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Managing program impacts in new product development: An exploratory case study on overcoming uncertainties

Managing program impacts in new product development

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Abstract
New product development (NPD) programs are designed to implement innovation strategies in a coordinated way. Managing program impacts in a multi-project setting is insufficiently covered in research and increasingly challenging in practice. This paper explores program impact management practice, by inquiring: 1) How and where are (strategic) impacts managed during an NPD program? 2) What kinds of uncertainties and ambiguities emerge as part of the program? 3) How do personnel make sense of and seek to overcome the ambiguities and uncertainties when managing program impacts? The qualitative study relies on in-depth access to a large-scale NPD program in the machine manufacturing industry. The results show that program impact includes several financial and non-financial aspects and is made jointly and separately by the program organization, thus involving different uncertainties and ambiguities. Through collective sensemaking, knowledge about the program impacts may be strengthened, and the impacts may be extended beyond immediate benefits.

Introduction

"No one comes, you see, in a couple of years, with a money briefcase bringing what [achieving a certain NPD program objective] is worth, telling: 'here is the million'" (Product management, 18-03-2014).

Programs are considered as entities of multiple projects that enable achieving business benefits (Levene & Braganza, 1996; Pellegrinelli, 1997) in the interface between single projects and organizational strategy (Shao & Müller, 2011). New product development (NPD) programs can be considered as vehicles for implementing innovation strategies as single NPD projects within programs are meant to be managed effectively to ensure the delivery of successful new products. However, assessing and managing the benefits attained from NPD programs is challenging and the total program impact is still poorly understood (Winter & Szczepanek, 2008; Shao & Müller, 2011; Shao et al., 2012). The total impact of the NPD program refers to the total (lifetime) effect on the value to the stakeholders involved, typically the company and its customers, including both financial and non-financial impacts (Martinsuo & Killen, 2014; Shao & Müller, 2011; Shao et al. 2012). There are numerous uncertainties affecting the multi-project setting (e.g., Petit & Hobbs, 2010; Korhonen et al., 2014; Martinsuo et al., 2014), stemming from the multi-project characteristics and context (Martinsuo 2013).

The practice of managing program impacts has been addressed in the literature to some extent (Shao & Müller, 2011; Winter & Szczepanek, 2008). However, it is unclear whether and how program management tools will actually support program execution to ensure the best possible impacts (Shao & Müller, 2011). One of the starting points to this paper is the contrasting finding that although a systematic use of the highly sophisticated tools and program models is suggested (Jaafari 2007), the systematic use of the models do not necessarily yield optimal organizational performance

(Pellegrinelli 2011). Hence, social processes of sensemaking may be required to understand and respond to the multi-project management requirements in its dynamic context (see e.g., Thiry, 2002; Christiansen & Varnes, 2009; Martinsuo, 2013; Martinsuo et al. 2014).

Because the existing research provides only partial and indirect reflections on managing NPD program impacts, there is a need for a detailed examination of managing NPD program impacts in practice. Although some studies address the practice of managing program impacts as an integration issue at different levels, they primarily focus on the antecedents of impacts (not the impact realization itself), and they mostly focus on organizational change programs (not NPD). Moreover, studies on multi-project organizing (e.g., Petit & Hobbs, 2010; Korhonen et al. 2014) have highlighted uncertainty as an issue to be managed, but previous studies do not cover how ambiguities, or the lack of understanding in general should be dealt with in NPD programs.

Goals and research questions

The goal of this paper is an increased understanding of managing program impacts in practice— particularly in multi-project NPD programs—and the identification of social mechanisms promoting program impacts under uncertainty and ambiguity. The focus is on three research questions: 1. How and where are (strategic) impacts managed during an NPD program? 2. What kinds of uncertainties and ambiguities emerge as part of the program? 3. How do personnel make sense of and seek to overcome the ambiguities and uncertainties when managing the program impacts?

The study will extend previous portfolio-centric and single-project-oriented research, particularly by exploring a strategic, multi-project NPD program, its pursued impacts, socially constructed impact management within different program activities, and related uncertainties and ambiguities. The paper is built on a case study of a large-scale NPD program set up to implement a global technology leader's innovation strategy. The paper thus contributes to the understanding of the activities underlying program impacts, and a wide range of challenges experienced and discussed when managing a program's impacts. Uniquely, the case study deepens the discussion on program impact management to the social processes of sensemaking related to program impacts. This paper suggests that by understanding the social processes of sensemaking, the mechanisms underlying program impacts may be better understood and the related ambiguities managed.

Literature review

Program impacts in general

Programs are defined as entities of multiple projects, aiming at achieving a set of major benefits that are more than just the sum of the projects they consist of (Pellegrinelli, 1997; OGC, 2003; Nieminen & Lehtonen, 2008). The foundations of program management differ from those of project management (Artto et al., 2008), and program management needs to be considered more broadly than in terms of merely managing large projects (e.g. Lycett et al., 2004). Pellegrinelli (1997) identifies higher level complexity, uncertainty, and goal ambiguity as characteristics of program management in comparison with single project management, and the program management should take into account these requirements. The realization process of the program impacts has rarely been examined, but there are several studies on the initial program impact definition and the *ex post* program success measurement (e.g., Shao and Müller, 2011).

When managing program impact, the total lifetime profitability and value to the parties involved should be understood and divided into a set of manageable elements. Some of the elements are financial, and some of them are non-financial and may relate to customer benefits, ecological value, learning, synergy, and other aspects (e.g., Martinsuo & Killen, 2014). The desired value elements should be translated into program objectives and related performance indicators. As programs involve multiple projects with complex causes and effects, a set of financial and non-financial indicators is needed to comprehensively understand the program impact, and to define its linkages to the strategy.

The total program impact, in the long term, is supposed to be transformed into business profitability (revenues, costs, and/or capital invested and related risks) and into the personal utility of the people involved. The impact can be viewed and perceived differently by different stakeholders

(Thiry, 2002; see also Martinsuo & Killen, 2014). In Thiry's (2002) view, value is about satisfying multiple stakeholders' needs through an efficient use of resources. Some authors have studied the achievement of desired impacts by using some related concepts such as value, strategic value, benefits, and specific types of impacts. Winter and Szczepanek (2008) characterize programs as value-creating processes where the attention should be placed more on the customer's value creation than on a certain product. Some authors focus on achieving strategic value, which may include economic profitability, stakeholder satisfaction, societal influence, and social and ecological responsibility more broadly (Eweje et al., 2012; Martinsuo & Killen, 2014). Although managing the financial and non-financial impacts of the programs is an essential part of program impact management in general, achieving program impacts has received very limited empirical attention.

The need to study program impacts in their context

The selected financial and non-financial performance indicators should constitute the overall 'theory' of business phenomenon; program impacts in this case. In practice, however, such a set of performance indicators cannot exist that would fully capture the intended total impact of the program (see e.g., Chapman, 1997), but the indicators are subject to collective sensemaking to better fit their context (Englund et al., 2013).

Lycett et al. (2004) highlight the necessity of moving from rigid and controlled program management toward more flexible program management where the program-specific features are taken into account and program management enables adaptability in the context of a changing environment. They also emphasize program management's relationship-oriented role due to the existence of multiple stakeholders with different interests. Indeed, integration of a program into a single entity is crucial (Dietrich, 2006; Lehtonen & Martinsuo 2008, 2009; Maniak & Midler, 2014; Turkulainen et al., forthcoming), since programs are used to fulfill certain strategies and, therefore, they need to be aligned with the organization's broader interests, even if the context evolves.

A key finding seems to be that there is no one single rule for integrating the program, but that the degree and nature of integration may vary depending on the context and situation. Thiry (2002) particularly proposes value management as a concept that is necessary for programs to make the right decisions and adopt emergent strategies if the program context changes during the program progress. Thiry (2004) has also highlighted the long-term and strategic nature of the program lifecycle, and suggests that programs should be viewed as systemic and learning entities that need to monitor and adjust their practices continuously in line with the evolving context. Winter and Szczepanek (2008) place an emphasis on program and project management in ensuring the value created to the organization, customers, and customers' customers.

