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The contextual nature of innovation – An empirical investigation of three software intensive products

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ABSTRACT

Context: New products create significant opportunities for differentiation and competitive advantage. To increase the chances of new product success, a universal set of critical activities and determinants have been recommended. Some researchers believe, however, that these factors are not universal, but are contextual.
Objective: This paper reports innovation processes followed to develop three software intensive products for understanding how and why innovation practice is dependent on innovation context.
Method: This paper reports innovation processes and practices with an in-depth multi-case study of three software product innovations from Ericsson, IBM, and Rorotika. It describes the actual innovation processes followed in the three cases and discusses the observed innovation practice and relates it to state-of-the-art.
Results: The cases point to a set of contextual factors that influence the choice of innovation activities and determinants for developing successful product innovations. The cases provide evidence that innovation practice cannot be standardized, but is contextual in nature.
Conclusion: The rich description of the interaction between context and innovation practice enables future investigations into contextual elements that influence innovation practice, and calls for the creation of frameworks enabling activity and determinant selection for a given context – since one size does not fit all.

1. Introduction

Considerable risk is involved in developing product innovations [1–3]. The reason being that many new products are targeted towards either emerging or untapped markets, where the products requirements are not fully expressed given customer demand is latent [3]. For new product development, there might be fewer synergies between innovating company's existing culture, climate, processes, practices, skills, and resources and the requirements of the development project [3]. This can be further complicated by the fast paced competitive environment with immense time-to-market pressure, that requires products to be released within short time-to-market [3,4]. However, companies need to address these challenges because innovations create significant opportunities for market growth, differentiation and competitive advantage [3,5].

To increase the chances of product innovation success a set of critical innovation activities was recommended by Song and Montoya-Weiss [3] based on the set of activities reported previously by Cooper and Kleinschmidt [6]. The Song and Montoya-Weiss' activities include strategic planning, business and market opportunity analysis and product commercialization. All of which should be performed well and with the right level of emphasis [3,6]. In addition, a consolidated list of determinants for product success has been reported by Edison et al. as a result of systematic literature review [7]. The determinants include differential advantage, strong market orientation, strong launch effort, technological strengths, marketing synergy, and management support [8–11] and should be used as enablers for innovation success. A common assumption of these works is that the more activities are performed and the more determinants are used, the better the chances of a product innovation success. Some researchers, however, have started to believe that innovation success enablers are not universal, but are dependent on the innovation context [12,13]. However, concrete cases of software intensive product innovations have not

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been analyzed for understanding how and why innovation practice is dependent on innovation context.

To study whether innovation practice is context-dependent and how such practice depends on contextual factors, this paper reports three in-depth case studies of product innovations from Ericsson, IBM, and Rorotika. Each case was analyzed by mapping the actual process used to innovate and comparing this process to state-of-the-art recommended activities. The paper provides a rich description of innovation practice for the studied cases and connects the observed activities and determinants to the challenges that the practitioners encountered to innovation context and success. The analysis of the cases showed that the *inherent properties of software, survival threat*, the presence or absence of *software and business legacy* and *entrepreneurial power and capabilities* influenced the use of innovation activities and the determinants.

For industry practitioners, this paper presents a set of contextual factors that should be considered when planning an innovation project and gives recommendations for how to plan the project. For researchers, the paper provides evidence that innovation practice cannot be standardized, but is contextual. The discovered interactions between innovation context and practice allow the generation of hypotheses about innovation practice selection. The generation of such hypotheses, which should be tested with future large-scale studies, is an essential step in the creation of a theory that improves the current understanding of innovation practice.

The remainder of the paper is structured as follows. Section 2 contains background and related work. Section 3 explains the research method. Section 4 describes the innovation cases. Section 5 describes and discusses the analysis results. Section 6 concludes the paper.

2. Background and related work

Many innovation management studies that report how to successfully innovate assume that innovation is normative in nature [14–16]. Large surveys have been performed to investigate trends, drivers of success, and best practice in new product development [3,6,17,18]. These surveys assumed that such state-of-practice is universal and evolves slowly as a result of trends. They do not investigate whether that assumption holds and do not investigate whether and which contextual factors influence the identified trends, drivers of success and best practices.

A plethora of definitions exists for *innovation* and *innovativeness* [7,19] as well as for the terms *radical*, *really new*, and *incremental* [19]. This has resulted in ambiguity in the way these terms are understood and utilized. A clear distinction between terms that characterize innovation is essential to ensure a common understanding, which is a prerequisite to understand how the processes differ for each type of innovation [19]. Garcia and Calantone identified an innovation typology of 15 constructs and 51 scale items and used them to model *innovativeness* in new product development [19]. The product innovations that we have chosen to study are *really new* based on that typology. We believe that such innovations are more commonplace than radical ones, as was also evident in our case companies, and that they create more opportunities for differentiation and competitive advantage than incremental ones.

At the macro-level, the concern is to evaluate how the characteristics of product innovation are new to the world, the market, or an industry [19]. Whereas, at the micro-level, the concern is to evaluate how the characteristics of the product innovation are new to the company or customer. Radical innovation is defined as an innovation that embodies a new technology which results in a new market infrastructure [3,20]. As can be seen from Table 1 such an innovation causes discontinuity both at micro and macro-levels [19]. A *Really New* innovation is an innovation that causes a discontinuity on macro-level either for marketing or technology, but not both (see Table 1) [19]. Whereas, incremental innovation is defined as an innovation that provides new features, benefits or improvements to the existing technology in the existing market [19]. Incremental innovation causes marketing and/or technology discontinuity at a micro-level; it does not introduce any discontinuity at a macro-level [19] (see Table 1).

Really New products create significant opportunities for differentiation and competitive advantage compared to incremental additions. For these reasons, the empirical study reported in this paper was performed to do an in-depth analysis of three Really New products.

