UNCERTAINTIES AND DYNAMICS IN THE PRACTICE OF INNOVATION PROJECT PORTFOLIO MANAGEMENT

Miia Martinsuo and Lauri Vuorinen
Tampere University, Department of Industrial Engineering and Management
miia.martinsuo@tuni.fi

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ABSTRACT

Innovation project portfolios face uncertainties and require dynamic approaches to management practice. The uncertainties are the most prevalent in firms that promote innovativeness in their strategies. Previous studies on the practice of innovation project portfolio management have not offered sufficient evidence on the conditions of high innovativeness. This study explores the practice of innovation project portfolio management, with the aim to identify patterns of managing uncertainty at the level of the portfolio specifically in highly innovative contexts. A qualitative case study research is implemented in two innovative companies in the construction and software industries. The findings reveal the uncertainties and related practices of innovation portfolio management during planning and managing the portfolio. Innovative firms discover and also cause uncertainties in the routine processes of IPPM. Idea sourcing, dynamic cross-project competition, and resource dynamics are revealed as possible mechanisms for managing uncertainty, particularly visible in the highly innovative firms. The study contributes by summing up the core dimensions of IPPM practice and showing evidence of uncertainty management in IPPM in highly innovative contexts.

Keywords: innovation portfolio, portfolio management, uncertainty

INTRODUCTION

Organizations implement innovation project portfolio management (IPPM) to reach strategic goals and to renew their business (Cooper et al., 1999). Researchers and practitioners have developed various processes and techniques to offer tools for managers for this pursuit (Archer & Ghasemzadeh, 1999; Dye & Pennypacker, 1999; PMI 2008, 2016). Innovation project portfolios, however, are very sensitive to the uncertainty of business (Martinsuo et al., 2014), and managers need flexibility, intuition and even improvisation in managing the portfolios (Jerbrant & Karrbom Gustavsson, 2013; Kester et al., 2009; 2011). Consequently, some studies have suggested a need to account for the contextuality of project portfolio management (PPM) (Martinsuo, 2013), and the ways in which strategies are translated to portfolios of projects in practice (Clegg et al., 2018). This study builds on this practice-centric view to IPPM, with specific focus on uncertainties and dynamics experienced by personnel involved with IPPM.

Previous research has already paid attention to the needs for changes in the innovation project portfolio. Some studies point out the importance of agility at the level of the portfolio: the need for the firm to adapt the innovation portfolio flexibly, if the business environment changes (Kester et al., 2011; 2014; Kock & Gemünden, 2016). As project portfolios exist in uncertain and dynamic environments, managers

need awareness of this uncertainty, to seize the opportunities and apply related changes to reconfigure the portfolio (Petit, 2012; Petit & Hobbs, 2010). However, uncertainties do not stem only from the external environment, but they may also appear within the parent organization and emerge bottom-up from single projects (Korhonen et al., 2014; Martinsuo et al., 2014), requiring portfolio managers' attention and action.

The practice of IPPM deals with what managers and other personnel do and how, in planning, selecting, steering, and implementing the portfolio. Some studies focus on the actions of managers – i.e., level of practice - in improvising and negotiation, when making decisions concerning the innovation portfolio or solving day-to-day issues in it (Blichfeldt & Eskerod, 2008; Christiansen & Varnes, 2008; Jerbrant & Karrbom Gustavsson, 2013). Managers appear to use somewhat different controls, to deal with uncertainties (Korhonen et al., 2014). When working in multi-project settings, project managers and personnel may alter their routines to survive project overload and, consequently, face new challenges (Karrbom Gustavsson, 2016). Such research draws attention to managers' daily actions associated with the dynamics in innovation project portfolios, and more practice-centric research has been called for (Clegg et al., 2018; Martinsuo, 2013; Martinsuo et al., 2019).

While previous research has already offered rich case descriptions and inspiring evidence on the practice of IPPM in various contexts, it has two relevant limitations that motivate this study. First, the previous research dominantly deals with large firms and, potentially, one or more portfolios within them, with an unclear link from the portfolio(s) to the firms' strategies (e.g. Blichfeldt & Eskerod, 2008; Christiansen & Varnes, 2008; Korhonen et al., 2014; Martinsuo et al., 2014; Petit, 2012; Petit & Hobbs, 2010). With large firms, the multiple different portfolios may represent quite different sub-strategies within the firm. As portfolios are managed to implement or renew the firm's strategy, there is a need to understand the portfolio and the uncertainties faced in its management more directly in light of the specific strategy. Second, the previous studies have had a rather open-ended approach to selecting the case firms and contexts, and an exploratory or descriptive orientation. However, to learn from successful firms, there would be a need to understand the IPPM practice in more specifically delimited conditions, such as those concerning high degrees of innovativeness. While the study of Jerbrant & Karrbom Gustavsson (2013), for example, has been carried out in medium-sized firms, the strategy-link remains unclear and the cases have not been selected with innovativeness or uncertain context in mind.

