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Performance Measurement in Finnish Industrial R&D Management

ABSTRACT

The objective of the paper is to describe what is the role of performance measurement (PM) in Finnish industrial R&D management today. The paper illustrates the key results of a survey conducted year 2001. The questionnaire was sent to 350 Finnish R&D managers of industrial companies that employed more than 200 employees. The analysis of the results is based on classification of objectives, measures and their purposes of use. Results show that typically, at firm level, R&D performance measurement is at the moment far from comprehensive, often relying on only few established measures in a rather unstructured manner. Life-cycle dimensions and versatile effects of R&D activities are not optimally reflected by the measures. However, the perceived goals and objectives of R&D characterize the multiple dimensions of product development more clearly than the metrics alone. Thereby, as a one conclusion, it could be argued that the potential of PM is not fully utilized in practical R&D management.

***Keywords**: R&D management, performance measurement, product development*

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INTRODUCTION

Several decades of R&D studies have produced a good deal of data with respect to effective management of product development. However, some studies have indicated that managers are still relying on gut-feel regarding "best practice" in new product development. Analogously, research has tended to be theory-driven instead of being applications-based. (Poolton – 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.

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". In this respect, managing industrial R&D, or new product development, seems to include several complex aspects – such as the identification of probable success projects, the total impact of R&D on various stakeholders (customers, supply chain, owners etc.), or the life cycle dimensions of product development – which could benefit from performance measurement.

This study was set up for gaining more information and understanding about the state of the R&D performance measurement in Finnish industry. The basic notions concerning R&D management, such as *the dominance of gut-feeling* and *somewhat poor R&D performance measurement*, pointed out by Poolton and Barclay and Driva as well as the general assumption that performance measurement has potential to contribute to R&D management many ways gave the motivation to approach the subject in Finnish context. The aim of the paper is to describe what are the main objectives of product development and what is the role of performance measurement in Finnish industrial R&D management today.

LITERATURE REVIEW

The concept of success in NPD

What is success?

Product development success can be considered as a general aim for any R&D activity. Unfortunately, success is very multidimensional. The question of which dimensions of success one should include and how can one measure the dimensions is an essential question to resolve within R&D management (Hultink – Robben, 1995). In that respect, relatively little discussion has focused on the resolution of dilemma of success itself. Yet, as Hart (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 product development success. (Griffin – 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 to be helpful in choosing the appropriate set of R&D metrics.

For example, Shenhar et al. (2002) 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. Indeed, if the success factors are not universal neither are the successful practices associated with the R&D management. Souder and Jenssen have studied successful new product development practices on a cross-cultural basis between Scandinavia and 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 for cultural variations. (Souder – 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 commercial success of the outcome. Further, Hultink et al. have concentrated on one of the antecedents, namely product launch decisions and launch support program, to understand new product success. (Hultink et al., 1999) However, in their study it remains unclear to some extent what is actually meant by "success" and "failure". 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 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).

How to be successful?

Despite of the extensive effort put to study R&D management and performance measurement during the past decades the fundamental question – how should R&D be actually managed to promote high new product success rates – remains open to some extent. Still, many findings and remarks that have contributed to the process of formulating an answer to this question have been established.

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 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 of markets and competitors' products. (Hollander, 2000)

On the basis of his extensive experience on new product development research, Cooper lists eight denominators of successful NPD. Levers, as Cooper calls them, 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 well defined new product strategy, adequate resources (needed people) and spending for NPD in an earlier study (Cooper – 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 – 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 collabora-

tion 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 – Cooper, 1999).

NPD performance measurement

When striving for effective (successful) new product development, R&D management faces several challenges, including project selection[1], 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 making good and effective decisions. It is often noted that performance measurement drives behavior and they are needed and useful for fostering prioritization of effort (Schumann et al., 1995). In this paper no distinction is made between different purposes of R&D measurement (project selection, communication, etc.). Whatever the purpose, measurement should nevertheless contribute to the information resources available when R&D efforts are managed. In general, the importance R&D performance measurement is getting more obvious, as:

> *"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).*

Two main challenges of R&D performance measurement include: 1) It is difficult to assess the actual payoff of R&D activities because of the typically rather long time period between the input and outcome (in the business sense), 2) When assessing the outcome (business performance), it is difficult to distinguish the contribution of product development from the contribution of other parties or factors that had influenced the outcome (other activities of the company, competitive factors, etc.) On the other hand, one of the common features of all performance measurement systems is that they include (at least implicit) assumptions concerning causes and effects. 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 business effects, this is especially important in the R&D context. When considering 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.