Earlier research suggests, essentially, that program management is not merely an extension of project management and control (e.g., Pellegrinelli, 2011), but one needs to understand the organizational behavior more broadly, and the uncertainties and ambiguities stemming from the program context (Pellegrinelli, 2011; Martinsuo, 2013). Thus, performance management would need to be complemented with learning and sensemaking processes (Thiry, 2002; also Dutton et al., 2014) to account for the uncertainty that prevails in complex programs and their environments.

Particularly in the context of this paper, in NPD, programs are included in the R&D portfolios of companies, with a general aim being to maximize the value of the investments (Cooper et al., 2001). Plenty of research has covered the management and performance of multi-project portfolios in product development (Cooper et al., 2001; Martinsuo & Lehtonen, 2007; Teller et al., 2012; Voss & Kock, 2013). In such studies, however, the project portfolio performance is typically covered in terms of strategic alignment, value maximization, and project portfolio balance, based on the managers' and employees' experiences. Wider impacts of the programs (including effects on the market, on the product platform, and on competences and processes) are not sufficiently covered in existing studies.

Uncertainty and ambiguity in program management practice

As concluded above, programs and projects are managed in context. In the NPD context, there is a natural time–space distance between the activities and their impacts (Jørgensen & Messner, 2010), which implies a high level of uncertainty (and also ambiguity, Englund et al., 2013) related to many activities. Consequently, uncertainties and ambiguities may affect the program execution at different levels. According to Thiry (2002), uncertainty deals with the difference between the data required and

the data already possessed; it is a "lack of information." Ambiguity, in turn, means the existence of multiple and conflicting interpretations; it is linked to confusion and lack of understanding. Pich et al. (2002) defined ambiguity in project management as unknown events or causalities, while complexity results from the interaction of too many variables.

In previous research on uncertainties in a multi-project environment (see e.g., Korhonen et al., 2014; Martinsuo et al., 2014), the focus has been largely on identifying and categorizing uncertainties and their management practices. A distinction has been made between *environmental-*, *organizational-complexity-* and *single-project-related uncertainties* that hamper the multi-project execution (Petit & Hobbs, 2010), and the means through which the managers deal with different uncertainties have been examined (Korhonen et al., 2014; Martinsuo et al., 2014). Overcoming the ambiguities as information inadequacies requires both learning and selection (Pich et al., 2002), which may take place in the social processes of sensemaking. However, as research has so far focused on the viewpoint of single managers toward the uncertainties and their management, there is inadequate understanding about the collective processes of overcoming uncertainties and ambiguities in programs. One way to tackle uncertainties in the program is through the idea of ambidexterity (Pellegrinelli et al., 2015; also van Buuren et al., 2010), where program-level activities involve more flexibility, and single projects are managed more straightforwardly. Overall, examining the ambiguity requires the examination of the interpretations of different stakeholders to understand the unknown events and causes and effects from different viewpoints. Ambiguities, however, have not been addressed sufficiently in the program impact management literature.

In the management accounting literature, performance and control represent central concepts and increasing attention has been paid to the social processes of sensemaking regarding the financial and non-financial impacts of the actions taken. Studies acknowledge the uncertainties in decision-making situations (Burchell et al., 1980; Chapman, 1997) and ambiguities regarding the translation of the decision-making and management into performance indicators (Mouritsen et al., 2009).

Englund et al. (2013) made a distinction between the definitional, representational, and operational ambiguity of accounting information. *Definitional ambiguities* represent change triggers in metrics, i.e., performance indicators, as the actors' mindset cannot "fully account for" the metrics that are in use (Englund et al., 2013, p. 442). For example, a member of an organization may not understand which specific costs are included in an indicator of project cost. *Representational ambiguities* are perceived uncertainties with regard to "what time–space bound numbers stand for 'in reality'" for actors (Englund et al., 2013, p. 442). For example, project cost or duration may show values that are either incomprehensible or that bring forth the need to take up another viewpoint on the object of measurement (cf. Englund et al., 2013). *Operational ambiguities* are perceived uncertainties with regard "to how time–space bound numbers can be 'causally' explained" (Englund et al., 2013, p. 443). In practice, members of an organization might find it difficult to identify reasons behind why certain metric values occur, e.g., project quality deviation, and may become puzzled about the real-life phenomena behind these deviating values (cf. Englund et al., 2013). This ambiguity could be dealt with by using suitable financial and non-financial performance indicators (Davila, 2000) and intentionally encouraging new ways of sensemaking regarding them within NPD programs.

Social processes of sensemaking in program impact management

Sensemaking has been considered as one of the key mental processes in strategic change (Gioia & Chittipeddi, 1991), and its role has also been identified in program management (Thiry, 2002) and product development (e.g. Christiansen & Varnes, 2009). In the study by Gioia and Chittipeddi (1991), sensemaking was seen to deal with the construction and reconstruction of meanings by the involved parties as they attempted to frame and understand the intended strategic change. Collective sensemaking is needed particularly in the early phases of a program to reduce ambiguities and pave the way toward operational program management, and sensemaking also becomes active later in the program due to changes (Thiry, 2002). Although much sensemaking takes place at an individual level within a social setting, this paper is particularly interested in the collective sensemaking of program members as multiple stakeholders construct and reconstruct the meaning of the program impact to pursue the program goals.

Sensemaking in NPD programs is challenged by the involvement of persons from multiple functional units and even from different organizations. Therefore, the particularly interesting

processes of sensemaking are social. Social processes of sensemaking take place both at the level of management and at the level of the project team's work. For example, managers' decision-making processes in selecting projects may be quite strongly influenced by the joint learning and negotiation processes among the management team (Christiansen & Varnes, 2008; Blichfeldt & Eskerod, 2008). Regarding NPD projects and programs, sensemaking has been discussed in connection with structured product development approaches and rules (Christiansen & Varnes, 2009). Christiansen and Varnes (2009) studied how functional and project managers made sense of the structured approaches (i.e., NPD models) and their rules, and noticed that these interpretations had an important role in what was actually implemented in practice, and in how these implementations took place. Improvisation by project and portfolio managers, in contrast to an official project management system, has also been identified in multi-project settings (Jerbrant & Gustafsson, 2013).

The negotiation and sensemaking in programs clearly complement the dominant rational view emphasized in project management with non-rational and social elements. One of the key issues emerging is that individuals use their intuition (besides rational judgment) when facing uncertainty. For example, Elbanna (forthcoming) states that competition uncertainty and environmental complexity were primary determinants of using intuition, which in turn increased team reflexivity in project execution. Clearly, uncertainties and complexities result in the need to use experience-based intuition and improvisation, and gaining positive outcomes from such settings requires cooperation among the parties involved. Dayan and Elbanna (2011) studied NPD projects and suggested that NPD project teams should be given more power to encourage their intuitive behavior and thus enable enhanced effectiveness in decision-making. However, the actual mechanisms underlying such uses of intuition and reflexivity remain unstudied in the program context.

Altogether, the social process of sensemaking among the program stakeholders drives the local interpretations of NPD program impacts at different levels and eventually represents a vital part of program impact management. This paper contributes to the literature by showing how the local, socially sense-made interpretations of NPD program impacts can be understood as constituents of program impact per se, and therefore is a key issue for researchers to address.

Research methodology

Research design
This study explores program impact management in a real-life R&D context. An exploratory, qualitative case study was conducted in a global technology leader company that offers its customers machinery and after sales for demanding production purposes. A case-study design was chosen to enable an in-depth analysis of a relevant and not yet well-known phenomenon (e.g. Yin, 2009). The choice of the case company was based on the researchers' interest in a highly demanding, yet typical engineering R&D context, the company's significant strategic interest in NPD activities, and the company's willingness to study the practices and impacts in its NPD program longitudinally. The case is unique in terms of the in-depth and longitudinal access of the researchers to the research site (over one decade). The case study was characterized by access to the actual events where program impacts were being discussed and possibly directed.

In particular, the case study is undertaken from the context of an NPD program, which is only rarely addressed in the program management research. The studied NPD program has its focus on "next-generation" machinery in a product category within the company. The number of machinery items manufactured annually in this category is around 1000, but the volume has thus far been divided into a number of different machinery models, tailored to the customers' needs. The company operates on a niche market.

