimations for a shorter period would be valuable for many companies. The reasons for this include the length of lead times of major components (in some cases a component's lead time may cover a large portion of the product's entire cycle), volatility in the prices of components, and, especially at the beginning of a life cycle, the lack of *de facto* sales history. However, Kurawarwala and Matsuo (1998) remind that the availability of data on *prior similar* products may act as a surrogate for the scarcity of data on any particular product. As the authors point out, the complete sales history and volume of a number of preceding products is typically available. On the basis of this, forecasts regarding future products can be produced.

Ryan and Riggs (1996) discuss the levels of different activities during the life cycle of a product. They recognize that the workload of various functions or activities depends on the life cycle stage. In fact, Ryan and Riggs have refined the traditional life cycle model. They have established a so-called five-element product wave, whose elements are design engineering, process engineering, product marketing, production, and end-of life activities. Illustrating the varying activity levels, according to Ryan and Riggs, a number of waves occur during the entire product life cycle. The first one is associated with the design of the first version of the product, the next wave with the second upgrade, and so on. Ryan and Riggs point out that the varying activity levels are a direct consequence of product introductions and redesigns that primarily have to be based on company strategy, core capabilities, and the state of the competitive environment. As an example of key activity, product innovation is often considered to take place only within the product development phase of the product life cycle. However, in terms of the innovation activity, the other phases of the life cycle are important as well. The other phases are not only essential due to the fact that they may provide product developers with information that is useful for feeding next-generation product development projects, but they can also provide opportunities for product innovation within a single product life cycle. (Boer et al. 2001)

Customer support is one of the issues that should be considered in comprehensive life cycle -oriented NPD. Goffin (1998) argues that to increase the likelihood of customer satisfaction, a firm has to consider the product's support requirements already during the design stage in new product development. Support, as Goffin (1998) sees it, may take different forms, including: installation, documentation, field service, user training and product upgrades. The important role of support is generally agreed on (see for example Lele 1986; Lele 1997; Suomala et al. 2002): effective product support will, for instance, increase customer satisfaction, provide competitive advantage, and serve as a source of revenue (Goffin 1998, p. 43). Considering that product design has a strong influence on support (Lele 1986), the measurement of support-related aspects is rather underdeveloped. In a survey covering responses from 66 companies, Goffin (1998) identified sixteen measures that were engaged to track product support during product design (see Table 12). According to Goffin (1998), these measures, if used in combination, offer a means for evaluating support requirements at the design stage more comprehensively than is currently often the case.

Table 12. Identified support measures (adopted from Goffin 1998, p. 49)

Support aspect	Design stage measure	Notes
Installation	Time required	Some companies used mean-time-to-install as a goal
	(Human) resource/skill level	
	Material/equipment required	
User training	Time to train the user	Only 20% of respondents applied
	Trainer's skill level	
Maintenance	Mean-time-between-maintenance	Evaluated by 44% but none of the respondents used all the measures
	Human resource	
	Time per maintenance	
	Material/equipment required	
Repair	Failure rate	Failure rate and MTTR were the most common measures of all
	Fault diagnosis time	
	Mean-time-to-repair (MTTR)	
	(Human) resource required	
Upgrades	Time required	
	(Human) resource required	
	Material/equipment required	

Also (Cohen and Whang 1997) put forth that managerial decision-making should focus on the profitability of the product over its entire life cycle rather than on the profitability of a single purchase transaction or on the profitability per a certain period of time. The authors note that the life cycle perspective is relevant and applicable for service industries as well. Also, regarding both product and services industries, it is not uncommon for companies to sell their products or services at a loss in order to gain profits from the after sales period. Indeed, a number of observations suggest that in many industries – including electronics, communication, machine construction, and car industry - the after sales period is very essential both in terms of total product revenues and, especially, generated profits (Suomala et al. 2002; Suomala et al. 2002). Cohen and Whang argue that in many industries, the profit margin of after sales service provided and the margin of service part sales exceeds the profit margin on the sale of the product itself.

4.3.3 Other than producer-based views on PLC

When assessing the interface between a product design and environment, the concept of product life cycle plays an important role. It is increasingly important to consider all aspects of the impacts of a product on its environment. Concerning the attributes of new products including functionality, time to market, profitability, reliability, safety, and cost of ownership, the life cycle perspective is viable to apply to each of them. Functionality, for instance, receives different interpretations along the life cycle. The comprehensive effect of time-to-market, for one, on the profitability depends on the length of product life cycle. The cost-of-ownership, on the other hand, may differ from one life cycle phase to another. Due to this, it is a question of emphasis whether certain product parameters that affect the ownership costs receive more attention than the others. (Pringle 2001)

A lot of valuable work regarding the life cycle assessment of products has been done with an environmental focus or emphasis on environmental issues. These include studies that – despite their specific environmental emphasis - are still quite generic at the level of their fundamental logic concerning the life cycle impacts of the products. Hence, these studies have potential to extend their analyses over a number of aspects in addition to those directly related to environmental impacts (see Kumaran et al. 2001; Leastadius and Karlson 2001). For instance, Kane et al. (2000), propose a stepwise life cycle engineering and assessment methodology for large made-to-order products (LMTO products). One of the requirements of the methodology is that it is possible to produce an estimation of the environmental impact of a product over its entire life cycle. The estimation often relies on measures that can be derived either from primary or secondary principles of clean design. Clean design refers to a number of both primary and secondary principles that can be regarded as – at least – indirect measures of life cycle impacts of products. The primary principles include (Kane et al. 2000, p. 177):

- Dematerialization, that is, using less material
- Substitution, that is, use materials with less harmful waste products
- Use external sources of energy, that is, solar/wind/tidal or bio fuels

The secondary principles include:

- Use recycled material
- Use recyclable material
- Energy efficiency
- Use biodegradable materials
- Extend life span of products

For the actual assessment of material flows and their effect on the environment one approach is provided by the ISO 14040 standard. The life cycle assessment (LCA) approach described in ISO 14040 is structured around four stages of analysis. The first stage sets the scope for the analysis. In other words, during the first stage, the boundaries for the system being assessed are defined. The second stage comprises an "inventory analysis", which means that all the material and energy flows that occur along the life cycle are determined. The third stage, impact assessment, determines the contribution of the predetermined energy and material flows to certain environmental effects. In the fourth stage, by using sensitivity analysis and subjective weighting, the actual environmental effects are combined and summarized to produce a holistic view. Kumaran et al. (2001) add one dimension to LCA, namely the identification of life cycle stages. It constitutes a basis for the entire analysis and may be seen as a part of setting the scope for LCA (see Kane 2000). Furthermore, Kumaran et al (2001) point out that life cycle impact analysis does not necessarily seek to quantify the specific impacts associated with a process or a product, it rather attempts to establish a link or connection between the potential impacts and the product (and its characteristics).

Cohen and Whang (1997) have developed a life cycle model that considers the product's life and its stages from the owner or user point of view to support the consideration of trade-off between profit from product sales and from after sales services. The after sales profit can be seen as a function of after sales service and its quality. Consistently with this, Cohen and Whang point out that after sales service quality can be regarded as one of the design and development decisions. Hence, it is implied that the tasks of product development could be extended to explicitly cover the entire life cycle of the product. "From product development toward product life cycle development"

Price and Coy (2001) have described the life cycle management (LCM) process at the 3M company. The LCM process addresses the general idea that the scope of a manufacturer's environmental responsibility extends to cover not only manufacturing and raw material supply but also the period of customer use and disposal. The example of 3M LCM shows that the environmental life cycle concerns are rather directly connected to competitive viewpoints. Namely, the two main objectives for LCM at 3M are, firstly, to identify the sources of competitive advantage that are based on the exemplary life cycle performance of a product and, secondly, to manage the environmental risks and resource consumption throughout the life cycle. Methodologically the life cycle management process, which is closely interlinked with the product commercialization process, relies on qualitative analysis. In addition, it is underscored that as a support to this qualitative process, more quantitative methods, such as life cycle assessment, could be beneficial. In a more detailed level, the LCM process can be described as a sequence of six discrete stages:

1. A complete LCM screen that aims to identify how a product can be adapted to gain the largest environmental, health, and safety (EHS) advantages. Typically, this review is carried out in the concept design phase for a new product.
2. Gathering of preliminary information concerning all the aspects of the product being developed. A number of scoping questions are employed at this phase. These questions include: What functions are included in the analysis? What is the typical use pattern for the product?
3. Developing charts on energy and raw material consumption and EHS exposures along the different life cycle stages.
4. Complete the LCM matrix, which comprises the sequence of relevant life cycle stages and, respectively, the qualitative assessment of EHS issues at each stage of the life cycle.
5. and 6. Assess the product advantages and disadvantages using a predetermined coding (+ for EHS opportunity and ? for risks, for instance)

4.3.4 Life cycle costs

The notion that virtually all the material and energy flows that occur within a product life cycle have an economic value leads to the idea of life cycle cost (LCC) of the product (Kane et al. 2000). Woodward (1997) defines the LCC for an item as:

> *"The sum of all funds expended in support of the item from its conception and fabrication through its operation to the end if its useful life."*

Or in other words, as Kumaran et al. (2001) formulate, the life cycle cost analysis is to provide a framework for calculating the total costs of design, development, production, use, and disposal of the product. Hence, LCC does not clearly represent either the developer's or user's point of view. Rather, LCC looks at the life cycle just as the product itself "experiences" it.

Building the cost structure so as to identify the potential cost trade-offs is one of the essential elements of LCC. Woodward (1997) points out that while alternative cost structures could be proposed, the required depth and breadth of the analysis mainly determines the appropriate structure. A typical three-category structure is depicted in Figure 14.

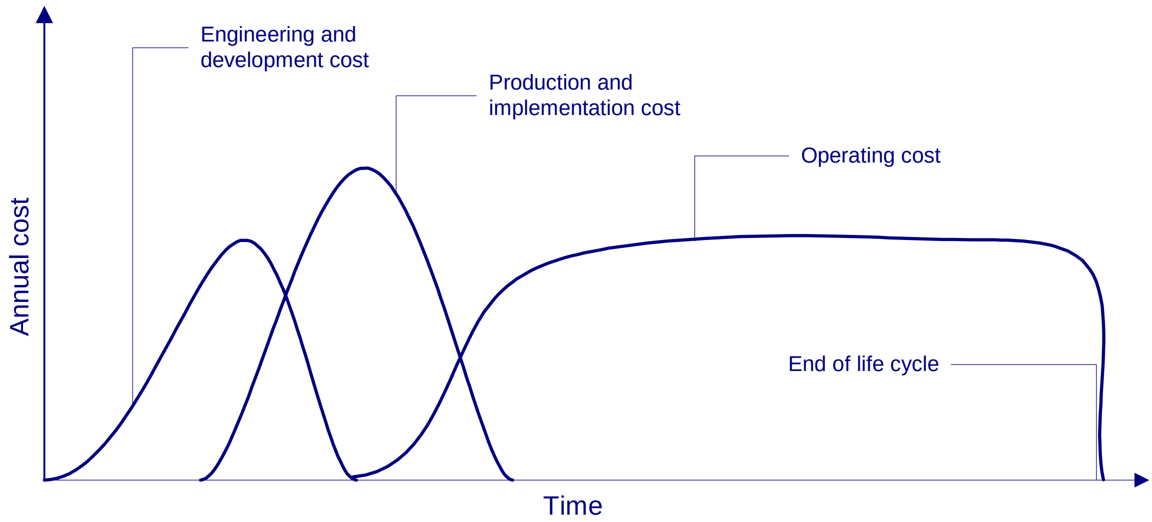


Figure 14. Cost categorization along product life cycle (adapted from Woodward 1997, p. 336)

A variety of methods have been established to identify and calculate the life cycle costs of a product. The models described in the literature feature a number of dimensions that may benefit from the life cycle cost assessment[25], including development of cost breakdown structures (CBS's), generation of cost estimates, total cost determination, and sensitivity analysis. (see for example Dalén and Bolmsjö 1996; Woodward 1997; Asiedu and Gu 1998; Emblemsvåg 2001; Kumaran et al. 2001) For instance, Emblemsvåg (2001) argues that as organizations become increasingly aware of both environmental costs and customer service costs, the costs of the entire life cycle become very important to assess. In conducting the life cycle cost analysis, Emblemsvåg stresses the handling of uncertainty (see also Badri et al. 1997, for the utilization of simulation in dealing with R&D project's uncertainty). Because uncertainty is more or less inherent in product development and related forecasting, uncertainty has to be included in LCC. The activity-based LCC that

[25] However, a study by Leastadius and Karlson (2001) reports that the use of life cycle assessment (LCA) techniques in product development is still underdeveloped. By using ABB as a case, they conclude that the current benefits from life cycle assessments are still quite modest due to the low integration of these methods with operational activities. In contrast with this, they found out that LCA is expected to be a valuable tool in the future and that it will stay in the toolbox of practitioners.

Emblemsvåg advocates utilizes Monte Carlo[26] simulations to handle uncertainty. The construction process of activity-based LCC consists of five main phases (Emblemsvåg 2001, pp. 19-22):

1. Create an activity hierarchy and network, which is supposed to describe the activities that take place during the product's life-span
2. Identify the resources
3. Identify both the resource and the activity drivers
4. Identify the relationships between the (activity) drivers and design parameters
5. Calculate the costs, energy consumption, and waste generation of the consumption of activities

Comprehensively, the life cycle costs of a product can be organized on the basis of product life cycle stages and different stakeholders included in the analysis. (see Table 13)

Table 13. Product life cycle costs (adapted from Asiedu and Gu 1998; Perera et al. 1999)

Phase	Manufacturer	User	Society
Product development/design	Market recognition, product development	-	-
Production	Raw material, labor, processing, energy	-	Waste, pollution, health damage
Distribution	Transport, inventory, damages	Transport, damages	-
Usage	Warranty, service	Energy, maintenance, breakdown	Pollution, health damage
Disposal and recycling	Recycling, disposal	Disposal dues	Pollution, health damage

As an example of a specific LCC application, Dalén and Bolmsjö (1996) have proposed life cycle -based costing for labor factor analysis. They have utilized life cycle thinking in estimating the total costs for an employee over the whole employment cycle. The analysis is made on the basis of three cost factors:

1. Employment costs consisting of recruitment, education, and training-related issues
2. Operational costs that reflect the salaries and related overheads
3. Work environmental costs that include the costs of absenteeism, rehabilitation, and pensions

According to Dalén and Bolmsjö (1996), the life cycle costs of an employee behave analogously to those of a production system. That is, if the costs are plotted as a function of time, the curve will look like a bathtub: At the first stage (acquisition phase) the costs are relatively high mainly due to the costs associated with the employment (analogously to the costs of purchase, installation, and projecting in the case of a production system). Within the second phase (operation phase), the costs are

[26] Monte Carlo simulation is a numerical approximation method used in mathematics, statistics, and operations research to resolve problems by the use of random sampling. The behavior of a system is simulated by feeding in values of the system variables, and repeating the operation over different sets of values so as to explore the system under a variety of conditions. http://www.manningaffordability.com/s&tweb/PUBS/Man_Mach/annexi.html

first decreasing to find an equilibrium. In the employment cycle, salaries and overheads mainly comprise the operational costs. Finally at the third stage, the work environmental costs will rise resulting in an increase in the total costs. In the case of a production system, the increasing costs in the final stage often relate to repairs and disruptions.

A presupposition that consumers – or industrial customers – are rational and that they make efficient selections to maximize their wealth is an interesting issue with regard to life cycle costing. For instance, decisions related to life cycle costs include temporal elements. Hence, to be in a position to make efficient decisions, taking into account the life cycle effects, customers are required to cope with two kinds of cost elements: those related to purchase and those that are connected with use and maintenance. The ability of customers to make efficient decisions that are based on total life cycle costs is analyzed for instance by Liebermann and Ungar (2002). They found out that, generally, consumers cope rather well with LCC situations. However, recent studies have shown that industrial investments decisions are seldom based on life cycle costs (Järvinen et al. 2004).

Kane et al. (2000, p. 181) have found that discounting economic values associated with future events is perhaps not as problem-free as one might expect. Kane et al. argue that sometimes discounting may conflict with the idea of life cycle consciousness: “There is, however, a dichotomy between discounting and sustainable development. Using a private-sector discount rate (typically 20-25%) reduces most costs in the intergenerational time frame (20 years) to a negligible level, diminishing the importance of such future issues as decommissioning.” As one solution, Kane et al propose variable rate discounting that utilizes a hyperbolic function to calculate the discounting factor (VDF):

$$VDF = \frac{1}{(1 + rt)}$$

, where r is the discount rate and t is time

Whereas constant discounting factor is given by:

$$DF = \frac{1}{(1 + r)^t}$$

According to Kane, it is even suggested that the variable rate discounting is actually closer to public’s time preference for money than constant rate discounting (Kane et al. 2000).

4.3.5 Length of life cycle

The profits from a product or service have to be earned during its economic life cycle. Therefore, an important consideration that also restricts the product development process and the practices employed is the relation between the product development lead time and the length of the product’s entire life cycle. If the development phase is relatively long compared with the entire life cycle, the efficiency of the development process gains importance. On the other hand, when the development phase is relatively short compared to the length of the entire life cycle, the efficiency of the development phase might not be a primary concern. In the former case, any practices (including utilization of performance measurement techniques) that require a lot of effort and resources and are time-consuming are more likely to be a burden for the life cycle profitability. This is because rapid product development is a prerequisite for the economic life cycle of a product. In the latter case, an effort taken – even a time-consuming one – in the product development phase is more likely to produce sufficient economic returns later in the life cycle. Especially in consumer markets, product development lead time is one of the most important competitive factors (Prasad 1997). Consistently with this, in many companies the actual development costs are rather small (10 – 20 percent) compared to the total cost of product, and the changes made during the development phase are relatively cost effective compared with those made in later phases (Prasad 1997, p. 95; Sievänen et al. 2001).

It has often been pointed out that the product life cycles are shortening on the average or that short life cycles are becoming increasingly common (see for instance Ryan and Riggs 1996; Kurawarwala and Matsuo 1998). This not necessarily the whole truth: As a clear majority of authors argue that the product life cycles are generally getting shorter, some evidence has been found to support the opposite view. According to Bayus (1994) for example, no clear empirical support exists for shrinking life cycles either at the level of industries, product categories, or product models. Furthermore, limiting the credibility of the shortening life cycle –argument to some extent, it is also noteworthy that this same argument has been constantly used for decades. For instance, already Clifford (1965) stated that life cycles are getting shorter. Instead of over-simplifying the issue too much, it would be more realistic to say that the length of life cycles differs across industries and very long life cycles exist as well. For instance, it has been noted that the length of product lifetime in many industries exceeds 10 years and it is not even uncommon to have product lifetime longer than 20 years. (Goffin and New 2001, p. 285; Suomala et al. 2002)

Despite the length, forecasting the life of an asset has a major influence on the life cycle analysis. But how to anticipate the length of life of a product? Woodward (1997) refers to five possible determinants of an asset's life expectancy:

- Functional life, which represents the period over which the need for the product is anticipated
- Physical life, the period that the product may be expected to last physically
- Technological life, which refers to the period after which technical obsolescence occurs (due to technically superior alternative)
- Economic life, which corresponds to the period after which economic obsolescence occurs along the emergence of a lower cost alternative
- Social and legal life, which represents the period over which human desire and/or legal requirements do not require replacement

Uncertainty is an inherent element of life cycle analysis and life cycle cost analysis. Therefore, (see for example Jiang and Zhang 2003), included elements and system costs within these analyses are typically represented by statistical distributions. Kane et al. (2000, p. 184), for one, underscore that it is a particularly challenging task to predict the life cycle of a product. Therefore, it is important for a methodology concerning life cycle assessment to allow the application of several potential life cycles. The occurrence of each alternative life cycle can be anticipated with some degree of probability.

Bauer and Fischer (2000) have conducted a time-series analysis on the sales data of pharmaceuticals to determine the long-term economic behavior of such products. As a part of the study, they have identified an international classification of product life cycles for pharmaceuticals. They ended up with three different life cycle patterns for pharmaceuticals that represent the real-life clusters of life cycles describing the sales patterns of new products in this industry (see Figure 15).

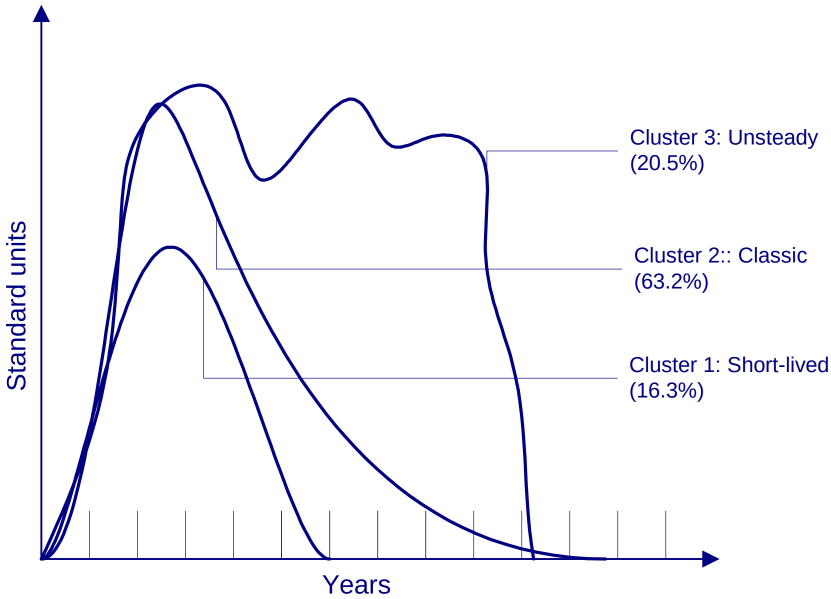


Figure 15. Alternative life cycle patterns (Bauer and Fischer 2000, p. 709)

It has been found out that the shape of the life cycle depends on the degree of innovativeness: the first movers and late movers seem to behave differently in terms of sales volume development. The first movers typically witness a long growth period toward the peak of the life cycle, while the late movers usually proceed more rapidly into the point of the highest sales volume of their life cycle. Further, one might observe that, according to Bauer and Fischer, the PLC describes the phases of a product from its introduction to the market until its withdrawal. Hence, this definition is based on the market presence of the product and the development phase of the product, for instance, is not considered as a life cycle phase of its own. This approach is quite natural and appropriate if the primary aim of the life cycle assessment is on the sales behavior of the product.

Curtis (1994) argues that a major determinant of product life is the ease of service and maintenance. According to him, many products are discarded because the costs of maintenance become too high compared to the perceived product value. Contrary to practices observed by Curtis (1994), to ensure the greatest influence the aspects of service, disassembly, and recycling have to be considered in the early stages of product design. It is proposed that these considerations can be made in conjunction with the design for assembly (DFA) analysis. By using the DFA structure, it is possible, for instance, to determine a disassembly sequence for a certain service task. Together with cost estimations related to service parts, one is able to assess the serviceability of the product to a certain extent.

4.3.6 Technology life cycle

Product life cycle can also be analyzed within a broader framework of technology life cycle. The framework of technology life cycle refers to an idea that technologies evolve – analogous to products – through a number of phases or stages whose characters are different from each other. First, a technology is created or developed, after which it will witness some kind of an introduction to the market. If it is able to demonstrate value to some extent, it will exhibit a wider adoption and application phase. Eventually, as more competitive new technologies are introduced, the technology life cycle will reach its end and the technology is replaced. It is argued that different technology life cycle phases have different kinds of characteristic features. For example, rapid innovation accompanies the early stages of technology life cycle. On the other hand, the importance of process innovation becomes more evident as the technology matures. Also, it is suggested that as technology gets more mature, the uncertainties and limitations related to technology decline enabling the standardization of products and processes.

Hence, relying on the concept of technology life cycle and its ideas about varying requirements, products that represent different technology life cycle phases should be managed with a different kind of emphasis. As the success criteria for a product differs from phase to phase, the products should demonstrate different qualities to be able to succeed. For instance, products that are essentially based on new technology (technology in the early stages of its life cycle) are likely to be able to demonstrate competitiveness in the market if they are merely technologically progressive and innovative. This is consistent with an observation made by Rhyne (1996), according to which technological genius or creativity may be a basis for success during the early stages of life cycle. In addition, technological quality in the early stages may also mask other organizational shortfalls to some degree. However, to be able to be competitive, products whose technological core is relatively mature have to meet different criteria related to, for example, cost efficiency and effectiveness.

The concept of the technology S-curve (Figure 16) is one of the models that have been presented to illustrate the nature of technology evolution during its life cycle. According to the concept, small or marginal improvements on a product's performance will require a relatively large development effort during the early stages of technology development. As the technology becomes more familiar and utilized in a variety of products, the improvements in performance can be achieved by a smaller effort. Finally, as the technology approaches its limits, the improvements in performance become increasingly difficult to obtain. However, although major breakthroughs are difficult to achieve towards the end of the life cycle, a series of incremental improvements may result in significant overall performance gain (Rhyne 1996).

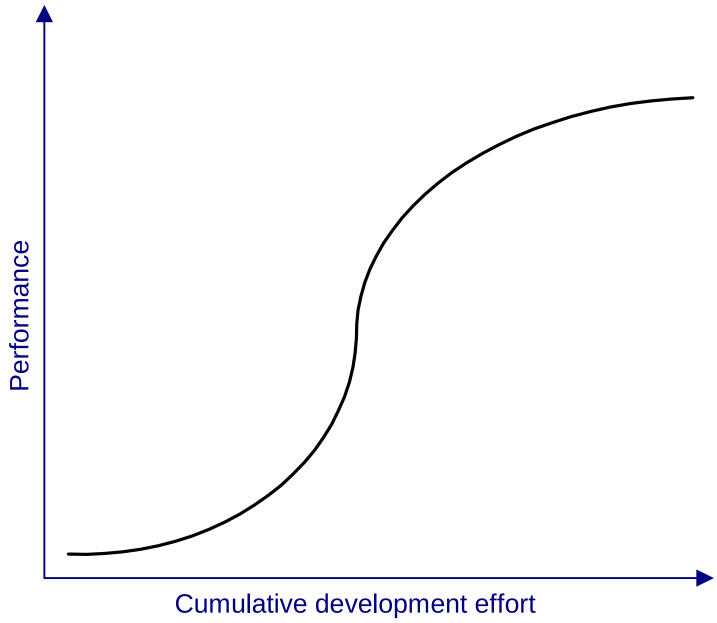


Figure 16. Technology S-curve (adapted from Meldrum 1995, p. 51).

Meldrum (1995) reminds that the technology and market life do not necessarily go hand in hand: although the technology may have reached its maturity, the market may not still be very mature. Alleged that technologies develop according to an S-curve, it is possible to provide an explanation for the impression that product life cycles seem short in high-tech markets. It may be that short product life cycles result from the fact that the technologies become easier to develop (Meldrum 1995). Of course, it is sometimes very difficult to determine whether a product is high-tech or a new technology product by its nature. Meldrum (1995) depicts this problem: “The worlds of automobiles and copiers both provide good examples of products which utilize a whole range of advanced and old technologies. Some of these will be regarded as high-tech, others will not. It is, therefore, difficult to differentiate between high-tech and non high-tech products purely in terms of the technology they incorporate”. In fact, Meldrum suggests that the customers and the suppliers are those who essentially determine whether a product is regarded as high-tech or not.

Further, the S-curve illustrates that product development faces different situations along the technology life cycle. Products that are based on emerging technology will probably require large investments to reach substantial performance improvements. Hence, at this point, product development -based strategies would be rather restricted or at least expensive. At the later stages, however, when moderate development efforts result in essential performance improvements, rightly timed product development efforts become an important means to produce competitive advantage. (Meldrum 1995) Lessons on successful innovations made during the mature phase of technology life cycle include (Rhyne 1996):

- The technology is not enough per se, it should also be used effectively. This calls for co-operation that covers both sales, customer service, financial department, and production.
- The technology is rarely too mature to be further developed and invested in. Small or even marginal improvements can make a difference.

- Look outside the organization. The best solutions for the problems in hand may be found somewhere else.