1 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 (e.g.) by Martino (1995).

It seems at least intuitively acceptable that performance measurement can serve as a facilitator for discussion about causes and effects, strategy and about different alternatives in general. However, the question then is what should be measured specifically in the R&D context. Ellis argues that without objectively measuring the process of innovation 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) Quite 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. (McLeod, 1988, p. 254) In addition, Cooper et al. point out that new product performance is a multidimensional concept. Therefore, a single measure for new product development (NPD) performance monitoring may not be enough. However, many companies still use only one or two measures. Having said that multiple measures are better than a single measure, Cooper continues that many of the measures may not be totally independent of each other. A holistic view of new product performance can be reached with a limited number of measures (Cooper – Kleinschmidt, 1995).

Davis et al. have established a method for analyzing a project's probability of success. Two classes of probability have been distinguished: technical probability and commercial probability. The technical aspect consists of factors such as proprietary position, competencies, complexity, access to external technology, and manufacturing capability. Commercial probability depends upon factors like customer/market need, market/brand recognition, distribution channels, customer strength, raw material supply, and environment. (Davis et al., 2001) The method of Davis et al. points out that many versatile factors should be considered when making R&D decisions. However, no scientific evidence has been reported to support the list of probability factors. Therefore, the model mainly serves as a tool for thought for R&D professionals.

Managing R&D strictly by measures, i.e. ranking and judging individual projects or actions based on the figures produced by R&D metrics, can sometimes be in conflict with the actual R&D payoff. A promising project does not have to be a star according to all R&D metrics. Partly because of the uncertainty associated with long-term future events affecting success criteria of new product development, it sometimes might be necessary to encourage also those projects that are not in line with the selected R&D metrics. Abetti points out that 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). In line

with this, Lewis (2001) has argued that too straightforward R&D measurement is risky. A versatile and structured set of metrics is likely to present the aspects of R&D in a form that enables managers to consider both long-term and short-term effects of R&D for various stakeholders. Therefore, versatile measurement aims, for instance, at reducing the risk of abandoning or promoting projects with too weak grounds.

Some studies have also focused on R&D measurement in Finland. Tuominen et al. (1999) suggested that performance measurement is an item that should be considered when innovation management systems are analyzed. In a Finnish case study (interviews in three large companies), however, they found that systematic approaches for competitive assessment that would focus on the product and its characteristics were virtually absent. This observation, though limited, suggests that that there are areas in product development where the potential of performance measurement has not been fully utilized. Ojanen et al. (2002) discussed the applicability of Malcolm Baldrige quality award criteria in R&D project assessment in Finland. As a result, they suggest that quality award criteria provide a good platform to derive new measures for product development. These new measures could, for instance, focus on the innovation process and its efficiency and effectiveness, the identification of customer needs, or R&D's business contribution. In general, quality award –based new measures seem to communicate the idea that R&D measurement could well be more multidimensional than it has been traditionally. In a previous study, Ojanen et al. (1999) found that Finnish high-tech manufacturing companies are striving to establish more multidimensional measurement of their product development activities. The finding was based on fifty interviews in five companies. Regarding the current Finnish practices they identified, for instance, poor measurement of customer perspective and, in general, a rather short-term orientation of performance measurement as well as a strong emphasis on financial measurement.