The NPD program was studied from 2011–2014, and the researchers were involved in different roles (collecting data and analyzing specific program impacts when needed), from the concept/technology development phase (2011–2012), to the execution of the NPD projects relating to the individual machinery models (2012–2014). The overall aim of the NPD program was to deal with the increasing price/cost consciousness of the customers, to develop a more modular/standardized product category (according to internal benchmarks), and to ensure the overall capability of the product category to remain profitable. The structure of the NPD program is illustrated in Figure 1.

The program management consists of the program-level activities, a set of technology projects supporting the attainment of the overall objectives, a set of concept projects, and a set of NPD projects that were executed after the concept projects. After the NPD program, the new products would enter the product lifecycle management (PLM) phase. In addition to the program-level objectives (for which the program manager was accountable), each project has its own objectives (and project managers, respectively), and these projects are expected to jointly and individually contribute to the overall program impact.

--- Insert Figure 1 about here ---

Although the company has advanced tools and practices for planning and controlling individual NPD projects, NPD program management represents a complex and relatively new task for many company representatives. As a result, besides the financial impacts of the program (volumes, prices, target costs, after sales, and cannibalization), the company representatives were willing to discuss (and develop a better understanding about) non-financial and more indirect impacts of the program with the researchers. This was a natural starting point for the research effort presented here.

Data collection and analysis
The data collection takes the form of a multi-method qualitative study, involving individual interviews, group interviews, and a multi-stakeholder workshop related to the program (primary data). Due to the longitudinal access of the researchers to the case company (2011–2014), it was also possible to supplement the data with a set of informal comments and background information to validate the attained research findings (secondary data). The timeline of the research and the empirical data collection is presented in Table 1.

--- Insert Table 1 about here ---

We use recorded and transcribed materials as the primary data that were coded with Atlas.ti. These primary data consist of two semi-structured interviews, workshop planning interviews, and a workshop. As part of the research process, there were more than 30 additional meetings related to the overall NPD program execution and to informal communication (calls, emails, ad hoc meetings) with the company representatives. Eight of those more than 30 meetings that had a particularly direct link to the topic of this paper are listed in Table 1, therefore serving as secondary data that enable triangulation and a validity check to be undertaken for the primary data.

The empirical material was coded with the help of the Atlas.ti software and analyzed accordingly, starting with the empirical questions of the paper. First, the roles and the viewpoints of the program stakeholders were coded (e.g., engineering, finance, R&D, product management). Second, the impacts under discussion were coded both as financial impacts (e.g., product costs, increased sales) and as non-financial impacts (e.g., being on time, market share). Third, the location/phase where the impact originated from was coded as well (e.g., concept development, NPD). Fourth, the uncertainties (e.g., about guidelines or goals) were coded together with different forms of ambiguities (e.g., definitional). Finally, the different forms of expressions (e.g., disagreement, consensus, humor) regarding the challenges in the NPD program management and the different means to overcome those challenges (e.g., processes, routines) were coded to grasp the different forms of discussing program impacts, and the identified avenues for enhancing the program impact-management practice. The findings were analyzed to gain a detailed understanding about the dynamics of the program impacts, and the joint efforts in identifying the challenges related to the impacts, and the means through which to overcome those challenges. Cross-tabulation, selected excerpts from the interviews, and summaries of commonalities and differences are used to report the key results. Altogether, the chain of evidence in this paper is built on the described analytical approach to the empirical material that was gathered.

Results

Definition and multifacetedness of the program's impact
Despite the seemingly clear target setting of the NPD projects and the overall program, the desired outcome of the NPD program implies a complex set of sub-targets. Based on the data set, there are several different impacts that are desired from the NPD program. At the same time, it is relatively difficult to trace which particular sub-targets should be met to reach the desired impacts. Additionally, it is not exactly clear as to how to prioritize these sub-targets.

Overall, different function representatives brought up different financial and non-financial impacts in different ways, and some patterns seemed to exist. The product cost effects were highlighted by most of the functions as a desired central financial impact. The wider profitability aspects were also highlighted. Besides product costs and profitability, a variety of other financial impacts were discussed, ranging from the business impacts on sales or on the sales price, to the more long-term or indirect cost effects. The direct cost effects of the projects were also mentioned.

Although the financial aspects dominated the discussion on the NPD program impacts, the informants also raised several non-financial (or essentially indirect) NPD program impacts. Many people, especially from the R&D department, discussed certain product features as desired program impacts, and component commonality was brought up by many as a desired impact of the NPD program. Customer value aspects, innovation in general, and quality issues were also discussed. A representative of the finance department discussed a wide range of non-financial impacts, such as the competitive position or market share that should affect the NPD program execution. It is a desired role for the business controller to actively seek the right financial indicators for the NPD programs with several direct and indirect impacts on the business and, therefore, the financial department representative recognized an ample range of impacts that were deserving of further attention to understand the dynamics between different financial impacts and the identified non-financial impacts.

Additionally, the NPD program was expected to result in increased modularization and standardization of the product family, better manufacturability and maintainability of the products, and other smaller-scale benefits. Although the program personnel and the NPD project managers seek to respond to the objectives of the NPD program, it is rather difficult to ensure or even comprehend whether the program is currently going toward its objectives. The need for simplified financial measures was described as follows:

> "We should take revenue costs and inventory levels [as performance indicators] […] and maybe the timing of the revenues at a generic level. The basis should be the original objective, if the revenues come earlier, it is positive; if later, it is negative […] The project manager should always bear in mind the impact [of his/her work] on the total profitability." (Finance, 19-12-2011)

The starting point for the NPD program was profitability; the new machinery generation should be more profitable than the existing one. At the same time, the strategy places emphasis on growth and technological leadership, which provide additional, more specific requirements for program impact management. Although the decisions are formally made for selecting and steering the NPD programs and projects, customer requirements are allowed to influence the program and project execution, which may have a negative influence on the desired time-to-market aspect. One reason for this lies in the desire for the company to be a technology leader, where the R&D personnel have a mindset through which they eagerly react to the emerging issues of their customers. Another reason for changing the scope of the NPD program during its execution is related, naturally, to the ambiguity of the scope and content of the NPD program and the projects included within it.

To avoid any unnecessary drift of the NPD program impacts, and to enable program impact management, R&D personnel felt that different co-existing impacts should be prioritized. In other words, besides merely translating different objectives into a set of performance indicators, defining (and re-defining) the desired program impact is a matter of compromising, as illustrated by the following quote.

"But it's the battle: when we have to be on the market, what we need to have ready versus price. So you just accept that you're not going to the market when planned, but we're now wasting a couple of months with the price." (R&D, 18-03-2014)

At the program level, defining the priority among, and analyzing the interplay between the different impacts seems to be an important, yet continuous task in terms of supporting single project execution. In the NPD program, for example, there are interrelated indicators for component commonality across the products and the direct component costs of the new products. Looking at the component cost is not enough; all of the impacts of the component choice regarding the common product platform, and perhaps related to the wider product architecture, need to be taken into account. A given component choice may increase the product cost, but it would still be beneficial due to the impacts of standardization. These effects require a detailed examination and cannot be defined accurately in an early phase of an NPD program.

Episodes and practices of impact management
Due to the multiple-level program activities, several viewpoints can also be held on the NPD program impacts. To illustrate the different viewpoints on financial and non-financial program impacts, the viewpoints on the strategy, the project portfolio as a whole, the program, and the single projects are highlighted separately in Table 2 (left-hand column). Some remarks are indirectly related to program execution, such as product lifecycle management (PLM) which is outside the program but uses the same engineering resources as the NPD activities do.

--- Insert Table 2 about here ---

Regarding the financial impacts, many discussed lifecycle income, profitability, and increased sales. At the levels of the portfolio as a whole and the program, financial terms include overall profitability and total cost considerations. In single projects, the product cost seems to be highlighted as an antecedent of the desired impact, even if the cost effectiveness is not the main strategic objective of the NPD program. Regarding the active sales phase of the products, people again highlight the lifecycle income, total cost, and profitability aspects of the products.

The non-financial terms used reveal that from the strategic viewpoint, competitiveness represents one major concern for the program (including market share and customer-demand aspects). At the program level, the impacts are translated into expectations related to the new machine generation, particularly in terms of the product features, quality, maintainability, and safety aspects. In single projects, these issues are supplemented with some innovation aspects and concerns about how the outcome of a single project can be used in subsequent projects. In this case, the NPD program was supposed to enhance component standardization and commonality, and this was discussed at the levels of the program and the single project, as well as with respect to the forthcoming PLM phase.