4.3.7 Measurement issues

Rink et al. (1999) point out that the financial management of a firm must consider, for instance, the profitability of a new product investment along the different life cycle stages. A product may seem unprofitable at the introduction stage, but it may actually provide the organization with an option to invest further to enter a new market. As a result, the product will turn profitable in the growth and maturity phases. According to this example, the financial management of the firm has to pay attention at the introduction stage to correctly value the options that are associated with the possible future investments and profits from the succeeding phases of the product life cycle. Another product life cycle -related issue for management is the balance (or lack of it) between life cycle phases represented by the company's present product portfolio. In terms of risk management and sufficient and continuous cash flow, it is advisable to have active products in different life cycle phases.

Hayes and Wheelwright (1979) have connected product life cycle with (manufacturing) process life cycle arguing that a change in either one of the dimensions should be accompanied by a change in the other one, too. According to Hayes and Wheelwright, just as a product evolves through a number of life cycle phases, the production process should be adapted accordingly. The authors argue that the process evolution typically begins with a state that is characterized by high flexibility and low cost efficiency. Towards the end of the product life cycle, the process becomes more standardized and automated. When measuring the performance of such processes, these characteristics should be taken into account. However, despite its ideological appeal, the linking between process and product life cycle remains questionable. Hayes and Wheelwright do not – in addition to some anecdotal issues – provide empirical support for the general idea. The idea that one particular type of production process would be more suitable for a certain type of product than for another seems logical per se. However, the validity of the idea that product evolution is accompanied with simultaneous process evolution is more doubtful. Above all, it is in clear contrast with many real-life cases in which the production process, once it is established, remains rather stable along the life cycle. This is especially true at the level of brands and even product forms. However, at the level of product classes, the connection between product and process evolution would be more applicable.

A study by Richardson and Gordon (1980) is one of the few that focus on the relationship between the product life cycle concept and performance measurement. Interestingly however, the total concept of PLC (and its general validity) is argued to be less central to the discussion presented by the authors. Richardson and Gordon identify that many products do not follow a standard life cycle pattern that consists of a sequence of a number of discrete stages, but rather, a wide range of life cycle patterns – from short-term fads to virtually everlasting commodities – exists. Hence, the precise form or life cycle behavior is not the key. The key is the finding that different life cycle stages merely exist and that the appropriate measures differ from stage to stage. Richardson and Gordon (1980) have studied performance measurement practices across the product life cycle stages in fifteen Canadian manufacturing companies. They propose that life cycle would be a suitable framework for establishing performance measures for manufacturing organizations. As a rationale for their study, Richardson and Gordon mention that too little attention has been paid to the changes in the criteria for evaluating a manufacturer's performance over the product life cycle. The underlying logic behind the dynamic performance measurement along the PLC is that the critical tasks of manufacturing change as a product moves through its life cycle (see for example Hayes and Wheelwright 1979; Hayes and Wheelwright 1979). As the critical tasks change, the appropriate performance measurement is also different from one stage to another. According to Richardson and Gordon (1980), measures that focus on innovation, responsiveness, and flexibility should be the most appropriate early in the life cycle. At the growth stage, measures that indicate ability to deliver gain importance, including indicators for capacity growth and utilization rates. At the mature stage, productivity and cost efficiency measures should be the most important. The observed industrial practices, however, differed quite clearly from those derived theoretically: firms did not measure performance in terms of life cycle. Instead, most measures were typically designed for or appropriate for mature products only.

To summarize, Richardson and Gordon (1980) suggest that the evaluation of performance should consider both product life cycle and operating strategy. Furthermore, the measurement should identify or support the prioritization of different performance areas. In other words, the measurement should be able to answer to what is critical for the firm and what is not.

Malmi et al. (2002, p. 25) have also connected performance measurement and the life cycle concept. However, they discuss organizational life cycle rather than product life cycle. The nature, focus, and emphasis of performance measures depend upon the situation – or the stage of corporate life cycle – of the organization. Typical measures for the organizations in an intensive growth phase include several measures that indicate the growth of sales. On the other hand, organizations that are in the middle of a mature and stable phase of their life cycle – constituting a majority of all organizations – tend to emphasize the measures of profitability. Further, towards the end of corporate life cycle the measures of cash flow gain more importance. (Malmi et al. 2002, p. 25)

4.3.8 Critical remarks

Polli and Cook (1969) were among the first to investigate the validity of the product life cycle concept. Despite the criticism that the concept has received more lately, Polli and Cook (1969) conclude that the life cycle model is valid in many common market situations. Furthermore, they add that the fit of the product life cycle model is the most importantly depending on the definition of the product used. The life cycle model was found to be more appropriate in product form analysis than at the level of product class.

According to Bauer and Fischer (2000), there are many problems unsolved with the PLC concept:

- Definition of metrics to trace life cycle phase transition
- The choice of proper level of aggregation (product class, product form, brand)
- Empirical generalization of the PLC

Also Massey argues that a number of problems have been identified with the PLC concept. Among them, there is an empirically observed phenomenon called second life: a product "refuses" to die despite a general belief that it is the decline stage. Also, automatic strategy implications on the basis of the life cycle phase are found to be rather problematic: extreme caution is needed when determining an appropriate strategy for a product based on a life cycle phase. This is because, for example, a product may look like it is entering the decline stage, whilst it actually just suffers from a temporary sales decline due to other factors than the life cycle phase. (Massey 1999)

For instance, at the level of product classes, many commodities such as Scotch whisky or French perfumes have lived a prosperous maturity stage for centuries. If a commodity serves to satisfy a kind of basic need, its life may be extended virtually endlessly. (Dhalla and Yuspeh 1976) It has even been argued that:

"It is a tautology that products are created and later die" (Mercer 1993)

However, Bauer and Fischer (2000) note that the existence of the product life cycle per se is not a question. This seems to be in contrast with the criticism the concept has received. Bauer and Fisher (2000) provide some insight regarding the focal points of criticism. First, there is a traditional ideal of PLC that is typically presented in marketing textbooks: product life cycle is depicted as a symmetrical bell-shaped curve. Inevitably, this kind of assumption on sales development is too restrictive and it is not capable of corresponding to empirical diversity. Second, a number of questions that are highly relevant for the practitioners are unsolved. These include: the length of the phases, the length of PLC in itself, unknown forces that moderate the variables in PLC's, influence of product newness, or order of entry on PLC.

Do the issues brought up within the PLC criticism actually jeopardize the applicability of the concept? No single answer can be given. To be able to approach the question, it is necessary to assess in detail the context within which the PLC concept is applied. In this context, product development measurement, the validity of the PLC concept is not an issue as such. For the purposes of measurement there is no reason to expect that a product would follow a smooth bell-shaped life cycle model. The key is to understand that the product will eventually go through various life cycle stages that can be associated with a number of distinct requirements. As a summary, the identified problems of the generic life cycle model include (see for example Dhalla and Yuspeh 1976; Grantham 1997):

- PLC is a self-fulfilling prophecy.
- Stages of the life cycle may vary in terms of length and behavior.
- Products may reincarnate or PLC's can be extended by means of marketing or design/engineering.
- It is difficult to determine at what stage the product actually is.
- Planning period of many organizations does not match the whole life cycle but rather a small part of it.

- PLC has lead to over-emphasis of new product introductions at the cost of neglecting older brands.
- In PLC analysis the definition of the concept of "product" is left ambiguous. It is unclear whether PLC refers to product class, product form, or brand. Dhalla and Yuspeh 1976 note, however, that the product form is thought of in most cases when referred to a "product" in the PLC context.
- Although it has been generally questioned that the product life cycle can be validated at any level (Dhalla and Yuspeh 1976, p. 103), the smallest validity of PLC is recorded at the level of brands: most market leaders for example in 1970's are still market leaders. (see Mercer 1993)

Concerning these problems, the most significant ones in terms of the realization of measurement seem to be the difficulty to determine at what stage the product actually is and the possible ambiguity of the concept of new product.

4.3.9 Summary

As a brief summary, a number of issues can be raised on the basis of both the criticism and support that the concept of PLC has received:

- PLC should not be regarded as a deterministic concept but a more existentialistic one: PLC does not determine the appropriate strategies but the appropriate strategies are able to affect PLC (Massey 1999, p. 305), (Tellis & Crawford 1981 in Massey 1999). That is, PLC is essentially a dependent variable – not an independent one – that can be affected by a number of means including those of falling under the broad categories of new product development and marketing.
- PLC would be a good framework for proactive rather than reactive management. For instance, in the spirit of "Lamarckism" (see Massey 1999), one should look at the most important attributes, which can be passed to future product generations. And also vice versa, the product management should identify those product attributes that are not required in a particular environment.
- Combination of the concept of product life cycle and the Lamarckian model of product evolution could be a fruitful basis for product innovations. The Lamarckian model of evolution implies active marketing research and a systematic approach to new product development (see the previous point).
- Product life cycle receives a number of interpretations depending on the selected viewpoint and the level of assessment. The marketing view that considers the life cycles of product forms, product classes, and brands is only one of them. The customer perspective of the life cycle is also able to provide the manufacturer with proliferant insights into product management.
- From the financial management point of view, the length of PLC is one of the most essential parameters. It determines the window of opportunity for gaining profits through the product. However, similar to PLC at a general level, it is important to perceive the length of life cycle also as a variable rather than as a constant.
- Product life cycle can be structured in meaningful ways depending on the selected interpretation. Structuring may comprise dividing the life cycle into discrete phases that constitute the sequence referred to as the entire life cycle. The discrete

phases may be associated with a number of features, requirements, or circumstances that are characteristic of a certain life cycle phase. Further, it is not necessary to structure the life cycle around discrete phases, but it is possible to depict a life cycle also as an evolutionary trajectory. This view is actually consistent with the real-life situation: a product does not jump from one stage to another, rather it evolves gradually as the environment changes.

Despite the fact that some of the product requirements are somewhat life cycle phase - specific, general requirements for product life cycle can be identified as well. An essential one is a product's profitability: an evident financial objective is that the cumulative profit from a product should be positive. Otherwise, in the business sense, the product's justification is questionable. However, even in this case, the product could produce some positive implications, for instance, by promoting organizational learning or providing the firm with a catalyst for important developments in the organization. To summarize, due to the nature of life cycle phases and the associated requirements, the quality and nature of R&D outcome cannot be determined only by assessing the direct output of a product development project or program or by evaluating the experiences of the first customers. If a set of multifaceted measures for new product development is pursued, product life cycles and their distinct phases should be carefully analyzed to be able to set comprehensive objectives for R&D activity.

5 The Tentative Framework: Multifaceted NPD Measurement

This section includes a discussion that aims to conclude and summarize the issues raised by the literature review on NPD management, performance measurement and life cycle management. On the basis of this, a conceptual framework for life cycle -conscious performance measurement (LCCM) in the product development context is proposed.

5.1 Summary of Relevant Literature

Research and development, or more specifically new product development, should be able to positively contribute to the future success of an organization. However, it has also been argued that product-centered strategy provides only a limited insight into the process by which the strategy of a firm is able to contribute to its future success (see for example Hamel and Prahalad 1994; Hamel 1996; Fowler et al. 2000). Two different approaches for the future success of an organization include product-centered strategy and competence-based strategy. The fundamental difference between these two is that while product-centered strategy focuses on products and (minor) improvements on them, competence-based strategy focuses on the capabilities[27] that underlie the firm’s ability to create successful products (see for example Prahalad and Hamel 1990). Fowler et al. (2000) distinguish between three types of competencies: technological, market-driven, and integration competencies.

However, in terms of competence development new products and NPD are important components. Fowler et al. (2000) argue that new product development activities combine the organization’s current competencies in marketing with its current technological competencies to create commercially viable products. Further, if the strategy of an organization emphasizes competencies over products, the product development -related investments are likely to focus on how to optimally build on and extend the current competencies to develop competitive products on a longer term. This view of competence-based product development is in line with the life cycle -conscious new product development. As Fowler et al (2000) note, it is very unusual the present competencies of a firm correspond directly to the needs that have been identified in product development. When organizations employ the knowledge integration process necessary to develop a new product, they actually engage in a process of problem solving in which they have to develop new capabilities to solve various unanticipated problems. This process implies the need for new capabilities and thus acts as a primary driver of new competencies.

Hence, a careful assessment and anticipation of product life cycles and an organization of products’ lives on the basis of a number of phases that are associated with different requirements could be one of the means to support the long-term competence development of a firm. Orientation towards future requirements using the product life cycle concept encourages or even enforces the firm to consider the

[27] Competencies and capabilities can be used as synonyms (Fowler et al 2000).

developments that are required in the long term to be able to stay competitive or to increase competitiveness.

It is noted by Fowler et al. (2000) that the measurement of competencies is difficult. This observation is based on the idea that competencies are dynamic and intangible. However, despite the difficulty, Fowler et al propose a number of measures for both market-driven, technological, and integration competencies. The measures proposed (for instance, measures such as "spending per customer", "on-time delivery", or "number of competitors serving this customer" for market-driven competencies, and measures such as "product profitability", "percent of sales from new products", or "number of competitors delivering similar products" for integration competencies) raise a question of what is the primary purpose for measuring competencies. If it is indeed as difficult to define proper metrics for competencies as the previous examples illustrate, it could be questionable to establish any explicit metrics at all. The measures that are proposed can be regarded as surrogate and ambiguous at best. At least regarding the measures used as an example, the general validity is a major concern. For instance, it should be a minimum requirement for the measurement of competencies to distinguish between the actual capability and the driver of a capability.

Instead of focusing on distinct metrics or measures, this study suggests that the overall framework for new product development performance measurement – the blueprint for life cycle -conscious PM – should also provide support for competence development and sustainable product development. Life cycle orientation in constructing performance measures facilitates the identification of requirements that need to be fulfilled in the long term. Combining the requirements derived from the needs of the different stakeholders of product development and the requirements associated with the whole life cycle of the product broadens the view on NPD performance and enables versatile and multidimensional target setting. While the measurement framework thus also supports long-term competence development, it does not advocate explicit measures for issues that cannot be properly measured. The identification of an important objective may be sometimes enough for directing attention towards issues that need to be further developed. In other words, an explicit measure is not an imperative of management.

The idea and the presented framework for multifaceted and life cycle -conscious performance measurement of product development relies heavily on the literatures on performance measurement, new product development management, and life cycle. These bodies of literature are all rather extensive. The key findings, however, provide the foundation for the measurement framework presented in this chapter.

Above all, the literature on performance measurement includes observations that are common to measurement systems in general. First, measures and measurement systems are not independent structures. Consistently with this, the construction of measures and measurement systems should be somehow anchored to wider frameworks such as organizational goals and schemes. Therefore, it has been commonly suggested that measures should be constructed or derived from the top down. A good alignment between the measurement system and organizational strategies and objectives would ensure the consistency (or external validity) of measurement. Second, in addition to external consistency, the measurement system should not include severe internal conflicts. It has been stressed that the internal coherence of measurement is important. Different measures should probably convey a reasonably consistent message for the decision-makers and utilizers if any real effect is desired. The identification of cause-effect relationships is a part of the process for ensuring the internal coherence of a measurement system. A cause-effect relationship can be identified, for instance, by analyzing past or present experiences and/or by employing specific tools such as strategy maps or cause-effect diagrams. Third, although the measurement of leading indicators – or causes if you like – has gained interest, it has been argued that in most cases measurement should focus on the outcomes, results, and achievements. Nevertheless, they are the primary objects for the measurement: if we are not able to properly identify the outcomes of our actions, there is little point in trying to identify a number of causes for outcomes we are not able to prove. Fourth, virtually all the measurement frameworks presented in the literature share the interest of comprehensiveness. Balanced scorecards, performance pyramids, or prisms illustrate that performance is a multidimensional subject that calls for comprehensive measurement. Consistently with this, simultaneous internal and external orientation and the inclusion of several stakeholders characterize the frameworks presented in the literature. Furthermore, as regards the purpose of measurement, it has been reminded that it should enable learning, for instance by facilitating learning from past mistakes. Complementing this, measurement should also provide a means for anticipating some future effects. The identification of leading indicators and determinants of success is part of this but sensitivity analyses and scenarios are needed, as well.

The literature of NPD management indicates a good number of findings. First, product development should be founded on a clear understanding of customer value. More specifically, it should be understood how the customers create value in their processes. All the product characteristics do not relate to customer value. Understanding customer value creation enables product development to focus on issues that are perceived as the most important and valuable. Second, in general, the importance of NPD performance measurement has been underscored by many studies. Performance measurement has been recognized as a means to improve the effectiveness of product development and a number of more specific purposes for measurement have been identified. To be effective, measurement should be simultaneously relatively simple and comprehensive. In other words, too sophisticated a measurement system will not likely be implemented and actively used. On the other hand, the dangers related to too straightforward measurement have also been pointed out. This is important since measures can be very powerful tools for directing efforts towards a certain direction. It can be regarded as a paradox: the need for comprehensive measurement has been identified, but there is a very limited number of practical solutions available and especially, it has been argued that the utilization of performance measurement in practice is not very well developed.

Third, the fact that product development success (or performance) is both a stakeholder- and context-specific issue makes measurement very challenging. In practice, success is very often assessed in relative terms, for example by comparing the achievements to prior expectations. Also, it has been remarked that success is a temporal variable. Success receives different interpretations depending on the life cycle phase, for example. Despite the dilemma of success, many cause-effect –

relationships have been established regarding the antecedents and consequences of success.

Fourth, life cycle -oriented measurement has been discussed to a very limited extent within the NPD performance measurement literature. On the other hand, it can be concluded from the literature that product life cycle is one contingent variable of a PM system's design. The concept of product life cycle implicates at least two issues that are important for performance measurement: 1) Comprehensiveness; it facilitates the inclusion of different stakeholders, a longer time frame and different phase-specific requirements. 2) Outcome orientation: the analysis of the whole PLC is able to depict the "total effects" of a product.

The literature on product life cycle can be summarized briefly as follows. First, PLC should not be regarded as a deterministic concept but a more existentialistic one. That is, PLC is essentially a dependent variable – not an independent one. It can be affected by a number of means including those that fall under the broad categories of new product development and marketing. Second, it has been suggested that PLC would be a good framework for proactive management rather than for reactive management. The concept of life cycle can be employed for identifying those product attributes that are (or are not) required in a particular environment. Third, product life cycle is not a homogenous concept but it receives a number of interpretations depending on the selected viewpoint and the level of assessment. The marketing view that considers the life cycles of product forms, product classes, and brands is only one of them. The customer perspective of life cycle is also able to provide the manufacturer with fruitful insights into product management. Fourth, from the financial management point of view, the length of product life cycle is one of the most essential parameters. It determines the window of opportunity for gaining profits through the product. However, similar to PLC at a general level, it is important to perceive the length of life cycle also as a variable rather than as a constant. Finally, PLC can be structured in a number of ways depending on the selected interpretation. Structuring may be interpreted as dividing the life cycle into discrete phases that constitute the sequence referred to as the entire life cycle. The discrete phases may be associated with a number of features, requirements, or circumstances that are characteristic of a certain life cycle phase. Further, it is not the only possibility to structure the life cycle on the basis of discrete phases, but it is possible to depict the life cycle also as an evolutionary trajectory. This view is consistent with the real-life phenomenon: a product does not jump from one stage to another; rather, it evolves gradually.

To conclude, life cycle – seen from one perspective or simultaneously from several perspectives – would have potential to serve as the overall framework for constructing performance measures. The effects of new products are time-dependent and comprehensive effects cannot be found unless a longer time frame is considered. This indicates the importance of proactive life cycle phase –specific analysis that should be extended to cover the whole anticipated life cycle. Proactive analysis can later be supplemented with a reactive one as data on the life cycle cumulates. In addition, the stakeholders (and success interpretations associated with them) should also be carefully considered in NPD to identify the comprehensive objectives for a new product and possibly conflicting interests. Outcome orientation, for one, indicates that NPD performance measurement should not only mean the measurement of the product development process but it should also track the actual achievements that will not be realized until customers have gained experiences from using the product. The identification of cause-effect –relationships and antecedents of success would also be important for continuous NPD management.

5.2 Life Cycle -Conscious NPD PM of Industrial Products

Figure 17 summarizes the idea of life cycle -conscious product development and provides a framework for constructing and evaluating the performance measures of new product development. The figure depicts three interpretations of the concept of life cycle consciousness in the context of product development performance measurement. The interpretations are not suggested as mutually exclusive; rather, they are intended to supplement each other. However, depending on the type of product and the market, the relative relevance of the interpretations may vary. That is, all the interpretations are not necessarily equally relevant or important in different environments.

According to the first interpretation, new product development is an activity that takes place primarily at the beginning of the product life cycle. Further, the entire life cycle of the product can be divided into smaller, and relatively homogenous, blocks that represent life cycle stages or phases that a product experiences during its life. Each phase includes a number of characteristics that can be translated into process or product requirements. As these requirements are collected together, the multifaceted set of product requirements can be formulated. Hence, the identification of distinct life cycle phases and associated product requirements constitutes a foundation for an NPD target-setting process for performance measurement. In this procedure, it is not necessary to restrict the possibly versatile interpretations of the concept of product life cycle. That is, product life cycle can either be evaluated from the perspective of customer, producer, or society – or these can be used in combination to be able to depict the product's life even more comprehensively. Further, the emphasis on and importance of a distinct life cycle phase can be determined, for instance, by evaluating the duration of the phases or the costs associated with them, or by assessing the workload of various corporate functions over the entire life cycle.

If the customer's perspective is adopted as the basis for the assessment, a thorough understanding of the customer's process and value creation is needed to be able to identify objectives and measures for distinct life cycle phases. The assessment could be founded on profits, costs, or other (non-financial) issues that the customer experiences during the identified life cycle phases. Regarding industrial investment products, producers are typically rather familiar with the customers' processes, at least at a general level. In that sense, constructing performance measures on the basis of the product life cycle phases experienced by the customers should be feasible in most cases. Naturally, the more detailed a description and quantification of the life cycle is pursued, the more effort and additional inquiries or customer/market studies are needed.

If the producer perspective is adopted as the basis, very little external information is likely to be needed. In the case of evolutionary product development, the producer could mainly lean on the life cycle analysis of previous or present products to understand the life cycle phases and associated requirements. If the product development includes revolutionary elements or if the product being developed is very different from the previous products of the producer, other means are likely to be employed. For example, benchmarking could provide analogies that would be useful for identifying life cycle patterns.

In addition to the identification of requirements, the first interpretation can also be useful for assessing the impacts of product development decisions. It can be argued that the effects of certain product development decisions relate to certain product life cycle phases more than to some others. To be able to assess the feasibility of product development decisions, this is an important point that should be considered as well.

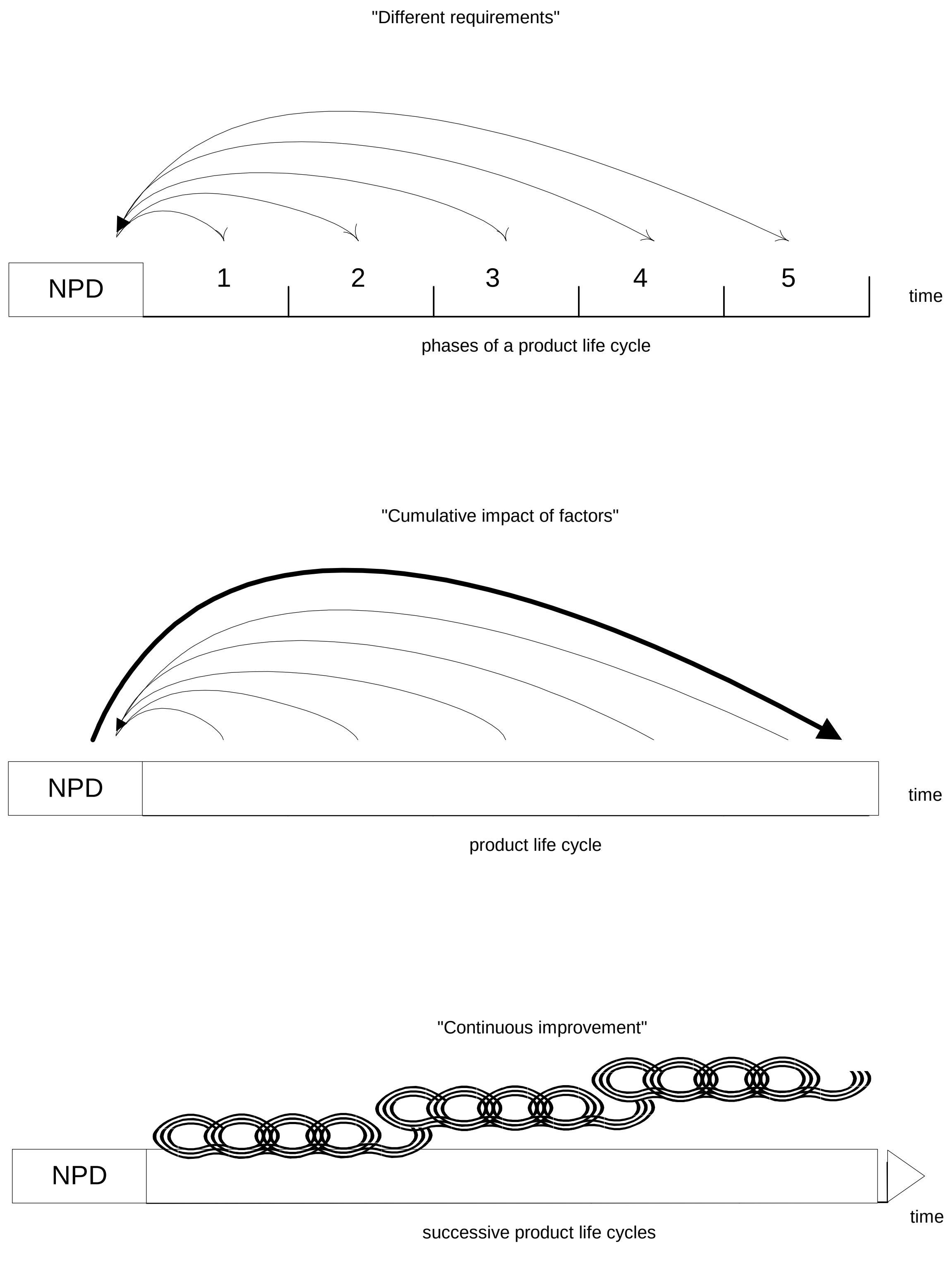


Figure 17. Life cycle and challenges of product development: three interpretations

According to the second interpretation, new product development is still regarded as an activity that takes place primarily at the beginning of the product life cycle. However, life cycle is not seen as a collection of distinct phases associated with a number of requirements; rather, it represents a continuum of time. The importance of this view is underscored by the fact that many industrial products still have very long life cycles. Hence, when developing these kinds of products, the developing company to a great extent determines its financial success potential for a long time due to the extensive product cost commitment (see for example Uusi-Rauva and Paranko 1998). If the cumulative impact (thick arrow in Figure 17) of a new product is not fully and carefully assessed, the financial possibilities and risks of the product remain ambiguous.

From the financial point of view, this interpretation of product life cycle can be addressed by applying investment calculations such as NPV or ROI (taking into account the appropriate discount rate) during product development. However, it is worth remembering that both the profitability of the product and the profitability of the after sales business associated with the product affect the financial success and constitute the total profitability of the product. Investment calculations should be based on well-grounded scenarios regarding the duration of life cycle and the cost structure of the product as well as on the activity consumption of the developed product. Development investments besides the initial NPD effort should also be included in the calculations.

If the second interpretation is assessed from the customer point of view, issues such as total cost of ownership (TCO) could be addressed. Inevitably, the customer has an interest in minimizing the life cycle costs and maximizing the life cycle revenues associated with a product. Hence, the costs that the customer experiences during the life cycle of a product could be perceived as a key objective for product development. Established methods or managerial practices such as target costing (Ansari et al. 1997; Cooper and Slagmulder 1997; Dutton and Marx 1999) and life cycle costing (Keoleian and Menerey 1993; Woodward 1997; Kaplan and Atkinson 1998; Emblemsvåg 2001) include the financial elements that are needed for life cycle - conscious NPD management. However, life cycle provides companies also with a framework for weighting and organizing non-financial measures of success. Consider, for instance, the need for maintenance and the availability of spare parts as a success measure of a new truck. Depending on the nature and duration of the life cycle experienced by the primary customer, this success measure receives different emphasis. If the primary customer uses the truck for 20 years, the maintenance is one of the key issues; however, if the customer buys a new one after every five years, the issue is probably not equally important.