It can be concluded on the basis of the literature that the success and performance of R&D is elusive, multifaceted and challenging to measure – and the identified practices do not correspond to true needs very well. Too a narrow-focused R&D performance monitoring is not able to capture the multidimensional essence of product development but a more comprehensive construct is needed for performance measurement. Despite the particular definition of success and anticipated antecedents of it, performance measurement should be able to capture at least some aspects of both causes and effects of successful product development. Analogously to the BSC framework presented by Kaplan and Norton (see e.g. Kaplan – Norton, 1992; Kaplan – Norton, 1993; Kaplan, 1996; Kaplan – Norton, 1996), it is proposed that the performance and success of new product development can be evaluated and measured from at least four directions that provide a versatile enough view covering the aspects presented in literature:

- Customer view: how well (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 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, 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.

These four directions together are assumed to reflect the essential parts of the product's value chain and life cycle. R&D represents a starting point for a product life cycle, supply chain – when seen broadly – is responsible for issues connected with the physical realization of the product and delivering the product to the customer, customer has the power to determine whether the product functionality and quality are consistent with the need, and finally, shareholder viewpoint demonstrates that successful R&D should – at least in the long term – result profitable business. The relative importance of these four viewpoints obviously depends on the strategy and the operating environment of the company.

METHOD

This survey research began in January 2001 with a literature review of the field of R&D performance measurement. During the fall 2001, the questionnaire was pre-tested with the assistance of three R&D managers. The pre-testing brought out only minor development needs in the questionnaire. The questionnaire was sent to respondents in September 2001. Replying to the questionnaire was made possible through the Internet and by mail.

The questionnaire was sent to 340 R&D managers of Finnish industrial companies that 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 represented the whole population of Finnish industrial companies that employed more than 200 employees. The motivation and also the limitation of this sampling strategy will be more fully discussed at the end of this paper.

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 sample of this study consists of 63 companies. Only three of the respondents represented staff other than the company's

R&D management staff. Those represented either general management or marketing management.

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 53 percent of the sample consists of companies that employ more than 200 but less than 500 persons.

Both versions of the questionnaire (web form and paper) were identical as regards the substance and order of appearance of the questions. Only the formatting of the versions varied slightly. 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 R&D. Especially the objectives of R&D, 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 R&D used, the purpose of measures and R&D managers' opinions about the quality of R&D performance metrics used.

The data were analyzed mainly statistically. 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 type 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 e.g. the important objectives of R&D, the metrics of R&D used and the purpose of measures. The data gained with open-ended questions were quite many-sided as written 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 obscures the chain of evidence of this study, but was necessary, given the large amount of unstructured data collected.

RESULTS

Objectives of R&D

The perceived objectives of R&D were clarified with open-ended questions. Respondents were allowed to subjectively indicate maximum of five important goals of their company's R&D. 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 R&D activity (Table 1).

However, the objectives were not equally at the same level. For instance, the most common objective for R&D, new product and technology development, could be considered as being the basic task of R&D. It is quite abstract as an objective and illustrates *what* should be done in R&D while many other objectives describe *how* this task of R&D should be completed. This basic task can be conducted e.g. in a customer-oriented way and by keeping on schedule with the project (Table 1).

Considering customer needs and improving customer satisfaction turned out to be a very common objective domain of R&D as was the case with improving the product's quality and features. Both goals were appreciated by 41 percent of the respondents (Table 1). 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 R&D lead times was considered important by a great portion of respondents. Examples of responses are as follows:

"Rapidity",
"Short development time",
"Persisting in the schedule", and
"Shortening the projects' lead times".

No more than 12 percent of respondents regarded company or product profitability as an important objective of a company's R&D (Table 1). Objective domain "other" turned out to be quite large (Table 1). It contained R&D objectives that were reported only by one company and the domain mainly comprise of goals that were unidentifiable. This may indicate slight misinterpretation of the question among some of the respondents.

TABLE 1. The perceived objectives of R&D.

N	R&D 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, e.g. 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-work 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

R&D objectives can be viewed from perspectives that are considered to be relevant in evaluating versatile R&D performance (Table 1: Perspective). In this study these perspectives were theoretically concluded to be the customers, the 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 Finnish industry? Answers can be found from the perceived important objectives of R&D.