To understand how impacts are actually being made within the program, the NPD program activities were divided into 1) technology projects, 2) concept development, 3) NPD projects, and 4) PLM. The discussions about the financial and non-financial impacts of the NPD program were categorized and analyzed, respectively (Table 2, right-hand column).

In the NPD program, applied technology research actually precedes or supports concept development and NPD activities. Due to the natural uncertainties of such research and simultaneity of research and development, there is a clear challenge in actually executing the NPD program as planned. The actual content of some of the NPD projects is dependent on the emerging outcomes of the technology development. In the NPD program, the company has chosen five technologies that the R&D team follows and develops further, in line with the objectives of the NPD program. Technology development creates new technological innovations to be adopted in the latter phases of the program.

"There [in research] it is more difficult […] there are no outputs, the output might be that we have knowledge. And I think, naturally you can't numerically measure that. […] Measurement-wise it's relevant that the project sticks with its budget and schedule, that sort of thing." (Finance, 19-12-2011)

However, as brought up by a representative of the finance department, the outcome of the technology development projects is difficult to measure and anticipate. It is important that such a project "sticks with its budget and schedule", but what is even more important is that the results are innovative and usable in the latter phases of the program, and that choices between competitive technologies are made and communicated to the rest of the program organization. In financial terms, however, technology development represents an investment with long-term impacts, but the monetary values of the choices made in technology development are typically understood only after the use of the new technologies in the products.

In the NPD program, there are concept development projects that precede the NPD projects. Several company representatives brought up how the framing of the NPD projects should be made through concept design, and this is a crucial phase, which paves the way for the actual NPD project, and for example for meeting the product cost target set for the NPD project. In the workshop, there were discussions on the roles of concept design and the output of the concept design as a starting point for the actual NPD project. The concept design is used in the case company for making major decisions concerning the product and also for providing the NPD project with a fixed product cost target. However, people were concerned about the fact that some decisions about the product cost targets were made without sufficient information. As the product concept becomes fixed in the concept development phase, it can cause harmful rigidity for the NPD project afterwards. In other words, although at the concept design phase costs are fixed, there is not yet enough information in terms of making justified decisions.

> "Well, in the concepts the cost is pretty much fixed. That's where the focus should
> be." (R&D, 18-03-2014)

Many referred to the fact that the actual interplay between concept development and NPD was immature in the company. Especially, there was a need for defining and communicating the outcome of the concept development to clearly support the NPD activities. There is a need for, e.g. finishing and testing some choices, modules, and components prior to the NPD project execution.

> "What is a challenge now is that there is the intention to make—so to speak—finished
> pieces of equipment before new product development projects for example. We're
> doing more component projects, finishing modules, tested modules that can then be
> picked into those new product development exercises to avoid having too many
> things on the risk list. To get entities more manageable." (Project Office, 20-06-2012)

As the product management is responsible for the product profitability, the impact of the NPD program can be measured as the profitability of the new product generation in the future. However, it is still a rather difficult task to identify the actual value added by the program activities and trace all the mechanisms underlying the financial impacts. As a result, the presence of multiple, rather vague objectives, such as innovation or technological leadership, can also cause trouble for NPD project execution, as was discussed earlier in the example about component costs and standardization. Indeed, the NPD project represents the interface of the NPD program to the rest of the organization:

> "This governance side […] Well, I see that our product development is a service
> function and we have the buyer–supplier relationship. Product development supplies
> and the product line buys. […] The product line clearly is responsible for business
> [...] it's a way to control that the output from product development is profitable."
> (Finance, 19-12-2011)

Moreover, because of the technology leader position of the company in the market, the culture in the NPD projects is to fulfill the customer needs and wishes to a large extent. This may cause scope changes during the NPD projects and postpone the market launch of the new product. The ambidexterity of the program and project levels is not present in the same way that the literature would suggest (Pellegrinelli et al., 2015; also van Buuren et al., 2010). The NPD projects are not merely a straightforward commercialization of the product concept, but the scope of the NPD projects

may change, and the time frame of their execution may change accordingly. In practice, the program management had to change the schedule for market launch and production ramp-up during the program due to an overly ambitious schedule at the program level. As a result, it was decided that individual new products should be launched sequentially, according to the new program schedule, to fulfill the different expectations set for the single NPD projects and the overall NPD program.

The NPD program-impact management is not completed even after the NPD projects have been completed. If an NPD project results in an immature product with options and features that had not been designed during the NPD project, these features are then designed for specific customer cases, for instance. Regarding the measurement of the NPD program impact, the value/cost of the PLM activities is not actively measured:

> "There are hundreds of projects, [in PLM] which is continuous, and which is a significant cost to us. There, control is in bad shape. It is probably quite intuitive [to select] what is done. Of course we have some needs in special projects, like we need to decrease production lead times." (Finance, 19-12-2011)

However, some impact is made when several PLM tasks are completed during the lifetime of the products. And, of course, during the lifetime of the product generation in the market, the direct financial impact of the NPD program is eventually determined.

Altogether, several activities need to contribute to the NPD program-impact realization, and the case company has clearly distinguished between those activities. However, the control and measurement of those activities may easily remain vague and relatively distant from the desired impacts. This is largely due to the uncertainties and ambiguities related to the impacts, which hamper straightforwardly managing different activities and their interfaces.

Overcoming the uncertainties and ambiguities hampering program impact management

As expected based on the literature, the studied NPD program impacts were also hampered by environmental-related, single-project-related, and organizational-complexity-related uncertainties and also definitional, operational and representational ambiguities. In line with the portfolio uncertainty literature and the complexities appearing in the NPD program, many of the uncertainties identified and discussed by the informants were related to the organizational-complexity issues. To provide a rich account of the sources of uncertainty in this case, in Table 3, the uncertainties are categorized into the three sources of uncertainty and also connected to the use of financial or non-financial impacts identified by the interviewees.

--- Insert Table 3 about here ---

The environmental uncertainty was only minimally discussed, for example with respect to the future trends in the manufacturing environment and the trends in the resource costs. There were some uncertainties stemming from single projects (or single activities within the NPD program). These appeared to be uncertainties about a single project's scope or schedule in situations where emerging issues in one part of the program led to changes in the other parts of the program. There were uncertainties about the goals of the single projects, in contrast to the overall expectations, if the single project was subject to change. There was also much discussion on the organizational-complexity and related uncertainties, especially about the uncertainties surrounding the goals and guidelines related to the program being translated into project management of a single-concept/NPD project. Uncertainties about goals were brought up both in financial and non-financial terms, thus leading to a feeling of uncertainty about accountability. It is a difficult question as to whether the manager accountable for the product cost should be the program manager, or the manager of a single-concept project, or the NPD project manager. Moreover, due to the uncertainty about goals and sometimes about their prioritization, accountability for the program and project goals remained relatively vague.

The uncertainties perceived by the managers in different roles deepen the understanding about the challenges in defining and managing the program impacts within the program. Besides uncertainty, various ambiguities were prevalent in the program in terms of multiple and conflicting interpretations, and a lack of understanding about the impacts and related uncertainties. Different

ambiguities were brought up several times during the discussions (see Table 3), the definitional ambiguities being the most commonly discussed type. Regarding the ambiguities, the focus of the discussion was on the financial impacts, probably because there can be several ambiguities related to the translation of the impact into a performance indicator in financial terms. Especially, discussions focused on the product cost and profitability as financial impacts of the NPD programs. The remarkable appearance of the definitional ambiguities may be related either to the fact that the definitions of the financial (and non-financial) impacts require much discussion in the NPD program examined, or to the fact that definitional ambiguities can be more straightforwardly brought up and observed in the discussions.

Deepening the discussion into different types of ambiguity in the NPD program context provides a detailed account of the dynamics underlying NPD program impacts and planning and controlling for those impacts during program execution. Regarding definitional ambiguity, there is a clear problem of setting targets according to the current/initial status in the early phase of the program, prior to NPD projects: "It is not so clear where the figure comes from." In the workshop, the engineers brought up how the wrong figures may be analyzed when looking at the different facets of product costs: "I think we now compare with the wrong figures, at least partially" (Engineering, 18-03-2014). There are clear differences between the prototype costs and the batch-production cost levels. More broadly, if the sales volumes are different from (lower than) the initial estimates, the costs will change (increase) accordingly. As a result, it would be beneficial to actively change the cost target according to the up-to-date understanding about the program impacts, or at least more clearly to define the calculation that is used as the actual cost (vs. the cost target).