The third interpretation implies that product development is an activity that takes place both at the beginning of the product life cycle and during it. In fact, in many cases, it is virtually impossible to determine where one life cycle ends and where another begins. Sequential product generations (see the circular stripes in Figure 17) may include a number of mutual components and features, which makes it difficult to separate distinct product life cycles; rather, the concepts of product family life cycle or product platform life cycle may be more appropriate in some cases. Even within the life cycle of a single product, innovations may take place not only at the beginning but also towards the end of life. Hence, the performance measurement of product development should acknowledge that the challenges and requirements of product development are connected with the innovation continuum. Consequently, product development performance or success receives different interpretations depending on the point of life cycle. At the beginning, it might be enough to obtain a few positive reference customers, while towards the end competitive products are likely to increase the pressure for better performance. Further, one of the key objectives – a continuous challenge – of product development during product life cycle is to ensure that viable products are sufficiently updated and kept competitive. On the other hand, as the product becomes more mature, more data on the product's technical and market performance will be available. This data would provide guidance for the further development of the product.

Regarding all the previous interpretations, performance measurement of product development is interested in and intended to grasp outcomes and effects that will become materialized not until after a period of time. Inevitably, this poses a challenge for the very act of measurement. However, a few practical solutions are available:

- One could measure now issues that are expected to have an impact on future effects. This implies the identification of cause-effect chains. For instance, the use of recurrent materials (percentage of all materials included in a product) can be perceived as an indicator that is primarily related to the recyclability of the product and the final stages of its life cycle, but that can be quantified already at the product development stage.
- One could postpone the actual measurement of issues that will be relevant in the future, but set targets for them now. For instance, customer satisfaction cannot be found until the product has been applied for a certain period of time; however, a target level for satisfaction can be set in the development phase. This may guide the product development into the desired direction.
- One could measure now issues that will be relevant in the future on the basis of anticipated effects and values. Scenarios and sensitivity analyses can be applied to demonstrate, for instance, the preferences between alternative product designs. For example, if after sales profitability is a major concern, the total profitability of a product can be simulated by anticipating the need and sales margin of spare parts. Different scenarios can be used to reveal the sensitivity of total profitability, depending on spare part consumption and other factors.

5.3 Stakeholder-oriented Performance Measurement

5.3.1 Performance dimensions

Fundamentally, stakeholder theory comprises the idea that a company or organization has stakeholders. On this account, stakeholder theory of the organization has several connections also to new product development and its performance measurement. As noted by Donaldson and Preston (1995), descriptive use, instrumental use, and normative use of stakeholder theory are the three interrelated but rather distinct aspects that comprise the entire theory.

First, descriptive use refers to situations where stakeholder theory is applied to describe or explain specific corporate characteristics and behavior. For example, stakeholder theory has been used to describe the nature of the firm, the way managers or board members think about managing, and relevant interests present in corporate activities. The argumentation used in the literature to justify the descriptive use of stakeholder theory typically attempts to show that the concepts and ideas represented in the theory correspond to the observed reality. (Donaldson and Preston 1995) In new product development, the identification of customers and suppliers and their interests as well as the identification of society-based requirements typically correspond to the descriptive use of stakeholder theory.

Second, instrumental use of stakeholder theory seeks to identify the possible connections between stakeholder management and the attainment of corporate goals. Studies in this domain have attempted to generate implications that stakeholder theory serves as a catalyst for corporate goals equal to or better than possible rival approaches. The instrumental justification often relies on the evidence of the connection between stakeholder thinking and corporate performance. (Donaldson and Preston 1995) The domain of NPD performance literature that investigates the relationship between different antecedents and consequences of new product success, for instance, represents this approach. That is, a study that investigates the relationship between performance and society or customer need anticipation, at least implicitly relies on the instrumental purpose of stakeholder theory.

Third, the normative essence of the theory considers issues that relate to the function of the organization. Within the normative approach, philosophical and moral guidelines for the operation and corporate management are identified and formulated. According to Donaldson and Preston (1995) normative aspects comprise the core of stakeholder theory. The justification of the normative approach typically appeals to fundamental concepts behind stakeholder theory such as individual right, group right, or “social contract”. (Donaldson and Preston 1995) Approaches to product development research that are colored by normative stakeholder theory can also be found. For example, studies that refer to environmental concerns or sustainable growth principles have a normative flavor.

It is argued that the key stakeholders of product development can be typified into four classes: company shareholders (owners), customers and utilizers of products/services (users), the developing organization, which may be comprised of internal and external actors (product development, R&D), and the supply chain that facilitates the realization of the product including internal and external supply chain members. The perspectives of these stakeholders related to the (new) product are depicted in Figure 18. Relevant questions and objectives for each stakeholder group would include, for example:

- **Customer view:** how well (for example compared with competitors’ products) does the product respond to the customer need, is the quality sufficient, what are the operating costs, is appropriate after sales support available?
- **Shareholder view:** does R&D and product development produce profitable business, is the growth rate of the business acceptable, what is the competitive position?
- **R&D view:** deployment of strategic resources, competence development, and learning.
- **Supply chain view:** cost efficiency, time to market, design for assembly or manufacture, availability of appropriate sales, and delivery channel/feasibility of the product from the supply chain point of view.

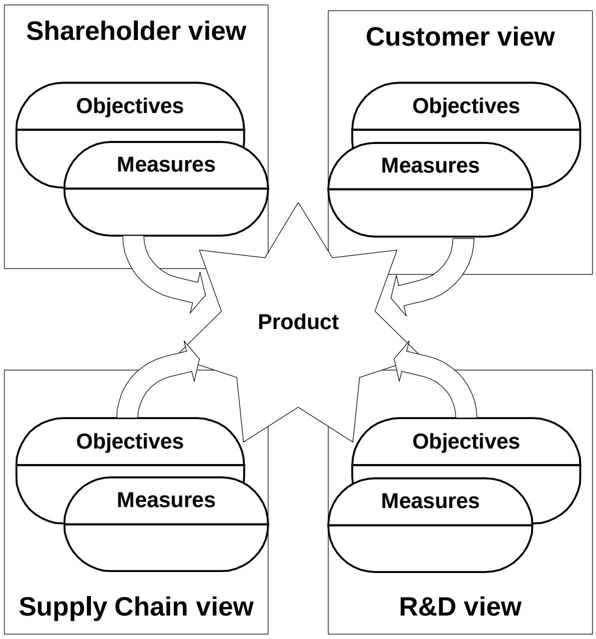


Figure 18. Perspectives of key stakeholders of product development

It is maintained that the supply chain view should be interpreted rather widely. Supply chain includes not only external actors such as suppliers or distributors, but also internal actors such as manufacturing, sales, and purchases.

Each stakeholder has a number of objectives regarding the new product or the product being developed. Some of the objectives may be mutual to all stakeholders whereas others are more stakeholder-specific. For example, product safety could be a concern for all the stakeholders. On the other hand, manufacturing investments needed for the new product are not a primary issue of interest for the customer but they could be one of the most important concerns for the shareholders. Of course, it goes almost without saying that also the customer will experience the high manufacturing investments through higher costs associated with the product.

Considering the objectives of different stakeholders, the overall success of a new product can be multifacetedly defined using the framework depicted in Figure 18. A successful product will basically fulfill the objectives derived from all the perspectives. Naturally, the emphasis on each perspective or view does not have to be equal. For a given product, for example the supply chain view could be less important compared to the other three stakeholder perspectives.

5.3.2 Combining stakeholders and life cycle requirements

To finalize the life cycle -conscious measurement framework, Figure 19 illustrates the idea of connecting life cycle phases and the requirements or objectives of different stakeholders into one framework.

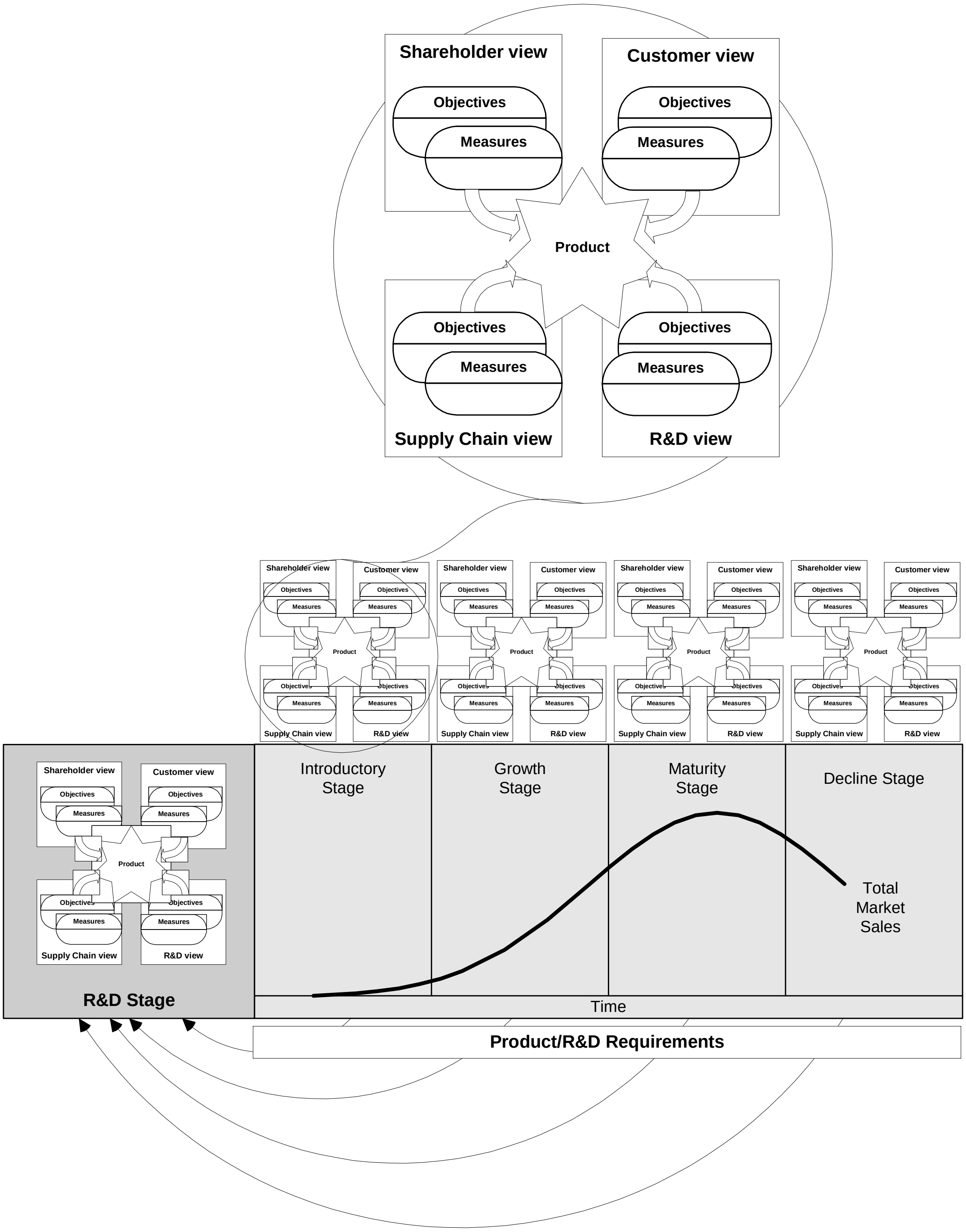


Figure 19. Stakeholder-specific objectives and requirements can be associated with life cycle phases

In this example, life cycle is depicted as the typical marketing life cycle seen by the producer. In this view, life cycle is comprised of introduction stage, growth stage, maturity stage, and decline stage. However, any life cycle model could be adopted as a basis for this synthesis. Analogously, life cycle could be organized on the basis of phases experienced by the customer: purchase, implementation, active use, maintenance, disposal, and secondary use, for example. In addition, the concept of life cycle can be combined with the four perspectives even without any life cycle phases at all.

Primarily related to the first interpretation of life cycle consciousness, multifaceted objectives for the product can be derived as depicted in the figure. As mentioned, the first phase is to identify the particular life cycle model and the phases associated with it. Second, the four perspectives to the product will be assessed separately in each phase of the life cycle: What objectives are related to the shareholder view in the introduction phase? What objectives are related to the product development view in the introduction phase? What objectives are related to the customer view in the introduction phase? What objectives are related to the supply chain view in the introduction phase? This sequence will be repeated regarding all the phases of the life cycle. It is important to acknowledge that it may be possible that all the perspectives or views have no significance in every phase. In other words, it could be possible that, for example, only the shareholder view, the supply chain view and the customer view are considered in the growth phase.

Third, the objectives that were identified for each stakeholder and for each life cycle phase will be collected and reflected back to product development. Hence, a tentative set of objectives for a product has been achieved. This includes also the identification of determinants that can be associated with the identified objectives. In other words, it should be considered by which means the identified objectives can be fulfilled. In practice, this set of objectives and cause-effect chains may contain issues that seem to be conflicting or internally ambiguous. However, to be able to rationally discuss and prioritize the objectives, a multifaceted set of tentative objectives are needed. Through selection and the elimination of secondary objectives, the more compressed set of final objectives can be reached.

Fourth, on the basis of prioritized and selected objectives, the process of creating and constructing measures can be initiated. However, as discussed above, it is not necessary to establish a measure for every objective. Taking into account the difficulties that are related to future-oriented measurement, the construction of the measures should be carried out cautiously. In many cases, the existence of the explicit objective can motivate and direct the efforts into issues that are important provided that the life cycle of the product has certain identified characteristics.

According to the second interpretation, rather than a collection of phases, product life cycle is a continuum of time. During that continuum, various factors contribute to the cumulative effects of a product. Combining this life cycle view with the perspectives presented in Figure 18 results in an idea that those cumulative effects can be assessed at least from the perspectives of shareholders, customer, supply chain, and R&D. From the customer point of view, it would be important to acknowledge, for instance, how certain product development decisions affect the investment costs or operating costs experienced by the customer or which design parameters contribute to the value a customer creates by using the product. From the shareholder point of view, it is naturally important to make sure that the cumulative profits (caused by the product and by the after sales business connected with it) are maximized. This example implicates not only rigorous profitability and cost management related to product design, but also a proper spare part strategy that creates profitable spare parts sales.

Further, from the product development or R&D point of view, the goals consistent with the second interpretation would include, for instance, effective competence and capability development during the whole product life cycle. The life cycle provides the product development with a possibility to learn from the customer experiences. The development of the next product can be at least partly built on the observations made during the previous product’s life cycle. Finally, the supply chain perspective may include objectives that are similar to those identified in the shareholder perspective. Others may include the length of supplier commitment (external supply chain) related to the product, or the estimated production investments related to the product (internal supply chain).

It is important to observe that the performance achieved with respect to one perspective may be independent of the performance achieved in another. Consider, for instance, the material cost of a product experienced by the producer. It is quite possible that the value of the product seen from the perspective of the customer does not depend upon the cost reduction of a certain component if the total quality of the product does not correlate with the cost of a single component (which is quite often the case). On the other hand, performance seen from one perspective may relate to the performance seen from another. Consider, for example, a situation in which a feature is added to a product to increase the value of the product for a customer. The additional feature also causes increased material costs as well as increased assembly costs, which lead to lower relative profitability due to an intensive competition allowing only a marginal selling price increase.

The third interpretation acknowledges that distinct product life cycles may be difficult to identify in some cases. Products can be continuously developed, which implicates a product’s life cycle is not a clear-cut period but rather a part of continuous evolution. Connecting this observation with the perspectives of the presented stakeholders leads to many performance targets or objectives for product development. From the customer point of view, it could be worth pursuing that the products of the following generations are at least partially compatible. Consider, for example, the compatibility of auxiliary equipment or spare parts associated with the product or a situation in which the product is not an independent unit but rather a part of a larger production system of the customer. From the manufacturing point of view, component commonality across successive product generations – for instance – could be an important objective.

Overall, the combination of the four stakeholder perspectives and the third life cycle interpretation implicates that the performance targets – just like the products being developed – can be perceived as a long continuum. The performance measurement of product development could be founded on the idea of continuous improvement: the performance of a new product should be – at least with regard to some perspective – better than the performance of an older product.

6 Empirical Results

This section comprises the key empirical findings made in the study. As discussed earlier, the empirical part of the study consists of a case study of six companies and a survey conducted within Finnish companies. The results are discussed respectively in two parts, after which a comparison between the empirical findings and the framework or blueprint proposed is conducted.

The case study seeks to produce insights into product life cycles in different companies (common and uncommon issues across companies) and thus in this context, multiple cases are primarily selected for enabling either literal or theoretical replication of observations. The selection of cases is purposeful in a sense that all the cases are reasonably homogenous: they all are middle-sized or large manufacturers of industrial investment goods. Also the concept of product life cycle was expected to be relevant one way or another in each case: especially in machine construction, the life cycles of products are relatively long including an after sales phase. Being the main unit of analysis, the relevance of life cycle is certainly necessary. On the other hand, the cases were selected in such a way that within the specified boundaries the cases would also differ in terms of size, products, and environment.

Also survey has been used as a research instrument but this study cannot be regarded as nomothetical. This is mainly because the mail survey was carried out to collect primarily qualitative and descriptive data on *the present state of* measurement practices rather than to collect quantitative data enabling identification of cause-effect chains and statistical generalizations. In other words, survey has been employed as a research instrument to support and complement the conceptual analyses and cases conducted in this study. As a whole, this study should be considered as qualitative and hermeneutic.

6.1 Case Study Results

This section presents the main findings made in the case study of six companies. The section begins with brief within-case discussions and ends with a cross-case analysis. First, the nature of product development and the perceived importance of a new product in each case company are briefly discussed. Second, the length of product life cycles, the distinct phases of PLCs, and their characteristics are discussed. Third, on the basis of the two issues just mentioned, requirements for a good process or product as interpreted at different stages of life cycle are considered. The companies represent three broad industries: metal and machine manufacturing, material and component manufacturing in electronics, and equipment manufacturing (electronics). The products supplied by these companies – despite their vast difference in character and size – can all be regarded as physical investment goods.

Especially in the within-case section, the findings of the case study are reported without intentional interpretation by the researcher, if possible. This means that the observations made in the interviews and collected by using the companies' product development and life cycle documentation are reported without inferences concerning the causes and effects or motives behind the statements. In other words, the study focuses primarily on the *perceptions* of the companies regarding their product life cycles. In fact, it is possible that the "true" life cycles differ from the perceptions to some extent, but this has not been the interest of the study (quite consistently with the naturalistic perception of science, see for example Hammersley and Atkinson 1995). Also, since the case section relies on company-specific terms and discourse, it is possible that some of the terms used are not totally consistent across cases. For example, it can be that the term "cross-functional" refers to collaboration between R&D, manufacturing, and purchase in another setting while in other setting it refers to the collaboration between marketing, R&D, and manufacturing.

6.1.1 Case A

Company A is a middle-sized Finnish subsidiary of an international corporation. It has less than 250 employees. The products include machinery and equipment used in many industries and environments. The industrial sector of Company A is metal industry and machine manufacturing.

The role of new product is said to be remarkably important. Products are continuously developed, which means that both evolutionary and revolutionary elements are present in product development. To a great extent, large global competitors set the pace for new product development and product introductions. As a result, the customers are used to a certain new product introduction pace.

At the general level, the characteristics of product life cycle in Company A can be described as follows:

- The product life cycle is relatively long (approximately five to ten years + the after sales phase), in which the significance of after sales and spare part business is high.
- The length of product life cycle from the customer point of view is approximately 25 years. Even over 30 years is not exceptional.
- Across the company's product line, PLCs are rather homogenous. The length is typically inversely proportional to the physical size of the product.

Seven life cycle phases were identified in Company A. It is important to acknowledge that they are not completely distinct but partly overlapping (especially as regards after sales). The identified life cycle phases primarily implicate the view of the producer. The following phases and tasks comprise the life cycle, respectively:

1. New product opportunity study
    - Market analysis
    - Tentative product specification
2. New product development
    - Product development, prototypes, testing
    - Manufacturing implementation
    - Marketing and manufacturing launch
3. Active production
    - "Learning by doing"

    - Education
    - Strong marketing effort
4. Production shutdown
    - Typically initiated by new product launch
    - Possible subcontracting
    - Serving secondary customers/markets
5. End of production
    - On the basis of profitability analysis, if available
    - Somewhat unclear criteria
6. After sales
    - Spare parts and service
7. End of product
    - Rarely happens

Respectively, the primary responsibility and the workload distribution of corporate functions were perceived as follows (Question 7c: Which corporate functions are primarily employed in life cycle phases?):

- Initial phases, opportunity identification
    - Top management
    - Marketing
- NPD
    - Cross-functional
- Active phase
    - Manufacturing
    - Sales and marketing
- Later phases
    - Manufacturing
    - Purchases

6.1.2 Case B

Company B is a business unit of a large and leading global manufacturer and supplier of process industry production systems, machines, and equipment in its field. The whole company has over 10,000 employees. The industrial sector of Company B is metal industry and machine manufacturing.

The objective of Company B is to be a technology leader in its field, which underscores the importance of innovativeness regarding key products. A clear majority of product development represents evolution. Revolutionary products are perceived as those that are new for the markets and customers. The evolutionary character of NPD is illustrated in the distribution of new products in terms of their newness (year 2001):

- 40 percent were product upgrades and improvements
- 40 percent were new for the company
- 20 percent were new for the market

At the general level, the characteristics of product life cycle in Company B can be described as follows:

- Product life cycle is relatively long (approximately 15 to 25 years for a platform and five years for a product + the after sales phase). The importance of after sales service is high.
- The length of product life cycle from the customer point of view is approximately 10 to 15 years.
- Across the company's product line, PLCs are rather homogenous. The lengths are the shortest in areas that are characterized by rapid technology development due to customers' process improvement.

Six life cycle phases were identified in Company B. Also in this case, the phases are not completely distinct but partly overlapping. The identified life cycle phases primarily implicate the view of the producer. The following phases and tasks comprise the life cycle, respectively:

1. Draft and concept phase + product development
    - The continuum from idea to concept
    - From concept to product
    - Prototypes, laboratory tests
2. Market launch
    - Primary segment definition
    - Sales arguments development
3. Production development/ redesign
    - Design for manufacturability
4. Product maturation
    - Increasing number of delivery projects
    - Strong competition
5. New product generation using the old platform
    - Redesign and improvement on the basis of the present platform and concept
6. Product fades out
    - The technology becomes uncompetitive
    - Too strong competitors

Respectively, the primary responsibility and the workload distribution of corporate functions were perceived as follows (Question 7c: Which corporate functions are primarily employed in life cycle phases?):

- Initial phases
    - Product development
    - Sales and marketing
- Production development
    - Manufacturing
    - Cross-functional team
    - External partners
- Later phases
    - Manufacturing
    - Delivery projects

    - Service
- New generation
    - New product development

6.1.3 Case C

Company C is a business unit of a large international Finnish corporation. The company has over 2,000 employees altogether. The products include vehicles and systems used in special applications. The industrial sector of Company C is metal industry and machine manufacturing.

The fact that the number of customers is somewhat limited characterizes the operational environment of Company C. Hence; a new product typically represents a response to evolved customer needs. New products are also seen as a means to improve cost efficiency and manufacturability. Product evolution is continuous, revolutions that are associated with essential technological leaps take place maybe once in a decade.

At the general level, the characteristics of product life cycle in Company C can be described as follows:

- Product life cycle is relatively long (approximately 20 to 30 years including the after sales phase). The importance of after sales and spare part business is high and these phases comprise roughly one half of the life cycle.
- The next-generation product is typically initiated and developed in the middle of the life cycle of the previous product.
- The length of product life cycle from the customer point of view is approximately 20 to 30 years.
- Across the company's product line, PLCs are rather homogenous. The length of component life cycle can be very different from that of end product..

Seven life cycle phases were identified in Company C. It is important to acknowledge that they are not completely distinct but partly overlapping (especially as regards after sales). The identified life cycle phases primarily implicate the view of the producer. The following phases and tasks comprise the life cycle, respectively:

1. Market and concept study
    - Cross-functional cooperation
    - Customer involvement
2. Product development
    - Development, prototypes
    - Customer involvement
3. Launch and the first customer delivery
    - Includes lots of engineering
    - Integrated project teams
    - Customer representation
4. Customer deliveries and versions
    - Same as previous
    - Includes also service development

5. Product support
    - Education
    - Product information distribution
    - On-site support
6. Product renovation and modernization
    - Major upgrade
7. End of product support
    - Exact end somewhat ambiguous

Respectively, the primary responsibility and the workload distribution of corporate functions were perceived as follows (Question 7c: Which corporate functions are primarily employed in life cycle phases?):

- Initial phases
    - Marketing
    - Product development
- Customer deliveries
    - Manufacturing
    - Product support
- Support and renovation
    - Product support
    - Product development

6.1.4 Case D

Company D is a large Finnish subsidiary of a leading global corporation in its field. The Finnish company employs over 400 people. The products include machines and special application vehicles. The industrial sector of company D is metal industry and machine manufacturing.

New products are seen as a means to improve sales, profitability, and the level of technology. Product evolution takes place continuously, but there is also room for revolutions due to the fact that the technology life cycle has not reached maturity: the products of the company have a relatively short history dating back to 1950's.

At the general level, the characteristics of product life cycle in Company D can be described as follows:

- The product life cycle is relatively long (the active phase is approximately 10 years). In addition, the importance of the after sales phase and spare part business is high. The length of the after sales phase may be almost 15 years.
- The length of product life cycle from the user point of view is approximately 15 years. The first user employs the product for about five years, after which follows the period of secondary users. The last five years do not typically result in any spare part sales.
- The concept of product life cycle will receive a different interpretation as the paradigm shift (selling a physical product vs. selling performance or output) takes place or becomes more obvious.

Six life cycle phases were identified in Company D. The life cycle phases are not completely distinct but rather partly overlapping (especially as regards after sales). The identified life cycle phases primarily implicate the view of the producer. The following phases and tasks comprise the life cycle, respectively:

1. Concept development
    - Technical testing of an idea
    - May not proceed
2. Business case study
    - Economical assessment
    - Investment calculations
3. Product development
    - Finalized concept
    - Concurrent development process
4. Market launch
    - Implementation throughout the organization
5. Active production
    - Stable phase
    - Minor modifications and evolution
6. After sales
    - "Spare part support never ends"

Respectively, the primary responsibility and the workload distribution of corporate functions were perceived as follows (Question 7c: Which corporate functions are primarily employed in life cycle phases?):

- Concept development
    - Product development, R&D
- Business study
    - Cross-functional
    - Manufacturing not included
- Product development and launch
    - Cross-functional
    - Manufacturing
    - Purchase
    - Quality
- Active phase
    - Manufacturing
    - Product development: minor refinements
- After sales
    - Service

6.1.5 Case E

Company E is a middle-sized Finnish subsidiary of an international corporation. The Finnish subsidiary employs less than 250 people. The products include materials and components used in many applications and environments. The industrial sector of Company E is electronics, and more specifically, component manufacturing.

The role of new products is to generate turnover and to improve profitability. Consistently with this, better manufacturability is also a key objective. The role of product revolutions has decreased during the last seven years, which is in fact the time that the company has been in business. Today, a majority of product development is comprised of product evolution that aims to improve efficiency.

At the general level, the characteristics of product life cycle in Company E can be described as follows:

- Product life cycle is shorter than in the previous cases (the active phase is approximately five to ten years). The fundamental issue is the lack of an after sales phase. It is not applicable because the company is a component producer whose products do not require actual after sales support.
- The length of product life cycle from the user point of view is difficult to estimate. This is because it depends heavily on the particular application. Many system products in which the components are employed are utilized for about 10 to 15 years.
- The life cycles of different products are not quite homogenous but the product line can be divided into two parts in terms of the nature of their life cycle.