The customer perspective was considered important by 67.2 percent of the respondents at the level of R&D objectives (Table 2). Objectives of customer perspective were associated with customer needs and satisfaction and product quality and feature improvements.

The most common perspective, at the level of R&D objectives, appeared to be the R&D's internal perspective that was valued by 77.0 percent of the companies (Table 2). In addition to the basic task of R&D, 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 R&D managers in the responses regarding the objectives of R&D (Table 2). 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 shareholders' perspective. Only 23.0 percent of the respondents referred to at least one R&D objective that was related to the company shareholder's perspective (Table 2). Objectives that were classified as belonging to the company shareholders' perspective were associated with profitability, competence and sales of a product, a product-line, or a company.

TABLE 2. The number of companies that perceived R&D objectives associated with a specific perspective.

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 perceived objectives of R&D 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 does not enable inevitable connection of objectives and life cycle phases (which is the case e.g. with the objective "*Correspond to customer needs*") or the objectives are related to a particular phase, mostly the beginning of life cycle ("*Short development time*"), which suggests that the life cycle is not considered as a whole – the possible versatility of requirements arising from different phases has not been recognized.

Performance metrics of R&D

The R&D managers were asked to define the performance metrics of R&D actually used in-house. According to the replies, 44 companies are utilizing at least one indicator of R&D performance. That is approximately 70 percent of the sample of this survey. The preceding portion is quite high when compared with international findings (Hertenstein – Platt, 2000, p. 315), (Griffin, 1997, pp. 429–458).

The R&D performance metrics used were classified into 14 different categories, which measured apparently different subjects. It appeared that 56.8 percent of companies measured the R&D performance with metrics that could be associated with time (Table 3). The time category contained metrics such as lead and cycle times and time schedules.

The second category of R&D performance metrics was sales or revenue. It contained metrics of which at least one was in use in 40.9 percent of the companies. The category included metrics like new products' sales per overall sales and absolute revenues either of a product, a product line, or a company (Table 3).

Both R&D project costs and overall costs of R&D were placed in the category of costs of R&D. It showed that 31.8 percent of the companies used R&D performance metrics associated with costs of R&D (Table 3).

Customer satisfaction was measured primarily by directly asking the customer, but also indirectly by market share measurements. Some sort of customer satisfaction measurement was practiced by 29.8 percent of the companies (Table 3).

The profitability category included typical profitability metrics such as return on investments and net profit of a company. *Costs of supply chain* consisted of cost of different parts of the supply chain. Efficiency of the R&D was measured with metrics like the R&D maturity index and number of accomplished product modifications. Innovation metrics were mostly connected with the number of patents and patent applications.

Also in the case of R&D performance metrics the category "other" turned out to be fairly large. 36.4 percent of companies reported at least one R&D performance indicator that was either unidentifiable or unclassifiable by the researchers (Table 3).

TABLE 3. R&D performance metric categories.

N	Category of R&D performance metrics	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	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 R&D managers were asked how satisfactory their experience has been of the used R&D performance metrics. The majority of the answers (55.8 percent) indicated slight or strong dissatisfaction among the respondents (Table 4). Furthermore, the results did not indicate any connection between satisfaction and the versatile use of metrics. Versatile use of R&D metrics in a company was seen to be associated with the number of different categories in which the metrics utilized by that company were classified. (Table 4: Different categories) It was also shown by the results that no particular category of the metrics was distinguished as causing more or less satisfaction among the respondents (Table 4).

TABLE 4. The R&D managers' satisfaction with the metrics used.

Opinion	Answers	Total	Different categories	Metric category code from the table 3													
				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

The R&D performance metrics used can also be viewed from the aforementioned important perspectives of R&D performance evaluation (Table 3: Perspective). Time, personnel, innovation, efficiency, and R&D volume metrics can be seen as indicators of the internal aspect of R&D 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 metric that was associated with internal aspect of the R&D (Table 5).

Company shareholders' perspective was seen to include metric categories such as sales and revenue, profitability, and combinations of them. 65.9 percent of the companies appeared to use metrics that were seen to relate with the company shareholders' interests (Table 5).