This study has a particular interest in highly innovative firms that use their innovation portfolio to renew the firm and, potentially, to drive renewal in the industry. These kinds of extreme contexts can potentially be informative concerning innovation portfolios that not just implement but also renew firm strategies. The purpose is to explore the practice of IPPM in these highly innovative contexts. The objective in this study is to identify the patterns of managing uncertainty in IPPM, and the focus is on the following research question:

H*ow do highly innovative firms manage uncertainties in the practice of IPPM*?

With this study, we intend to add to the ongoing scientific discussion concerning uncertainties in IPPM, and the practice of managing innovation portfolios. We want to develop understanding on how the high degree of innovativeness may be reflected into IPPM uncertainties and practice in firms from different industries. This study is delimited to highly innovative organizations (according to their strategy and market position) operating on dynamic markets where changes are ordinary. The empirical study concerns business-to-business firms, not the consumer sector.

The paper is structured as follows. Next, previous research on the uncertainties and dynamics in IPPM is reviewed, and a summary of key issues concerning the practice of IPPM is offered. Then, we introduce the qualitative two-case research design and ConstructionCo and SoftwareCo as the highly innovative medium-sized companies, with fairly small innovation portfolios as the context for studying the practice of IPPM. The results section reports the uncertainties and practices of planning and managing the innovation portfolios across the two case firms. We show that innovative firms discover and also cause uncertainties in their routine IPPM processes. Possible mechanisms for managing uncertainty are shown in terms of idea sourcing, cross-project competition, and resource dynamics. Finally, the contributions and managerial implications are summarized, and limitations and ideas for forthcoming research are discussed.

LITERATURE REVIEW

From formal techniques to practice in innovation project portfolio management

A significant amount of previous research has mapped and tested such techniques that can explain PPM success. For example, standards and bodies of knowledge list specific structures, governance bodies and actor roles, and techniques for assessing and planning projects, selecting and prioritizing projects, controlling and optimizing the portfolio (PMI 2008, 2016). Also, the early studies on PPM success have identified various techniques and processes for the purposes of driving PPM success, including the assessment and prioritization of projects in line with strategy (Cooper et al., 1999; Dye & Pennypacker, 1999).

Many studies, however, have pointed out that it is not specific techniques as such that explain success, but rather the way in which managers use those techniques. For example, Martinsuo & Lehtonen (2007) cover goal setting, availability of information and systematic decision making as antecedents of portfolio management efficiency - not the specific techniques used for them. Jonas et al. (2013) draw attention to management quality as the nature of the processes in which the techniques are applied. Similarly, Unger et al. (2012) use the concept of PPM quality as an antecedent to success, with influence from various project management office related routines, and Kock and Gemünden (2016) focus on decision making quality in IPPM. While the various PPM techniques may represent good practices learned over time, it is in fact the situation-specific practice of PPM that matters for success.

This study follows the practice-centric view to PPM and acknowledges the need to understand it also in the specific contexts of the portfolios. Martinsuo (2013) reviewed previous research and pointed out the need to apply project portfolio management appropriately to the specific situations and contexts faced in the portfolios. A contingency view is generally acknowledged and accepted in PPM research, testing the success implications of certain PPM practices across different contexts (e.g. Kock et al., 2016; Müller et al., 2008; Voss & Kock, 2013). However, it is not sufficient to consider contingencies only cross-sectionally regarding the portfolio as a whole. Additionally, there is a need to understand uncertainties, risks and changes as experienced in the dynamic circumstances faced as part of the portfolio (Martinsuo, 2013) and evolving over time.

Uncertainties, dynamics and related practices in IPPM

Previous studies draw attention to what managers actually do (instead of describing what the portfolio management approach is officially), when implementing IPPM in certain circumstances. The general understanding is that strategy is supposed to guide

the definition and selection of the project portfolio and assessing its situation as a whole (Archer & Ghasemzadeh, 1999; Dye & Pennypacker, 1999; Cooper et al., 1999), and strategic alignment, value and balance have consequently been used in empirical studies as dominant success measures concerning PPM. However, research points out the possibility of path-dependency, i.e., managers' tendency to select portfolios based on previous choices and commitments (e.g. Aaltonen, 2010). Path-dependency implies that the portfolio builds on the past, it reflects the difficulty of terminating projects, despite their problems, and possibly a reluctance to seize novel, risky possibilities. In a similar way, research also acknowledges the emergence of novel strategies and intentional modification and even disruption of the portfolio, in light of managers' anticipation of the future (Kopmann et al. 2017a, b; Midler, 2013). These studies reveal how the innovation project portfolio takes shape, evolves and connects with strategy, and also identify the importance of actions as part of managing and steering the portfolio.