Eight success-critical innovation *activities* have been identified critical for *really new* product development stated in [3,6]. In the paper we have excluded "fuzzy" front end activities which include creativity and idea generation/refinement to keep a reasonable scope.

Activity 1 – Opportunity recognition relates to the initiation of an innovation activity. *Activity 2 – Initial screening* concerns the initial go/no go decision for the product innovation project, including the allocation of funds to a new product idea. *Activity 3 – Strategic planning* involves the preliminary assessment and integration of a new product's market opportunity, strategic aims and objectives, and resource needs for realizing the innovation. *Activity 4 – Idea development and solution screening* involves generating, elaborating, and evaluating possible solutions for the identified opportunity. *Activity 5 – Business and market opportunity analysis* concerns the marketing tasks for converting new product ideas into well-defined sets of features that satisfy customers' needs and wishes. *Activity 6 – Technical development* refers to the design, engineering, test, and development of the core product. *Activity 7 – Product testing* concerns the validation of the product together with the planned marketing and advertisement programs. *Activity 8 – Product commercialization* involves the coordination, implementation, and monitoring of the new product launch.

We have chosen these eight activities as a benchmark for innovation state-of-the-art in our study because these represent

Table 1
Combinations of discontinuities and corresponding innovation types (from [19]).

Input: discontinuities				Output: innovation type
Macro-marketing discontinuity	Macro-technology discontinuity	Micro-marketing discontinuity	Micro-technology discontinuity	
1	1	1	1	Radical
1	0	1	0	Really new
0	1	1	0	Really new
1	0	1	1	Really new
0	1	1	1	Really new
0	0	1	1	Incremental
0	0	0	1	Incremental
0	0	1	0	Incremental

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a consolidation of literature and have been evaluated with a large number of new products development projects. The activities used in reference [3] are a set of activities reported in reference [6]. The practices within each activity have been taken from reference [6]. In addition the selection of the eight activities (stated in [3], [6]) allowed us to focus on the innovation development projects. Consequently, we removed activities related to creating an innovative company, such as creativity and idea generation, portfolio management, engineering design, and the use of New Product Development (NPD) and market research tools, from the scope of the here presented research (discussed in [16,17]).

Proficient execution of all these innovation activities has been proposed to be a determinant of new product success [6]. Some of the activities are believed to have a stronger effect on innovation success than others, however [6,21–24]. It is particularly critical that product commercialization, strategic planning, and business and market opportunity analysis are performed with the right level of emphasis [3]. In which circumstances *really new* product development should emphasize proficiency of a given activity more and when less has not been explored, however.

In addition to innovation activities, *determinants* for innovation success have been proposed [7]. Edison et al. [7] performed a literature review of the empirical literature for identifying success factors of new product development. A summary of the determinants is available online [25]. In the online supplementary data, the categories (i.e. the text outside brackets in the right column) have been proposed by Edison et al. in [7]. The text in the brackets in the right column are the actual determinants extracted by Edison et al. via systematic literature review. In our study we used these determinants as a-priori set to analyze and discuss why the case products we studied were successful, respectively failed.

3. Research methodology

The study presented in this paper was carried out as a multi-case study that involved three independent cases. We performed in-depth semi-structured focus group interviews to reconstruct the cases and to elicit the experiences of the involved practitioners [26].

Such a qualitative research approach is useful when the purpose is to explore an area of interest and to improve the understanding of certain phenomena [26,27]. Our study aimed at gaining an in-depth understanding of the innovation processes that are carried out by software product companies and to analyze the effect of contextual factors on the choice of activities and determinants for innovation success. Semi-structured focus groups with relevant roles, including product managers, project managers, developers, testers, sales and marketing persons, which participated in the studied innovations allowed us collecting the rich and diverse data needed to achieve these aims. During the focus groups the innovation context and an end-to-end description of the innovation process was elicited and explored. The focus groups enabled real-time data triangulation and allowed a group opinion about the joint experience to emerge.

Table 2 presents the research questions. RQ1 was formulated to investigate to what extent the activities and determinants for innovation success were used in the three studied cases. RQ2 was formulated to identify the contextual factors that explained the relevance of activities and determinants for innovation success and to analyze the effect of these factors in the three studied cases.

3.1. Research design

The sampling strategy we used was a combination of typical case variation sampling and convenience sampling [28] within our industrial collaboration network. Section 3.2 describes the three participating companies. A contact person at each company proposed a list of *really new* innovations that the person thought would be representative *really new* products for the company. Table 3 gives an anonymous overview of companies (X, Y, Z) and case products (P1, P2, P3). The products P1 and P2 were developed with a sequence of two innovation projects that resulted in product versions V1 and V2 respectively. P3 was developed with one single project. P1 and P2 represented established products. At the moment of the study, P3 had not been officially launched. However, it was in the beta test phase, and the customer feedback so far had been very positive. For that reason, we have classified P3 to be a market success.

We used the focus group meetings to answer the research questions. Participants in these group meetings were key members of the respective innovation project. The focus group sessions varied in length from 100 to 120 min. Audio recordings and extensive written notes were used to capture as much data as possible. Each focus group meeting started with a description of the purpose of the study and then confirmed the type of innovation (*really new)* with a questionnaire for classifying the case product being studied based on the innovation typology [19]. To answer RQ1 and RQ2, we used semi-structured questionnaire-supported interviews [26] during which we elicited the structure of the innovation project and discussed significant challenges and determinants of innovation success.

The focus group meetings were run by one moderator and two facilitators. The moderator performed the group interview by engaging all the participants in the discussion and by keeping the discussion focused. An interview guide was followed for that purpose. One of the facilitators monitored the non-verbal communication of the focus-group participants and took extensive notes during the session. The second facilitator (the contact person) was well versed with the company's processes and culture. He facilitated the work of the focus group by taking notes from the company's perspective thereby enriching the collected data. The involvement of two facilitators, in addition to the moderator ensured observer triangulation [29].