The supply chain perspective consisted of metric categories like costs of supply chain and product's produceability. The R&D performance was measured from supply chain's perspective by 38.6 percent of the companies (Table 5).

The customer perspective appeared to be the least measured perspective among the companies. 29.9 percent of the companies used R&D performance metrics that were associated with customers (Table 5). The perspective consisted of customer satisfaction measures.

TABLE 5. The number of companies that used R&D performance metrics associated with specific perspectives.

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 or comprehensiveness of R&D performance measurement can also be analyzed by looking at the number of different perspectives represented by the performance measurement. Following Table 6 summarizes this assessment.

TABLE 6. The number of different perspectives represented by the performance measures used in companies (N = 44).

Number of perspectives	Number of companies
1	14
2	15
3	9
4	6

Only six companies seem to utilize measures that altogether cover the all 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.

Based on the measures typically utilized in R&D 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 e.g. with the measure "*net profit of a company*") or the measures are related to a particular phase, mostly 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.

Relationship between the perspectives of objectives and metrics

Performance measurements and metrics should support and be aligned with objectives of an

organization. The performance metrics at best concretize the given objectives and communicate about them. When comparing the R&D performance metrics with the important perceived objectives of R&D, it is possible to analyze how the management accounting system is actually aligned with the given objectives of R&D. 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 R&D and the R&D performance metrics can be found with the company shareholders' perspective. 23.0 percent of the companies valued the objectives of R&D that were associated with the company shareholders' perspective while 65.9 percent of the companies used metrics that indicated the company shareholders' interests (Table 6). The difference was 43.0 percentage units.

The customer perspective showed also a notable margin between objectives and metrics. The margin was 37.7 percentage units. But in contrast to the company shareholders' perspective, the number of objectives in R&D considered to be important from the customer perspective greatly surpassed the metrics used (Table 7). Smaller gaps between objectives and the metrics used occurred 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 7. The relationship between the perspectives of the important R&D objectives and the used metrics.

		Objectives		Performance metrics		
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		

Another important fact to notice is that 61 companies (96.8 percent of the sample) reported objectives of R&D while 44 companies (69.8 percent of the sample) defined the metrics of R&D used. In general there is more wishful thinking than measuring in the R&D of the companies.

DISCUSSION ON THE VALIDITY AND THE RELIABILITY OF THE RESULTS

The validity and reliability of a study can be seen as prerequisites for a piece of research to be able to provide the research field with credible theory development and contribution. Validity

refers to the ability of the study to capture and measure the very phenomena that it is expected to do. Reliability refers to the replicability of the results and accuracy (or correctness) of the measurements applied in the study.

Reliability

The empirical data were collected from one person (respondent) in each company. This poses some threats to reliability for the possible respondent bias. However, the respondents were selected in such a way that the respondent would have good knowledge concerning the main questions asked in the study. The questionnaires were mailed to product development managers because it is very likely that the product development manager or director (person who in change of product development in a company) is aware of measures that are applied for product development performance measurement.

Second, potential respondent bias was reduced by the design of the questionnaire. Accordingly, most of the key questions were open-ended. This strategy was selected to reduce the risk that a respondent would mechanically select an answer-alternative without having proper arguments to do that. For instance, the fact that it was explicitly asked to name the specific measures in place decreases the probability of collecting just perceptions of individual respondents.

The reliability of the study can be assessed also by comparing the obtained results with corresponding national and international studies (Griffin, 1997; Ojanen et al., 2002; Hertenstein – Platt, 2000; Ojanen et al. 1999; Tuominen et al., 1999). The main results (e.g. narrow focus, rather strong dissatisfaction) seem to be reasonably well in line with the findings of these studies. Also, the researcher have conducted a number of case studies in companies similar to those represented in the sample of this particular study. Heuristic comparisons of the results of this survey and the observations made in the case studies show no essential conflicts regarding the current state of Finnish performance practices.

Validity

Many dimensions of validity can be established (including, for instance, construct, internal, external, face, content and predictive validity). Two dimensions that are expected to have the greatest relevance in this study will be taken under further consideration. These dimensions are construct validity and external validity.