Through the contextuality of portfolios, PPM studies have increasingly paid attention to how managers deal with uncertainties and changes, due to the dynamic, evolving contexts typical to innovation portfolios. Some studies concentrate on the choices and decisions of what is done in the portfolio, i.e., portfolio planning. For example, the case studies of Petit (2012; Petit & Hobbs, 2010) portray PPM as a dynamic capability that deals with how managers take into account the uncertain environment (also Killen & Hunt, 2010). Such studies show evidence of the types of changes that occur concerning project portfolios, managers' sensing activities to identify changes in the business environment (Petit & Hobbs, 2010), and ways to seize the opportunities and possibilities as part of business models and governance choices (Petit, 2012). Martinsuo et al. (2014) differentiate the portfolio uncertainties to those stemming from the environment, parent organization's complexity and single projects and reveal how managers frame them differently as threats, neutral and opportunities. The framing, in their study, is reflected also in the managers' responses to uncertainties: rational, structural, or cultural and political (Martinsuo et al., 2014). Furthermore, due to the social nature of decision making, the negotiated decision making in PPM has been emphasized (Blichfeldt & Eskerod, 2008; Christiansen & Varnes, 2008). Instead of rationality based on evidence only, the decision processes may combine evidence, power and opinions (Kester et al., 2011) and even include bargaining (Martinsuo, 2013).

As the uncertainties in the context of the portfolio, hereby, link directly with managers' sensemaking and negotiation processes that goes on continuously, also the micro-level actions concerning later modifications and changes in the portfolio deserve attention. Petit (2012) discusses reconfiguring, i.e., changes in the portfolio in terms of what is done and how resources are allocated. He also acknowledges the possibility to transform the portfolio management processes, due to the experienced changes. Some researchers characterize how the managers deviate from the official PPM systems and routines due to specific circumstances and improvise, to solve situation-specific issues in a flexible manner (Jerbrant & Karrbom Gustavsson, 2013). Due to their unique perspectives, different managers may apply different approaches to controlling the portfolio, potentially causing challenges to their interactive negotiation and collaboration processes (Korhonen et al., 2014). Karrbom Gustavsson (2016) specifically point out that it is not just managers but personnel more broadly who face the different situations concerning portfolios and may adjust and alter their routines, to survive the possible multi-project overload. She discusses disruptions from the environment and various "narrowing strategies" as ways to isolate projects from the

external influences. These are examples of empirical studies that clearly reveal the dynamic and challenging character of managing the evolving portfolios in practice.

Figure 1 summarizes some key issues identified in previous research, concerning the practice of IPPM in context. As the empirical evidence very typically focuses on one specific issue only, this study attempts to view practices regarding IPPM dynamics more holistically, primarily concerning planning and managing the portfolio.

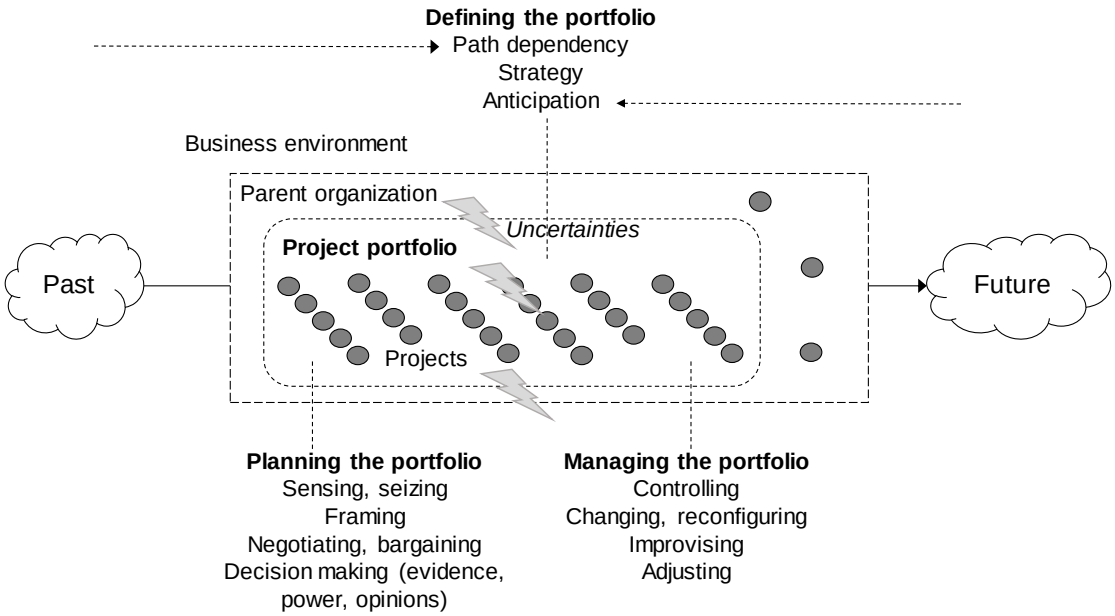

Figure 1. Summary of key issues in the practice of IPPM in context, based on previous research.