The three products represented three units of analysis in an embedded case study given the context is software intensive product development companies in general and the research goal is to

Table 3
Company, products and number of focus group participants.

Company	Product	Number of participants
Company X	P1 V1	5
Company X	P1 V2	5
Company Y	P2 V1	1
Company X	P2 V2	3
Company Z	P3	2

Table 2
Research questions.

RQ1: To what extent does state-of-the-art in *Really new* Product development compare to state-of-practice for the three case products?
RQ2: How do the contextual factors affect the state-of-practice for the three case products?

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study innovation activities and determinants. Thematic analysis [30] was used to analyze the collected data with a mix of deductive a-priori coding templates [31] and inductive codes [32]. The a-priori codes referred to the selected innovation activities and determinants collected from that state-of-the-art. Thematic analysis enabled us to discover activities and determinants that were important for describing the reported innovation practice. The activities and determinants were identified through "careful reading and re-reading of data" [33] and recognizing patterns within the data. The identified activities and determinants then became categories for analysis. The data analysis was reflexive and iterative as suggested in [34]. The stages of coding and analysis are available online with detailed examples [25].

To identify the contextual factors that affected the studied product innovations we clustered the interviewees' descriptions of how the situation of the innovation project affected the innovation activities. Again, thematic analysis was used to analyze the data. We used inductive codes that were taken from descriptions of the interviewees for labelling the clusters. This approach was chosen because no comprehensive contextual innovation model existed that could be used to build a-priori coding templates. The identified contextual factors thus correspond to those reported by the interviewees and were not influenced by a-priori models. The similarities and differences between our results and existing work in contextual innovation [12,13] were then used to discuss how the cases we observed extend the understanding of the contextual nature of innovation.

3.2. Participating companies

The companies Ericsson, Rorotika, and IBM participated in this research. The brief description of the companies are taken from their respective websites, i.e. Ericsson [35], Rorotika [36] and IBM [37,38].

Ericsson AB is a Swedish leading global telecommunication system provider offering a wide range of products and solutions. It has developed and marketed many innovative products and solutions (e.g. multimedia solutions and telecom services) for fixed networks and mobile networks.

Rorotika Technologies (Pty) Ltd. is a South African company. Rorotika was started by a group of people who has strong mobile telecommunications background in the areas of product and operational development. Rorotika develops network-based solutions for mobile network operators that can help them attain significant improvements with respect to their key business performance indicators.

IBM is an American multinational technology and consulting corporation. IBM is in the business of manufacturing and selling computer software and hardware. It also provides infrastructure, hosting, and consulting services in areas ranging from nanotechnology and mainframe computers.

3.3. Threats to validity

Threats to validity were classified according to case study research methodology [27,39] and Wohlin et al. [40].

Construct validity is about generalization of the results of the study to the concept or theory behind the study [40]. The study's major threat to construct validity was that questionnaires and interview questions might not have been interpreted as intended. To minimize this threat, a presentation containing objectives of the study along with definitions of key terms was given at the start of each focus group session. During the interviews, the moderator and facilitators discussed and clarified confusions of the participants related to the interpretations. With regard to the role of moderator, the threat of moderator's control over the focus group is always existing [41]. However, to minimize the effect of this threat, a continuous and conscious effort was made by both the moderator and facilitator to interrupt as little as possible. At the same time, the moderator actively tried to ensure equal participation by all the participants.

Internal validity concerns the influences that can affect the correctness of the causal relations between the variables investigated in the study [40]. The study's major threat to internal validity is that the wrong contextual factors were discovered to explain innovation practice. This threat is relevant because we employed explanation building to answer RQ2. To mitigate this threat to validity, we identified as many factors as possible that might have directly or indirectly affected innovation practice and performed member checking of the analysis results with the study participants. Another internal validity threat could arise due to the fact that in case of both P1 and P2, Company X is involved which could affect the causal relations between the factors investigated in the study. However, in each product case, entirely different product groups were involved. As a result, the chances of common hidden factors that lead to apparent causal relationships are minimal.

External validity is concerned with the generalizability of results [40]. We are aware that we have studied only three case products. The detailed narratives and in-depth contextual analysis, however, enable readers to compare the presented cases with their own situation. The influences of contextual factors and innovation activities and determinants are presented in a way that enables replication in further studies for generalization by theory [39].

Reliability is concerned with the dependency of data collection and analysis on the specific researchers [27]. We have mitigated this threat with observer triangulation, the use of a research database, building a chain of evidence, and member checking. Two researchers and one industry practitioner performed the audio-recorded focus groups and took notes. All empirical material and the coding details were stored in an excel sheet. The chains of evidence were built using codes to connect the transcribed audio recordings and the questionnaires with the answers of the research questions. The transcripts and the analysis results were sent to participants for member checking to ensure that their answers were not misunderstood or misinterpreted.

4. Results – the innovation cases

This section describes the innovation process observed for the three products that are outlined in Table 3. The structure used to report the cases is based on the narrative strategy [42]. References to activities, challenges, and determinants allowed us constructing a chain of evidence for answering RQ1 and RQ2.

4.1. P1 – Product characterization and Innovation process

Product P1 was a software-based service for a new type of telecommunication contracts. At the moment of initial development, mobile phone services were exclusively offered on a contract-based postpaid basis. These contracts excluded individuals with poor credit ratings and minors under the age of 18 from owning and using mobile phones. P1 reduced the credit requirements for customers by offering pre-payment. The development of P1 required the adaptation of software and hardware for telecom operators to enable the new type of phone calls. A proprietary solution, already a part of a product FT, enabled Company X to rapidly develop the product and to explore untapped markets, such as developing countries, via P1.

P1 was developed with a sequence of two innovation projects. The product version V1 satisfied the needs of the customer who requested P1. The product version V2 scaled the performance of

P1 to market needs. Fig. 1 gives an overview of the two innovation projects. The figure also shows, as bursts, the challenges that were faced by Company X while developing the two versions of P1 along with the determinants that enabled the development of the product.