An essential question with respect to construct validity is “what is Finnish”. An average Finnish industrial company employs less than 20 persons. Moreover, about 98 percent of all Finnish companies (all sectors included) employ less than 50 persons (Tilastokeskus, 2003). In this respect, the sample of this study is unlikely able to capture the whole spectrum of Finnish

practices related to product development performance management. On the other hand, many of the small companies are manufacturing-focused subcontractors, which – importantly – are not active in product development. Furthermore, it is very unlikely to find explicit performance measures or measurement systems in very small companies. Therefore, larger companies were selected as a focus group for they would be able to provide the study with more "grip" – more concrete data (employed measures, measurement systems, or innovative means to utilize measurement in product development management) – on the subject of the study. In other words, it was expected that somewhat larger companies, if any, would employ explicit measurement of their product development activities.

However, due to this issue, caution is needed when the results of this study are generalized. The external validity of the findings is restricted to reasonably similar companies meaning, for instance, that the current state and the requirements for performance measurement are probably different when essentially smaller companies are concerned. However, it is possible with a certain confidence to argue that the analysis of smaller companies in Finland would not reveal more multidimensional and sophisticated performance measurement practices of product development. Therefore, it is suggested that the study is able to fairly describe the *state-of-the-art* of these issues in Finnish context.

CONCLUSIONS

The aim of the paper was to describe the practices of R&D performance measurement and the needs that can be derived from the objectives and characteristics of new product development in Finnish industrial enterprises.

The results of this study indicate – regarding the important perceived objectives of R&D (Table 2) – that companies are not very comprehensively taking into consideration the versatile effects of R&D. Especially the company shareholders' perspective surprisingly appeared to be rather weakly appreciated among the companies. The proportions shown in Table 2 could be compared with the degree of 100 percent, which would signify that every company is considering each of the four perspectives (customers, R&D itself, shareholders, and supply chain) as being important from the R&D performance point of view.

Regarding to the performance metrics of R&D used, the results of this study suggest that the ability to measure things that are considered to be important is weak in some cases (Table 7). That is especially the case with the customer perspective. The results also indicate a contrary situation. The metrics used measured the R&D performance very often from the company shareholders' 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 R&D metrics used to be dissatisfactory. The versatile use of metrics was not in any case associated with the satisfaction felt among the respondents. It was also shown that no particular category of the metrics can be associated with more or less satisfaction among the respondents.

One of the main observations made during the study seems interestingly inconsistent with the prior perceptions: if a primary aim of R&D 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 metrics dominate the financial measurement at company level. Another important issue, life cycle performance of new products, receives little explicit attention by practitioners. Although the product requirements that arise from different phases of life cycle might have an importance that should be taken into account in R&D measurement, it is not very surprising that life cycle – related measures are somewhat neglected. Given the importance of and risen interest towards life cycle management issues, it is inevitable that more discussion and suggestions based on both academic research and industrial experiences are needed on the subject.

The difference between perceived R&D objectives and measures used raises some questions. It might be that the measuring of some important issues requires an effort that it 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 contradictory to expect that the objectives and the measures should be exactly consistent with each other. Also, it should be pointed out that R&D objectives and R&D measures may be at least partly hierarchical i.e. 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.

Methodologically, the greatest limitation of the study is related to the assignment of objectives and measures to a particular performance view (customer, R&D, shareholder, supply chain). It might be questionable to strictly associate one objective or one measure with only 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 should be done to fully develop the logic needed to connect measures and objectives to the above-mentioned four directions or views.

Further research should be focused on how to improve the soundness of the connection between objectives, measures, and different views of performance. Conducting several in-depth interviews with R&D professionals to clarify their opinions concerning the relation of those three main concepts could do this. Another survey tackling the problem of the assignment of measures and objectives would be beneficial. Yet another important finding that highlighted

possible subjects for further research was the fact that the customer perspective was considered important but was not generally being measured for the use of R&D management. Is this an implication of poor ability to measure customer satisfaction or does the problem concern attitudes? ■

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