RESEARCH METHOD

Research design and cases

Due to the exploratory nature, a qualitative multiple case study strategy was used in this research. Case study can be considered as a good means to understand the practice of IPPM in a real-life context (in line with Yin, 2009), and a two-case study was designed to enable comparison across cases. Each case is studied as an entity and they are then compared, to identify context-specific issues and to enable replication.

As a search criterion, we focused on highly innovative, growth-oriented organizations that represent a dynamic context and acknowledged innovativeness in their industry. We focused on project-based organizations that both carry out project business and implement their innovation activities as projects and, thereby, would have an active innovation project portfolio. Furthermore, we sought for medium-sized organizations, in order to be able to focus on the firms' innovation activities holistically, through the strategic innovation project portfolio (i.e., one innovation portfolio per firm). With these search criteria, we came up with two firms representing different industries, to enable cross-case comparison. We will refer to these firms as ConstructionCo and SoftwareCo. Some background information of the firms and their innovation projects is presented in Table 1. Both companies have grown fairly fast and continue to grow and hire new talents. Both have recently developed innovative solutions and have established innovation strategies for the future.

Table 1. Background information of the case companies.

	ConstructionCo	**SoftwareCo**
Industry and business type	• Construction and related services and software • Project-based	• Software solutions • Project-based
Net sales 2017	>200 MEUR	>50 MEUR
No. of employees	>250	>400
Nature of the innovation projects	• Focused on innovative business models and new business openings	• Focused on product development, patenting and creating new intellectual property rights (IPR)
Management of the innovation projects	• Processes considered vaguely defined or under development by the interviewees • Frameworks under development for the ideation phase and the implementation phase	• Processes considered well defined by the interviewees • Frameworks in use for the ideation phase, the implementation phase and the patenting and IPR process

ConstructionCo offers solutions, services and software for the construction industry, both in commercial construction and private sector (housing and renovations). Their approach is very innovative as they perceive construction "as a service", instead of "assembly", and they strive for leadership in service and software business in the construction industry. The company has received external funding for their innovation activities and consider innovation as a strategic process. Their business is divided into three main areas: construction, services, and smart solutions. ConstructionCo wants to be perceived as visionary in the very conservative construction industry, and they have established an innovation-oriented strategy, reflected also in the definition of related management roles.

SoftwareCo sells, develops and implements software for other firms and organizations in a business-to-business market. They have a very innovative core product that they use for tailoring and versioning for different uses. The company has various technology partners with whom they develop compatible software solutions. They also offer technical support, consultancy services and training related to their solutions. The company's core product was a major innovation when it was first released, and it still is, compared to their competitors. SoftwareCo released a new, innovative artificial intelligence based feature to their core product recently. The company has received several awards and recognitions for being innovative and visionary in their field. It is also among the fastest growing European companies in its industry.

Data collection

Data were collected through interviews. Purposive sampling was used when choosing the interviewees, with the intent to gain first-hand experience and knowledge about the IPPM activities in the firms at the different levels of the innovations. Each case company's contact person helped with identifying suitable persons for the interviews and arranging the interview dates. All the interviews were held face-to-face except for one telephone interview.

The interviewees were mainly manager-level people, but also some project-level personnel participated to bring in different viewpoints. The interviews lasted from 26 minutes to 93 minutes (average 62 minutes). Table 2 summarizes the interviewees' background and interview data.

Table 2. Interview data in the case companies.

	ConstructionCo	**SoftwareCo**
No. of interviews	6	4
Interviewees' job profiles	Business developer, business development team lead, Chief Innovation Officer, Chief Technology Officer, development engineer, group product manager, Vice President of R&D, team lead	
Average duration of interviews	60min (29-93min)	55min (46-59min)

An interview outline was developed in collaboration with a partner team in another university implementing a similar research with different types of companies. The outline was then translated to the interviewees' native language. The interview had an informal start where some background information about the research was shared. Then, the interviewee's job position and overview to the interviewee's experiences concerning IPPM were first inquired. The interview outline included themes concerning: the innovation context and strategy; systems of innovation governance (including projects, portfolios and programs); innovation processes; connections between the governance levels (projects, portfolios, programs, and firm); further comments about the entire interview. More detailed sub-questions and themes were included in the thematic interview outline and prompted from interviewees, upon need. Despite the structured thematic outline, the questions were discussed in a flexible order with the interviewees, depending on the issues emerging based on the interviewees' experience. The interviews were recorded and transcribed. The researcher also took notes and transcribed them for verification purposes.

Data analysis

The transcribed interviews were coded following a systematic, qualitative content coding approach. Before the actual coding, we summarized the overall understand about the nature of innovation projects and IPPM in the case companies.