4.1.1. P1 V1 – Innovation activities, challenges, and determinants for innovation success

4.1.1.1. Activity 1 – Opportunity recognition. Technology competence and demand from a customer enabled the development of V1. The technology behind P1 had existed for a long time prior to the conception of P1, but was originally conceived for fixed-line telephony only.

4.1.1.2. Activity 2 – Initial screening. Based on the customer's demands, Company X took a decision at the corporate level to develop the P1 service for mobile telephony, despite the opposition of the business director of development: "*If I had a choice as director of business development, I would have chosen mobile positioning as the product to develop over P1*". No formal technique or criteria were used for the activity of initial screening.

4.1.1.3. Activity 3 – Strategic planning. No formal strategic planning was done prior to the development of P1. Company X decided at the corporate level to develop P1 for mobile telephony, but without any formal assessment of resource requirements, market opportunities, and strategic objectives.

4.1.1.4. Activity 4 – Idea development and solution screening. This activity was not performed consciously for the first version of P1. One of the focus group participants stated: "*Someone in Helsinki found a solution to incorporate P1 into mobile telephony*."

4.1.1.5. Activity 5 – Business and market opportunity analysis. Company X created a quick business case at headquarters together with the P1-requesting customer. Some employees of Company X lobbied against the solution because they perceived it as old fashioned, poorly designed, and unable to scale. However, the marketing department assumed: "*We will not exceed 50'000 subscribers.*"

4.1.1.6. Activity 6 – Technical development. The development of P1 was straight-forward for Company X. The required technology, infrastructure, and domain knowledge were readily available. Marketing recognized time-to-market as a critical factor in meeting the P1's market window. The work was time-boxed at the expense of quality. Third-party components were used to accelerate development.

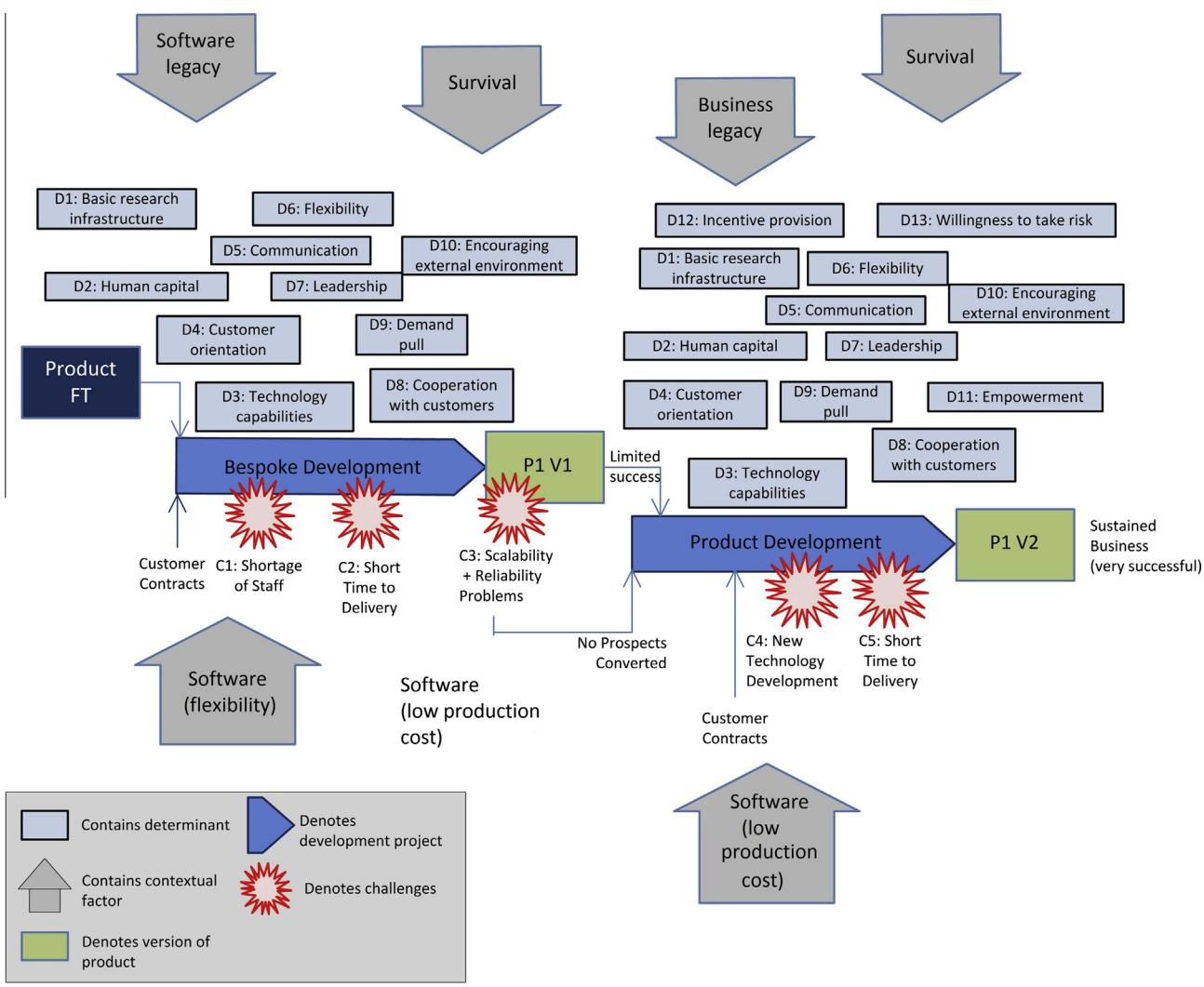

Fig. 1. Sequence of projects that led to the two versions of P1.

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4.1.1.7. Activity 7 – Product testing. Due to the time-to-market pressure, the company decided to release the first version of P1 without thorough testing. There were no field tests of the product.