An example of representational ambiguity in Table 3 can be connected to the discussions on accountability and also on the expected volumes and profits of the products under development. As the NPD programs are about future business opportunities (a word with perhaps positive connotations), there is a tendency toward positive estimates in terms of revenues, costs, and volumes. It is rather difficult to be in charge of an NPD project that is based on unrealistic estimates, and when the indicators and estimates do not represent the project correctly, and thus do not "reflect the reality" of the project for which the project manager is accountable for. In response to this ambiguity, more active updating, and a detailed reflecting upon the initial business impact analyses was suggested. Another example of representational ambiguity was the need to understand the "big picture" with respect to the financial and non-financial aspects of modularization and standardization in the NPD program. The justification of the modularization was difficult at the level of a single product, and the managers described how they did not have such a "good understanding" of that aspect. There were no clear indicators about the volume break-even points, after which modularization or standardization would be profitable, and it was one of the challenges within the NPD program to actually make reasonable choices to proceed toward the overall aim of increased standardization.

Operational ambiguity can be connected to the component design choices, with the desired cost savings in mind. If the component selection was made only based on the direct costs, the influence on the program impact may be negative due to the unreleased potential in terms of component standardization. As a result, the cost impacts cannot be causally explained with the help of straightforward cost implications. As noted earlier, however, detailed definitions and clear priorities of the different (seemingly competing) objectives require managerial work on a case-by-case basis.

Social process of sensemaking in program impact management

Witnessing (and also facilitating) the workshop discussions among the program stakeholders enabled access to different modes of discussion and the related forms of verbal (words) and non-verbal (e.g. laughter) expressions regarding program impact management. The expressions chosen by the informants were, of course, affected by their personalities, but analyzing the joint and individual discussions in the NPD program management at the level of the expressions used, enables a deeper understanding about the ways to enhance the NPD program management in practice. The forms of discussion were categorized into expressions of certainty/uncertainty and consensus building/destruction. For example, humor, guessing, and hesitating were coded as expressions of uncertainty, whereas reality checks, giving examples, and providing strong facts were coded as expressions of certainty. Admitting and compromising were connected to consensus building, whereas disagreement and competitive sensemaking were connected to consensus destruction.

As a generic observation, examining program impact in its social context enables a better understanding of the social process of sensemaking influencing program impact management. By examining dialogue excerpts from the case company, various forms of expressions were witnessed regarding program impacts. These expressions provide viewpoints on overcoming the ambiguities in program impact management. For example, humor (as a form of uncertainty) and competitive sensemaking (as a form of consensus destruction) seemed to shift the focus away from comfortable discussion and bring up new ideas and solutions. Table 4 illustrates the expressions used when speaking about financial and non-financial impacts.

--- Insert Table 4 about here ---

Expressions of certainty and uncertainty were used during the discussion, which confirms the idea that the program impacts represent a challenging topic that fosters discussion. The expressions of certainty took the form of reality checks and real-life examples, such as "we know the costs if we want to know the costs" (financial impacts) and component standardization is "always an increase in the costs of a single product" and should thus lead to positive (non-financial) impacts. In addition, these expressions of certainty were made to foster development and were not aimed at defending the existing NPD program-management practice. Regarding the expressions of uncertainty, the informants used humor and wondering, and they emphasized their "own opinion" to convey the idea of uncertainty related to the issue. Especially product cost targets, cost estimates, and different viewpoints toward product costs were brought up with uncertainty.

Due to the importance of the concept design in defining and also in freezing some program impacts, the engineers and other R&D representatives were worried about their ability to actually influence the program impact in the NPD project phase. The R&D people bring up this concern with humor, "[an] engineer is the kind of creature that when he has a target, he tries to go towards it," or by wondering, "Do we have a place for a disciplinary action here with regard to costs?" These expressions facilitate the consensus, i.e., joint sensemaking and agreement on what should be done to improve program impact management. The organizational culture seemed to allow the discussion through different forms of expressions to enhance the NPD program impact-management practice. Consensus building took the form of admitting, "[w]e have been let's say a bit lazy in calculating some of the product costs," or strengthening others' opinions by referring to colleagues' expressions, and by providing another, supportive viewpoint to the same issue. At the workshop, several function representatives were gathered together; therefore, it was only natural that the parties involved sought consensus and solutions to the challenges in the NPD program.

Although there was a natural aim for consensus building in terms of development ideas, there was also room for consensus destruction, especially in the form of competitive sensemaking, to ensure that alternative viewpoints were taken into account when developing the NPD program-management practice. Consensus destruction was witnessed in discussions regarding product features and their creation within the overall program context in contrast with the focus on the product costs. There were concerns about the overemphasis on the cost discipline as a primary way to gain program impacts: "[We] are speaking a lot about cost reductions … we should focus a little bit more on features that we can do for the customer." As a result, the balancing between formal, financial control of the NPD programs and the non-financial expectations is central. In addition to the issues stemming from the current NPD program, there were also alternative opinions regarding the right means with which to develop the NPD program-impact management in the company. Even if there were some uncertainty due to the lack of information, the human interaction aspects were also highlighted with competitive sensemaking: "that is a cultural change, but that has nothing to do with the tools."

Through the collective sensemaking, by allowing different forms of expressions, several timely issues were discussed regarding the NPD program impacts and their management. Due to the uncertainties and ambiguities, no straightforward solutions were (or could have been) found, but several avenues for further development were identified and preliminarily discussed. In fact, interviewees in our primary data set also recognized ways to go forward, although there were uncertainties hampering program impact. The ways were classified as guidelines, human interaction, information technology, and processes.

The parties involved in the discussions brought up the need for new guidelines for target setting and also new processes for setting clearer targets and following them during program execution. Moreover, some ideas for new costing tools and databases were brought up, respectively. However, although the financial terms were commonly used in finding ways to overcome the ambiguities, many aspects that were discussed were related to the human interaction within the NPD program management. For example, a new process of updating the business impact analyses according to changes in the business context would facilitate project management and communication within the program. In the long run, the updated business impact analyses would advance the collective skills of estimating the NPD program impacts and setting reasonable objectives for different types of R&D activities (as a change in the organizational culture).

Discussion

This paper has sought an increased understanding of managing program impacts in practice, particularly in NPD organized into multi-project programs. The results suggest that NPD program impact management takes place also between R&D activities, across single project responsibilities and may take the form of collective sensemaking among the program personnel. In particular, different financial and non-financial aspects emerge in discussions at different levels, in different phases of the program. This should be taken into account in defining and controlling NPD program impacts.

As suggested in this paper, different uncertainties and ambiguities need to be dealt with both appropriate performance indicators and through collective sensemaking. The different types of ambiguities (Englund et al., 2013), i.e., definitional, representational and operational, were helpful especially in analyzing the collective sensemaking about non-financial impacts that involve significant ambiguities from the beginning until the end of the program execution. With respect to the financial impacts, especially the definitional ambiguities i.e., defining right financial target for complex NPD programs, represent a major challenge. Thus, further research should address the wider implications of the ambiguities in program impact management practice.

One clear implication of the results of the paper is a grown need for episodic support for the (NPD) program activities, regardless of their content and actual status. Christiansen and Varnes (2008, 2009) highlight the need for sensemaking and organizational support for decision-making as a collective construction in project portfolio management. Carlile (2002), among others, has addressed boundary objects as means to overcome organization barriers in complex NPD settings. Hence, as a research implication stemming from this paper, NPD program impact management should not be limited to (or connected only to) the management of pre-defined program activities, but social processes for redefining and reconstructing NPD program impacts need to be encouraged.

How and where are (strategic) impacts managed during an NPD program?