Six life cycle phases were identified in Company E. The identified life cycle phases primarily implicate the view of the producer and they are quite strongly focused on the beginning of product life. The following phases and tasks comprise the life cycle, respectively:

1. Concept development
    - Market and technology (existing technologies) analysis
    - Risk assessment
2. Development plan and decision
    - Project plan
    - Project initiation
    - Product specification
3. Product and process development
    - Development
    - Alpha tests
4. Pilot product
    - Beta tests
    - Manufacturing launch
5. Market launch
    - First sales
6. End of life
    - Stable phase
    - Active manufacturing and sales

Respectively, the primary responsibility and the workload distribution of corporate functions were perceived as follows (Question 7c: Which corporate functions are primarily employed in life cycle phases?):

- Concept development
    - Marketing

  - Product development (minor role)
- Development plan
  - Management of various functions
- Development and pilots
  - Product development
  - Gradually manufacturing
- End of life
  - Manufacturing
  - Sales

6.1.6 Case F

Company F is a large Finnish subsidiary of an international corporation. The number of employees in Finland is over 500. The products of Company F include equipment and systems used in special applications. The industrial sector would be electronics, and more specifically, equipment manufacturing.

Concerning the role of product development, it has a significant strategic emphasis. The fundamental rule is that the performance of a new product should always exceed that of its predecessor. Revolutionary steps in product development are taken approximately every five years. However, in the future the frequency will probably increase. In addition, product evolution takes place continuously.

At the general level, the characteristics of product life cycle in Company F can be described as follows:

- The length of product life cycle is about five years but it is getting shorter and will probably decrease to three or four years (the active phase). In addition to this, after sales extends the life by seven years, which is the length of the spare part availability guarantee.
- The length of product life cycle from the user point of view depends on the customer segment. Two main segments exist and within these, typical life cycles are about four years and ten years.
- The life cycles of different products are rather homogenous.

Six life cycle phases were identified in Company F. The identified life cycle phases primarily implicate the view of the producer. The phases are perceived as rather distinct so they do not overlap each other. The following phases and tasks comprise the life cycle, respectively:

1. Product development
   - Strong effort to create a new product platform
2. Platform launch and start
   - "Completing the tails of product development"
   - Marketing launch
   - Further development, "year models"
3. Steady supply
   - Focus on sales and manufacturing
4. Facelift and (re)focus

        - Product improvements
        - Boosting the profitability
        - Possible subcontracting
5. Harvest
        - End of development
        - Price competition
6. End of product
        - On the basis of the volume of orders

Respectively, the primary responsibility and the workload distribution of corporate functions were perceived as follows (Question 7c: Which corporate functions are primarily employed in life cycle phases?):

- Product development and platform launch
    - NPD
    - Marketing
    - Manufacturing
    - "Learning phase"
- Steady phase
    - Manufacturing
- Facelift
    - Product development
    - Marketing
- Harvest and the end
    - Manufacturing

6.1.7 Cross-case comparison

Table 14 includes a brief summary and descriptions of the cases regarding the role of new product and overall characteristics of the companies. The first two columns contain mainly public information, but the third column summarizes the opinions of interviewees in each company regarding the nature of NPD and the role of a new product. Companies A, B, C, and D represent metal industry and machine manufacturing. Companies E and F are connected with electronics; one focuses on components and materials, while the other is primarily an equipment supplier. In terms of size, small companies are not represented; two companies are middle-sized[28], while four are clearly large. All the companies are at least partly located in Finland, but all of them also have international or global operations.

Regarding the nature of product development, an inevitable observation is that products are developed rather continuously. That is, product development does not only take place at the beginning of a product's life cycle; rather, the companies set objectives in order to improve products in a more evolutionary manner. It would be very unusual for a product to stay competitive for several years without smaller or bigger evolutionary steps during its active life. On the other hand, all interviewees perceived that product development includes also revolutionary elements. Quite as

[28] According to the guidelines set by the EU Commission, turnover of less than 50 MEUR and the number of employees less than 250.

expected, the companies regard the role of a new product as important. The importance is founded on the fact that new products are expected to improve profitability through more optimal manufacturability (lower costs) or the ability to set higher prices on the basis of improved performance.

Table 14. Description and comparison of cases

	Description of company	Industry	Role of new product
Company A	Middle-sized (less than 250 employees) Finnish subsidiary of international corporation. Products include machinery and equipment used in many industries and environments.	Metal industry/ Machine manufacturing	Role of new product is remarkably important. Products are continuously developed, both evolutionary and revolutionary elements are present. Large global competitors set the pace for new product introductions. As a result, customers are used to a certain new product introduction pace.
Company B	Business unit of large (over 10,000 employees) and leading global manufacturer and supplier of process industry production systems, machines, and equipment in its field.	Metal industry/ Machine manufacturing	Company's objective is to be a technology leader, which underscores the importance of innovativeness regarding key products. A clear majority of product development represents evolution. Revolutionary products are those new for the markets and customers.
Company C	Business unit of large international Finnish corporation (over 2,000 employees). Products include vehicles and systems used in special applications.	Metal industry/ Machine manufacturing	Number of customers is somewhat limited. Hence, a new product typically represents a response to evolved customer needs. New products are also seen as a means to improve cost efficiency and manufacturability. Product evolution is continuous, revolutions take place maybe once in a decade
Company D	Large (over 400 employees) Finnish subsidiary of leading global corporation in its field. Products include machines and vehicles.	Metal industry/ Machine manufacturing	New products are seen as a means to improve sales, profitability, and the level of technology. Product evolution takes place continuously, but there is also room for revolutions due to the fact that the technology life cycle has not reached maturity.
Company E	Middle-sized (less than 250 employees) Finnish subsidiary of international corporation. Products include materials components used in many applications and environments.	Electronics/ Component manufacturing	New products generate turnover and profitability. Better manufacturability is also a key objective. The role of product revolutions has decreased during the last seven years, which is the time that the company has been in business. Today, product development equals evolution that aims to improve efficiency.
Company F	Large (over 500 employees) Finnish subsidiary of international corporation. Products include equipment and systems used in special applications.	Electronics/ Equipment manufacturing	Product development has significant strategic emphasis. New product performance should always exceed that of its predecessor. Revolutionary steps are taken every five years. However, in the future the frequency will probably increase. In addition, product evolution takes place continuously.

Table 15 depicts the product life cycle phases as perceived by the six companies. The six rightmost columns comprise the phases that were mentioned by the interviewees. The first column, in contrast, summarizes more generic life cycle phases that seem to fit all case companies.

Table 15. Identified product life cycle phases grouped according to generic life cycle phases

Generic	Company A	Company B	Company C	Company D	Company E	Company F
Feasibility studies/ preliminary phases				Concept development	Concept development	
	New product opportunity study		Market and concept study	Business case study	Development plan and decision	
Product development	New product development	Draft and concept phase + product development	Product development	Product development	Product and process development	Product development
Market launch					Pilot product	
		Market launch	Launch and the first customer delivery	Market launch	Market launch	Platform launch and start
Active phase	Active production	Production development/ redesign	Customer deliveries and versions	Active production	End of life	Steady supply
Support, maintenance and further development		Product maturation	Product support	After sales		Facelift and (re)focus
		New product generation using old platform	Product renovation and modernization			Harvest
End-of-life phases	Production shutdown					
	End of production					
	After sales					
	End of product	Product fades out	End of product support			End of product

Although all the identified life cycles have their own characteristics, they are also essentially similar to each other. First, they are all seen from the perspective of the producer or supplier – not from that of the customer. When structuring the life cycles of their products, some companies tend to emphasize the beginning of the life cycle (for example Company E: a more detailed description of the initial phases), while others perceive the end of life on a more detailed level (for example Company A). It is important to notice that all the metal industry companies (A-D) perceive after sales or service as important. Company B, however, forms something of an exception because it does not explicitly mention after sales as a distinct phase. This is founded on the fact that the company sees its product as a sum of the physical product and service. Hence, after sales service is regarded as an inherent part of the product. Further, Companies E and F have not explicitly identified an after sales phase. In case of Company E, this is simply because the components and materials supplied by the company do not require maintenance, as such. On the contrary, Company F indeed *has* an after sales period (a seven-year guarantee after the end of production), but it was not mentioned – for some reason – during this part of the interview.

In terms of length, the product life cycles (see Table 16) reported by the companies vary between 10 years (Company E and Company F, after sales not included) and 37 years (Company C). The phase numbers refer to the respective numbers presented in the within-case section. It should be noted that when the after sales phase is included, it may partly overlap with the manufacturing phase. Hence, the true length of product life cycles may be a bit shorter. The single longest phase is typically after sales or support: between 7 years (Company F) and 25-30 years (Company C). The length of after sales exceeds 20 years also in Companies A and D.

Table 16. Length of product life cycle (producer view)

Phase No.	Company A	Company B	Company C	Company D	Company E	Company F
1	0.5	3.0	1.5	0.5	0.0	2.0
2	1.0	1.5	1.5	0.2	0.2	2.0
3	5.0	3.0	2.5	2.0	1.5	2.0
4	3.0	7.0	5.0	0.0	0.8	1.0
5	0.0	0.0	25.0	10.0	0.0	2.0
6	20.0	4.0	0.0	15.0	7.5	1.0
7	0.0		1.5			
Total	**29.5**	**18.5**	**37.0**	**27.7**	**10.0**	**10.0**

Table 17 summarizes the requirements associated with life cycle phases. The observations and findings that were made in each company are not reported separately (see Appendix C for a more detailed table). Rather, the findings are presented at an aggregate level. This is feasible due to the fact that the interviewees had something of a consensus regarding the identified requirements. It can be said that the views of different companies were both overlapping and supplemented each other.

Table 17. Requirements for a good or successful product and the process associated with it organized on the basis of generic life cycle phases

Generic	Summary of all companies
Feasibility studies/ preliminary phases	Correct and accurate identification of customer needs is important: "With this, we cannot afford to fail". Setting the target cost is also essential. The product and the competencies of NPD should be consistent.
Product development	On the basis of the previous phase, the aim is to obtain the defined technical specifications. Achievement of technical objectives related to product and product development lead time are key issues. Life cycle costs of the product should be considered. Other objectives include fluent start for actual product development, achievement of development budget and schedule targets, sufficient product quality and profit margin.
Market launch	Good start with the sales. Sufficient number of customer deliveries. Emphasis is on customer and product development perspectives. Small number of product modifications and versions. Customers are aware of the new product. It is about "redeeming the promises given at the beginning".
Active phase	Emphasis on financial perspective: product cost, product profitability, cost effective purchases. Good product quality. In addition, manufacturability (fluent manufacturing launch) and easiness of assembly are important. Consistency of the product with the entire supply chain. A key measure is the success of tailored customer versions. It is important to reach the target cost level set for the product. After a short delay, more evidence on the ability of the product to respond to customer needs will be obtained.
Support, maintenance, and further development	Earning through the product. Emphasis is on the financial perspective. The roles of product development, the customer, and marketing gain importance. Rather analogous to the product development phase. Availability of service and spare parts. A technically capable and viable product is a core objective. As a rule of thumb: "If it is rather quiet, everything has probably gone well". Only at the end of product life cycle is a final closing of the "accounts" regarding the product possible. Increased sales (measures by volume). "Successful demand peak". Efficient and effective after sales support. Availability of material and items for manufacturing.
End-of-life phases	The objective, from the customer point of view, is to reach a sufficient level of continuity. The ability to respond to the needs of the customer. In addition, meeting profitability targets is essential. From the financial point of view: unprofitable products have to be removed. A clear product deletion would be a good objective. Rapid and effective spare part sales, delivery and maintenance service. Cost effective and profitable customer service.

According to the interviewees, a crucial issue in the beginning is the correct identification of customer needs. Feasibility studies may also include setting a target level for product cost. This will guide the further stages of product development and help to determine whether the product is feasible in the first place. In addition, it has been pointed out that it is important to ensure a reasonable coherence between product development competences and product requirements. The product development phase mainly implies the traditional measures of NPD success and performance such as lead time or the achievement of development budget targets. Furthermore, one company explicitly suggests that life cycle cost should be assessed and controlled during this phase.

The third phase, market launch, implies issues such as the fluent start of sales of a new product and the gaining of positive reference customers. Customer awareness regarding the new product and a small number of product modifications are also perceived as important measures of the launch phase. The active phase of life cycle underscores the importance of traditional financial success measures. Product cost, profitability, and cost effectiveness in general are considered key issues. In addition, product quality and the suitability of the product for the supply chain could be a feasible measure of success.

The last two phases emphasize profitability and good earnings through the product on one hand and the availability of components on the other hand. Many companies maintain that these later stages provide firms with valuable possibilities to improve demand by upgrading and enhancing the performance of a product or by reducing product cost. The quality and effectiveness of after sales service becomes important as well. Further, one company suggests that a reasonable continuity has to be reached in order to satisfy the needs of customers. This remark relates to the fact that successive product life cycles, no matter how distinct, comprise a continuum from the supplier company's and customer's point of view.

Overall, what does the case study contribute to the theoretical part of the study? The tentative framework for connecting NPD PM and product life cycle that was founded on the literature study included three different conjectures regarding the relationship between product development and product life cycle:

1. Product life cycle as an assemblage of discrete phases and requirements. The objectives and success measures of NPD could be derived by identifying these phase-specific requirements taking into account the relevant stakeholders.
2. Product life cycle as a continuum of time. The objectives and the interpretations of success of product development could be determined on the basis of the anticipated cumulative impacts of products and the identification of their determinants.
3. Emphasis on the fact that product life cycle is a dependent variable that is affected by product development and by a number of other actors inside and outside the company. Challenges and performance standards evolve during PLC.

The relevance of and justification for the first conjecture is founded on the fact that – despite some critical remarks – product life cycle is a viable concept that provides us with an acceptable model of reality. Companies perceive that their products have life cycles and that the life cycles include distinct phases and respective requirements. The case study confirmed that companies did not find it difficult to name product life cycle phases. Even more importantly, it was perceived that life cycle phases are associated with specific requirements that vary during the product life cycle. The first conjecture receives support also from the literature (Hultink and Robben 1995); (Foster et al. 1985; Griffin and Page 1996).

As the case study points out, many companies face substantial challenges due to the fact that the life cycles, including after sales or service, are quite long. This is also shown in the literature (see for example Lele 1986; Lele 1997; Goffin 1998, p. 43; Suomala et al. 2002). Profitability, to a great extent, depends not only on the physical product but increasingly also on after sales business and service function. Life cycle costing is one of the means that can be applied to grasp the cumulative effects of products and product life cycles. Overall, as Fangel (1993) argues, handling the entire life cycle becomes more important. This underscores the relevance of the second conjecture.

The justification for the third conjecture is founded on the observation made in case studies that products are subjects for continuous evolution. Product development takes place both in the beginning of and during the life cycle. Therefore, performance measures should adapt themselves to ever-changing challenges and requirements. The nature of product development work is not a constant (see for example \Grantham, 1997; Ryan and Riggs, 1996); rather, the development work and the process of setting performance standards are different when, for instance, revolutionary or evolutionary innovations are concerned.

All the conjectures seem to be in line with the present trend, according to which companies, instead of supplying physical products, increasingly emphasize their role as system providers or even performance providers. Hence, the question of what is a product and what is a product's life cycle becomes even more challenging. Further, companies are likely to face increasing pressure for firmer and more systematized life cycle management of products – whatever they are.

6.1.8 Summary

- Product life cycle seems to be a feasible concept in different industries for identifying tasks and issues related to a particular product.
- Distinct (but partly overlapping) life cycle phases were identified in all the cases.
- For the respondents, it seemed to be feasible to identify a number of characteristics for each phase. Among other things, the workload of different corporate functions can be utilized as a basis for structuring the life cycle.
- Product requirements for each phase were also identified. The requirements seem to differ from phase to phase. Some companies understand the importance of managing the whole life cycle of a product.
- The length of product life cycle in the case companies is often extensive, especially due to long after sales phases.

6.2 Survey Results

As noted before, the R&D spectrum – from basic research to actual product development – includes a number of activities that are very different from each other. Therefore, as a part of the study, it was inquired what portion of the R&D staff of the surveyed companies is allocated to a particular phase of R&D. The question seemed to be somewhat difficult to answer for some companies, and thus the total number of replies to this question remained lower than the total number of respondents. Table 18 depicts the results regarding this. One can observe from the table that the main focus is on the later phases of the spectrum: 49 percent of the companies do not have any basic research staff at all and approximately 40 percent of the companies have allocated one to four persons for basic research. On the other hand, over 40 percent of the companies have more than ten employees in product development.

Table 18. Distribution of staff in the R&D spectrum (n=51 companies)

	Number of companies					
Number of allocated employees	Basic research	%	Applied research	%	Product development	%
0	25	49.0 %	11	21.6 %	5	9.8 %
1 - 4	20	39.2 %	20	39.2 %	15	29.4 %
5 - 9	3	5.9 %	12	23.5 %	10	19.6 %
10 - 14	2	3.9 %	2	3.9 %	4	7.8 %
15 - 19	1	2.0 %	3	5.9 %	3	5.9 %
20 -	0	0.0 %	3	5.9 %	14	27.5 %
Sum	51	100.0 %	51	100.0 %	51	100.0 %

On the basis of this, it seems fair to conclude that the performance measurement of product development (in contrast with research and development) is practically a relevant unit of analysis. The main scope of industrial R&D, at least in terms of employee allocation and money invested (see for example Jaakkola and Tunkelo 1987; IRI 2000), is product development. In line with this, it should be considered a minimum requirement from the management point of view to be able to establish proper measurement practices for that activity.

6.2.1 Objectives of product development

The perceived objectives of product development were clarified with open-ended questions. Respondents were allowed to subjectively indicate a maximum of five important goals of their company's product development. The replies were attained from 61 companies. Based on the responses, it was possible to recognize 16 different objectives or objective domains that reflected similar kinds of interests for the company's product development activity. (Table 19)

However, the objectives were not equally at the same level. For instance, the most common objective for product development, “new product and technology development”, could be considered the basic task of product development. It is quite abstract as an objective and essentially illustrates *what* should be done in product development while many other – more specific – objectives can be employed to describe *how* this task of product development should be completed. This basic task can be conducted for example in a customer-oriented way and by staying on schedule with the project. (see the identified objectives in Table 19)

Considering customer needs and improving customer satisfaction turned out to be a very common objective domain of product development as was the case with improving the product’s quality and features. Both goals were appreciated by 41 percent of the respondents (Table 19). Responses that were seen to relate with customer needs and the satisfaction objective domain were for instance as follows:

> *“Customer-oriented”,*
> *“Solve the customers’ problems”,*
> *“Correspond to customer needs”, and*
> *“Improve customers’ profitability”*

As regards the objective domain named improving the product’s quality and features, the responses that were seen to associate with it were, for example:

> *“Quality”,*
> *“Improve product’s quality”,*
> *“Improve the reliability of devices”, and*
> *“Technical performance”*

Also keeping the R&D projects on schedule and shortening the product development lead times was considered important by a great portion of the respondents. Examples of the responses are as follows:

> *“Rapidity”,*
> *“Short development time”,*
> *“Persisting in the schedule”, and*
> *“Shortening the projects’ lead times”*

No more than approximately 12 percent of the respondents regarded (that is, explicitly mentioned) company or product profitability as an important objective of a company’s product development (see row 10 in Table 19). The objective domain “other” turned out to be quite large (see the last row of Table 19)). It contained specific product development objectives that were reported only by one company and the domain mainly comprised goals that were unidentifiable. This may indicate a slight misinterpretation of the question among some of the respondents. The responses included:

> *“Education of new employees”,*
> *“Consistency with the legislation” and*
> *“Serving as a resource pool”*

Table 19. Perceived objectives of product development (n=61 companies)

N	Product development objective (is to…)	Companies	%	Perspective
1	Develop new products and technology	26	42.6 %	R&D
2	Consider customer needs and improve customer satisfaction	25	41.0 %	Customer
3	Improve product's quality and features	25	41.0 %	Customer
4	Persist in project's schedule and shorten lead times	23	37.7 %	R&D
5	Improve cost effectiveness in a product supply chain	20	32.8 %	Supply chain
6	Consider different requirements of the supply chain, for example produceability of a product	14	23.0 %	Supply chain
7	Be efficient	12	19.7 %	R&D
8	Be innovative	10	16.4 %	R&D
9	Improve cost effectiveness of R&D	8	13.1 %	R&D
10	Improve company's or product's profitability	7	11.5 %	Shareholders
11	Improve manufacturing process	6	9.8 %	Supply chain
12	Improve company's or product's competitiveness	6	9.8 %	Shareholders
13	Extend and intensify co-operation done in R&D	5	8.2 %	Other
14	Increase knowledge and learning	4	6.6 %	R&D
15	Influence company's or product's sales	2	3.3 %	Shareholders
16	Other	27	44.3 %	Other

Product development objectives can be viewed from perspectives that are considered to be relevant in evaluating the multifaceted performance of product development (Table 19: column Perspective). According to the tentative theoretical framework, these perspectives were concluded to be the customers, the product development or R&D itself, the product's supply chain, and the shareholders of the company. In theory, it should not be reasonable to emphasize any particular aspect over another; on the contrary, the requirements of each stakeholder should even be assessed individually. Is this done in the Finnish industry? Answers can be found from the perceived important objectives of product development (Table 20).

The customer perspective was considered important by 67.2 percent of the respondents at the level of product development objectives. The objectives of the customer perspective were associated with customer needs and satisfaction and product quality and feature improvements.

The most common perspective, at the level of product development objectives, appeared to be the R&D's internal perspective that was valued by 77.0 percent of the companies (Table 20, the first row). In addition to the basic task of product development, which was to develop new products and technology, the R&D internal perspective included objectives that were associated with a project's schedule and lead-time, efficiency, innovativeness, cost effectiveness of R&D, and knowledge increment or learning.

The supply chain perspective was appreciated by 47.5 percent of the product development managers in the responses regarding the objectives of product development (Table 20). The objectives of the supply chain perspective were related with product costs, cost effectiveness of the supply chain, produceability, and manufacturing process improvements.

The least valued perspective turned out to be the company shareholder perspective. Only 23.0 percent of the respondents referred to at least one product development objective that was related to the company shareholder perspective (Table 20). Objectives that were classified as belonging to the company shareholder perspective were associated with profitability, competence and sales of a product, a product-line, or a company.

Table 20. Number of companies that perceived product development objectives associated with a specific perspective (n=61 companies)

N	Perspective	Companies	%
1	R&D itself	47	77.0 %
2	Customer	41	67.2 %
3	Supply Chain	29	47.5 %
4	Shareholder	14	23.0 %
5	Other	32	52.5 %

The nature of the perceived objectives of product development did not indicate very clearly that the requirements that arise from different product life cycle phases would strongly affect the formulation of objectives. Either the objectives are expressed at such a general level that it does not enable the inevitable connection of objectives and life cycle phases (which is the case for example with the objective "*Correspond to customer needs*") or the objectives are related to a particular phase, mostly to the beginning of life cycle ("*Short development time*"), which suggests that the life cycle is not regarded as a whole – the possible versatility of requirements arising from different phases has not been recognized.

6.2.2 Performance measures of product development

The product development managers were asked to define the performance measures of product development actually used in-house. According to the replies, 44 companies employ at least one indicator of product development performance. That corresponds to approximately 70 percent of the sample of this survey. The preceding portion is quite high when compared with international findings (Hertenstein and Platt 2000, p. 315), (Griffin 1997, pp. 429-458). However, the result may be partly due to a response bias: it is very likely that those companies that answered the questionnaire are more active in NPD performance measurement than those that left no answers.

Table 21 illustrates the association between the number of R&D employees and performance measurement employed in product development. Quite as expected, the proportion of the companies having product development performance measures is higher in companies that have a bigger R&D unit. Consistently, the overall number of measures seems to relate to the number of R&D employees (correlation 0.61 between the number of measures and the number of R&D employees).

Table 21. Number of R&D employees and performance measurement (n=51 companies)

Number of R&D employees	Frequency	%	Number of companies having NPD measures	%	Number of measures	% of all measures	Average number of measures
0	7	14 %	3	43 %	14	8 %	4.7
1 - 4	6	12 %	2	33 %	5	3 %	2.5
5 - 9	6	12 %	4	67 %	12	7 %	3.0
10 - 14	8	16 %	7	88 %	26	15 %	3.7
15 - 19	6	12 %	5	83 %	30	17 %	6.0
20 - 39	5	10 %	3	60 %	14	8 %	4.7
40 - 59	5	10 %	4	80 %	9	5 %	2.3
60 -	8	16 %	8	100 %	65	37 %	8.1
Sum	51	100 %	36		175	100 %	4.9

The product development performance measures used were classified into 14 different categories, which represented apparently different subjects. It appeared that 56.8 percent of the companies measured product development performance with metrics that could be associated with time. (Table 22) The time category contained mainly measures such as lead and cycle times and time schedules. Examples of specific measures are as follows:

> *"Product development project lead time",*
> *"Development schedule punctuality",*
> *"Schedule objective vs. schedule realization" and*
> *"Time to market"*

The second most typical category of product development performance measures was sales or revenue. It contained measures of which at least one was in use in 40.9 percent of the companies. The category included measures like new products' sales per overall sales and absolute revenues of either a product, a product line, or a company. (Table 22)

Both product development project costs and overall costs of product development were placed in the category of costs of product development. It showed that 31.8 percent of the companies used performance measures associated with costs of product development. (Table 22: the third row) Examples include:

> *"Project budget",*
> *"NPD project costs" and*
> *"Costs of product development"*

Customer satisfaction was measured primarily by directly asking the customer, but also indirectly by market share measurements or by keeping track of the number of reclamations. Some sort of customer satisfaction measurement as a part of product development measurement was practiced by 29.6 percent of the companies. (Table 22: the fourth row)

The profitability category included typical profitability measures such as return on investments and net profit of a company. *Costs of supply chain* consisted of measures that were focused on the cost of different parts of the supply chain:

> *"Direct product costs",*
> *"Manufacturing costs" and*
> *"Warranty costs"*

Effectiveness and efficiency of product development were measured by employing measures like the product development success rate, R&D maturity index, and number of accomplished product modifications. Innovation measures, on the other hand, were mostly connected with the number of patents and patent applications.

Consistently with the identified objectives, also in the case of product development performance measures, the category "other" turned out to be fairly large. 36.4 percent of the companies reported at least one R&D performance indicator that was either unidentifiable or unclassifiable by the researchers. (Table 22: the last row) The main reason for this was that the reported measures were either too general or too company-specific. Examples of these answers include:

> *"Spice index",*
> *"Measures related to quality" and*
> *"Capability of new technologies"*

Table 22. Product development performance measure categories (n=44 companies)

N	Category of product development performance measures	Companies	%	Perspective
1	Time	25	56.8 %	R&D
2	Sales or revenue	18	40.9 %	Shareholders
3	Costs of R&D	14	31.8 %	R&D
4	Customer satisfaction measures	13	29.6 %	Customer
5	Profitability	13	29.6 %	Shareholders
6	Costs of supply chain	12	27.3 %	Supply chain
7	Effectiveness and efficiency	11	25.0 %	R&D
8	Innovation	9	20.5 %	R&D
9	Product's produceability	8	18.2 %	Supply chain
10	Volume-based	7	15.9 %	R&D
11	Personnel	6	13.6 %	R&D
12	Strategic	5	11.4 %	Other
13	Combination of profitability and sales or costs	3	6.8 %	Shareholders
14	Other	16	36.4 %	Other

The used product development performance measures can also be viewed from the aforementioned important perspectives or views of product development performance evaluation (Table 22: Perspective). Time, personnel, innovation, effectiveness and efficiency, and product development volume measures can be seen as indicators of the internal aspect of product development performance. That showed to be the most common perspective among the companies in view of the fact that 81.8 percent of the companies used at least one measure that was associated with the internal aspect of product development or R&D. (Table 23)

The company shareholder perspective was seen to include measure categories such as sales and revenue, profitability, and combinations of these. 65.9 percent of the companies appeared to use measures that were seen to relate with the company shareholders' interests (Table 23).

The supply chain perspective consisted of measure categories like costs of the supply chain and the product's produceability. R&D performance was measured from the supply chain's perspective by 38.6 percent of the companies. (Table 23)

The customer perspective appeared to be the least measured perspective among the companies. 29.9 percent of the companies used R&D performance measures that were associated with customers. (Table 23) The perspective consisted of customer satisfaction measures.