4.1.1.8. Activity 8 – Product commercialization. P1 was delivered to the product-requesting customer. Since it was developed for a single customer, no further product commercialization activities were performed.

P1 V1 was an instant hit. However, business and market opportunity analysis underestimated its success: "*The potential of the product was learnt later, when the product took off.*" Within one year, the customer had over 250,000 subscribers instead of 50,000. Also, telecom operators other than the initial customer showed interest in P1 and started sales negotiations with Company X.

4.1.1.9. Influence of context. P1 V1 was created in a difficult situation. Company X was threatened in its survival and traded product quality off for time-to-market speed. The IT boom at that time made development resources scarce (see C1 in Fig. 1). Together with a lack of formal planning this led to an immense workload and ad-hoc development processes.

The chosen development practices, technologies, and components enabled the development of an acceptable product, but the needed scalability and reliability were absent. P1 V1 was not sufficiently tested due to the fear of losing the market window: "*The first generation was rolled out too quickly without proper testing*" according to the project manager for Product P1. The market demand was incorrectly estimated: "*A business case was produced but underestimated.*" as pointed out by the director of business development and project manager. To meet deadlines, sub-optimal solutions were implemented by using third party components: "*If we had built everything ourselves, we would have missed the market window.*" was stated as justification by the project manager and one of the developers of P1 V1. As a result, although P1 V1 met the customer's expectations initially, it failed to scale and was not reliable enough when confronted with the growing demand. Fig. 1 and Table 4 summarize the encountered challenges together with their causes and implied problems.

Despite the challenges, P1 V1 was successfully delivered and adopted by the customer who requested it. A number of determinants for innovation success were present in this case and at the same time a number of determinants were absent. Fig. 1 and Table 5 give an overview.

Determinants related to both the external environment and company internals enabled the success. External determinants were the *demand by the customer*, *untapped potential markets*, and active *customer cooperation*. Internally, the company's *skilled and motivated staff* managed to develop a useful product within a tight deadline by *adapting the existing development process*. In addition, Company X's local office had all the *industrialization in place* to develop and deliver P1. However, the project was not a result of planned innovation. The *threat of survival* for the company reduced the value and importance of many of the usual determinants of innovation success, and at the same time enabled innovation.

Table 4
The challenges of P1 V1 with their causes and implied problems.

Challenges	Causes for challenges	Implied problems
C1: Scarcity of staff for development	IT boom, lack of resource planning	Immense workload
C2: Short time to deliver product to customer	Old development process suited for a 24 month development cycle	Immense workload, informal development processes
C3: Scalability and reliability problems of P1 V1	Incorrect estimation of users during a business and market opportunity	Customer complaints

Table 5
Determinants of success for P1 V1.

Determinant category	Determinant of innovation	Observations
Organizational resources	D1: Research infrastructure [43]	Company X had the industrialization to develop and deliver P1
	D2: Human capital [44,45]	"Highly skilled, motivated and "hungry" core team was working with state-of-the-art technologies both in Telecom and in software development" as indicated by the director of business development
	D3: Technology capabilities (firms technological competences, derived from in-house R&D) [46,47]	
Customer orientation	D4: Customer orientation [48]	P1 was developed as direct demand from customer
Communication	D5: Communication [49]	Good team communication
Culture	D6: Flexibility [50]	The development organization was very flexible and adapted fast to new situations, which greatly in developing and delivering P1
Leadership	D7: Leadership [49,51,52]	For Company X, the business director development acted as a key driver of the move of P1 to Company X
External collaboration	D8: Cooperation with customers [53]	During the development of P1 there was close cooperation with the customers which enabled insights into their needs
Market	D9: Demand pull (market pull) [43,54,55]	For both versions, contracts with customers were signed at some point of time and the solution had to be delivered within a tight timeline
	Demand growth [56][a]	Wrong estimates of market demand (see challenge C3)
External environment	D10: A local context that encourages investment in innovation-related activity [43]	"In the country where Operator C was operating, there was a new untapped market booming at that time (mobile phones for people with no credit history) which made P1 a huge success" was stated by the project manager and director of business development
Human resources	Human resources [57][a]	Scarcity of staff for development due to an IT boom (see challenge C1)
Strategy	Strategic attention [58][a]	Company X at that time only used to provide consultancy services rather than developing and delivering a product from start to an end (no strategy for this type of innovation). Therefore, competency of end-to-end thinking was not present at that time

[a] Confirmed absence of determinant.

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4.1.2. P1 V2 – Innovation activities, challenges, and determinants for innovation success

4.1.2.1. Activity 1 – Opportunity recognition. Commercial use of P1 exposed reliability, availability, and scalability problems. The business director of development saw the consequent customer complaints as an opportunity to improve P1. However, headquarters hindered him the start of development of P1 V2 because no customer wanted to pay for the development effort.

4.1.2.2. Activity 2 – Initial screening. This activity was not applicable since the aim of developing P1 V2 was to address the quality problems with P1 V1.

4.1.2.3. Activity 3 – Strategic planning. P1's product team decided to start the project despite the negative stance of headquarters. The team classified the project work as "*skunk-work and parallel activities*" (quote by the director of business development). Their pragmatic approach led to the omission of formal strategic planning. This resulted in an exceptionally high workload during the development of P1 V2, since resources were not planned adequately.

4.1.2.4. Activity 4 – Idea development and solution screening. The internal stakeholders got together to identify the best solution for handling quality issues. A "*beauty contest*" was held to identify the best solution. Cash awards and recognition were given as incentives to participants. As a result, "*...participants came up with brilliant ideas...*" (quote by the product manager) that were developed and tested with rapid prototyping.

4.1.2.5. Activity 5 – Business and market opportunity analysis. In parallel to the prototyping, a telecom operator decided to buy the next version of P1. He signed a contract that guaranteed the release of P1 V2 within six months. The contract allowed the product team to make development official.