The focus of the coding was on two main aspects of IPPM: uncertainties in innovation projects and the related IPPM practices. The coding was mainly inductive. Regarding uncertainties, we sought for any occasions where some characteristics of projects faced change pressures through uncertainties (e.g., resource requirements, project scope, project progress or strategic alignment), and how different project and portfolio actors reacted to those uncertainties. Regarding practices, we coded the different practices at place in the companies or the lack of practices described by the interviewees, as they related to the mentioned uncertainties (e.g., processes for project evaluation).

After coding, case-specific narratives were written and a cross-case comparison was conducted. The findings section presents a thematic analysis result, combining the main issues from both the cases. Following the logic of Figure 1, the results are divided into uncertainties and practices for planning the portfolio, and for managing the portfolio.

As a partial validation task, preliminary case-specific results from the interviews were reported to each firm's contact person, with the intent of verifying the findings and possibly adding further information upon need. At this point, no content-related corrections were requested by the contact persons.

FINDINGS

Innovation project portfolios in the case companies

Both companies organize their innovation projects in a single project portfolio. In ConstructionCo, the focus of the innovation project portfolio is on innovative business models and new business openings. In SoftwareCo, the innovation project portfolio is strongly focused on the company's core product and product development. Both companies conduct also smaller development tasks that are not included in the innovation project portfolios.

In both companies, there are some guidelines or project management frameworks instructing innovation project management. In ConstructionCo, more systematic approaches have been developed recently, due to a significantly growing investment into innovation projects. In SoftwareCo, a typical (as perceived by the interviewees) agile approach to product development project management is followed.

Both companies, according to the interviewees, considered themselves relatively innovative (with respect to the industry). In addition to the interviewees' perceptions, innovativeness is evident in the companies' external communication (e.g., marketing material).

Uncertainties and practices in planning the innovation portfolio

In both companies, the interviewees identified several sources for project ideas. The most mentioned examples included both the company personnel and external actors such as customers, suppliers and other partners. The interviewees of both companies described an open and supportive atmosphere for innovation and development. There is a relatively flat organizational structure in both companies and the interviewees described how it is easy for anyone to be heard. For example in SoftwareCo:

> *We can quickly familiarize ourselves with some new thing [e.g., a new technology]. We can try it out a bit and then decide, whether it should be studied further or not.* (SoftwareCo)

In addition, both companies try to actively identify project ideas from the environment. Due to the nature of its business, SoftwareCo interviewees mentioned different expert reports and analyses as ways to follow the technological development of the industry. In both companies, even more in ConstructionCo, the role of the top management was discussed. The interviewees described how networking and participation in different events by the top management (e.g., the CEO) can bring new ideas for innovative projects. For example:

> *The top management has lots of discussions with investors and start-up companies and other companies in our industry about the future.* (ConstructionCo)

In ConstructionCo, there is also a formal structure for creating partnerships with potential collaborators, especially individuals or startup companies. In this initiative, a potential partner can propose a collaboration idea for ConstructionCo. If the idea is

considered relevant, a collaboration structure can be initiated. As an interviewee described this partnership scheme:

> *It is a channel where we want to find other companies to work with us. And find individuals with ideas of the problems they would like to work on together with us.* (ConstructionCo)

Despite the similarities in the open and supportive atmosphere and the various sources for project ideas, a key difference between the companies was the level of systematics in identifying and collecting project ideas. This issue was considered significantly more problematic in ConstructionCo than in SoftwareCo.

In ConstructionCo, the interviewees described a lack of systematics in creating and selecting new projects. The interviewees emphasized how project ideas could originate from various sources, but there was no process or IT solution for collecting, storing and evaluating those ideas. In particular, whether a project idea was taken into consideration for implementation was often considered somewhat person-dependent. This challenge was described by the interviewees for example in this way:

> *We don't really have any place for those development ideas. It is typically so that an employee discusses an idea with his/her supervisor, then it is up to this supervisor whether anything happens.*
>
> *Getting your idea to progress is more based on that you know the right people and talk with them; it is kind of an informal influence channel. -- In practice it can be more like that "hey, can we include this issue as well?", even if we have those official processes for decision-making, there are also these informal aspects.* (ConstructionCo)

In contrast to ConstructionCo, SoftwareCo uses a systematic method (i.e., an IT solution) for collecting and storing project ideas. They also have regular innovation events to facilitate the development of new project ideas. The interviewees described how all project ideas regardless of their source are stored in the system:

> *What works well is that we have a very transparent way for storing the development ideas. I mean, anyone can save their ideas. -- Compared to some larger corporation, here you can really see your own ideas in the end product, regardless of your role in the organization.* (SoftwareCo)

However, even with the systematic approach for collecting the project ideas, the transparency can be reduced later. As the same interviewee continued: *"The person who saved the idea would like to get some information about what is happening".*

In both companies, some comments about the uncertainty of evaluating project ideas were made. In SoftwareCo, the key question is the prioritization of project ideas (especially product features). This evaluation is largely based on the product managers' and product management's expertise. The interviewees explained how there can be numerous competing development ideas that require prioritization by the product management and the product managers:

> *It is the product manager's task to participate in those discussions [comparing the competing project ideas], to facilitate the discussions and to create her best view of what will be done next. Sometimes there are some larger innovations or projects which are led more from top to down as well.* (SoftwareCo)

Goal setting was perceived differently at the level of the overall innovation project portfolios and the individual projects. Goal setting at the portfolio level was considered relatively clear in both companies. For instance in SoftwareCo, the interviewees perceived that the product strategy was guiding the innovation project portfolio in a clear way:

> *Our innovation activities of course mirror the corporate and product strategy.* (SoftwareCo)

The relationship between the portfolio and the project level was considered more challenging in both companies, especially ConstructionCo. The interviewees described "a level missing between the two" and discussed how it could be difficult to translate the overall visions and strategies at the portfolio levels to the goals of individual projects. In addition, the company has received significant external funding for its innovation projects. Rules for utilizing that money have been formulated, but it was still not considered self-evident, what kinds of activities should be funded with that money:

> *It is not completely clear what we want to fund with that money. The goal is [the defined goal of the external funding]; if some innovation activities are not considered relevant, they might have to compete for funding in other budgets.* (ConstructionCo)

In SoftwareCo, the issues of linking the product strategy (i.e., the portfolio level) and the project goals were emphasized less than in ConstructionCo. However, the interviewees perceived the product strategy somewhat general or high-level at times, and discussed the challenge of prioritizing projects. In addition, the importance of focusing on defining the project scope at the project front end was discussed. As an interviewee described:

> *The idea is that we define clearly, facilitated by the product management or a product manager, what is it that we are going to do. – Project scope can of course be adjusted later, but the first version should be defined in quite a detailed way.* (SoftwareCo)

Uncertainties and practices in managing the innovation portfolio

Regarding the management of ongoing projects, there are clear processes for monitoring the innovation project portfolio in both companies. In SoftwareCo, an agile approach (Scrum) to software development is followed. Following this approach, projects are reviewed biweekly. In ConstructionCo, the approach is quite similar.

In addition to the biweekly reviews, ConstructionCo has divided the lifecycles of innovation projects into three phases: discovery, go to market and scale phase. If everything goes perfectly according to plan, projects are reviewed biweekly and they progress through the three phases from small analyses to a full-size market solution. However, the interviewees described several situations where plans can be altered or projects can even be terminated. The interviewees emphasized also how it is not self-evident at all, that a project will be allowed to continue to the next phase: *"Project funding is granted only for one phase. After that, there will be a new review and a new investment decision."*

Regarding deviations from plans, problems or needs for changes in projects can be identified either in the biweekly review meetings or at the milestones between the three project phases. Typical responses include the allocation of additional resources to

support the project, or the modification of the original project plans. Two example projects discussed by the interviewees illustrate these aspects:

> *[regarding an ongoing innovation project] after the discovery phase there would be the go to market phase. But then it was decided to divide this project into two. The broader productization project was returned to the discovery phase for further development, but the more practical demo case was allowed to continue to the next phase.* (ConstructionCo)

> *We have, for example, terminated one ERP project. After requirements specification the cost of the project started to grow so much that it was decided to kill the project. And then also a more modern system appeared and we have now introduced that system.* (ConstructionCo)

There were some statements about the potentially conflicting expectations faced by the project managers in ConstructionCo as well. There can be occasions, where the feedback from the management group, the business unit representatives and the members of a project-level steering group are not aligned. This can require difficult improvisation and compromises from the project managers. As an interviewee described this aspect:

> *It can decrease the motivation of the project manager, if she doesn't know who she should listen to and what is the most important issue at the moment.* (ConstructionCo)

In SoftwareCo, two main issues discussed by the interviewees were project prioritization and project scope alterations. Even if these are changes to plans, all interviewees considered these more as "part of project management or product development" than real challenges or problems. As the interviewees described these aspects:

> *Of course re-prioritization takes place all the time; that is, it is decided that now some other project is more important than this one and then we might stop this project for a couple of months.*

> *It is a typical feature of product development that project scope can change. Project scope can increase or reduce or…it is quite normal.* (SoftwareCo)

The interviewees emphasized also the issues of resource estimation and allocation. The limited availability of development resources can affect the scheduling of the innovation portfolio and it can be challenging to estimate the schedules and resource needs at the project front end. As the interviewees discussed these aspects:

> *Then we estimate the resource requirements. And that resource estimate can, of course, affect whether this project will be implemented now or later.* (SoftwareCo)

> *What can sometimes be challenging is that there are resource constraints and schedule pressures. It requires quite a strong focus, there isn't always time for a project even if the idea was good.* (SoftwareCo)

Cross-case summary
The main findings are summarized in Table 3.

Table 3. Sources of uncertainty, and practices of innovation project portfolio management in the case companies.