In this paper, the understanding about the program impacts as a set of financial and non-financial performance indicators was refined. In programs, one intends to translate strategic objectives into a set of reasonable performance indicators (Shao & Müller, 2011). Typically, in NPD, one has to make some decisions without accounting figures (Davila, 2000; "strategizing" in Jørgensen & Messner, 2010). However, by carefully defining the performance indicators and revisiting them from time to time, the possibilities of being able to manage the program impact with the help of accounting and the performance indicators can be extended. Regarding the performance indicators, the priorities and interdependences of the performance indicators should be set. Especially, as NPD programs contain technology projects and subsequent NPD projects, the achievements of the technology projects (in terms of the performance indicators) should be clearly translated into performance indicators for the NPD projects.

Besides defining the desired program impacts in the form of performance indicators and their enactment, the program impact management takes place through a social process of sensemaking by the parties involved, including framing, managing, and creating the program impact (Thiry, 2002). Planning and realizing program impacts is a process, to which several parties contribute through social sensemaking (Christiansen & Varnes, 2009). Building on Thiry (2002), program management should combine the viewpoints of learning and performance, and the management should take place

in an iterative manner. Unlike in previous studies, the actual events of collective sensemaking within the NPD program were witnessed in this study, and also different forms of expressing one's ideas and opinions regarding program impact management were distinguished. As presented in this paper, the discussion on the program impacts may require both consensus building (aiming at agreement) and consensus destruction (i.e., disagreement) to be successful in making sense of the program impacts. In addition, the stakeholders of the program expressed uncertainty and certainty regarding the impacts under discussion, when needed, to reveal the challenges related to impact management, or to provide other stakeholders with their knowledge about a specific impact.

The results show that different stakeholders seem to have different viewpoints toward the program impacts. Pellegrinelli et al. (2015) argued that program-level activities should manage the ambiguities and uncertainties to enable a relatively straightforward project execution. Besides identifying several organizational complexity related uncertainties among NPD personnel, this paper suggests that different types of ambiguities may emerge at different levels, among different stakeholders, and that managing such ambiguities is at the core of managing program impacts. In fact, the program ambiguities seem to stem from the fact that in an NPD program, there are multiple levels of activities (program and project levels) and different types of subsequent activities (technology projects, concept design, and NPD projects) (cf. Maniak & Midler, 2014). As the desired impacts need to be communicated to different levels, and the results of the previous activities should serve different purposes for subsequent ones, there is a high requirement for collective sensemaking in terms of overcoming the ambiguities.

What kinds of uncertainties and ambiguities emerge as part of the program?

Uncertainties in this paper are perceived to cover the difference between the data required and the data already possessed (Thiry, 2002). In our results, because people identified considerable uncertainty about goals and their prioritization, accountability for the program and project goals remained relatively vague. Indeed, organizational complexities seemed to account for the most significant source of uncertainty with regard to program impacts in our results. This is a clear indicator for researchers to complement rational viewpoints on program management (emphasizing straightforward progression from strategy to implementation) with socially colored accounts on program management practice in which strategic viewpoints are difficult to implement and translate into project goals within program.

Ambiguity, in turn, in this paper refers to a lack of understanding (Pich et al., 2002), resulting in the need for change in the formal management systems (cf. Englund et al., 2013), for example, to attain or even extend the program impacts. To gain deeper insights into the different types of ambiguities and overcoming them through program impact management, a categorization of definitional, operational, and representational ambiguities was used (Englund et al., 2013). In this study, the different forms of ambiguities were identified and the discussions involving the different forms to overcome those ambiguities were witnessed. Both Thiry (2002) and Lehtonen and Martinsuo (2008) highlighted the need for iterations in better understanding the program at the initiation phase. In this paper, such iterative cycles were seen among the NPD program stakeholders, during the program execution, featuring different forms of expressions and processes of sensemaking in overcoming the perceived uncertainties and ambiguities.

The definitional ambiguities were quite often brought up by the stakeholders with respect to the cost estimates of the new products. Through the process of sensemaking, it was agreed that cost targets should be set with a more comprehensive description about its content. Otherwise, some stakeholders may talk about different costs, thus resulting in an ambiguity in cost estimates. Regarding representational ambiguity, it was discussed how the estimates of the costs and other impacts should be updated more often to continuously represent the desired program impact. Operational ambiguity was witnessed, as some program goals (such as standardization) implied indirect effects on the costs and profits, and those impacts cannot easily be translated into simple performance indicators. The new understanding of ambiguities in program impact management in this paper clearly adds to the research on multi-project uncertainty management (e.g. Petit & Hobbs, 2010; Martinsuo et al., 2014; Korhonen et al., 2014) by pointing out the centrality of social processes where program personnel interact around uncertainties and ambiguities regarding program impacts.

How do personnel make sense of and seek to overcome these uncertainties and ambiguities when managing program impacts?

Highlighting the need for sensemaking and iterations in a complex multi-project environment clearly supports and confirms earlier research (cf. Thiry, 2002; Christiansen & Varnes, 2009; Martinsuo, 2013; Martinsuo et al. 2014). As a novel contribution, this study has shown evidence of the actual processes of sensemaking, the different forms of expression when discussing the program impact, and ways to overcome the challenges related to them. On one hand, social sensemaking, as defined here through different forms of expression, represents a mechanism through which the program stakeholders' capabilities for intuitive decision-making are increased, and decision-making thus becomes more effective in an ambiguous, complex setting (Dayan & Elbanna, 2011; Elbanna, forthcoming). On the other hand, the process of social sensemaking as reported in this paper is an extension of the development of NPD management practice (Christiansen & Varnes, 2009), increasingly featuring use-based interpretations and feedback.

Especially in the NPD programs with several uncertainties and ambiguities, the social processes of sensemaking may even represent desired activities in terms of defining and realizing the program impacts—even beyond the expectations. Although intended ambiguities in the NPD program under analysis were not witnessed, the social sensemaking seemed to result in desired discussions about program impacts and advanced means to manage program impacts related to the processes, guidelines, information technology, and human interaction. Thus, in line with the conclusion of Thiry (2002), program management requires new tools and approaches that would actually suit complex and remarkably ambiguous settings. Particularly, program impact management would benefit from a forum for collective sensemaking to better understand the different forms of ambiguities at hand, and rules, routines, and supportive tools to jointly and individually overcome them.

Overall, discussing the process of identifying and responding to the different types of ambiguities holds two potential contributions. First, typically, managing the impact of the programs has been examined by taking snapshots from the practice through interviews (see e.g., Pellegrinelli et al., 2015). Although these studies clearly contribute to the dynamics underlying program impacts, they cannot address the evolutionary aspects of collective sensemaking in program impact management. By taking part in discussions where different types of ambiguities were first identified (through initial meetings and workshop pre-interviews) and then jointly elaborated on (in workshop discussions), the overall process of learning (cf. Thiry, 2002) about the dynamics of program impacts and finding ways to ensure their accomplishment were witnessed. Second, the categorizations of intertwined concepts of uncertainty (Petit & Hobbs, 2010) and ambiguity (Englund et al., 2013) were used together in the NPD program management context, to better understand their interplay in practice. Understanding the ambiguities in a detailed manner is of great importance in settings with uncertainty (*ex ante*), with multiple stakeholders, and with a set of intertwined activities, as in NPD program impact management. So far, Englund et al. (2013) have used their categorization of the ambiguities in the context of *ex post* performance measurement under relatively static circumstances.

Conclusions

Theoretical contributions

The findings of this paper suggest that by understanding the social processes of (collective) sensemaking, the antecedents and dynamics of (NPD) program impacts may be better understood and thus enhanced. More particularly, as an implication, an increased attention is required for the current and desired means for supporting NPD program impact management across program activities. The observed processes of collective sensemaking in the NPD program context serve as one example of such means. The paper demonstrates an evolutionary process of identifying and elaborating on the uncertainties and ambiguities hampering program impact management, and provides examples of the means through which to negotiate and overcome those ambiguities, potentially extending the actual program impact. This is especially valuable in the context of NPD program management with multiple activities and different levels of management, thus resulting in different types of ambiguities.

This paper confirms that the program impact cannot be purely rationally anticipated and managed. The ambiguities and uncertainties not only hamper program impact management, but they

also represent one starting point for the process of collective sensemaking that could potentially extend the actual impact beyond the immediate benefits. In fact, ambiguities may be both desired and unnecessary in the NPD program context, and these should be identified and managed accordingly. The paper responds to this challenge by introducing a novel approach for identifying different forms of expressions related to the uncertainties and ambiguities, and by extending our understanding about the dynamics in managing financial and non-financial impacts of the NPD programs. On one hand, without some (even desired) ambiguities and uncertainties about potential impacts, some impactful programs could fail to get the initial go-decision; on the other hand, ambiguities and uncertainties can hamper program execution and impact management once the program is initiated.