4.1.2.6. Activity 6 – Technical development and Activity 7 – product testing. The existing development process was designed for 24 months projects, hence was inconsistent with the 6 months deadline. In addition, the team decided to develop the solution from scratch eliminating the third-party components. At the same time, the omitted strategic planning led to resource bottlenecks. These factors resulted in immense time-to-market pressure that the product team decided to address by developing the product "*in the agile way*" and with shift work: "*the development worked from 10 a.m. till 10 p.m. and the testing tested from 10 p.m. till 10 a.m. seven days a week.*" according to the director of business development. This led to conflicts with headquarters because the company's standard testing procedures were not followed.

4.1.2.7. Activity 8 – Product commercialization. For P1 V1, no special launch activities were undertaken.

4.1.2.8. Influence of context. Also the project for P1 V2 faced immense challenges. Fig. 1 and Table 6 give an overview.

The team was unable to predict how well solution design would meet requirements and technology capabilities (see challenge C4 in Fig. 1 and Table 7). An immense workload resulted from unanticipated work necessary to build the product due to repeated backtracking necessary to correct wrong design decisions.

The determinants for P1 V1 were also present for P1 V2. *Willingness to take risk* and *incentives for technical solution identification* were additional determinants. They helped to address the quality

Table 6
Challenges of P1 V2 and their causes and implied problems (see Fig. 1).

Challenges	Causes for challenges	Implied problems
C4: New technology development	Limitations of existing technology (unmet latency, capacity requirements)	Immense workload, repeated back tracking during development
C5: Short time to deliver product to customer	Old development process suited for 24 months development cycle	Immense workload, informal development processes

Table 7
Determinants of success for P1 V2.

Determinant category	Determinant of innovation	Observations
Organizational resources	D1: Research infrastructure [43]	Company X had the industrialization to develop and deliver P1
	D2: Human capital [44,45]	"Highly skilled, motivated and "hungry" core team was working with state-of-the-art technologies both in Telecom and in software development"
	D3: Technology capabilities (firms technological competences, derived from in-house R&D) [46,47]	
Communication	D4: Communication [49]	Good team communication
Empowerment	D11: Skilled people have ownership to innovate in their area [48] [52,59]	"It was locally decided to start development of second version of P1 despite no decision centrally" remark by the director of business development
Culture	D12: Incentive provision [60]	A beauty contest was held and a cash award and recognition was offered as incentives to identify the best possible technical solution for the problem at hand
	D6: Flexibility [50]	The development organization was very flexible and adapted fast to new situations, which helped alot in developing and delivering P1
Leadership	D7: Leadership [49,51,52]	For Company X, the business director development acted as a key driver of move of P1 to Company X
External collaboration	D8: Cooperation with customers [53]	During the development of P1 there was close cooperation with the customers which enabled insights into the needs
Market	D9: Demand pull (market pull) [43,54,55]	"The contract with the customer was signed at some point of time and the solution had to be delivered within a tight timeline"
Human resources	Human resources [57][a]	Scarcity of staff for development due to IT boom (see challenge C1)
Risk	D13: Willingness to take a risk [61]	P1 V2 was initiated despite commitment from the customer initially
Strategy[a]	Strategic attention [58][a]	Company X provided only consultancy and did neither develop nor deliver products (no strategy for this type of innovation). Thus, the competency of end-to-end thinking were absent

[a] Confirmed absence of determinant. Determinants of success for P1 V1 were also present for P1 V2.

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problems and to initiate the development of P1 V2 despite the initial lack of customer commitment. Also *strong leadership* was a central determinant for P1 V2. The director of business development observed the quality problems of P1 V1 and persuaded employees to start the project despite lack of formal permission from headquarters. Without that project initiation, competitors would have replaced P1 V2 by the time the customer had signed the contract.

The company's survival threat and the tight release deadline made innovation planning useless. They encouraged shortcuts and abandoning of traditional development practices.

4.2. P2 – Product characterization and innovation process

P2 is an award-winning solution that offered dynamic discounts for pre-paid mobile phone calls. The flexible tariffs allowed shifting traffic load within a telecom provider's network, away from periods of peak congestion to times with excess capacity. This shifting improved network use efficiency and reduced the need for costly infrastructure. The flexible tariffs increased the telecom providers' revenue and grew the subscriber base.

P2 was developed with a sequence of three projects. Employees of a telecommunications operator O created the idea for P2 and developed a prototype to test the concept. Company Y was later established (by a group of former employees of Company O) to develop and commercialize P2 V1. Company Y collaborated then with Company X to expand market reach with P2 V2. Fig. 2 gives an overview of the project sequence. The figure also shows as bursts the challenges that were faced while developing P2 along with the determinants that enabled development of the product.

4.2.1. P2 V1 – Innovation activities, challenges, and determinants for innovation success

4.2.1.1. Activity 1 – Opportunity recognition. Operator O was confronted with an increase in traffic and network congestion during off-peak hours. Employees of the radio optimization department observed that people were placing calls during off-peak hours when O offered low tariffs. They believed that right incentives for callers could avoid congestion and reduce investments in costly infrastructure.

4.2.1.2. Activity 2 – Initial screening. There was neither a formal process nor dedicated time for innovation. Most of the development in O was driven by operational requirements. Consequently, there was no initial screening that led to selection of the idea behind P2.

4.2.1.3. Activity 3 – Strategic planning. Within O no formal assessment of a new product's market opportunity, strategic aims and objectives, or resource needs was performed.