Phase of IPPM	Sources of uncertainty	Practices and experiences in the case companies
Planning the portfolio	- How are different sources for project ideas utilized?	- Events for innovation project ideation (both companies).
		- Top management's role in sensing the external environment (both companies).
		- Systematic procedures for identifying and creating partnerships (ConstructionCo).
	- How are project ideas collected?	- A systematic IT solution (SoftwareCo) vs. lack of systematics and some issues of person dependence (ConstructionCo).
	- How are project ideas evaluated and planned?	- Aligning project goals to portfolio goals (both companies), and evaluating the value of innovation project ideas (esp. ConstructionCo).
		- Project scope definitions considered highly important and project resource estimations highly difficult (SoftwareCo).
Managing the portfolio	- How are innovation projects progressing?	- Project monitoring as part of the project management model (both companies).
	- Are the goals of a project still valuable?	- Project scope modifications (both companies) or terminations (esp. ConstructionCo) if needed.
	- How should competing projects be prioritized?	- Changing project priorities considered part of the everyday work (SoftwareCo).
	- How are competing projects resourced?	- Some difficulties in reallocating resources to different projects (both companies).

In planning the innovation project portfolio, the uncertainties stem from the organization's ways of identifying, selecting and evaluating innovation projects. Regarding project identification and selection, various external sources for project ideas were identified and some internal events promoting idea generation are at place in both companies. It is uncertain which ideas are filtered into the decision making processes. Especially in ConstructionCo, there are some issues in collecting project ideas in a systematic way. Regarding project evaluation, interviewees of both companies discussed some challenges in linking the more high-level goals of the innovation project portfolio to the goals of the individual projects. Defining the scopes for projects, specifying their resource needs, and making sense of higher level strategies include uncertainty that may require later adjustments.

In managing the innovation project portfolio, both companies rely on projects being managed using the project management model. This appears to imply that projects are expected to proceed according to plans, and primarily in case of deviations or major

changes they again receive portfolio-level attention. According to these project management models, innovation projects are reviewed regularly (typically biweekly). In these regular sessions (both companies) and at project milestones (in ConstructionCo), various changes to innovation projects can be made. In SoftwareCo, where the number of innovation projects is higher and the projects are mostly related to the company's core product, most of the changes deal with changing project priorities and with slight changes to project scopes. In ConstructionCo, on the other hand, the number of simultaneous projects is lower and the nature of the projects varies a lot more. Consequently, the changes are also more varied including project terminations, dividing projects into multiple projects and returning projects to previous stages, for example. In both companies, resource estimates and resource availability are focal issues both when planning and prioritizing the portfolio, and during portfolio management.

DISCUSSION

This study begun with the knowledge that uncertainty is an inherent part of IPPM, and changes are needed in managing the innovation project portfolio. Following an active discussion on the practice perspective to IPPM, this study purposely focused on highly innovative portfolios to identify patterns of managing uncertainty as part of IPPM. Previous research already offered preliminary knowledge on the practice of IPPM, in terms of defining, planning and managing the innovation portfolio. While relevant practices have been identified earlier, they are usually discussed in separate studies without a holistic view and specific attention to the context. With this background in mind, this study asked: *How do highly innovative firms manage uncertainties in the practice of IPPM?* While the findings partly lend support to previous research in revealing some rational, structural and cultural approaches to uncertainty management (Martinsuo et al., 2014) and sensing mechanisms to interpret the environment (Petit & Hobbs, 2010), they also show uncertainty and its management in a slightly different light.

The empirical interview-based study revealed how uncertainty emerges as part of the portfolio and project management processes of the case companies, in the actions of managers and personnel. While earlier research has already mapped the types of uncertainties (Korhonen et al., 2014; Martinsuo et al., 2014; Petit & Hobbs, 2010), our results show the **discovery and creation of such uncertainties in the routine process** of portfolio creation and management. Namely, the ways in which project ideas are sourced, collected and evaluated, and consequently how projects are managed, re-assessed, prioritized and resourced cause and filter uncertainty into the portfolio, through the actions and interpretations of managers and personnel. The findings show that particularly the degree of systematics in the existing project management model vs. person dependency can both enable and delimit the inflowing information regarding uncertainty into the portfolio.

Through the analysis, the findings draw attention to three main issues in the management of uncertainty in IPPM, supplementing previous research. Firstly, the studied portfolios of the highly innovative firms had a rather strong emphasis on portfolio planning and, more specifically, the **sourcing of new project ideas** as a mechanism to promote and manage uncertainty and a predecessor of project evaluation and selection. Some previous research already offers evidence on the positive connection between certain aspects of ideation, innovation front end success and portfolio performance (Kock et al., 2015, 2016), with focus on strategic alignment of ideation, front-end process formalization, and creative encouragement as the key

factors (Kock et al., 2015). In contrast to such previous research, our study points out idea sourcing as an uncertain process, potentially enabling the renewal of the strategy (and not just aligning with it) and person-dependent creativity. The empirical evidence showed that the path of certain ideas into the portfolio is not easy or straightforward, but sensitivity to uncertainties during portfolio ideation may be crucial for enabling strategy renewal.