Managerial implications

The use of workshops as facilitating the collective sensemaking regarding the challenges related to the NPD program impacts is a notable example of a managerial implication. The managers might also consider how different forms of expressions take place (or are desired/allowed) in their (NPD) programs, and what could be the means to foster new kinds of discussions to overcome the ambiguities hampering the program performance.

The different facets of the financial and non-financial performance indicators should also be acknowledged by the practitioners. In NPD programs under uncertainty, there is a clear need to pay attention to the definitions of the indicators (definitional ambiguity) and to the choice of the indicators continuously representing the desired operational outcomes (representational/operational ambiguity).

Limitations and further research

Due to the exploratory nature of the case, the program impact management under examination does not represent best practice, but, the paper presents the (potentially desirable) overall process to enhance NPD program-impact management through increased attention being placed on the collective process of sensemaking. However, further research is required to better understand the different evolutionary paths of program impact management in practice. A comparison between NPD programs and other programs could be an interesting setting from this viewpoint. Moreover, further research should also address the dynamics between advanced performance indicators and collective sensemaking in terms of overcoming the ambiguities related to them: Are the advanced performance measures and the collective processes of sensemaking related to them supplementary or complementary to each other? The findings of this paper tentatively suggest that they are supplementary in nature, by highlighting the overall evolutionary process of enhancing the (NPD) program impact management.

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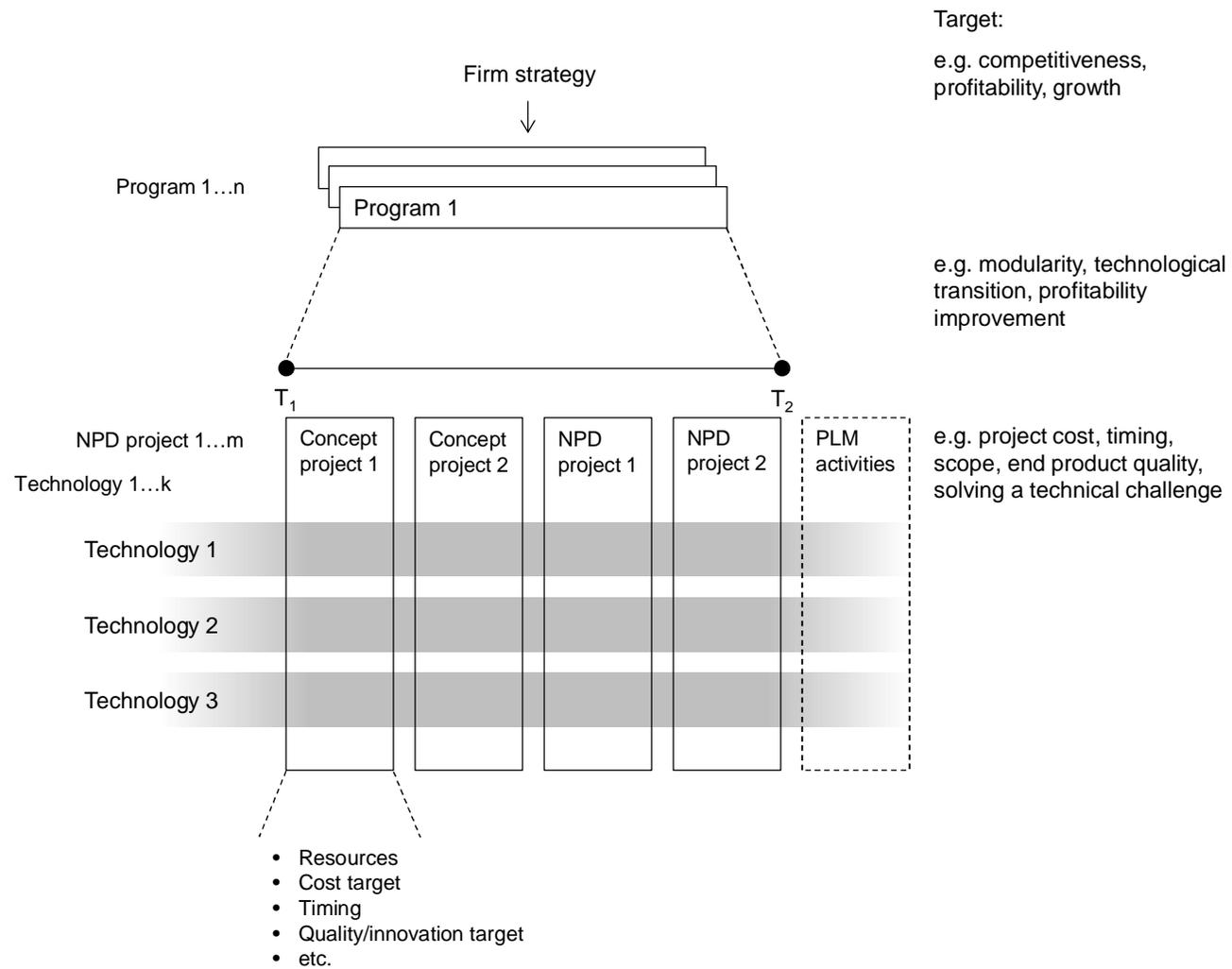Yin, R.K. (2009). Case Study Research: Design and Methods, Sage Publications.

Fig. 1. Where is the impact being made? A rough illustration of the structure of the NPD case program.

Table 1: Background for the data collection.

#	Data class	Date	Functions present	Situation	Data type
1	Primary data	December 19th 2011	Finance (1)	Semi-structured interview	Transcribed recording
2	Primary data	June 20th 2012	Engineering (1), Project office (1)	Semi-structured interview	Transcribed recording
3	Secondary data	September 25th 2012	Engineering (1), R&D (1), financial management (1)	Research project meeting	Jotted notes
4	Secondary data	October 1st 2013	Engineering (1)	Research project meeting	Jotted notes
5	Secondary data	October 1st 2013	Finance (1), Production department (1), R&D (2)	Workshop planning	Jotted notes
6	Secondary data	October 28th 2013	Project office (1, another division)	Benchmark from another division	Transcribed recording
7	Secondary data	November 28th 2013	Production department (2), R&D (1)	Workshop planning	Jotted notes
8	Secondary data	November 29th 2013	Project manager (1, another division)	Benchmark from another division	Jotted notes
9	Secondary data	January 14th 2014	Engineering (1), Production department (1)	Workshop planning	Jotted notes
10	Primary data	January 28th 2014	Engineering (2), Product management (2), Production department (2)	Pre-workshop group interview	Transcribed recording
11	Primary data	February 4th 2014	R&D (5)	Pre-workshop group interview	Transcribed recording
12	Primary data	February 11th 2014	Project office (1), R&D (4)	Pre-workshop group interview	Transcribed recording
13	Primary data	March 18th 2014	Engineering (1), Product management (1), Project office (1), R&D (3)	Workshop on "Cost management practice & project steering"	Transcribed recording
14	Secondary data	April 8th 2014	Engineering (1), Production department (1), R&D (1)	*Ex post* reflections on the workshop	Jotted notes

Table 2: Impact types mentioned from different viewpoints and in different phases.