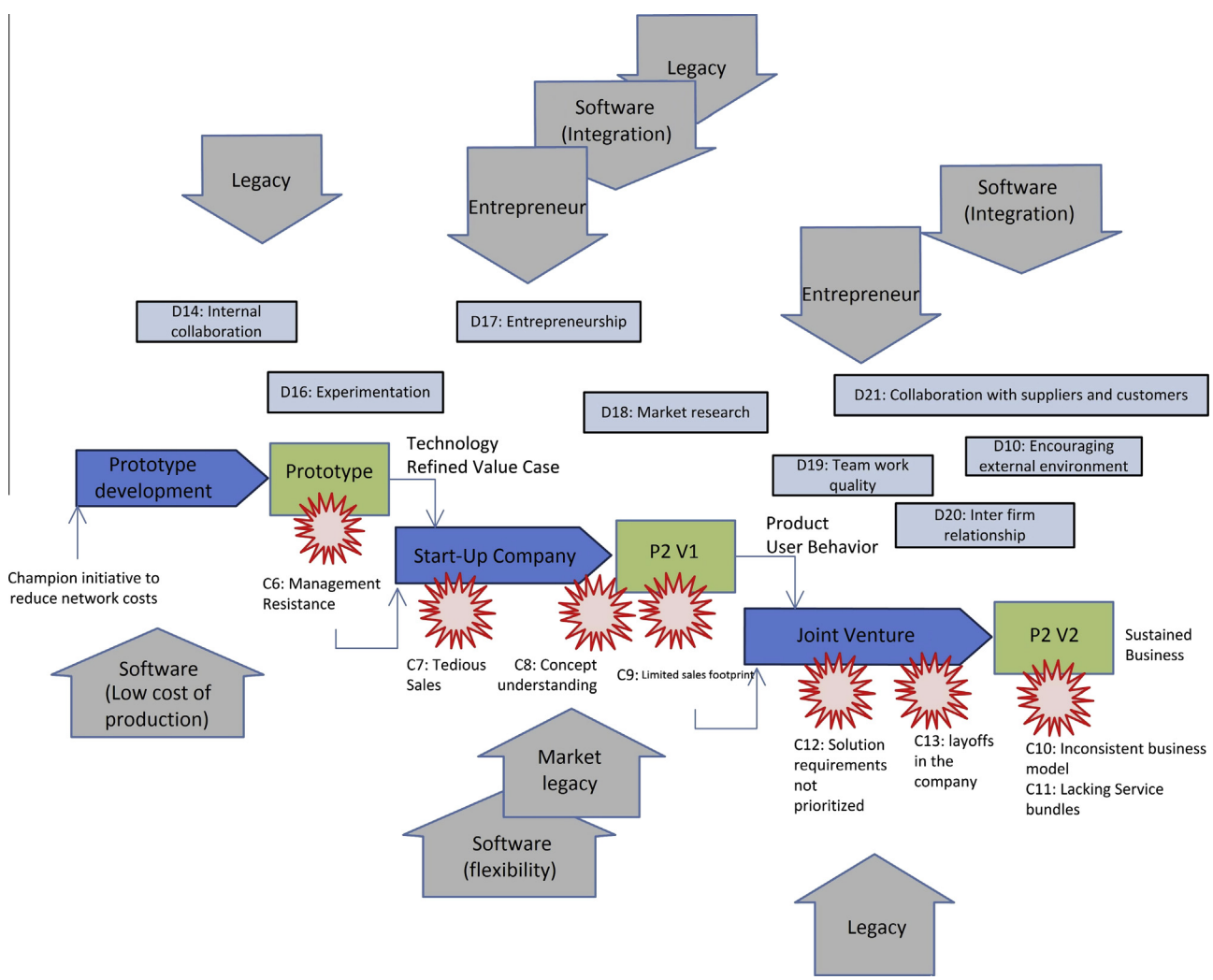

Fig. 2. Sequence of projects that transformed the initial idea into the software product P2 V2.

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4.2.1.4. Activity 4 – Idea development and solution screening. The employee who investigated the congestion problem knew how to obtain call traffic information in collaboration with billing and subscription experts. A multidisciplinary team was established to plan changes in the billing and subscriber registration systems. The department allowed the employee to implement a prototype in his spare time and tested prototype in a small geographical area. Promising results were achieved, but not enough to convince the marketing department to allow a larger trial. Management stopped the development of the new product P2. The employee eventually created a new company, Company Y, together with colleagues to pursue the P2 concept independently.

4.2.1.5. Activity 5 – Business and market opportunity analysis. Without direct demand from any end customer for the product no explicit business and market opportunity analysis was done. Instead the results of the pilot test were used to estimate the viability of P2 and to define its features.

4.2.1.6. Activity 6 – Technical development. The technologies were known and the problem was well understood by the employees. As a result the development of P2 was straightforward for the company.

4.2.1.7. Activity 7 – Product testing. The concept was novel and risky. Hence, the product was tested in detail to check its functionality and reliability under real-life working conditions.

4.2.1.8. Activity 8 – Product commercialization. Company Y worked on marketing, business models, and pricing and prepared for the operational support of P2. Customers were telecommunications operators. Their initial fear of P2's novel and unfamiliar concepts was contained by the possibility of recruiting new subscribers. Such recruitment outweighed discount-related revenue losses and lead to significant gains in the long-term.

After some initial sales, Company Y discovered that they lacked the market presence and size to approach large telecommunication operators. It hence decided to cooperate with an existing telecommunication infrastructure supplier.

4.2.1.9. Influence of context. The project for P2 V1 also faced challenges. No program was in place to foster innovation. Management approval for creating P2 required tenacity. Most people would not have put in this level of effort into "*making it happen*". The innovator struggled to convince O's upper management of the merits even with the promising pilot test results (see C6 in Fig. 2). The concept was perceived risky because it had not been applied in the industry before. Table 8 summarizes the challenges.

To address management resistance, the innovators launched Company Y. However, also the new company struggled. The novel product concept made it difficult to convince prospective customers. This challenge lessened over time as P2 was deployed and the market gained confidence. Still staff turnover at customer companies required continuous work to ensure that the concepts of P2 remain understood and to avoid termination of the product due to ignorance.