Secondly, the findings showed the **dynamic cross-project competition** as a mechanism to manage uncertainty which, consequently, requires repeated and rearranged strategic alignment over time. Previous research has largely concentrated on the project selection phase as the moment of cross-project competition, prioritization and decision making (Cooper et al., 1999; Dye & Pennypacker, 1999), with emphasis on strategic criteria for evaluation and comparison. Our results showed that the linking between strategy, portfolio and project goals is not so straightforward and momentary at all but, rather, it evolves over time and is quite uncertain both due to external uncertainty, uncertainty concerning project information and changes, and uncertainty in managers' assessments. Particularly the highly innovative nature of the case firms' businesses implied that the momentary project assessments change over time, the idea of "what is valuable" may change, and so does the competition between projects. As the expectations of different decision makers may conflict and change, decision making about the portfolio is much more dynamic than portrayed in the momentary event of project selection. It is possible that the highly innovative context is particularly susceptible to this evolving character of the portfolio and requires flexibility for project decision making over time, not just during project selection.

Thirdly, the innovative contexts were informative regarding **the resource dynamics and related implications of uncertainty**. The resource allocation challenges in multi-project contexts are previously known (Engwall and Jerbrant, 2003), and the challenges of anticipating resource needs during project ideation and selection and availability of resources for new projects were also identified in this study. The findings, additionally, draw attention to resource re-allocations, transfers and rearrangements following from uncertainty and changes. As all projects may have their specific capability requirements and schedule goals, firms may experience the challenges of finding suitable resources throughout the implementation of the projects, if changes take place. Therefore, resource allocation issues need to be considered as a quite dynamic part of IPPM, requiring managerial attention also later when projects are being implemented.

CONCLUSIONS

This study engages in the ongoing scientific discussion concerning uncertainties in IPPM, and the practice of managing innovation portfolios. The focus was on firms that are considered as top innovators in their business, with high ambitions concerning innovations. We wanted to understand how the high degree of innovativeness may be reflected into IPPM uncertainties and practice in firms.

The findings offered insights to the practice-centric research on IPPM particularly concerning the management of uncertainty. We showed that the innovative firms sense their environment to discover ideas and acknowledge uncertainties, but they also cause uncertainties themselves as part of the routine processes of IPPM through the ways in which ideas and projects are created, assessed, monitored and managed. To complement previous research that has already identified uncertainties and practices for portfolio planning and management, we revealed idea sourcing, dynamic cross-project competition, and resource dynamics as possible mechanisms for managing uncertainty, particularly visible in the highly innovative firms. As contributions, the study has

mapped the core dimensions of IPPM practice into one coherent framework (figure 1) and showed evidence of uncertainty management in IPPM in highly innovative contexts.

This study has implications for IPPM practitioners. The findings emphasize the importance of systematic front-end processes for generating and collecting project ideas, evaluating projects, and aligning them with strategy. The findings also highlight the challenging nature of linking project goals to portfolio goals and strategies in uncertain contexts, encouraging managers to develop practices and procedures for uncertainty awareness and tolerance. Furthermore, the study describes the often-mentioned challenges of resource estimations and resource (re)allocations in multi-project management. Particularly in highly innovative contexts, the courage for resource changes may require novel capabilities for managers, proposing new possibilities for management development and training.

The main limitations of this study are related to the research design and the methodological choices of the empirical study. The focus on two companies in the same geographical area limit the generalizability of the findings. We have offered background information on the case companies to assist readers in evaluating this limitation. The number of interviewees is limited, partly due to the small portfolios and the medium-sized firms, with limited involvement of personnel in innovation activities. We sought for key informants concerning innovation projects and consequently interviewed persons with varying roles and backgrounds to manage this potential limitation. The data collection framework was originally developed for more general purposes than for identifying uncertainties and related management practices. It is possible that this framework has not been optimal for identifying all the micro-level issues dealing with IPPM practice. For example, issues concerning the framing of uncertainties and decisions, and the bargaining taking place during portfolio planning were not clearly identified in the data. Further research is encouraged, to systematically pinpoint the various practice-related issues in IPPM.

We encourage further research concerning the uncertainties and practice of IPPM in four domains:

1. Holistic qualitative and quantitative studies of portfolio-related uncertainty management in different types of contexts (not just highly innovative).
2. Holistic qualitative and quantitative studies of all the aspects of IPPM practice (possibly connected with novel measures of portfolio success), covered in Figure 1.
3. Detailed qualitative studies of portfolio changes and reconfiguration, and their antecedents, in highly turbulent or innovative contexts.
4. Detailed qualitative studies of cross-project competition and how it evolves during portfolio management over time.

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