Table 23. Number of companies that used product development performance measures associated with specific perspectives (n=44 companies)

N	Perspective	Companies	%
1	R&D	36	81.8 %
2	Shareholders	29	65.9 %
3	Supply Chain	17	38.6 %
4	Customer	13	29.6 %
5	Other	18	40.9 %

The versatility and comprehensiveness of product development performance measurement can also be analyzed by looking at the number of different perspectives represented by the performance measurement. Table 24 summarizes this assessment.

Table 24. Number of different perspectives represented by the performance measures used in companies (n=44 companies)

Number of perspectives	Number of companies
1	14
2	15
3	9
4	6

Only six companies seem to utilize measures that altogether cover all the four perspectives that were specified. The performance measures in nine companies constitute three different perspectives that are relevant in product development performance measurement. A majority of companies (n=29) cover one or two perspectives by their measures. Further, if it was assumed that the companies who responded are active in their NPD performance measurement, the results would not indicate comprehensive measurement practices that consider the objectives of several stakeholders.

On the basis of these reported measures typically utilized in product development management, one is not able to conclude that the requirements that arise from different product life cycle phases are comprehensively taken into account. The situation is actually quite similar to that of objectives. Either the measures are defined to be so general that it is very questionable to connect the measures to a particular life cycle phase (which is the case for example with the measure "*net profit of a company*"), or the measures are related to a particular phase, mostly to the beginning of life cycle ("*sales of new products*"), which suggests that the possible versatility of requirements arising from different phases has not been fully recognized. In addition, the survey did not produce explicit evidence that the whole life cycle and the cumulative effects during the life cycle had been taken into account in NPD performance measurement.

6.2.3 Relationship between the perspectives of objectives and measures

Performance measurement should support and be aligned with the objectives of an organization. The performance measures, at best, concretize the given objectives and communicate about them. When comparing the product development performance measures with the important perceived objectives of product development, it is possible to analyze how the management accounting system is actually aligned with the given objectives of product development. In this study, it is reasonable to carry out the comparison at the level of perspectives.

The greatest difference between the important perceived goals of product development and the performance measures were found with the company shareholder perspective. 23.0 percent of the companies explicitly identified the objectives of product development that were associated with the company shareholder perspective, while 65.9 percent of the companies employed measures that indicated the company shareholders' interests (Table 25). The difference was 43.0 percentage units.

The customer perspective also showed a notable margin between objectives and measures. The margin was 37.7 percentage units. But in contrast to the company shareholder perspective, the number of objectives in product development considered to be important from the customer perspective greatly surpassed the measures used. (Table 25: The second row) Smaller gaps between objectives and the used measures were observed in the supply chain's and R&D's perspectives. The difference between both perspectives turned out to be less than 10 percentage units.

Table 25. Relationship between the perspectives of the important product development objectives and the employed measures

		Objectives		Performance measures		
N	Perspective	Companies	%	Companies	%	Margin
1	Shareholders	14	23.0 %	29	65.9 %	-43.0 %
2	Customer	41	67.2 %	13	29.5 %	37.7 %
3	Supply Chain	29	47.5 %	17	38.6 %	8.9 %
4	R&D	47	77.0 %	36	81.8 %	-4.8 %
5	Other	32	52.5 %	18	40.9 %	11.5 %
	Number of companies	61		44		

Overall, an important fact to notice is that 61 companies (96.8 percent of the sample) reported the objectives of R&D while 44 companies (69.8 percent of the sample) defined the measures R&D used. In general there seems to be more wishful thinking than measuring in the product development of the companies.

6.2.4 Needs and purposes

The identified measures were associated with a number of purposes in product development. Altogether 30 companies reported at least one purpose for measurement. Table 26 summarizes the most typical purposes. The most common purpose for measurement was the assessment of effectiveness and efficiency. Sixteen companies identified this purpose for measurement. In addition, altogether 30 measures were employed for this purpose and 15 out of them can be regarded as different from each other. Other important purposes include process quality improvement (9 companies, 15 measures), resource allocation (8 companies, 29 measures), and the assessment of staff innovativeness (7 companies, 10 measures). Regarding the last rows of the table, curiosities included recruiting (one company) and flexibility assessment (one company, three measures).

Table 26. Purpose of measurement (n=30 companies)

Purpose of measurement	Number of companies	% of all companies	Number of measures	% of all measures	Number of different measures
Assessment of effectiveness, efficiency, or productivity	16	53.3 %	30	17.4 %	15
Process quality improvement	9	30.0 %	15	8.7 %	11
Resource allocation	8	26.7 %	29	16.9 %	23
Assessment of staff innovativeness	7	23.3 %	10	5.8 %	6
Assessment of corporate profitability	6	20.0 %	7	4.1 %	7
Reward systems	5	16.7 %	6	3.5 %	5
Product decision	5	16.7 %	14	8.1 %	13
Assessment of customer satisfaction	4	13.3 %	9	5.2 %	6
Capability assessment	3	10.0 %	8	4.7 %	8
Timing decisions	3	10.0 %	4	2.3 %	4
Assessment of product stance in the market	3	10.0 %	7	4.1 %	4
Benchmarking	2	6.7 %	5	2.9 %	4
Staff competence assessment	2	6.7 %	3	1.7 %	3
Sales improvement	2	6.7 %	2	1.2 %	2
Technology assessment	2	6.7 %	3	1.7 %	3
Decreasing product development cost	2	6.7 %	3	1.7 %	3
Assessment of competitiveness	2	6.7 %	8	4.7 %	7
Project management	1	3.3 %	4	2.3 %	4
Recruiting	1	3.3 %	1	0.6 %	1
Flexibility assessment	1	3.3 %	3	1.7 %	3
Organizing projects	1	3.3 %	1	0.6 %	1
SUM	85		172	100.0 %	

The product development managers were also asked how satisfactory their experience had been of the used product development performance measures. The majority of the answers (55.8 percent, or 24 out of 43) indicated slight or strong dissatisfaction among the respondents. (Table 27: Number of answers) Furthermore, the results did not indicate any clear connection between the satisfaction and the versatile use of measures. Versatile use of product development measures in a company was seen to be associated with the number of represented categories in which the measures utilized by that company were classified. (Table 27: Number of represented categories) It was also shown by the results that no particular category of the measures was distinguished as causing more or less satisfaction among the respondents (Table 27: The last fourteen columns).

Table 27. Product development managers' satisfaction with the measures used (n=63 companies)

Opinion	Number of answers	Total number of represented measure categories	Number of represented categories (on average)	Measure category code from Table 22 (the figure indicates the number of companies having at least one measure in a particular category)													
				1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
Highly dissatisfied	7	28	4.0	3	2	1	4	3	1	2	2	1	3	2	2	1	1
Somewhat dissatisfied	17	56	3.3	11	4	4	5	6	5	4	3	4	2	1	1	0	6
No opinion	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somewhat satisfied	16	70	4.4	10	10	8	4	4	6	4	4	3	2	3	2	1	9
Highly satisfied	3	5	1.7	1	2	0	0	0	0	1	0	0	0	0	0	1	0
No response	20	1	0.1	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Table 28 summarizes the answers to an open-ended question, which inquired the information needs of product development managers. Although the number of answers was to some extent limited, some issues came up. For example, more profound information regarding markets, customers, and competitors were requested. On the other hand, some indications that the long-term effects of NPD should be better tracked were obtained as well. In addition, competence measurement seems to be a topic that attracts a number of managers.

Table 28. Information needs of NPD managers that are not fulfilled by the present measures

Question XXII: "What information, that you don't have at the moment, would you need for product development management?"
Domain A: More profound market and customer information
"Perhaps even more profound information on customers, markets, and their development."
"More accurate customer information."
"Information on how satisfied the customers are with our products."
Domain B: Competitors and their NPD
"Innovations made by competitors, and the results associated with them."
"Better material for competitor assessment."
Domain C: Economic effects
"Some kind of life cycle -thinking and industrial learning. In other words, the decreasing of manufacturing costs and the impact of product development on this."
Domain D: Capability and competence measurement
"I would need a compact measurement system that tracks the capabilities."
"Analyses that relate to competencies and capabilities, we only have a gut feeling at the moment."

Overall, it seems that too many product development managers are unsatisfied with the available performance measures although the present measures are able to fulfill some of the fundamental information needs. The performance measurement practices in Finnish companies are not as comprehensive and multidimensional as they could be. The open-ended questions implicate that performance measures (or other information sources) should, better than before, convey the nature of the dynamics associated with the business environment. They should also be able to provide more profound information on the relevant stakeholders of product development.

6.3 Comparative Analysis – Present Practices vs. LCCM

The framework or the template proposed by Otley for describing and analyzing management accounting practices and control systems can be applied in this study (the framework was introduced in the literature review). The comparison between the measurement blueprint proposed in this study and the observed present state of PM in the Finnish industry is organized according to the Otley's five elements that represent five critical questions to be addressed when analyzing management control systems (Otley 1999, pp. 365-366). According to Otley, a comprehensive control system involves at least implicit answers for each of the five elements identified. The elements should be addressed both individually and in combination.

1. *What are the key objectives that are central to the organization's overall future success, and how does it go about evaluating its achievements for each of these objectives?*

The LCCM framework suggests that objectives are derived from the needs of the relevant stakeholders and from the requirements associated with product life cycle phases and cumulative life cycle effects. Regarding the life cycle, the units of analyses were structured according to three conjectures that were focused on: 1) distinct life cycle stages, 2) overall life cycle and the cumulative effects associated with it, and 3) the changing role of product development on the basis of continuous product improvement and evolution.

Empirical observations of PM practices indicate that this is not the reality at the moment. The results of the survey regarding the important perceived objectives of product development indicate that companies are not very comprehensively taking into consideration the multidimensional effects of product development. Especially the company shareholder perspective surprisingly appeared to be rather weakly appreciated among the companies. The proportions shown in Table 25 could be compared with the degree of 100 percent, which would implicate that every company is considering each of the four perspectives (customers, R&D itself, shareholders, and supply chain) as being important from the product development performance point of view.

Empirical observations regarding product life cycles, on the other hand, suggest that product life cycle is a feasible unit of analysis. In addition, distinct product life cycle phases can be identified in many industries. It goes without saying that product life cycles are different in terms of duration, phases, and characteristics depending on the product, application, and industry. However, when the product life cycle is identified in a particular context and at an appropriate level, it is able to provide a framework for setting objectives for product development.

Regarding Otley's first dimension, developing performance measurement practices towards LCCM ideas requires more comprehensive and systematic identification of both stakeholders and product life cycles. Through this process, a set of objectives for product development performance measurement can be obtained.

2. *What strategies and plans has the organization adopted and what are the processes and activities that it has decided will be required for it to successfully implement these? How does it assess and measure the performance of these activities?*

The LCCM framework suggests no explicit strategies but product life cycle is an issue that is affected by the strategy selection of an organization. The LCCM framework implicates that the potential life cycle should be carefully analyzed including sensitivity analyses and scenario building regarding the key factors and attributes of product development. These analyses would provide more profound understanding concerning the life cycle stages and the overall life cycle of a product. Further, it is suggested that product life cycle could be not only assessed from the manufacturer point of view but the customer point of view (if not that of society) could be adopted as well. Overall, this procedure is needed to overcome the problems associated with too narrow a focus and short-term orientation concerning product development performance.

According to the LCCM framework, performance measurement is founded on the multifaceted set of objectives and goals identified through the life cycle assessment. A number of variables and determinants of success can be associated with the identified objectives to enable cause-effect –oriented measurement and to facilitate the measurement of the overall system: outcomes, outputs, and processes (input variables).

Empirical observations of PM practices indicate that measurement partly fails to track the overall schemes of an organization. Regarding the performance measures of product development used, the results of this survey suggest that the ability or willingness to measure things that are considered to be important is weak in some cases (Table 25). That is especially the case with the customer perspective. The results also indicate a contrary situation. The metrics used measured product development performance very often from the company shareholder perspective although this perspective was not considered a very important one. That might be due to the predominance of financial accounting in the past. The majority of the R&D managers felt the product development measures used to be dissatisfactory. The versatile use of measures was not in any case associated with the satisfaction felt among the respondents. It was also shown by the results that no particular category of the measures was distinguished as affecting the level of satisfaction among the respondents.

Further, it should be asked if there were any contradictions between the observed needs of measurement and the practices associated with it. This question received some answers from the survey. If the primary aim of product development were to promote a company's long-term profitability, it could be expected that measures of (long-term) profitability would be very common. However, this is not the case in practice. Sales or revenue measures dominate the financial measurement at the company level. The issue of life cycle performance of new products receives little explicit attention from practitioners. Although the product requirements that arise from different phases of life cycle might have an important role that should be taken into account in product development measurement, it is not very surprising that life cycle -related measures are somewhat neglected: this is consistent with the literature and with the overall findings made in the survey. Thirdly, the difference between the perceived product development objectives and the measures used reveals some contradictions. It might be that the measuring of some important issues requires an effort that is not realistic to allocate for this purpose. On the other hand, sometimes it just feels too inconvenient to analyze an issue to an extent that enables systematic measurement. Furthermore, it is important to realize that all the issues and objectives – even important ones – do not have to be measured. Therefore, it is actually to some degree unrealistic to expect that the objectives and the measures should be exactly consistent with each other. Also, it should be pointed out that product development objectives and product development measures may be at least partly hierarchical, that is, an issue or factor that is perceived as an important objective could be pursued utilizing a measure, which seems to be – at first sight – quite different from the objective.

Empirical observations regarding product life cycles, however, indicate that some requirements (see Table 17) for successful products could be determined on the basis of the PLC phase. This suggests that performance measurement could be founded on the analysis of product life cycle. Further, constructing measures on the basis of these identified requirements could employ a number of means including workload analysis, duration analysis, and life cycle cost analysis.

Concerning Otley's second dimension, developing performance measurement practices towards LCCM ideas requires a more accurate identification of requirements for a product especially from the customer and supply chain point of view, better alignment between the objectives and measures, and, overall, better balance within the measurement system without overemphasis on particular issues.

3. *What level of performance does the organization need to achieve in each of the areas defined in the above two questions, and how does it go about setting appropriate performance targets for them?*

The LCCM framework suggests that the level of performance that has to be achieved is a context-specific issue. Generally, the comprehensive interpretation of performance suggests that the level of performance in each area should be considered both separately and together. The performance of a product should be acceptable considering all the relevant stakeholders and life cycle requirements. In contrast with many industrial practices, the level of achieved performance cannot be totally observed during a product development project or along a development process. The level of performance can be multifacetedly evaluated as the effects become observable – that is, during the product life cycle.

The target setting, according to the LCCM framework, is founded on at least three principles. First, historical data regarding the products and their life cycle should be utilized whenever applicable. This data may reveal potential life cycle patterns as well as achieved levels of performance. Second, the future effects of products can be based on future projections and anticipations that are founded, for example, on alternative design parameters, market forecasts, or customer and/or market studies. Third (as a complement to forecasts and projections), sensitivity analyses and scenarios can be helpful when setting targets. For example, considering the objective of cumulative profitability, it would be very valuable to understand the role of after sales business on the total profitability of a product.

Empirical observations regarding PM practices revealed that the most typical measures of product development employed in Finnish companies were focused on the inputs rather than on the outcomes. Typical input measures included indicators of product development time and measures of development costs. In addition, the most common outcome measure was focused on sales in contrast with profitability. On the basis of the survey evidence, the measurement of NPD in Finland could be much more outcome-oriented than what it is at the moment.

Empirical observations regarding product life cycles indicate that product development management, or at least the sample of product development managers, understands that product life cycle poses a number of long-term challenges that can be answered through effective product development. In other words, there is no illusion in the heads of product development managers that the NPD process is the only thing that needs attention. On the other hand, it can be asked why there are no explicit measures in place that could show the long-term effects of product development if this principle is indeed well understood.

Regarding Otley's third dimension, developing performance measurement practices towards LCCM ideas requires more outcome orientation and explicit targets that imply the long-term effects of product development. Input or in-process measurement can be applied as well, but primarily for supporting the identification of cause-effect chains.

4. *What rewards will managers and other employees gain by achieving these performance targets (or, conversely, what penalties will they suffer by failing to achieve them)?*

The LCCM framework suggests no explicit reward structure. However, consistently with the two main themes – comprehensiveness and long-term orientation – the implicit message is that the rewards of the product development staff should be founded on the long-term impact of that activity. Regarding monetary rewards, one of the prerequisites for them should be an achieved (positive) monetary effect of actions. In the product development context, positive monetary effects may take the form of decreased life cycle costs of a product or a positive development of long-term product profitability. In line with this, to be able to have such reward structures proper measures to track these effects have to be in place.

Empirical observations regarding Finnish PM practices revealed that rewarding was one of the most popular purposes for NPD measurement. Five companies reported that they employ product development measurement for rewarding their staff. Measures employed in NPD reward systems included:

- The success of the developed products in objective tests and comparative analyses
- The number of innovations
- The progress made regarding personal action plans
- The realized vs. expected schedule of projects
- Cost competitiveness of products

It is interesting that these measures are employed for rewarding purposes. The only financial measure is the last one, which is a cost-based measure. Regarding the four other measures, the first one is related to the outcomes while the three others illustrate either process dimensions or outputs that cannot be associated with any bottom-line success. However, it is possible that the companies that employ these measures use also other (company-wide) measures in their measurement systems.

With respect to Otley's fourth dimension, developing performance measurement practices towards LCCM ideas requires that possible rewards or penalties be founded on the long-term assessment of impacts. Rewards that are based on short-term effects may give signals that are contradictory to the long-term nature of product development.

5. *What are the information flows (feedback and feed-forward loops) that are necessary to enable the organization to learn from its experience, and to adapt its current behavior in the light of these experiences?*

The LCCM framework suggests that product development performance measurement is essentially based on the utilization of both the feedback and the feed-forward loops of information. Only a small portion of relevant information needed for measuring the performance of product development is present during the development process. Life cycle -conscious measurement, at best, explicates the organization's experiences regarding a new product constituting a long-term oriented view of product performance. Feedback provides essential information regarding the actual financial success of a product, the customers' experiences with it, and the wellness of the product in terms of supply chain requirements. Feedback is also needed to collect historical data on causes and effects and the determinants of desired performance. Overall, life cycle -conscious performance measurement becomes more applicable as more data on product life cycles cumulate. The feed-forward element of LCCM, on the other hand, suggests that actually the whole life cycle is developed and affected in product development. Performance measurement can be applied to communicate the expectations regarding the product that were made at the beginning of its life cycle. In contrast, the evidence gained during the later phases verifies or questions these earlier expectations. Together, these phases constitute a valuable learning process.

Empirical observations regarding PM practices suggest that learning and competence development is an important part of product development. However, managers seem to think that the present measures are not able to fully depict the developments in these dimensions. Measurement is mainly practiced regarding those issues that can be easily quantified without any remarkable delay. Further, the managers are not too satisfied with the present measures in general, which supports the idea that the quality of the information produced by the measurement system should be further improved.

Concerning Otley's fifth dimension, developing performance measurement practices towards LCCM ideas requires measurement that is also interested in issues that cannot be evaluated immediately. Performance measurement is about communication, which means that sometimes even the issues that are difficult to measure have to be concerned in the measurement system design. Performance measurement can convey powerful messages even without quantitative measures.

To summarize the potential trajectory of product development performance measurement in the light of LCCM, certain issues seem evident. Developing more comprehensive performance measurement systems requires at least:

- More explicit identification of the stakeholders
    - At the level of identified objectives
    - At the level of employed measures
    - Customers' needs and objectives are not fully represented
    - Supply chain members' needs and objectives are not fully represented
    - Product development's needs and objectives are not fully covered as regards, for example, competence development and learning evaluation
- More explicit life cycle and outcome orientation
    - Identification of distinct life cycle phases
    - Analysis of product requirements associated with the PLC phases, especially from the customer point of view (conjecture 1)
    - Negligible measurement of the cumulative effects of new products should be improved by, for example, applying life cycle costing and analyzing after sales profitability (conjecture 2)
    - Measurement of continuous product improvement seems to be underdeveloped (conjecture 3). It is related to, for example, the limited utilization of profound market information.
        - Some indications found (for example, comparison of manufacturing costs between successive product generations)
        - Measurement of product platform or concept effectiveness: no explicit evidence
- Better alignment between the measures and the objectives and goals

7 Conclusions and Implications

7.1 Discussion of Results

The discussion of the results is feasible to build on the established research questions and objectives. The study includes three research questions that will be first discussed.

> *A. Multifaceted performance measurement and the concept of product life cycle- conscious new product development: What would be the potential role of product life cycle in new product development performance measurement and management?*

Life cycle or product life cycle is able to provide NPD performance measurement with a temporal frame that facilitates multifaceted measurement. Life cycle is a multidimensional concept that includes several perspectives and interpretations. These can be perceived as mutually complementary. For managerial purposes and for performance measurement construction, life cycle can be organized, for instance, on the basis of the phases that the customer experiences when utilizing the product. In addition, a different life cycle perception can be obtained when the product life cycle and its phases are assessed from the manufacturer's or society's point of view. The most comprehensive requirements for a product can be revealed when all the different views are taken into account.

The study does not argue that multifaceted performance measurement can only be realized through life cycle consciousness. It is quite likely that also other measurement ideas could have been produced on the basis of the analysis of the PM doctrine, ideas which would be able to provide some answers for the problems encountered within new product development performance measurement. However, it is argued that the proposed framework is well in line both with the identified NPD measurement problems and with the general guidelines discussed regarding the feasible and appropriate measurement of organizational activities.

> *B. How would it be possible and expedient to organize the measurement of (new) product development performance taking into account the challenges and requirements that arise from the product life cycle and its discrete phases?*

The study proposed three interpretations for synthesizing NPD performance measurement and the concept of life cycle. These are not mutually exclusive but they rather support each other. The essence of the first conjecture is that a life cycle is an assemblage of life cycle phases and that the phases are associated with a number of requirements that should be observed in product development. Product development is seen as an activity that is mainly carried out at the beginning of the product life cycle. The phase-specific requirements can be useful when determining the objectives for product development but they can also be applied when anticipating the effects of certain product development decisions concerning, for instance, the product's parameters. Performance measurement that is founded on the first conjecture requires systematic identification of PLC phases and product requirements from the different stakeholders' point of view. Importantly, it is possible that the requirements are partly contradictory, which means that the realization of PM requires also prioritization of objectives and stakeholders.

The second conjecture or interpretation suggests that PLC can be perceived as a continuum of time. Product development, which takes place at the beginning of the life cycle, determines the success potential of an organization for a long time. As shown in the case study, the lengths of product life cycles in many industries are extensive, especially when all the impacts are considered. NPD performance measurement that is consistent with the second conjecture requires long-term measures of success, such as the ones based on the whole life cycle costs experienced by different stakeholders or the ones that focus on the long-term profitability of the product. These would include measures not only for the profitability of the physical product but also for indirect services associated with it.

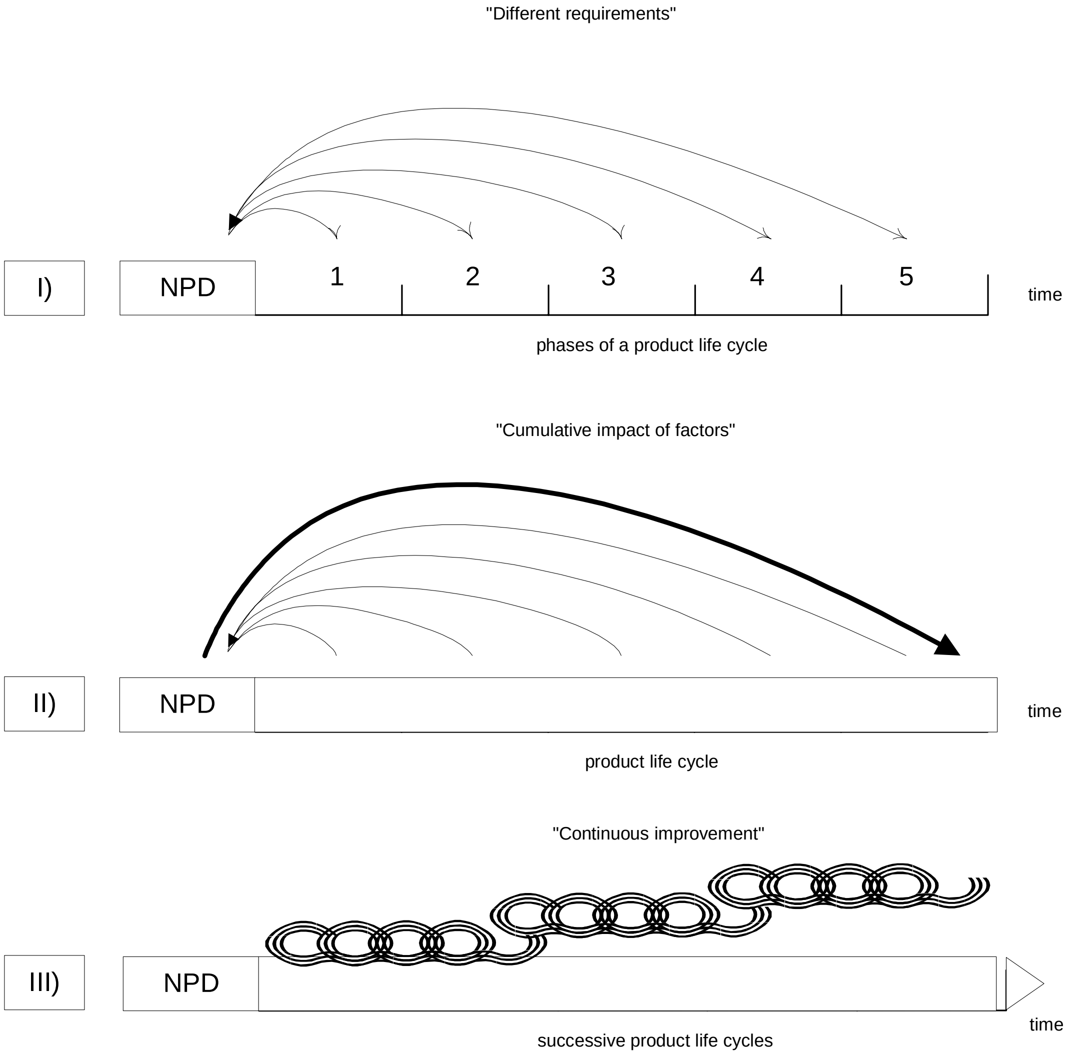


Figure 20. Three basic conjectures

According to the third conjecture, product development is an activity that is more or less continuous in an organization. Product development takes place at the beginning of the PLC but companies are also required to practice product development during life cycles. Rarely would products stay competitive unless they were continuously improved during their lives. From the product development management point of view, this implies that it is imperative to practice continuous improvement and make sure that the capabilities gradually develop. On the other hand, evolutionary product development can be founded on explicit customers' or other stakeholders' experiences, which may help to allocate resources to the right issues. Performance measurement consistent with the third conjecture is focused on the explication of continuous improvement and the capability development that takes place. It should also rely on the data gained from the real-life experiences related to the product. Overall, the third conjecture suggests that if it is difficult to distinguish a separate product life cycle, the long-term nature of product development effects can be reflected by the measurement that seeks to identify improvements made through the gradual development of products and product platforms.

> *C. What is the difference between this idea of new product development performance measurement and the present state of NPD performance measurement in the Finnish industrial context?*

Consistently with the existing literature, this study maintains that the performance measurement of new product development is not as well developed as one may expect. Hence, it can be argued that the idea of multifaceted and life cycle -conscious measurement of product development activities does not reflect the present state of the issue in the Finnish industrial context.

As the comparative analysis pointed out, the present state of measurement is characterized by a relatively narrow focus. Only a very limited number of companies measure their product development activities in a way that implicates a simultaneous inclusion of different perspectives. Even the financial perspective, which is the most represented one at the level of measures, is mainly founded on sales measures, which do not really expose the bottom-line effects of product development activities.

Overall, the present practices of measurement are not as long-term or outcome-oriented than those suggested. To be able to prove the importance of a product development effort for an organization, it is necessary to more comprehensively track the multidimensional effects (and causes for those effects) on a number of stakeholders.