	Viewpoint	Impacts discussed from the viewpoint	Phase	Impacts foci discussed regarding the phase
Impacts in financial terms	Strategic	Increased sales Increased sales price Lifecycle income Product cost Profitability Project cost	Technology development	Project cost
	Whole project portfolio	Product cost Profitability	Concept development	Product cost
	Program	Increased sales price Product cost Profitability Total cost	New product development	Profitability Project cost
	Single projects	Increased sales price Indirect cost effects **Product cost (mildly highlighted)** Profitability Project cost	Product lifecycle management	Profitability Project cost Total cost
	Tasks outside projects	Lifecycle income Product cost Profitability Project cost Total cost		
Impacts in non-financial terms	Strategic	Compliance to emission regulations Component commonality Customer value Market share New product acquired into offering Product features Product maintainability Modularity Product update Responding to competition Responding to customer demand Technological leadership	Technology development	Being on time Compliance to safety regulations Innovation Knowledge Which technologies would be applicable
	Whole project portfolio	Compliance to emission regulations Compliance to safety regulations Customer value Innovation Product update Responding to competition Responding to customer demand	Concept development	Knowledge Outcome as input to next projects Product features
	Program	A new machine generation Component commonality Product features Product maintainability Product safety Product update Quality	New product development	Compliance to safety regulations Innovation Knowledge Outcome as input to next projects Product features Technological leadership Which technologies would be applicable
	Single projects	Component commonality Customer value Innovation Knowledge Outcome as an input to next projects Product features Product maintainability Product safety Quality	Product lifecycle management	Compliance to safety regulations Lower production lead time Responding to competition
	Tasks outside projects	Component commonality Lower production lead time		

Table 3: Uncertainties and ambiguities spoken about in the primary data with regard to impacts (mentioned uncertainties and ambiguities with particular foci highlighted).

	Uncertainties regarding program impact	*Ambiguities regarding program impact*
Impacts in financial terms	***Environmental uncertainty*** Uncertainty about cost-reduction rate Uncertainty about future manufacturing principles ***Organizational-complexity-related uncertainty*** **Uncertainty about accountability (mildly highlighted)** Uncertainty about accounting object Uncertainty about calculation scope Uncertainty about future organizing Uncertainty about goal prioritization **Uncertainty about goals (mildly highlighted)** **Uncertainty about guidelines (mildly highlighted)** Uncertainty about internal communication Uncertainty about learning curve Uncertainty about measure relevance Uncertainty about outcome Uncertainty about purchasing Uncertainty about resourcing consequences Uncertainty about stakeholder viewpoints required Uncertainty about what lies behind figures ***Uncertainty stemming from single projects (or programs)*** Uncertainty about goal division into sub-goals Uncertainty about impact comparison object Uncertainty about project scope Uncertainty about schedule	***Definitional ambiguities*:** **Strongly highlighted** Example: "The problem is there that how the target cost is set. It's not so clear where the figure comes from. And it's difficult for engineering really to find ways to go to the target cost because we don't know really where this figure comes from." (R&D, 04-02-2014) ***Operational ambiguities:*** **Mildly highlighted** Example: "Is it really wise to standardize the main steel structures? I don't know." (Product management, 28-01-2014) ***Representational ambiguities:*** Mentioned Example: "How much is that in a percentage?" (Engineering, 28-01-2014)
Impacts in non-financial terms	***Environmental uncertainty*** (Not mentioned) ***Organizational-complexity-related uncertainty*** Uncertainty about accountability Uncertainty about goal prioritization **Uncertainty about goals (mildly highlighted)** Uncertainty about guidelines Uncertainty about internal communication Uncertainty about measure relevance Uncertainty about outcome Uncertainty about purchasing Uncertainty about resourcing consequences Uncertainty about stakeholder viewpoints required ***Uncertainty stemming from single projects (or programs)*** Uncertainty about project scope Uncertainty about schedule	***Definitional ambiguities*:** Mentioned Example: "Indeed, engineering must then be able to—in a way against it when the feature has been specified—find out the thingies that belong there. [...] Then when it's only a small volume, then what is its significance? Is it a terrible problem in manufacturing? Or in something else? How should it be priced?" (R&D, 11-02-2014) ***Operational ambiguities:*** Mentioned Example: "And the modularization is something else, we have to look at the big picture, and it's not so easy at the moment to really justify that why the hell we have to do this, so that it's ok for that product and that product and that product and that product. And we don't have so good an understanding about that." (R&D, 04-02-2014) ***Representational ambiguities:*** Mentioned Example: "Actually we have one good example from harmonization-modularization from one component [...] we can't basically let's say make numbers: has it saved money or not? We can't say that one. We only know that those components costs are now higher and those are lower, but we don't know what the overall result is." (R&D, 04-02-2014)

Table 4: Expressions used when speaking about impacts (mentioned ambiguities with particular foci highlighted).

		Expressions of certainty	*Expressions of uncertainty*	*Expressions of consensus building*	*Expressions of consensus destruction*
Impacts in financial terms	Foci	Giving a real-life example **Reality check (mildly highlighted)** Strong fact	Guessing Hesitation **Humor (mildly highlighted)** **Own opinion (mildly highlighted)** Taboo **Wondering (mildly highlighted)**	**Admitting (mildly highlighted)** Compromising Conclusion Consensus building **Strengthening others' opinions (mildly highlighted)**	**Competitive sensemaking (mildly highlighted)** Disagreement
	Examples	**Giving a real-life example:** "We do have to make the purchasing decision for some of the components already way before the gate two." (R&D, 18-03-2014) **Reality check:** "When you measure the project managers about schedule and project budget at some point, they just know the stuff then. It's not rocket science." (Finance, 19-12-2011) "What I'm referring to here, we know the cost if we want to know the costs." (Engineering, 28-01-2014)	**Humor:** "The starting point is kind of shaky. You don't know even the comparison level [...] An engineer is the kind of a creature that when he has a target, he tries to go towards it [timid, dark laughter]." (R&D, 11-02-2014) **Own opinion:** "I see that the discussion in the area of cost is increasing. [...] I don't know the reason for that but it's how I see it." (R&D, 04-02-2014) **Wondering:** "Well, here we have a good question. Do we have a place for disciplinary action here, with regard to costs?" (R&D, 18-03-2014)	**Admitting:** "We have been let's say a little bit lazy in calculating some of the product costs." (R&D, 04-02-2014) **Compromising:** "I don't think that they [technical and cost perspectives] exclude each other … no of course not … but we just have to know what we are doing" (Production department, 28-01-2014) **Strengthening others' opinions:** "When choosing the alternative designs there the costs are not the driver as [a colleague from the same function] said." (Production department, 28-01-2014)	**Competitive sensemaking:** "So I think our main problem here is that we cannot predict the right cost beforehand." (Product management, 28-01-2014) "I agree that this is [about] mindset as well, so that is a cultural change, but that has nothing to do with the tools." (Engineering, 28-01-2014) **Disagreement:** "I don't see that the modular structure itself reduces the labor hours but it gives the possibility to reduce the lead time" (Production department, 28-01-2014)
Impacts in non-financial terms	Foci	Giving a real-life example **Reality check (mildly highlighted)** Strong fact	Guessing Hesitation Humor **Own opinion (mildly highlighted)** Wondering	Admitting Compromising Conclusion Consensus building Strengthening others' opinions	**Competitive sensemaking (strongly highlighted)** Disagreement
	Examples	**Giving a real-life example:** "If the project is late six months, it surely is noticed when the competitor potentially sells six months earlier or longer its number-one product that we can't yet respond to." (Finance, 19-12-2011) **Reality check:** "I don't know any example that we would have had courage to go and standardize components. Because it's always an increase in the costs of a single product. If an engineer wants personal merit, he attempts to choose the cheapest component that supposedly makes him succeed in that project." (R&D, 11-02-2014)	**Hesitation:** "I see that we have a strategy, at least in the ideal world it's so that we have the strategy and from that you derive targets for the product line [...] And that way it flows down to project-level targets, or actually to portfolio management" (Finance, 19-12-2011) **Own opinion:** "It would be great to update the business plan also because of external factors [...]" (Finance, 19-12-2011) **Wondering:** "But what's the effect of modularization and standardization?" (R&D, 02-04-2014)	**Strengthening others' opinions:** "But that's definitely the most important discussion in the workshops, that of how we set the target cost and how we relate that to the features of the product." (R&D, 04-02-2014) **Consensus building:** "That's it. It's now at a point where competitors are outstripping it. We have to do something about it." (R&D, 11-02-2014)	**Competitive sensemaking:** "Maybe the question is do we have some features in our units that actually customers are not paying for, they are not willing to pay for them, we just add them [features]." (Engineering, 28-01-2014) "I would like to have slightly different discussions or lead a discussion in a different direction. We are speaking a lot about cost reductions and that's kind of a negative feeling when you are speaking about that and shrinking your possibilities to do things here. And we should focus a little bit more on features that we can do for the customer" (R&D, 04-02-2014)