Regarding the five objectives set for this study, a number of observations can be made. The following comprises the main results that can be associated with the objectives, respectively:

> *I. To structure and analyze the concept of product life cycle in the context of new product development. This objective includes answering the question of what elements comprise product life cycle and identifying the different types of life cycles relevant regarding NPD performance measurement.*

The concept of life cycle has been discussed both separately and connected with a number of managerial themes. It was found that the validity of PLC has been occasionally questioned but that the concept still seems to an expedient tool for organizing the long-term requirements for a product. The case study was founded on the product life cycle seen from the perspective of the producer. Important phases across the case companies included: development phase, introduction or implementation phase, active phase or steady phase, and, very often, also an after sales or maintenance phase.

> *II. To establish and analyze the concept of life cycle -conscious NPD performance measurement. This includes identifying the various requirements for performance measurement that are founded on the characteristics of life cycle.*

The literature study and the case study were employed to fulfill this objective. As discussed earlier, the analysis produced three conjectures that were based on different interpretations of life cycle and the role of product development. It was also pointed out that the product should not only be assessed from the manufacturer point of view but that life cycle may have quite different meanings – but very useful meanings regarding performance measurement – if it is seen from the customer point of view. (Consider, for instance, the life cycle of a chocolate bar from the customer and from the manufacturer point of view.)

> *III. To build a construct or a conceptual model that connects product life cycle with new product development performance measurement. The construct should take into account the different stakeholders of the product and the interpretations regarding the product life cycle. As a result, the conceptual model should provide a multifaceted framework for measuring NPD performance.*

The proposed framework was tentatively discussed in Chapter 5 and further developed on the basis of the case study. The extensive literature study was conducted first to ensure a good alignment between the proposed framework and the guidelines set in the literature and second, to demonstrate the lack of such multifaceted blueprint in the doctrine.

> *IV. To identify and evaluate the present state of performance measurement in Finnish industrial new product development. Interests in this broad issue include the perceived objectives for NPD, the measures employed, and the satisfaction associated with the present state of measurement.*

The survey and its key findings were reported to provide an illustration regarding the present state of NPD PM in Finnish industrial companies. The results show that the measurement practices of product development are neither comprehensive nor satisfactory in terms of stakeholder- or life cycle orientation.

> *V. To establish a "development path" or a trajectory from the present state of the performance measurement of Finnish industrial product development towards a state of more multifaceted performance measurement of development activities.*

On the basis of the proposed framework and the study on the present state of measurement, the trajectory was discussed in Chapter 6.3. Overall, it has been pointed out that life cycle -conscious performance measurement could be employed for structuring and fully analyzing the objectives of new product. Thereby it has been suggested, at least implicitly, that this would lead to more successful product development. However, the empirical demonstration of that implication has not been within the scope of this study. Further, it is important to acknowledge that external factors are often crucially important in successful product development. Hall, for instance, remarked that research and development drive innovation in the biotechnology industry but market demand is a critical factor that affects the business performance of a firm (Hall and Bagchi-Sen 2002). In addition, there are also a number of other issues that facilitate effective and successful product development. All of these issues cannot be discussed simultaneously and not all of these issues can be considered only in the product development phase of the R&D spectrum. As one example, Drejer (2000) suggests that in order to be able to respond the competition in the market, a firm has to pay attention to the integration of product and technology development. Finally, as Fleming and Sorensen (2001) cite the economist Ken Arrow:

> *"The process of innovation is, virtually by definition, filled with uncertainty; it is a journey of exploration into a strange land."*

In other words, there are probably limits for rationalizing product development. My sincere belief is that this study would have pushed these limits at least marginally further.

7.2 Contribution of the Dissertation

The literature suggested that the performance measurement of product development is not as effective as it should be. Despite the efforts from the managerial or practical side and from the academic side, the "performance measurement community" has not been able to resolve the challenges of NPD PM. New ideas and suggestions have been welcomed to overcome the problems, for instance, associated with the construction process of a PM system, the short-term focus of measurement, and the lack of outcome orientation.

Consistently with these shortcomings, the primary contribution of the study is the proposed multifaceted framework for measuring product development. It is meant to be applicable in the product development phase in the process of considering issues that are important given a particular product. The framework facilitates the analytical selection of objectives for constructing measures and can enable finding a balance for the measurement system. Overall, it connects two streams of literature: PLC and NPD PM.

Case study findings can be seen not only as a part of this primary contribution but also as an independent contribution in itself. The six case studies produced evidence concerning the *perceived* nature of industrial PLC. It was shown that distinct life cycle phases and the requirements associated with the phases can be identified within a number of settings. The case studies also showed the applicability of the framework at least within some industrial environments.

The survey results and the comparative analysis constitute a part of the contribution of this study. The information regarding the present state of NPD PM in the Finnish industry in terms of measures employed, objectives identified, and measurement purposes has some novelty value. On the other hand, the survey results confirm and refine the international findings made in the literature. The comparative analysis depicts the development potential of Finnish NPD performance measurement and sets a number of guidelines for comprehensive measurement.

7.3 Managerial Implications

The study suggests that product life cycle is a key contingency variable of performance measurement in the product development context and it should be considered in NPD performance measurement system design. Management control systems can be seen as mechanisms that are intended to provide managers with information that is perceived as important in developing and maintaining viable patterns of behavior. Life cycle -oriented or -conscious performance measurement of new product development is in line with the contingency theory of management accounting, which suggests that the choice of appropriate control techniques depends on the circumstances surrounding a specific organization. Key contingent variables include the strategy and objectives an organization chooses to pursue. That is, different strategies and different organizational plans are likely to cause different control system configurations. (Otley 1999, pp. 365-366)

As a whole, the study indicates that there are several ways in which NPD performance measurement would benefit from the concept of product life cycle. First, life cycle orientation would provide companies with an expedient framework for constructing the performance measures of NPD. The framework is likely to reduce the short-termism typically associated with NPD performance measurement, when the long-term effects of new products and requirements that arise from the later stages of PLC are considered a foundation for performance measures.

In addition, life cycle could provide help for weighting the criteria and the measures utilized in NPD on the basis of the relative importance of the distinct PLC phases and the requirements associated with them. Further, a comprehensive framework such as PLC would help in finding a balance for the measurement system and in directing sufficient attention towards the comprehensive effects of new products.

Finally, as Tipping (1995) points out, measures – no matter how sophisticated or comprehensive they are – only provide data or information for improving something. Effective measurement requires an appropriate system that takes into account the characteristics of the particular environments. But above all, effective measurement requires the right attitudes and motivation to actually utilize the information provided by the system and energy to improve and continuously develop the measurement system to better reflect the challenges faced in the business.

7.4 Limitations of the Study and Guidelines for Further Research

One of the limitations regarding the survey is the relatively low response rate. This may have caused a bias in the responses. In other words, more passive firms may not be represented in the survey results. The open-ended questions employed in the survey constitute both a strength and a weakness. It can be that the open-ended questions produced more reliable or "thought-out" answers as regards the true measurement practices. When no ready answers were given, the respondents had to reflect on their answers more profoundly. On the other hand, it was difficult to totally objectively associate an answer to an open-ended question with a measurement category, for instance. The analysis of the answers, however, was made on the basis of various measurement categories. The problem of connecting an answer with a category was tried to overcome by relying on the opinions of two rather independent researchers. Both researchers made the association by themselves and the results were discussed together to produce the final classification of objectives and measures.

Another limitation of the survey is related to classification as well: the assignment of objectives and measures to a particular performance view (customer, R&D, shareholder, supply chain) is highly difficult. It might be questionable to strictly classify one objective or one measure under one performance view. In most cases, it could be claimed that a measure or objective would be relevant in more than one view. More work could be done to fully develop the logic needed to connect measures and objectives to the above-mentioned four directions or views.

Further, a survey is not necessarily an optimal instrument when collecting information on conceptually challenging or difficult issues. The following example gives some insight into this problem. Kerssens-van Drongelen and Bilderbeek (1999) first conducted a survey after which they put forth a number of in-depth interviews among the surveyed companies:

> *"Furthermore, we observed in the interviews that several companies did not perceive their individual performance evaluation system to be a type of performance measurement, whereas in our opinion it was. Thus the actual percentage of companies measuring at multiple levels is certainly higher than it first [on the basis of the survey] appeared." (Kerssens-van Drongelen and Bilderbeek 1999, p. 40)*

This limitation was tried to overcome in this study by employing open-ended questions in the survey. In other words, we did not ask whether a company utilized this or that measure or a measure at all. Instead, we explicitly asked the companies to name the objectives and measures they were using. Still, it is impossible to say to what extent the answers reflect the reality and to what extent they only reflect the respondents' ideas about reality.

The case study of the six companies and a limited number of interviewees provide only a limited empirical context within which the ideas presented in this study seem to apply. This allows no statistical generalizations. Naturally, the study did not seek to produce statistical generalizations but rather contextual ones. The case studies were not able to provide data on the true life cycles of the products but rather on the perceptions regarding the product life cycles in these companies. This is not, however, a fundamental problem. The actual implementation of the measurement framework can and will produce more reliable data on the actual life cycles and the issues related to them.

Overall, the limitations of the study can be discussed in the dimensions of validity and reliability. Validity can be further divided into external validity, internal validity, and construct validity.

Despite the fact that the primary aim of the study has not been to produce generalizations, it is appropriate to discuss the generality of the results of this study, Overall, the generalizability or the external validity of case studies (that is, case studies of multiple cases) relies on replication logic. On the other hand, the generalizability of qualitative research relies on contextual generalization. The case studies provided the study with a (replicated) context within which the results (the LCCM framework) are relevant. The study is mainly focused on industrial companies that produce industrial investment goods. In terms of size, middle-sized and large companies have been dealt with. Above all, the case studies featured certain issues that define the boundaries for generalizing the results:

- The ability to identify and structure the product life cycle
- The extensive length of PLC
- The continuous evolution of products

Construct validity was promoted by using multiple sources of evidence in the case studies. The interviewees' opinions were triangulated by using other documents and evidence that were available. These included technology reports, life cycle management models, and data gained by direct observation (two companies). In addition, the interview memos were circulated among the studied companies. In data analysis and composition, the process relied partly on the expertise of two researchers.

As pointed out by Yin (1994), internal validity is a concern of causal studies. This is not one of those. In other words, the purpose of this study was not to find cause-effect links within the cases that would explain certain investigated phenomena. As regards the case studies, the units of analyses were associated with the concept of life cycle. The researcher did not try to explain why the life cycles were what they were but he was to investigate whether it is possible to overall identify PLCs, life cycle phases, and requirements.

Reliability refers to the ability to repeat the same research process using the same material. Taking into account that the majority of the study has been conceptual, the question of reliability in this sense is interesting to answer. In my opinion, it is not very likely that another researcher would have ended up with exactly the same conclusions and frameworks. However, the phases of the research and the documentation were prepared with such rigor that the same researcher would not end up with totally different conclusions if the material was revisited. Finally, with conceptual research, it is somewhat unclear whether it is the repeatability of the research process or the applicability and reliability of the given framework that is the major point of interest.

The practical limitations of the study include some issues. The lack of the ability to rely on historical data regarding life cycles may make it very difficult to actually practice the LCCM proposed in this study. If the life cycle cannot be anticipated, it could be very challenging to place any objectives or measures on the basis of life cycle requirements. Thus, the LCCM framework is likely to be the most applicable in those environments that are characterized by the feasibility of reasonable life cycle anticipation. Also, if different measures were employed in different parts of a life cycle, one of the practical challenges would be the difficulty to identify a shift into a particular phase. As shown in the literature, life cycles may take different forms and the sales pattern, for instance, cannot be straightforwardly used as a basis for life cycle analysis. In addition, the proposed LCCM could lead to too heavy a procedure for some companies. The systematic way to construct measures that is advocated by the framework means that the construction process may require considerable effort if all the relevant stakeholders, life cycle interpretations, and life cycle phases are analyzed within the process. Finally, to support the practical implementation process, more practical ideas concerning, for instance, the actual measures will be needed.

Future research could be focused at least on the following themes: First, specific measures that would support the presented blueprint should be constructed and tested in different organizations. Conceptual research approach or constructive research approach would be suitable methods regarding this theme. Second, quantitative evidence on the product life cycles in metal industry should be collected. This can be done either by survey research or by in-depth case studies. Third, implementation of the measurement framework in an organization that practices product development would provide more information concerning the feasibility and applicability of the framework in a real-life situation. The appropriate research strategy for this could be action research or constructive research.

"A rose is a rose is a rose" - Gertrude Stein

References

Aaltio-Marjosola, I. (1999). Case-tutkimus metodisena lähestymistapana, Metodix. **2000**.

Aaltonen, P., A. Koivula, M. Pankakoski, V. Teikari and M. Ventä (1996). Tiimistä toimeen: Kuinka kirkastat tiimin tavoitteet ja luot mittariston sekä palautejärjestelmän. Espoo, Teknillinen korkeakoulu.

Abetti, P. A. (2002). "From science to technology to products and profits. Superconductivity at General Electric and intermagnetics General (1960-1990)." Journal of Business Venturing **17**: 83-98.

Akao, Y., Ed. (1990). Quality function deployment, Productivity Press.

Akgün, A. E. and G. S. Lynn (2002). "Antecedents and consequences of team stability on new product development performance." Journal of Engineering and Technology Management **19**: 263-286.

Alasuutari, P. (1999). Laadullinen tutkimus. Tampere, Vastapaino.

Ancona, D. G. and D. F. Caldwell (1992). "Demography and design: predictors of new product team performance." Organization Science **3** (3): 321-341.

Andersin, H., J. Karjalainen and T. Laakso (1994). Suoritusten mittaus ohjausvälineenä. Helsinki, MET.

Anderson, C. R. and C. P. Zeithaml (1984). "Stage of the Product Life Cycle, Business Strategy, and Business Performance." Academy of Management Journal **27** (1): 5-24.

Anderson, E. W. and C. Fornell (1994). "Customer satisfaction, market share, and profitability: Findings from Sweden." Journal of Marketing **58** (3): 53-66.

Ansari, S. L., J. E. Bell, J. H. Cypher, P. H. Dears, J. J. Dutton, M. D. Ferguson, K. Hallin, C. A. Marx, C. G. Ross and P. A. Zampino (1997). Target costing: the next frontier in strategic cost management. Chicago (IL), Irwin.

Anthony, M. T. and J. McKay (1992). "Balancing the product development process: Achieving product and cycle-time excellence in high-technology industries." Journal of Product Innovation Management **9**: 140-147.

Argyris, C. (1991). "Teaching Smart People How to Learn." Harvard Business Review (May-June): 99-109.

Arnaud, G. (2002). "Developing in-company research: a French review of observation strategies." Management Decision **40** (2): 101-115.

Asiedu, Y. and P. Gu (1998). "Product life cycle cost analysis: state of the art review." International Journal of Production Research **36** (4): 883-908.

Athaide, G. A., P. W. Meyers and D. L. Wilemon (1996). "Seller-Buyer Interactions During the Commercialization of Technological Process Innovations." Journal of Product Innovation Management **13**: 406-421.

Awasthi, V. N., C. W. Chow and A. Wu (1998). "Performance measure and resource expenditure choices in a teamwork environment: the effects of national culture." Management Accounting Research **9**: 119-138.

Ax, C. and U. Ask (1995). Cost Management, Studentlitteratur.

Badri, M. A., A. Mortagy, D. Davis and D. Davis (1997). "Effective analysis and planning of R&D stages: a simulation approach." International Journal of Project Management **15** (6): 351-358.

Barfield, J. T., M. R. Kinney and C. Raiborn, A. (1994). Cost Accounting: Traditions and Innovations. St. Paul, West Publishing Company.

Batson, R. G. (1987). "Characteristics of R&D Management which Influence Information Needs." IEEE Transactions on Engineering Management **34** (3): 178-183.

Batty, J. (1988). Accounting for Research and Development. Aldershot, Gower Publishing Company ltd.

Bauer, H. H. and M. Fischer (2000). "Product life cycle patterns for pharmaceuticals and their impact on R&D profitability of late mover products." International Business Review **9**: 703-725.

Bayus, B. L. (1994). "Are product life cycles really getting shorter?" Journal of Product Innovation Management **11** (4): 300-308.

Berg, P. (1999). Appraisal for the technology programmes : development and verification of a new assessment model in some national technology programmes of the construction industry in Finland, Tampere University of Technology**:** 192.

Berg, P., V. Leivo, J. Pihjalamaa and M. Leinonen (2001). Tuotekehitystoiminnan laadun ja kypsyyden arviointi, MET.

Bjørnenak, T. and F. Mitchell (2002). "The development of activity-based costing journal literature, 1987-2000." European Accounting Review **11** (3): 481-508.

Boer, H., S. Caffyn, M. Corso, P. Coughlan, J. Gieskes, M. Magnusson, S. Pavesi and S. Ronchi (2001). "Knowledge and continuous innovation. The CIMA methodology." International Journal of Operations & Production Management **21** (4).

Bourne, M., J. Mills, M. Wilcox, A. Neely and K. Platts (2000). "Designing, implementing and updating performance measurement systems." International Journal of Operations & Production Management **20** (7): 754-771.

Brinker, B. J., Ed. (1997). Emerging Practices in Cost Management: Performance Measurement. Emerging Practices in Cost Management. Boston, WG&L/RIA Group.

Brown, K. K. (1995). Strategic Performance Measurements. Florida CPA Today. **1995:** 28-30.

Brown, M. G. and R. A. Svenson (1998). "Measuring R&D Productivity." Research Technology Management **41** (6): 30 - 36.

Brown, S. L. and K. M. Eisenhardt (1995). "Product development: past research, present findings, and future directions." Academy of Management Review **20** (2): 343-378.

Brown, W. B. and D. Gobeli (1992). "Observations on the Measurement of R&D Productivity: A case study." IEEE Transactions on Engineering Management **39** (4): 325-331.

Campbell, A. J. and R. G. Cooper (1999). "Do Customer Partnerships Improve New Product Success Rates?" Industrial Marketing Management **28**: 507-519.

Chenhall, R. H. (1997). "Reliance on manufacturing performance measures, total quality management and organizational performance." Management Accounting Research **8**: 187-206.

Chiesa, V. and C. Masella (1996). "Searching for an effective measure of R&D performance." Management Decision **34** (7): 49-57.

Chow, C. W., K. M. Haddad and J. E. Williamson (1997). "Applying the balanced scorecard to small companies." Management Accounting **1997** (August): 21-27.

Clark, K. B. and T. Fujimoto (1990). "The power of product integrity." Harvard Business Review (November-December): 107-118.

Clark, K. B. and T. Fujimoto (1991). Product Development Performance. Strategy, Organization, and Management in the World Auto Industry. Boston, Harvard Business School Press.

Clifford, D. K. (1965). "Managing the product life cycle." Management Review (June): 34-38.

Coccia, M. (2001). "A basic model for evaluating R&D performance: theory and application in Italy." R&D Management **31** (4): 453-464.

Cohen, M. A. and S. Whang (1997). "Competing in Product and Service: A Product Life-Cycle Model." Management Science **43** (4): 535-545.

Cokins, G. (1999). Why is traditional accounting failing quality managers? Activity-based costing is the solution. Quality Congress. ASQC ... Annual Quality Congress Proceedings, Milwaukee, ASQC.

Constantinides, K. and J. K. Shank (1994). "Matching accounting to strategy: one mill's experience." Management Accounting **1994** (September): 32-36.

Cooper, R. (1990). "ABC: A Need, Not An Option." Accountancy (September): 86-88.

Cooper, R. (1990). Explicating the Logic of ABC. Emerging Practices in Cost Management. B. Brinker, J. Boston, Warren, Gorham & Lamont**:** L6-1 - L6-5.

Cooper, R. and R. Kaplan, S. (1988). "Measure Costs Right: Make the Right Decisions." Harvard Business Review **66** (5): 96-103.

Cooper, R. and R. Slagmulder (1997). Target costing and value engineering. Portland, Productivity Press.

Cooper, R. and R. Slagmulder (1999). "Designing ABC Systems for Strategic Costing and Operational Improvement." Strategic Finance **81** (2): 18-20.

Cooper, R. and R. Slagmulder (1999). "Develop Profitable New Products with Target Costing." Sloan Management Review (Summer): 23 - 33.

Cooper, R. G. (1985). "Selecting Winning New Product Projects: Using the NewProd System." Journal of Product Innovation Management (2): 34 - 44.

Cooper, R. G. (1996). "Overhauling the New Product Process." Industrial Marketing Management **25**: 465-482.

Cooper, R. G. (1997). Winning at new products. Accelerating the process from idea to launch, Addison-Wesley Publishing Company.

Cooper, R. G. (1999). "The Invisible Success Factors in Product Innovation." Journal of Product Innovation Management **16**: 115-133.

Cooper, R. G. and E. J. Kleinschmidt (1995). "Benchmarking the Firm's Critical Success Factors in New Product Development." Journal of Product Innovation Management **1995** (12): 374-391.

Cooper, R. G. and E. J. Kleinschmidt (1996). "Winning businesses in product development." Research Technology Management (July/August): 18-30.

Cordero, R. (1990). "The measurement of innovation performance in the firm: An overview." Research Policy **19**: 185-192.

Curtis, C. C. (1994). "Nonfinancial performance measures in product development." Journal of Cost Management (Fall): 18-26.

Curtis, M. (1994). "Designing for the future." World Class Design to Manufacture **1** (4): 46-48.

Dalén, P. and G. S. Bolmsjö (1996). "Life-cycle cost analysis of the labor factor." International Journal of Production Economics **46-47**: 459-467.

Davila, T. (2000). "An empirical study on the drivers of management control system's design in new product development." Accounting, Organizations and Society **25**: 383-409.

Davis, C. R. (2002). "Calculated Risk: A Framework for Evaluating Product Development." MIT Sloan Management Review (Summer): 71-77.

Davis, J., A. Fusfeld, E. Scriven and G. Tritle (2001). "Determining a projects's probability of success." Research Technology Management **2001** (May-June): 51-57.

De Bono, E. (1991). Minä olen oikeassa, sinä väärässä. Juva, WSOY.

Delano, G., G. S. Parnell, C. Smith and M. Vance (2000). "Quality function deployment and decision analysis. An R&D case study." International Journal of Operations & Production Management **20** (5): 591-609.

Dell'Isola, A. (1997). Value Engineering: Practical Applications for Design, Construction, Maintenance and Operations. Kingston, RS Means Co.

Dhalla, N. K. and S. Yuspeh (1976). "Forget the product life cycle concept!" Harvard Business Review (January-February): 102-112.

Donaldson, T. and L. E. Preston (1995). "The stakeholder theory of the corporation: concepts, evidence, and implications." Academy of Management Review **20** (1): 85-91.

Dougherty, D. (1990). "Understanding new markets for new products." Strategic Management Journal **11**: 59-78.

Dougherty, D. (1992). "Interpretive barriers to successful product innovation in large firms." Organization Science **3** (2): 179-202.

Drejer, A. (2000). "Integrating product and technology development." European Journal of Innovation Management **3** (3): 125-136.

Drejer, A. and J. O. Riis (1999). "Competence development and technology. How learning and technology can be meaningfully integrated." Technovation **19**: 631-644.

Driva, H., K. S. Pawar and U. Menon (2000). "Measuring product development performance in manufacturing organisations." International Journal of Production Economics **63**: 147-159.

Drucker, P. F. (1994). "We need to measure, not count." Drucker Management **1994** (Fall): 2-4.

Dutton, J. J. and C. A. Marx (1999). Target Costing. Handbook of Cost Management. J. B. Edwards. Boston, Warren, Gorham & Lamont**:** D2-1-26.

Dye, R. A. (2001). "An evaluation of "essays of disclosure" and the disclosure literature in accounting." Journal of Accounting and Economics **32**: 181-235.

Easton, G. (1992). Learning from case studies. Salisbury, Prentice Hall.

Eccles, R. G. (1991). "The performance measurement manifesto." Harvard Business Review **1991**: 131-137.

Eckel, L., K. Fisher and G. Russel (1992). Environmental performance measurement. CMA. **1992:** 16-23.

EIRMA (1985). Evaluation of R&D output. Paris, European Industrial Research Management Institute**:** 67.

EIRMA (1995). Evaluation of R&D projects. Paris, European Industrial Research Management Association**:** 101.

Eisenhardt, K. M. (1989). "Building Theories From Case Study Research." Academy of Management Review **14** (4): 532-550.

Elias, A. A., R. Y. Cavana and L. S. Jackson (2002). "Stakeholder analysis for R&D project management." R&D Management **32** (4): 301-310.

Ellis, L. (1997). Evaluation of R&D Processes: Effectiveness Through Measurements. Boston, Artech House.

Ellis, L. W. and C. C. Curtis (1995). "Measuring customer satisfaction." Research Technology Management **38** (5): 45-56.

Eloranta, E. and J. Räisänen (1986). Ohjattavuusanalyysi. Tutkimus tuotannon ja sen ohjauksen kehittämisestä Suomessa. Helsinki, SITRA.

Emblemsvåg, J. (2001). "Activity-based life-cycle costing." Managerial Auditing Journal **16** (1): 17-27.

Emory, W. C. (1985). Business research methods. Homewood, Richard D. Irwin, Inc.

EPA (1993). Life Cycle Design Guidance Manual - Environmental Requirements and The Product System. Washington, National Pollution Prevention Center , University of Michigan**:** 181.

Epstein, M. J. and J.-F. Manzoni (1997). "The balanced scorecard and tableau de bord: translating strategy into action." Management Accounting **1997** (August): 28-36.

Ernst, R. and D. N. Ross (1993). "The delta force approach to balancing long-run performance." Business Horizons **1993** (May-June): 4-10.

Eskola, J. and J. Suoranta (2001). Johdatus laadulliseen tutkimukseen. Jyväskylä, Vastapaino.

Euske, K. J., N. Frause, T. Peck, B. Rosenstiel and S. Schreck (1998). Service process measurement: Breaking the code. Bedford, CAM-I.

Everaert, P. and W. Bruggeman (2002). "Cost targets and time pressure during new product development." International Journal of Operations & Production Management **22** (12): 1339-1353.

Fangel, M. (1993). "The broadening of project management." International Journal of Project Management **11** (2): 72.

Filson, D. (2002). "Product and process innovations in the life cycle of an industry." Journal of Economic Behavior & Organization **49**: 97-112.

Firth, R. W. and V. K. Narayanan (1996). "New Product Strategies of Large, Dominant Product Manufacturing Firms: An Exploratory Analysis." Journal of Product Innovation Management **13**: 334-347.

Fisher, J. (1992). "Use of nonfinancial performance measures." Journal of Cost Management **1992** (Spring): 31-38.

Fisher, J. (1995). "Implementing target costing." Journal of Cost Management **9** (2): 50 - 59.

Flapper, S. D. P., L. Fortuin and P. P. M. Stoop (1996). "Towards consistent performance management systems." International Journal of Operations & Production Management **16** (7): 27-37.

Fleming, L. and O. Sorensen (2001). "The Dangers of Modularity." Harvard Business Review (September): 20-21.

Fogelholm, J. and J. Karjalainen (2001). Tuotantotoiminnan mittaaminen. Vantaa, WSOY.

Foster, R. N., L. H. Linden, R. L. Whiteley and A. M. Kantrow (1985). "Improving the return on R&D: I." Research Technology Management (January-February): 12-17.

Foster, R. N., L. H. Linden, R. L. Whiteley and A. M. Kantrow (1985). "Improving the return on R&D: II." Research Technology Management (March-April): 13-22.

Fowler, S. W., A. W. King, S. J. Marsh and B. Victor (2000). "Beyond products: new strategic imperatives for developing competencies in dynamic environments." Journal of Engineering Technology Management **17**: 357-377.

Frigo, M. L. and K. Krumwiede (1998). Cost Management Group Survey on Performance Measurement: Tips on Implementing the Balanced Scorecard Approach., IMA.

Fry, T. D. and J. F. Cox (1989). "Manufacturing performance: local versus global measures." Production and inventory management journal **30** (2): 52-56.

Garcia, R. and R. Calantone (2002). "A critical look at technological innovation typology and innovativeness terminology: a literature review." The Journal of Product Innovation Management **19**: 110-132.

Globerson, S. (1985). "Issues in developing a performance criteria system for an organization." International Journal of Production Research **23** (4): 639-646.

Goffin, K. (1998). "Evaluating Customer Support During New Product Development - An Exploratory Study." Journal of Product Innovation Management **15**: 42-56.

Goffin, K. and C. New (2001). "Customer support and new product development." International Journal of Operations and Production Management **21** (3): 275-301.

Gomes, J. F. S., P. C. de Weerd-Nederhof, A. W. Pearson and M. P. Cunha (2003). "Is more always better? An exploration of the differential effects of functional integration on performance in new product development." Technovation **23**: 185-191.

Gooderham, G. (2001). "The top 10 lessons of implementing performance management systems." Journal of Cost Management **2001** (January/February): 29-33.

Grady, M. W. (1991). "Performance measurement: implementing strategy." Management Accounting **1991**: 49-53.

Grant, R. M. (1996). "Prospering in Dynamically-competitive Environments: Organizational Capability as Knowledge Integration." Organization Science **7** (4): 375-387.

Grantham, L. M. (1997). "The validity of the product life cycle in the high-tech industry." Marketing Intelligence & Planning **15** (1): 4-10.

Green, D. H., D. W. Barclay and A. B. Ryans (1995). "Entry strategy and long term performance: conceptualization and empirical examination." Journal of Marketing **59** (4): 1-16.

Griffin, A. (1997). "PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices." Journal of Product Innovation Management (14): 429 - 458.

Griffin, A. (2002). "Product development cycle time for business-to-business products." Industrial Marketing Management **31**: 291-304.

Griffin, A. and A. L. Page (1996). "PDMA Success Measurement Project: Recommended Measures for Product Development Success and Failure." Journal of Product Innovation Management (13): 478 - 496.

Grossman (2002). "Managing product life." Strategic Decision **18** (8): 25-28.

Grönfors, T. (1996). Performance management: The effects of paradigms, underlying theory and intrinsic processes. Espoo, Facile Publishing.

Hall, L. A. and S. Bagchi-Sen (2002). "A study of R&D, innovation, and business performance in the Canadian biotechnology industry." Technovation **22**: 231-244.

Hamel, G. (1996). "Strategy as a revolution." Harvard Business Review (July-August): 69-82.

Hamel, G. and C. K. Prahalad (1994). Competing for the Future. Boston, Harvard Business School Press.

Hammersley, M. and P. Atkinson (1995). Ethnography. Principles in Practice. London, Routledge.

Hannula, M. (1999). Expedient Total Productivity Measurement. Industrial Engineering and Management. Tampere, Tampere University of Technology.**:** 179.

Hannula, M. and P. Suomala (1997). Tuottavuuden kehittämisen esteet pirkanmaalaisissa pkt-yrityksissä. Tampere, Tampereen teknillinen korkeakoulu.

Happonen, H. (2001). Framework for integrating knowledge and process dimensions of a product development system : a Theoretical and empirical study in the field of modern process automation. Automation and Control Institute. Tampere, Tampere University of Technology**:** 188.

Hardy, J. W. and E. D. Hubbard (1992). "ABC: Revisiting the Basics." CMA Magazine (November): 24-28.

Harness, D. R., N. E. Marr and T. Goy (1998). "The identification of weak products revisited." Journal of Product and Brand Management **7** (4): 319-335.

Hart, S. (1993). "Dimensions of Success in New Product Development: an Exploratory Investigation." Journal of Marketing Management **1993** (9): 23-41.

Hart, S. and N. Tzokas (2000). "New product launch "mix" in growth and mature product markets." Benchmarking: An International Journal **7** (5): 389-405.

Hayes, R. H. and S. C. Wheelwright (1979). "The dynamics of process-product life cycles." Harvard Business Review (March-April): 127-136.

Hayes, R. H. and S. C. Wheelwright (1979). "Link manufacturing process and product life cycles." Harvard Business Review **57** (1): 133-140.

Herath, H. S. B. and C. S. Park (1999). "Economic Analysis of R&D Projects: An Options Approach." The Engineering Economist **44** (1): 1-35.

Hertenstein, J. H. and M. B. Platt (2000). "Performance measures and management control in new product development." Accounting Horizons **14** (3): 303-323.

Hirons, E., A. Simon and C. Simon (1998). "External customer satisfaction as a performance measure of the management of a research and development department." International Journal of Quality & Reliability Management **15** (8/9): 969 - 987.

Hoffeecker, J. and C. Goldenberg (1994). "Using the balanced scorecard to develop companywide performance measures." Journal of Cost Management **1994**: 5-17.

Hollander, J. (2000). Genesis, a product assessment instrument used during the product development process. 7th International Product Development Management Conference, Leuven, Belgium, EIASM.

Hoover, W. E., E. Eloranta, J. Holmström and K. Huttunen (2001). Managing the Demand-Supply Chain. Value Innovations for Customer Satisfaction, John Wiley & Sons Inc.

Hopwood, A. G. (2002). "'If only there were simple solutions, but there aren't': some reflections on Zimmerman's critique of empirical management accounting research." The European Accounting Review **11** (4): 777-785.

Horvath, P., R. Gleich and S. Schmidt (1998). "Linking target costing to ABC and a US automotive supplier." Journal of Cost Management **12** (2): 16 - 24.

Howley, M. (1990). "Criteria for Success in New Product Development for Consumer Goods: A Comparative Study." European Journal of Marketing **24** (4): 55-60.

Huber, G. P. and A. H. Van de Ven (1995). Longitudinal Field Research Methods. Studying Processes of Organizational Change. Thousand Oaks, Sage Publications.

Hull, D. L. and J. F. Cox (1994). "The field service function in the electronics industry: Providing a link between customers and production/marketing." International Journal of Production Economics **37**: 115-126.

Hultink, E. J., K. Atuahene-Gima and I. Lebbink (2000). "Determinants of new product selling performance: an empirical examination in The Netherlands." European Journal of Innovation Management **3** (1): 27 - 34.

Hultink, E. J., S. Hart, H. S. J. Robben and A. Griffin (1999). "Launch Decisions and New Product Success: An Empirical Comparison of Consumer and Industrial Products." Journal of Product Innovation Management **17**: 5-23.

Hultink, E. J. and H. S. J. Robben (1995). "Measuring New Product Success: The Difference that Time Perspective Makes." Journal of Product Innovation Management **1995** (12).

Huotari, V. (2002). "Usko metodiin." Tieteessä tapahtuu **20** (2).

Hyland, P., J. Gieskes and T. Sloan (2002). Performance measurement and product innovation. Continuous Innovation in Business Processes and Networks, Helsinki University of Technology, Espoo, Finland.

ICMS Inc. (1992). Activity dictionary. A Comprehensive Reference Tool for ABM and ABC.

Ijiri, Y. (1975). Theory of Accounting Measurement. Sarasota, American Accounting Association.

IMA (1998). Practices and Techniques: Tools and Techniques for Implementing Integrated Performance Measurement Systems. Montvale, Institute of Management Accountants**:** 54.

IMA (1998). Tools and techniques for implementing target costing. Montvale, Institute of Management Accountants**:** 46.

Innes, J. and F. Mitchell (1995). "ABC: A follow-up survey of CIMA members." Management Accounting **73** (7): 50-51.

IRI (2000). R&D Facts 2000, Industrial Research Institute. **2000**.

Ittner, C. D. and D. F. Larcker (1997). "Product Development Cycle Time and Organizational Performance." Journal of Marketing Research **34** (February): 13-23.

Ittner, C. D. and D. F. Larcker (1998). "Are nonfinancial measures leading indicators of financial performance? An analysis of customer satisfaction." Journal of Accounting Research **36**: 1-35.

Ittner, C. D. and D. F. Larcker (1998). "Innovations in Performance Measurement: Trends and Research Implications." Journal of Management Accounting Research **10** (6): 205-238.

Ittner, C. D. and D. F. Larcker (2001). "Assessing empirical research in managerial accounting: a value-based management perspective." Journal of Accounting and Economics **32**: 349-410.

Ittner, C. D. and D. F. Larcker (2002). "Empirical managerial accounting research: are we just describing management consulting practice?" The European Accounting Review **11** (4): 787-794.

Jaakkola, J. and E. Tunkelo (1987). Tuotekehitys - ideoista markkinoille. Espoo, Weilin+Göös.

Jackson, T. W. and J. M. Spurlock (1966). Research and Development Management. Homewood, Illinois, Dow Jones-Irwin, Inc.

Jiang, R. and P. J. Zhang (2003). "Required characteristics of statistical distribution models for life cycle cost estimation." International Journal of Production Economics **83**: 185-194.

Johnson, H. T. and R. S. Kaplan (1987). Relevance Lost: The Rise and Fall of Management Accounting. Boston, Harvard Business School Press.

Johnson, H. T., T. P. Vance and R. S. Player (1991). "Pitfalls in Using ABC Cost-Driver Information to Manage Operating Costs." Corporate Controller (Jan/Feb): 26-32.

Jokioinen (2003). Interview: Important design parameters in paper machine industry.

Jones, C. T. and D. Dugdale (2002). "The ABC bandwagon and the juggernaut of modernity." Accounting, Organizations and Society **27**: 121-163.

Järvinen, A., P. Suomala and J. Paranko (2004). Elinkaarilaskennan nykytila raideliikenteen toimitusketjussa. Tampere, Tampereen teknillinen yliopisto.

Kald, M. and F. Nilsson (2000). "Performance Measurement At Nordic Companies." European Management Journal **18** (1): 113-127.

Kane, G., J. L. Stoyell, C. R. Howarth, P. Norman and R. Vaughan (2000). "A stepwise life cycle engineering methodology for the clean design of large made to order products." Journal of Engineering Design **11** (2): 175-189.

Kaplan, R. S. (1992). "From ABC to ABM." Management Accounting: 54-57.

Kaplan, R. S. (1998). "Innovation Action Research: Creating New Management Theory and Practice." Journal of Management Accounting Research **10**: 89-118.

Kaplan, R. S. and A. A. Atkinson (1998). Advanced management accounting. Upper Saddle River, Prentice Hall.

Kaplan, R. S. and D. P. Norton (1992). "The balanced scorecard - measures that drive performance." Harvard Business Review **1992** (January-February): 71-79.

Kaplan, R. S. and D. P. Norton (1993). "Putting the Balanced Scorecard to Work." Harvard Business Review (September-October): 134-147.

Kaplan, R. S. and D. P. Norton (1996). The balanced scorecard. Translating strategy into action. Boston, Harvard Business School Press.

Kaplan, R. S. and D. P. Norton (2001). "Transforming the Balanced Scorecard from Performance Measurement to Strategic Management: Part I." Accounting Horizons **15** (1): 87-104.

Kaplan, R. S. N., David P (1996). "Using the balanced scorecard as a strategic management system." Harvard Business Review **74** (1): 11.

Kasanen, E. and K. Lukka (1993). "The Constructive Approach in Management Accounting Research." Journal of Management Accounting Research **5**: 243-265.

Kasanen, E., K. Lukka and A. Siitonen (1991). "Konstruktiivinen tutkimusote liiketaloustieteessä." Liiketaloudellinen Aikakauskirja (3): 301-327.

Kato, Y. and G. Boer (1995). "Target costing: An integrative management process." Journal of Cost Management **9** (1): 39-51.

Keegan, D. P., C. R. Jones and R. G. Eiler (1991). "To implement your strategies, change your measures." Price Waterhouse Review **1991** (1): 29-38.

Kennerlay, M. and A. Neely (2002). "A framework of the factors affecting the evolution of performance measurement systems." International Journal of Operations and Production Management **22** (11): 1222-1245.

Keoleian, G. A. and D. Menerey (1993). Life Cycle Design Guidance Manual - Environmental Requirements and the Product System., Environmental Protection Agency. National Pollution Prevention Center. University of Michigan.

Kerssens-van Drongelen, I. C. (2001). "The iterative theory-building process: rationale, principles and evaluation." Management Decision **39** (7): 503-512.

Kerssens-van Drongelen, I. C. and J. Bilderbeek (1999). "R&D performance measurement: more than choosing a set of metrics." R&D Management **29** (1): 35 - 46.

Kerssens-van Drongelen, K. and A. Cook (1997). "Design principles for the development of measurement systems for research and development processes." R&D Management **27** (4): 345-357.

Kessler, E. H., P. E. Bierly and S. Gopalakrishnan (2000). "Internal vs. external learning in new product development: effects on speed, costs and competitive advantage." R&D Management **30** (3): 213-223.

Kettunen, P. (1974). Yritysten tutkimisesta. Jyväskylä, Jyväskylän yliopiston taloustieteen laitos.

Kim, B. and H. Oh (2002). "An effective R&D performance measurement system: survey of Korean R&D researchers." Omega: The International Journal of Management Science **30**: 19-31.

Kim, C. W. and R. Mauborgne (1998). Oikeudenmukainen prosessi: Johtaminen tietotaloudessa. Yritystalous**:** 28 - 39.

Kortge, G. D. and P. A. Okonkwo (1992). "Linking marketing strategy to new-product development." Journal of Education for Business **68** (1): 21-26.

Krogh, L. C., J. H. Prager, D. P. Sorensen and J. D. Tomlinson (1988). "How 3M evaluates its R&D programs." Research Technology Management (November-December): 10-14.

Krumwiede, K. R. (1998). "ABC: Why It's Tried and How It Succeeds." Management Accounting (IMA-USA) (April): 32-38.

Kulvik, H. (1977). Uusien tuotteiden onnistumiseen tai epäonnistumiseen vaikuttavat tekijät. Helsinki, Helsingin teknillinen korkeakoulu**:** 93.

Kumaran, D. S., S. K. Ong, R. B. H. Tan and N. A. Y. C. (2001). "Environmental life cycle cost analysis of products." Environmental Management and Health **12** (3): 260-276.

Kurawarwala, A. A. and H. Matsuo (1998). "Product Growth Models for Medium-Term Forecasting of Short Life Cycle Products." Technological Forecasting and Social Change **57**: 169-196.

Kärkkäinen, H., P. Piippo and m. Tuominen (2001). "Ten tools for customer-driven product development in industrial companies." International Journal of Production Economics **69**: 161-176.

Laakso, T. (1997). Performance evaluation and process interventions : a method for business process development. Espoo, Finnish Academy of Technology.

Lahikainen, T., J. Lyly-Yrjänäinen and J. Paranko (2003). The role of cost information in strategic shift: designing a product for a new strategy. 6th Manufacturing Accounting Research Conference, Enschede, Netherlands.

Lahikainen, T. and J. Paranko (2001). Easy Method for Assigning Activities to Products - an Application of ABC. 5th International Seminar on Manufacturing Accounting Research, Pisa, Italy, EIASM.

Laitinen, E. K. (1992). Yrityksen talouden mittarit. EspooWeilin+Göös.

Laitinen, E. K. (1996). Framework for small business performance measurement. Vaasa, Vaasan yliopisto.

Laitinen, E. K. (1998). Yritystoiminnan uudet mittarit. Helsinki, Kauppakaari.

Larson, E. W. and D. H. Gobeli (1988). "Organizing for Product Development Projects." Journal of Product Innovation Management (5): 180 - 190.

Lawrence, J. E. and D. Cerf (1995). "Management and reporting of environmental liabilities." Management Accounting **1995** (August): 48-54.

Leastadius, S. and L. Karlson (2001). "Eco-efficient products and services through LCA in R&D/design." Environmental Management and Health **12** (2): 181-190.

Ledwith, A. (2000). "Management of new product development in small electronics firms." Journal of European Industrial Training **24**: 137-148.

Lehtonen, T. J. (2002). Organisaation osaamisen strateginen hallinta. Kasvatustieteiden tiedekunta. Tampere, Tampereen yliopisto.

Lele, M. M. (1986). "How Service Needs Influence Product Strategy." Sloan Management Review (Fall): 63-70.

Lele, M. M. (1997). "After-sales service - necessary evil or strategic opportunity?" Managing Service Quality **7** (3): 141-145.

Leonard-Barton, D. (1990). A Dual Methodology for Case Studies. Longitudinal Field Research Methods. Studying Processes of Organizational Change. G. P. Huber and A. H. Van de Ven. Thousand Oaks, Sage Publications**:** 373.

Lewis, M. A. (2001). "Success, failure and organisational competence: a case study of the new product development process." Journal of Engineering Technology Management **18**: 185-206.

Lichtenberg, F. R. (1990). "Issues in measuring industrial R&D." Research Policy **19**: 157-163.

Liebermann, Y. and M. Ungar (2002). "Efficiency of customer intertemporal choice under life cycle cost conditions." Journal of Economic Psychology **23**: 729-748.

Lindman, M. (1997). Managing Industrial New Products in the Long Run. Business Administration. Vaasa, University of Vaasa**:** 336.

Lingle, J. H. and W. A. Schiemann (1994). "Is data scatter subverting your strategy?" Management Review **1994**: 53-58.

Luft, J. and M. D. Shields (2002). "Zimmerman's contentious conjectures: describing the present and prescribing the future of empirical management accounting research." The European Accounting Review **11** (4): 795-803.

Lukka, K. (2000). The Key Issues of Applying the Constructive Approach to Field Research. Management expertise for the new millenium: in commemoration of the 50th anniversary of the Turku School of Economics and Business Administration. T. Reponen. Turku, Turku School of Economics and Business Administration**:** 113-128.

Lukka, K. and M. Granlund (2002). "The fragmented communication structure within the accounting academia: the case of activity-based costing research genres." Accounting, Organizations and Society **27** (1-2): 165-190.

Lukka, K. and E. Kasanen (1995). "The problem of generalizability: anecdotes and evidence in accounting research." Accounting, Auditing & Accountability Journal **8** (5): 71-90.

Lukka, K. and J. Mouritsen (2002). "Homogeneity or heterogeneity of research in management accounting?" The European Accounting Review **11** (4): 805-811.

Lyly-Yrjänäinen, J. (2003). Applying a Product Portfolio in Activity Assignment. Tampere, Tampere University of Technology**:** 107.

Lynch, R. and K. Cross (1995). Measure up! How to measure corporate performance. USA, Blackwell Publishers.

Lynn, G. S., K. D. Abel, W. S. Valentine and R. C. Wright (1999). "Key Factors in Increasing Speed to Market and Improving New Product Success." Industrial Marketing Management **28**: 319-326.

Maccarrone, P. (1998). "Activity-based management and the product development process." European Journal of Innovation Mangement **1** (3): 148-156.

Magnan, G. M., S. E. Fawcett and L. M. Birou (1999). "Benchmarking manufacturing practice using the product life cycle." Benchmarking: An International Journal **6** (3): 239-253.

Maisel, L. S. (1992). "Performance measurement: The balanced scorecard approach." Journal of Cost Management **6** (2): 6.

Malmi, T., J. Peltola and J. Toivanen (2002). Balanced Scorecard. Rakenna ja sovella tehokkaasti. Helsinki, Kauppakaari.

Manninen, A., Ed. (1997). Rauno Tamminen 50 vuotta - näkökulmia liiketaloustieteeseen. Johtamiskoulutuksen julkaisuja 6. Jyväskylä, Jyväskylän yliopiston täydennyskoulutuskeskus.

Marshall, C. and G. B. Rossman (1999). Designing Qualitative Research. Thousand Oaks, Sage.

Martino, J. P. (1995). R&D Project selection. New York, John Wiley & Sons, Inc.

Massey, G. R. (1999). "Product evolution: a Darwinian or Lamarckian phenomenon." Journal of Product and Brand Management **8** (4): 301-318.

Matthews, W. H. (1991). "Kissing Technological Frogs: Managing Technology as a Strategic Resource." European Management Journal **9** (2): 145-148.

McGrath, M. M. and M. N. Romeri (1994). "The R&D Effectiveness Index: A Metric for Product Development Performance." Journal of Product Innovation Management **11** (3): 213 - 220.

McKinnon, J. (1988). "Reliability and Validity in Field Research: Some Strategies and Tactics." Accounting, Auditing & Accountability Journal **1** (1): 34-54.

McLeod, T. (1988). The Management of Research, Development and Design in Industry. Aldershot, Gower Technical Press.

McMann, P. and A. J. Nanni (1994). "Is your company really measuring performance?" Management Accounting **1994** (November): 55-58.

McNair, C. (2000). Value Quest: Driving Profit and Performance by Integrating Strategic Management Processes. Bedford, CAM-I.

McNair, C. J. L., Richard L; Cross, Kelvin F. (1990). "Do Financial and Nonfinancial Performance Measures Have to Agree?" Management Accounting **72** (5): 7.

McWilliams, B. (1996). The measure of success. Across the Board. **1996:** 16-20.

Mecimore, C., D. and A. Bell, T. (1995). "Are We Ready for Fourth-Generation ABC?" Management Accounting **76** (7): 22-26.

Meldrum, M. J. (1995). "Marketing high-tech products: the emerging themes." European Journal of Marketing **29** (10): 45-58.

Mercer, D. (1993). "A Two-Decade Test of Product Life Cycle Theory." British Journal of Management **4**: 269-274.

Merriam-Webster and OnLine (2002). **2002**.

Meyer, M. H., P. Tertzakian and J. M. Utterback (1997). "Metrics for Managing Research and Development in the Context of the Product Family." Management Science **43** (1): 88-111.

Miller, W. L. (1995). "A broader mission for R&D." Research Technology Management **38** (6): 24-36.

Montoya-Weiss, M. M. and R. Calantone (1994). "Determinants of new product performance: A review and meta-analysis." Journal of Product Innovation Management **11**: 397-417.

Moores, K. and S. Yuen (2001). "Management accounting systems and organizational configuration: a life-cycle perspective." Accounting, Organizations and Society **26**: 351-389.

Moorman, C. (1995). "Organizational market information processes: cultural antecedents and new product outcomes." Journal of Marketing Research **32** (3): 318-335.

Morbey, G. K. (1988). "R&D: Its relationship to company performance." Journal of Product Innovation Management **5**: 191-200.

Morbey, G. K. and R. M. Reithner (1990). "How R&D affects sales growth, productivity and profitability." Research Technology Management (May - June): 11 - 14.

Mäkinen, S. (1999). A strategic framework for business impact analysis and its usage in new product development. Acta polytechnica Scandinavica. IM. Espoo, The Finnish Academy of Technology**:** 213.

Nanni, J. A. J. and R. J. Dixon (1992). "Integrated performance measurement: Management accounting to support the new manufacturing..." Journal of Management Accounting Research **4** (fall92): 19.

Neely, A. (1999). "The performance measurement revolution: why now and what next?" International Journal of Operations & Production Management **19** (2): 205-228.

Neely, A., M. Gregory and K. Platts (1995). "Performance measurement system design: A literature review and research agenda." International Journal of Operations & Production Management **15** (4): 80-116.

Neely, A., H. Richards, J. Mills, K. Platts and M. Bourne (1997). "Designing performance measures: a structured approach." International Journal of Operations & Production Management **17** (11): 1131-1152.

Neilimo, K. and J. Näsi (1980). Nomoteettinen tutkimusote ja suomalainen yrityksen taloustiede. Tutkimus positivismin soveltamisesta. Tampere, Tampereen yliopisto**:** 145.

Neilimo, K. and E. Uusi-Rauva (1999). Johdon laskentatoimi. Helsinki, Edita.

Nelson, E. (1992). "The product life cycle of engineered metals: a comparative analysis of the application of product life cycle theory." The Journal of Business and Industrial Marketing **7** (2).

Ness, J. A. and T. G. Cuzuzza (1995). "Tapping the full potential of ABC." Harvard Business Review **73** (4): 130-139.

Ness, J. A., M. J. Schroeck, R. A. Letendre and W. J. Douglas (2001). "The Role of ABM in Measuring Customer Value." Strategic Finance (March): 32-37.

Nihtilä, J. (1996). Integration Mechanism in New Product Development. Department of Industrial Management. Hensinki, Helsinki University of Technology**:** 162.

Niiniluoto, I. (1997). Johdatus tieteenfilosofiaan. Käsitteen- ja teorianmuodostus. Keuruu, Otava.

Nixon, B. (1998). "Research and development performance measurement: a case study." Management Accounting Research **9**: 329 - 355.

Nonaka, I. (1994). "A Dynamic Theory of Organizational Knowledge Creation." Organization Science **5** (1): 14-37.

Näsi, J. (1980). Ajatuksia käsiteanalyysistä ja sen käytöstä yrityksen taloustieteessä. Tampere, Tampereen yliopiston Yrityksen taloustieteen ja yksityisoikeuden laitos**:** 41.

Näsi, J. (1980). Liiketaloustiede soveltavana tieteenä: Perusongelmien hahmotus ja analyysi. Tampere, Tampereen yliopiston Yrityksen taloustieteen ja yksityisoikeuden laitos**:** 44.

Näsi, J. (1983). Tieteelliset tutkimusotteet ja suomalainen liiketaloustiede, hallinto. Viitekehyksen konstruointi ja historiallis-paradigmaattinen analyysi. Tampere, Tampereen yliopisto, yrityksen taloustieteen ja yksityisoikeuden laitos.**:** 81.

Oakley, P. (1996). "High-tech NPD success through faster overseas launch." European Journal of Marketing **30** (8): 75-91.

O'Donnel, F. J. and A. H. B. Duffy (2002). "Modelling design development performance." International Journal of Operations and Production Management **22** (11): 1198-1221.

Ojanen, V., H. Kärkkäinen, P. Piippo and M. Tuominen (1998). Supporting the selection of performance measures for R&D at company level. Lappeenranta, Lappeenrannan teknillinen korkeakoulu.

Olkkonen, T. (1994). Johdatus teollisuustalouden tutkimustyöhön. Espoo, Helsinki University of Technology.

Olve, N.-G., J. Roy and M. Wetter (1999). Performance drivers : a practical guide to using the balanced scorecard. Chichester, Wiley.

Ormala, E. (1986). Analysing and Supporting R&D Project Evaluation: An Applied Systems Analytic Approach. Espoo, Helsinki University of Technology**:** 118.

Osawa, Y. and M. Murakami (2002). "Development and application of a new methodology of evaluating industrial R&D projects." R&D Management **32** (1): 79-85.

Otley, D. (1999). "Performance management: a framework for management control systems research." Management Accounting Research **10**: 363-382.

Ottum, B. D. and W. L. Moore (1997). "The Role of Market Information in New Product Success/Failure." Journal of Product Innovation Management **14**: 258-273.

Palmer, E. and D. Parker (2001). "Understanding performance measurement systems using physical science uncertainty principles." International Journal of Operations and Production Management **21** (7): 981-999.

Patterson, W. C. (1983). "Evaluating R&D performance at Alcoa Laboratories." Research Technology Management (March-April): 23-27.

PDMA (2002). PDMA Handbook of New Product Development: Glossary of New Product Development Terms, PDMA. **2002**.

Pearson, A. W., W. A. Nixon and I. C. Kerssens-van Drongelen (2000). "R&D as a business - what are the implications for performance measurement?" R & D Management **30** (4): 355-366.

Perera, H. S. C., N. Nagarur and M. T. Tabucanon (1999). "Component part standardization: A way to reduce the life-cycle costs of products." International Journal of Production Economics **60-61**: 109-116.

Pessemier, E., A. (1966). New-Product Decisions - an analytical approach. New York, McGraw-Hill Book Company.

Pillai, A. S., A. Joshi and K. S. Rao (2002). "Performance measurement of R&D projects in a multi-project, concurrent engineering environment." International Journal of Project Management **20**: 165-177.

Pinto, J. K. and D. P. Slevin (1989). "Critical success factors in R&D projects." Research Technology Management (January - February): 31 - 35.

Player, S. and R. Lacerda, Eds. (1999). Arthur Andersen's global lessons in activity-based management. Wiley Cost Management Series, John Wiley & Sons, Inc.

Poh, K. L., B. W. Ang and F. Bai (2001). "A comparative analysis of R&D evaluation methods." R&D Management **31** (1): 63-75.

Polli, R. and V. Cook (1969). "Validity of the product life cycle." The Journal of Business **42** (4): 385-400.

Poolton, J. and I. Barclay (1998). "New Product Development From Past Research to Future Applications." Industrial Marketing Management **27**: 197-212.

Prahalad, C. and G. Hamel (1990). "The Core Competence of the Corporation." Harvard Business Review **68** (May/June): 79-91.

Prasad, B. (1997). "Re-engineering life-cycle management of products to achieve global success in the changing marketplace." Industrial Management & Data Systems **97** (3): 90-98.

Price, E. E. and D. R. Coy (2001). "Life cycle management at 3M. A practical approach." Environmental Management and Health **12** (3): 254-259.

Pringle, P. (2001). "The life cycle process." Manufacturing Engineer (December): 284-287.

Provost, L. and S. Leddick (1993). "How to take multiple measures to get a complete picture of organizational performance." National Productivity Review **1993** (Autumn): 477-490.

Pryor, T. (1998). Pryor Convictions: 31 Insights Into ABM. Arlington, ICMS.

Pullman, M., W. Moore and D. Wardell (2002). "A comparison of quality function deployment and conjoint analysis in new product design." The Journal of Product Innovation Management **19**: 354-364.

Rabino, S. (2001). "The accountant's contribution to product development teams - a case study." Journal of Engineering and Technology Management **18**: 73-90.

Raffish, N. (1991). "How Much Does That Product Really Co$t?" Management Accounting (March): 36-39.

Rangone, A. (1997). "Linking organizational effectiveness, key success factors and performance measures: an analytical framework." Management Accounting Research **8**: 207-219.

Ransley, D. L. and J. L. Rogers (1994). "A Consensus on Best R&D Practices." Research Technology Management (March/April): 19-26.

Repenning, N. P. (2001). "Understanding fire fighting in new product development." The Journal of Product Innovation Management **18**: 285-300.

Rhyne, L. C. (1996). "Product development in the late stages of a technology life cycle: lessons from the America's Cup 1995." Journal of Product and Brand Management **5** (2): 55-67.

Richardson, P. R. and J. R. M. Gordon (1980). "Measuring total manufacturing performance." Sloan Management Review (Winter): 47-58.

Riistama, V. and E. Jyrkkiö (1991). Operatiivinen laskentatoimi: Perusteet ja hyväksikäyttö. Espoo, Weilin + Göös.

Rink, D. R., D. M. Roden and H. W. Fox (1999). "Financial Management and Planning with the Product Life Cycle Concept." Business Horizons **1999** (September-October): 65-72.

Rouhiainen, P. (1997). Managing New Product Development Project Implementation in Metal Industry. Tampere, Tampere University of Technology**:** 293.

Rummler, G. A. and A. P. Brache (1995). Improving Performance. How to Manage the White Space on the Organization Chart. San Francisco, Jossey-Bass.

Ryan, C. and W. E. Riggs (1996). "Redefining the product life cycle: the five-element product wave." Business Horizons **39** (5): 33-41.

Salmi, T. and M. Järvenpää (2000). "Laskentatoimen case-tutkimus ja nomoteettinen tutkimusajattelu sulassa sovussa." Liiketaloudellinen Aikakauskirja (2): 263-275.

Sandström, J. and J. Toivanen (2002). "The problem of managing product development engineers: Can the balanced scorecard be an answer?" International Journal of Production Economics **78** (1): 79-90.

Santos, S. P., V. Belton and S. Howick (2002). "Adding value to performance measurement by using system dynamics and multicriteria analysis." International Journal of Operations and Production Management **22** (11): 1246-1272.

Schneiderman, A. M. (1996). Metrics for the order fulfillment process (Part I). Emerging Practices in Cost Management. Performance Measurement. B. J. Brinker. Boston, WG&L/RIA Group. **1997:** K3-1 - K3-13.

Schneiderman, A. M. (1996). Metrics for the order fulfillment process (Part II). Emerging Practices in Cost Management. Performance Measurement. B. J. Brinker. Boston, WG&L/RIA Group. **1997:** K4-1 - K4-12.

Schroeder, R., L. G. D. Scudder and E. Elm (1989). "Innovation in manufacturing." Journal of Operations Management **8** (1): 1-15.

Schumann, P. A., D. L. Ransley and D. C. Prestwood (1995). "Measuring R&D Performance." Research Technology Management **38** (3): 45 - 55.

Sharman, P. (1995). How to implement performance measurement in your organization. CMA. **1995:** 33-37.

Shenhar, A. J., A. Tishler, D. Dvir, S. Lipovetsky and T. Lechter (2002). "Refining the search for project success factors: a multivariate, typological approach." R&D Management **32** (2): 111-126.

Sherman, J. D. and E. A. Olsen (1996). "Stages in the project life cycle in R&D organizations and the differing relationships between organizational climate and performance." The Journal of High Technology Management Research **7** (1): 79-90.

Sievänen, M., P. Suomala and J. Paranko (2001). Activity-based costing and product profitability. 5th International Seminar on Manufacturing Accounting Research, Pisa, Italy.

Slater, S. F. and J. C. Narver (1993). "Product-market Strategy and Performance: An Analysis of the Miles and Snow Strategy Types." European Journal of Marketing **27** (10): 33-51.

Slater, S. F., E. M. Olson and K. R. Venkateshwar (1997). "Strategy-based performance measurement." Business Horizons **1997** (July-August): 37-43.

Slevin, D. P. and J. K. Pinto (1986). "The Project Implementation Profile: New Tool for Project Managers." Project Management Journal (September): 57 - 71.

Smith, A. E. and A. K. Mason (1997). "Cost Estimation Predictive Modeling: Regression Versus Neural Network." The Engineering Economist **42** (2): 137-161.

Song, X. M. and M. M. Montoya-Weiss (1998). "Critical Development Activities for Really New versus Incremental Products." Journal of Product Innovation Management **15**: 124-135.

Song, X. M., M. M. Montoya-Weiss and J. B. Schmidt (1997). "Antecedents and Consequences of Cross-Functional Cooperation: A Comparison of R&D, Manufacturing, and Marketing Perspectives." Journal of Product Innovation Management **14**: 35-47.

Souder, W. E. and S. A. Jenssen (1999). "Management Practices Influencing New Product Success and Failure in the United States and Scandinavia: A Cross-Cultural Comparative Study." Journal of Product Innovation Management **16**: 183-203.

Stadler, M. (1991). "R&D dynamics in the product life cycle." Journal of Evolutionary Economics **1991** (1): 293-305.

Stake, R. E. (1995). The Art of Case Study Research. London, Sage.

Stivers, B. P., T. J. Covin, H. Green and S. W. Smalt (1998). "How nonfinancial performance measures are used." Management Accounting **1998** (February): 44-49.

Suomala, P. and H. I. Kulmala (2001). Performance Measurement in Supply Networks. 24th EAA Annual Congress, Athens, Greece.

Suomala, P., M. Sievänen and J. Paranko (2002). Customization of Capital Goods - Implications for After Sales. Moving into Mass Customization - Information Systems and Management Principles. C. Rautenstrauch, R. Seelmann-Eggebert and K. Turowski, Springer**:** 231-248.

Suomala, P., M. Sievänen and J. Paranko (2002). "The effects of customization on spare part business: a case study in the metal industry." International Journal of Production Economics **79** (1): 57-66.

Szakonyi, R. (1994). "Measuring R&D Effectiveness - I." Research Technology Management (March - April): 27 - 32.

Szakonyi, R. (1994). "Measuring R&D Effectiveness - II." Research Technology Management (May - June): 44 - 55.

Tanaka, T. (1993). "Target costing at Toyota." Journal of Cost Management **7** (1): pp. 4 - 11.

Tenhunen, J. and J. Ukko (2003). Yritysyhteistyö ja laskentatoimi päijäthämäläisissä yrityksissä. Lappeenrannan teknillinen yliopisto.

Terwiesch, C., C. Loch and M. Niederkofler (1998). "When Product Development Performance Makes a Difference: A Statistical Analysis in the Electronics Industry." Journal of Product Innovation Management **15**: 3-15.

Thomson, K. (1995). The benefits of measuring customer satisfaction. CMA. **1995:** 32-36.

Tipping, J. W. Z., Eugene; Fusfeld, Alan R; (1995). "Assessing the value of your technology." Research Technology Management **38** (5).

Treacy, M. and F. Wiersema (1993). "Customer Intimacy and Other Value Disciplines." Harvard Business Review (January-February): 84-93.

Treacy, M. and F. Wiersema (1995). The discipline of market leaders : choose your customers, narrow your focus, dominate your market. Reading, Perseus Books.

Turney, P. B. B. and A. J. Stratton (1992). "Using ABC to Support Continuous Improvement." Management Accounting **74** (3): 46-50.

Ulrich, K. T. and S. D. Eppinger (1995). Product design and development. New York (NY), McGraw-Hill.

Upchurch, A. (2002). Cost Accounting - Principles and Practice, Prentice Hall.

Uusi-Rauva, E. (1986). Yrityksen ohjauksen tunnuslukujärjestelmä. Helsinki, Tuottavuuskeskus ry.

Uusi-Rauva, E. (1996). Ohjauksen tunnusluvut ja suoritusten mittaus. Tampere, Tampereen teknillinen korkeakoulu.

Uusi-Rauva, E. and J. Paranko (1998). Kustannuslaskenta ja tuotekehityksen tarpeet. Tampere, TTKK / Teollisuustalous.

Uusitalo, H. (1995). Tiede, tutkimus ja tutkielma. Johdatus tutkielman maailmaan. Juva, WSOY.

Wahlström, K. (1998). "Suomessa kehitetty balanced scorecard -mittaristo." Yritystalous **1998** (1): 53-57.

Vaivio, J. (1999). "Exploring a 'non-financial' accounting change." Management Accounting Research **10**: 409-437.

Van de Ven, A. H. and M. S. Poole (1990). "Methods for studying innovation development in the Minnesota Innovation Research Program." Organization Science **1** (3): 313-335.

van den Ende, J. (2003). "Modes of governance of new service development for mobile networks. A life cycle perspective." Research Policy: 1-18.

Vartiainen, M., T. Rantamäki, M. Hakonen and A. Simola (1999). Tuotekehityksen palkitseminen. Helsinki, Metalliteollisuuden kustannus.

Weisenfeld, U., J. C. Reeves and A. Hunck-Meiswinkel (2001). "Technology management and collaboration profile: virtual companies and industrial platforms in the high-tech biotechnology industries." R&D Management **31** (1): 91-100.

Werker, C. (2003). "Innovation, market performance, and competition: lessons from a product life cycle model." Technovation **23** (4): 281-290.

Werner, B. M. and W. E. Souder (1997). "Measuring R&D performance - state of the art." Research Technology Management **40** (2): 34 - 42.

Werner, B. M. and W. E. Souder (1997). "Measuring R&D performance - U.S. and German practices." Research Technology Management **40** (3): 28 - 32.

Westkämper, E., J. Niemann and A. Dauensteiner (2001). "Economic and ecological aspects in product life cycle evaluation." Proc Instn Mech Engineers **215**: 673-681.

Whittaker, B. (1999). "What went wrong? Unsuccessful information technology projects." Information Management & Computer Security **7** (1): 23-29.

Virkkunen, H. (1961). Laskentatoimi johdon apuna, Liiketaloustieteellinen tutkimuslaitos.

Wisner, J. D. and S. E. Fawcett (1991). "Linking firm strategy to operating decisions through performance measurement." Production and Inventory Management Journal **1991** (3/4): 5-11.

Woodward, D. G. (1997). "Life cycle costing-theory, information acquisition and application." International Journal of Project Management **15** (6): 335-344.

Wyland, D. W. (1998). "Keep your product in play: Introducing full life-cycle management." Chain Store Age (September): 186.

Yin, R. K. (1993). Applications of case study research. Newbury Park, CA, Sage Publications.

Yin, R. K. (1994). Case study research: design and methods. Newbury Park, CA, Sage Publications.

Zeller, T. L., D. R. Kublank and P. G. Makris (2001). "Uses ABC to Succeed." Strategic Finance (March): 25-31.

Zif, J. and D. J. McCarthy (1997). "The R&D Cycle: The Influence of Product and Process R&D on Short-term ROI." IEEE Transactions on Engineering Management **44** (2): 114-122.

Zimmerman, J. L. (2001). "Conjectures regarding empirical managerial accounting research." Journal of Accounting and Economics **32**: 411-427.

Zirger, B. J. and M. A. Maidique (1990). "A model of new product development: an empirical test." Management Science **36** (7): 867-883.

Appendices

Appendix A: the interview platform applied in the case studies (in Finnish)
Appendix B: the questionnaire employed in the survey (in Finnish)
Appendix C: the identified life cycle phase –specific requirements

Tuotteen elinkaari

Määrittely

Tuotteen elinkaarella tarkoitetaan sitä ajanjaksoa, jonka aikana tuote vaikuttaa jonkin sidosryhmän tai osapuolen toimintaan. Erikseen voidaan tarkastella tuotteen elinkaarta esimerkiksi tuotteen valmistajan näkökulmasta tai tuotteen loppukäyttäjän näkökulmasta. Tuotteen elinkaaren vaiheet jaetaan tuottajan näkökulmasta esimerkiksi seuraavasti:

- Kehitysvaihe
- Markkinoinnin, tuotannon ja jakelun aloitus
- Aktiivinen tuotantovaihe
- Tuotannon alasajo, valmistuksen lopettaminen
- Jälkimarkkinavaihe, varaosa- ja huoltopalvelut
- Tuotetuen lopetus

Käyttäjän näkökulmasta elinkaaren vaiheita voidaan nimetä seuraavasti:

- Tuotteen käytön aloitus
- Aktiivinen käyttövaihe
- (toissijainen käyttö)
- Edelleenmyynti tai hävitys

Kysymykset

1. Missä määrin tuotteenne[29] kehittyvät evolutionaarisesti – vähitellen pieniä parannuksia – ja miltä osin revolutionaarisesti – merkittävin harppauksin?

2. Mikä merkitys/vaikutus tuotteen uutuudella tai iällä on teidän kannaltanne?

3. Kuinka pitkä on tuotteen tyypillinen elinkaari näkökulmastanne - kuinka usein tarvitaan uusi korvaava tuote?

4. Tarvitaanko varaosa- tai muuta huoltoa olennaisesti pidemmälle/lyhyemmälle ajalle kuin elinkaari muutoin on?

5. Voidaanko yrityksenne tuotteita käsitellä kokonaisuutena elinkaaritarkastelussa - onko tuotteiden keskinäinen vaihtelu suurta tässä mielessä?

6. Kuinka pitkään käyttäjä tyypillisesti käyttää tuotetta?

[29] Tuote saattaa olla liian epämääräinen käsite elinkaaritarkasteluun yhdistettynä. Erikseen voidaan käsitellä tuoteluokkaa/product class (esim. henkilöauto tai tupakka), tuotealaluokkaa/product form (esim. polttomoottoriauto tai filtteritupakka) ja brändiä (Toyota Corolla, Camel). Edelleen yhden brändin sisällä saattaa olla useita tuotesukupolvia, useita tuotteita, jotka eroavat toisistaan hyvin merkittävästi (kehitys 1970-luvun Toyota Corollasta Corollaan vm. 2002)

7. Nimeä tuotteen elinkaaren vaiheet järjestyksessä tuottajan näkökulmasta?
    a. Mikä on kunkin vaiheen kesto(karkeasti/tyypillisesti)?
    b. Mistä tunnistat eri vaiheet/mitkä ovat tunnusomaiset piirteet?
    c. Mille yrityksen funktioille eri vaiheet tyypillisesti ovat kaikkein kuormittavimpia?
    d. Mikä määrittää hyvän eli onnistuneen tuotteen kussakin vaiheessa?
        i. Asiakkaan näkökulma
        ii. Toimitusketjun näkökulma
        iii. Omistajan näkökulma
        iv. T&K:n näkökulma

Vaihe	**A**	**B**	**C**	**D**
1:				
2:				
3:				
4:				
5:				
6:				
7:				

Arvoisa vastaanottaja,

Tämä kysely on suunnattu yrityksenne tuotekehityksestä vastaavalle henkilölle. Kysely on osa TTKK:n Teollisuustalouden laitoksella toimivan tutkimusryhmän *Cost Management Centerin (CMC)* tutkimusprojektia, jonka tavoitteena on selvittää tuotekehityksen suoritusten mittauskäytäntöjen nykytila suomalaisissa teollisuusyrityksissä. Voitte vastata kahdella tavalla, joko täyttämällä web-kyselyn alla olevassa internet-osoitteessa tai postittamalla kyselylomakkeen oheisessa vastauskuoressa. Pyytäisimme teitä käyttämään vastaamiseen ensisijaisesti web-lomaketta.

http://butler.cc.tut.fi/~jamsen/kysely/kysely.htm

Kyselyn tulokset tulevat olemaan osa yhtä väitöskirjaa ja diplomityötä. Lisäksi kyselyn tuloksista kirjoitetaan raportti, joka lähetetään kaikille vastaajille. Tätä varten kysymme myös yhteystietonne, jotka web-kyselyssä voitte jättää vastattuanne ensin varsinaiseen kyselyyn. Mikäli vastaatte postin välityksellä, voitte kirjata yhteystietonne erilliseen osoitelomakkeeseen ja postittaa sen kyselyn ohessa. Vastaukset käsitellään luottamuksellisina ja anonyymeinä, eli vastauksianne ei yhdistetä edustamaanne yritykseen.

Mikäli yrityksessänne ei ole tuotekehitystoimintaa, olkaa ystävällisiä ja ilmoittakaa siitä seuraamalla kyselyssä olevia ohjeita. Näin emme vaivaa teitä tarpeettomasti.

Kyselyn täyttämiseen kuluu aikaa noin 15 – 20 minuuttia. Pyydämme teitä vastaamaan keskiviikkoon 14.11.2001 mennessä. Mikäli teillä on kysyttävää, yhteystietomme löytyvät tämän kirjeen alareunasta. Kiitos vaivannäöstänne!

Tampereella,

Miikka Jämsen　　　　　　Petri Suomala

Taustakysymykset

Jos yrityksessänne EI ole tuotekehitystoimintaa, palauttaisitteko tyhjän vastauskuoren.

Kyselyn liitteenä on kyselyssä käytetyt käsitteet ja tarkempi ohjeistus kysymykseen XV. Kyselyn kohdat, joihin liitteessä on lisävalaistusta on alleviivattu.

I Mistä jalostusketjun osista yrityksenne on vastuussa?
tuotekehityksestä
ostosta
tuotannosta
jakelusta
markkinoinnista

II Mikäli yrityksenne vastaa myös tuotannosta, niin mikä on yrityksenne pääasiallinen tuotantomuoto?
jatkuva tuotanto
sarjatuotanto
yksittäistuotanto

III Kuinka kauan olette työskennellyt tässä yrityksessä?
0 – 1 vuotta
1 – 5 vuotta
5 – 10 vuotta
yli 10 vuotta

IV Mikä on toimenkuvanne yrityksessä?

V Kuinka kauan olette työskennellyt tässä tehtävässä?
0 – 1 vuotta
1 – 5 vuotta
5 – 10 vuotta
10 à vuotta

VI Miten luonnehtisitte yrityksenne kohtaamaa kilpailua?
1.
2.
3.

VII Mikä on yrityksenne tämänhetkinen henkilöstömäärä? ___________

VIII Mikä on yrityksenne pääasiallinen toimiala?
Toimiala   Valinta
Tekstiilien ja vaatteiden valmistus
Nahan ja nahkatuotteiden valmistus
Puutavaran ja puutuotteiden valmistus

Massan, paperin ja paperituotteiden valmistus; kustantaminen ja painaminen
Koksin, öljytuotteiden ja ydinpolttoaineen valmistus
Kemikaalien, kemiallisten tuotteiden ja tekokuitujen valmistus
Kumi- ja muovituotteiden valmistus
Ei-metallisten mineraalituotteiden valmistus
Metallien jalostus ja metallituotteiden valmistus
Koneiden ja laitteiden valmistus
Sähköteknisten tuotteiden ja optisten laitteiden valmistus
Kulkuneuvojen valmistus
Muu mikä?____

Tuotekehitys

IX Kuinka monta henkilöä työskentelee välittömästi yrityksenne tuotekehityksessä? _________

X Miten välittömästi tuotekehityksessä työskentelevien henkilöiden määrä on kehittynyt viimeisen viiden vuoden aikana?
laskenut merkittävästi
laskenut hieman
pysynyt samana
kasvanut hieman
kasvanut merkittävästi

XI Miten oletatte välittömästi tuotekehityksessä työskentelevien henkilöiden määrän kehittyvän seuraavan viiden vuoden aikana?
laskemaan merkittävästi
laskemaan hieman
pysymään samana
kasvamaan hieman
kasvamaan merkittävästi

XII Arvioikaa seuraavia väitteitä asteikolla:
1 = täysin eri mieltä
2 = hieman eri mieltä
3 = en osaa sanoa
4 = hieman samaa mieltä
5 = täysin samaa mieltä

Tuotekehitykseen tulisi yrityksessänne panostaa enemmän.
Yrityksenne tuotekehityksen tuottavuus on erittäin hyvä.

XIII Oheisessa taulukossa on esitetty tuotekehitykseen liittyviä ominaisuuksia. Rastittakaa ne, jotka kuvaavat yrityksenne tuotekehitystä.
Tuotekehityksen ominaisuus Valinta
Tuotekehitys on pääosin teknologialähtöistä.
Tuotekehitys on pääosin asiakaslähtöistä.

Tuotekehityksessä tehdään yhteistyötä yrityksen ulkopuolisten tahojen kanssa.

XIV Mikä prosenttiosuus yrityksenne tuotekehityksessä tehdystä työstä kirjataan projekteille (asiakas-, uustuote- ja tuoteparannusprojektit, muut) ?

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XV Asettakaa oheisen janan yläpuolella sijaitseviin tekstikenttiin kussakin tuotekehityksen vaiheessa työskentelevien henkilöiden lukumäärä sekä käynnissä olevien projektien lukumäärä. Katso tarvittaessa tarkemmat ohjeet kyselyn liitteestä.

Henkilöstöä	Henkilöstöä	Henkilöstöä
Projekteja	Projekteja	Projekteja

XVI Kirjatkaa oheisiin avoimiin tekstikenttiin enintään viisi tärkeintä tuotekehityksellenne asetettua tavoitetta. Tavoitteiden ei tarvitse olla tärkeysjärjestyksessä.

Tuotekehitykselle asetettu tavoite

1.
2.
3.
4.
5.

Suoritusten mittaus

XVII Arvioikaa seuraavia väitteitä asteikolla:
1 = täysin eri mieltä
2 = hieman eri mieltä
3 = en osaa sanoa
4 = hieman samaa mieltä
5 = täysin samaa mieltä

Suoritusten mittaus on turha rasite yrityksenne johtamiskäytännöissä
Suoritusten mittaus ei tue yrityksenne strategiaa.
Suoritusten mittaus ei heijasta yrityksenne kriittisiä menestystekijöitä.
Yrityksenne suoritusten mittaus on liian monimutkaisesti toteutettu.
Yrityksenne suoritusten mittauskäytännöt eivät ole kehittyneet viimeisten viiden vuoden aikana.

Tuotekehityksen suoritusten mittaus

XVIII Nimetkää alla olevaan taulukkoon käytössänne olevat tuotekehityksen suorituksen mittarit. Pyrkikää nimeämään käyttämänne mittarit mahdollisimman havainnollisiksi ja konkreettisiksi. Mikäli yrityksessänne ei ole käytössä tuotekehityksen suorituksen mittareita, niin jatkakaa vastaamista kysymyksestä XXI.

Parempi esimerkki: Uusien tuotteiden (alle kolme vuotta markkinoilla) osuus yrityksen liikevaihdosta.
Huonompi esimerkki: Tuotekehityshenkilöstön innovatiivisuus. (liian moniselitteinen ja abstrakti)

Nro	Mittari
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	
16.	
17.	
18.	
19.	
20.	

XIX Kirjatkaa oheiseen taulukkoon tuotekehityksen mittareiden käyttötarkoitukset yrityksessänne. Kirjatkaa käyttötarkoituksen jälkeiseen sarakkeeseen käytettävien mittareiden numerot edellä olleesta taulukosta.

Nro	Käyttötarkoitus	Mittarit
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

XX Arvioikaa seuraavia väittämiä asteikolla:
1 = täysin eri mieltä
2 = hieman eri mieltä
3 = en osaa sanoa
4 = hieman samaa mieltä
5 = täysin samaa mieltä

Olette erittäin tyytyväinen käyttämiinne tuotekehityksen suoritusmittareihin.
Käyttämänne tuotekehityksen suoritusmittarit mittaavat päätöksenteon kannalta oleellisia asioita.
Käyttämänne tuotekehityksen suoritusmittarit mittaavat juuri haluttua ilmiötä.
Käyttämänne tuotekehityksen suoritusmittarit ovat mittaustavasta johtuen epäluotettavia.
Tuotekehityksen suoritusmittareiden käyttö kuormittaa yritystänne liikaa niistä saatuun hyötyyn nähden.

XXI Minkä, muun kuin tuotekehityksen suoritusmittareista saadun, tiedon avulla ohjaatte yrityksenne tuotekehitystä?

XXII Mitä tietoa, jota teillä ei tällä hetkellä ole käytettävissänne, tarvitsisitte tuotekehityksen johtamiseen? Miten käyttäisitte tietoa?

XXIII Oliko kyselylomakkeessa joku kysymys vaikeasti ymmärrettävä tai jostain muusta syystä vaikeasti vastattava? Jos oli, niin mikä ja miksi?

Kiitos vastauksestanne!

Generic	Company A	Company B	Company C	Company D	Company E	Company F
Feasibility studies/ preliminary phases	Correct and accurate identification of customer needs: "With this, we are not afford to fail".		Correct identification of customer needs. Consistency of the product with the competencies of product development.	The primary objective is target product cost, which is defined in collaboration. The second objective is product development lead time. The third objective is a certain level of product development cost.	The success cannot be confirmed until at the final stage: end of life. The success cannot be confirmed until at the stage five: product release.	
Product development	On the basis of previous phase, the aim is to obtain the technical specifications defined. Achievement of technical objectives related to product. Product development lead time.	The ability of the product to respond the real needs of the customer.	The perspectives of customer and product development are emphasised. Technical performance of the product. Life cycle costs of product.	Sufficient specifications for the product development. On the basis of this, fluent start for actual product development.	The success of this phase is determined mainly internally. The key objectives include lead time and reaching the target level of development budget.	Product developed according to specified schedule. Sufficient product quality and profit margin. Main cost target is direct manufacturing cost.
Market launch		Good start with the sales. Sufficient number of customer deliveries. Emphasis is on customer and product development perspectives.	Financial and customer perspectives are emphasised. Key objectives include sufficient product sales and profitability.		The success of this phase is determined mainly internally. The key objectives include lead time and reaching the target level of development budget.	Small number of product modifications and versions. Customers are aware of the new product. It is about "redeeming the promises given at the beginning".
Active phase	Emphasis on financial perspective: product cost, product profitability, cost effective purchases. In addition, manufacturability and easiness of assembly are important. Consistency of the product with the entire supply chain.	The profitability of the product. Emphasis is on financial and supply chain perspectives.	The perspectives of customer and product development are important. In addition, financial perspective should be taken into account. A key measure is the success of tailored customer versions.	Fluent manufacturing launch. It is important to reach the target cost level set for the product. After a short delay, more evidence on the consistency of the product with the customer needs. Effective after sales support.	The most important objectives include cumulative sales and profitability of the product during its life cycle.	No problems for the service organisation. Product is easy to sell. Good product quality.
Support, maintenance, and further development		Earning through the product. Emphasis is on financial perspective. The role of product development and marketing gain importance. Rather analogous to the first phase.	The perspectives of customer and supply chain are important. Availability of service and spare parts. The perspectives of customer and product development gain importance. Technically capable and viable product is a core objective.	As a rule of thumb: "If it is rather quiet, everything has probably gone well". Only at the end of product life cycle a "final closing of the accounts" regarding the product is possible.		Increased sales (measures by volume). "Successful demand peak" No problems at the manufacturing. Efficient and effective after sales support. Availability of material and items for manufacturing.
End-of-life phases	Customer perspective is important. The ability to respond the needs of customer. In addition, meeting profitability targets is essential. From the financial point of view: unprofitable products have to be removed. A clear product deletion would be a good objective. Rapid and effective spare part sales, delivery and maintenance service. Cost effective and profitable customer service.	The objective, from the customer point of view, is to reach a sufficient level of continuity. The effectiveness of after sales and service is a suitable measure.	Customer perspective should be taken into account.			No more problems.

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