A second challenge limited market reach of company Y. It did not meet partner requirements of prospective customers. They were comfortable with large companies, especially for network infrastructure purchases, but company Y was a small startup. Table 9 summarizes the challenges.

Table 10 shows the determinants for P2 V1. *Strong internal collaboration* and *specialized knowledge* within the problem area enabled product development. The *pilot tests* helped to test assumptions and reveal aspects of caller behavior that were not considered before. This empirical data enabled answering risk-related questions raised by prospective customers, hence eased sales.

The lack of management support for product commercialization limited the value of innovation planning. Instead the champion and colleagues started company Y and developed and marketed the product. Marketing strategies adapted to the novel and risky nature of the product enabled sales.

4.2.2. P2 V2 – Innovation activities, challenges, and determinants for innovation success

4.2.2.1. Activity 1 – Opportunity recognition. Company Y lacked market reach and size. It approached existing contacts in company X, the market leader, to initiate a partnership.

4.2.2.2. Activity 2 – Initial screening. Company X had neither formal mechanism nor criteria for idea screening. The contact person at company X believed that P2 fitted the portfolio and decided to consider it.

4.2.2.3. Activity 3 – Strategic planning. P2 failed to convince management of company X during the initial product review: "*that concept did not feel like doing a business in general, although in some markets it might make sense.*" The contact person was convinced of the idea, however, and operator O pushed him to pursue P2. The office of Company X at the location of company Y also saw potential in P2. Consequently, the two companies X and Y started

Table 8
Challenges of P2 at telecom operator O and their causes and implied problems (see Fig. 2).

Challenges	Causes for challenges	Implied problems
C6: Management difficult to convince regarding the idea and its merits	No innovation program, risk-averse and conservative management	Development effort during spare time. Immense effort to get approval for pilot tests

Table 9
Challenges of P2 at startup company Y and their causes and implied problems (see Fig. 2).

Challenges	Causes for Challenges	Implied Problems
C7: Tedious sales	Risk averse customers that were difficult to convince about the idea and its value	Limited product success
C8: Difficult to maintain an understanding of the concept at the customer companies	Churn of staff at customer companies	Immense follow up effort
C9: Small startup company	Customers prefer to purchase network infrastructure from large established companies	Limited sales footprint

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Table 10
Determinants for P2 V1 (see Fig. 2).

Determinant category	Determinant of innovation	Observations
Internal collaboration	D14: expert knowledge consolidated across business divisions, technical disciplines, product technologies, and target markets from within the enterprise [62]	"The process from the concept to finding a practical solution to each of the technical barriers was an important activity as it showed that a multitude of skills and knowledge was needed to produce a workable product..." according to the champion of P2 V1
Technology	D15: Knowledge and experience in science and engineering [63]	
R&D	D16: Experimentation and pilot test [59]	"... a limited geography pilot tested the main assumptions and revealed several aspects of human behavior that were not known (or considered) before the pilot. Data from the trial data revealed new benefits while questions from skeptics helped in developing a solid justification for the concept" according to the champion of P2 V1
Individual	D17: Entrepreneurship	Company Y established by the champion and former O employees
Market	D18: Market research [64]	"The first commercial implementation provided an opportunity to test the Take-to-Market strategy (Viral marketing approach). It also provided the first input data on which to develop a more complete business case, revealing the potential of the product when applied to an entire network. A very detailed analysis (6 week of intense analytics) of this particular implementation produced a very convincing set of results which formed the back bone of future marketing material. This analysis also gave us the experience to speak with some authority on what could be expected in other markets..." according to the champion of the product
Management	Management support [65][a]	There was little management support for commercial implementation, nationally at telecommunication Operator O (see challenge C6)

[a] Confirmed absence of determinant.

a partnership to build an end-to-end solution for dynamic discounting, P2 V2.

4.2.2.4. Activity 4 – Idea development and solution screening. P2 was difficult to integrate into existing systems. Technical analyses and experiments were necessary to understand how to build an integrated, end-to-end solution. These pre-studies were performed jointly by the two companies.

4.2.2.5. Activity 5 – Business and market opportunity analysis. P2 implied a business model that Company X was unfamiliar with. Company X was used to "*develop and sell products and not business solutions*". P2 was not a product in itself, but combined products and services into a system for delivering the discounting service. The unfamiliarity of company X with this type of offering made it difficult to establish the business model and to convince employees to correctly market P2.

4.2.2.6. Activity 6 – Technical development. P2 had already been developed by Company Y. The pre-study results showed how P2 had to be integrated with the existing systems of Company X.

4.2.2.7. Activity 7 – Product testing. A lot of product testing was performed. P2 V2 was released without problems.

4.2.2.8. Activity 8 – Product commercialization. Company X, used to sell products, struggled with the business model of P2: "*the business solution only gives a framework. You need to build around it for the customer.*" P2 depended on continuous risk management and support services. The policies of company X did not allow bundling such services with an offering, however. Consequently, the product managers and the sales force did not see any real market interest. Sales training was tried as a solution, but was ineffective; "*no one except me went on course to learn how to handle business solutions*" was the statement from company X product manager. Still, P2 V2 continued to be offered to the market despite limited sales.

4.2.2.9. Influence of context. Company X both enabled P2 and introduced challenges that made development difficult and limited its success. The organization confused the concept of a business solution with a packaged product. P2 was a type of offering that was inconsistent with the legacy of company X. This challenge arose because no detailed strategic planning was carried out. Table 11 summarizes the challenges.

Company X did not have an adequate approach established for managing solution development. Business units had to prioritize solution requirements over requirements of the products that the solution integrated. Such a process was not in place.

The misunderstood business solution concept hindered an adequate service offering. Employees did not accept or understand the business model and did not participate in education and training for selling business solutions. Company X would have had to share risk with customers in order to make sales, but they did not. Hence,

Table 11
Challenges of P2 V2 and their causes and implied problems (see Fig. 2).

Challenges	Causes for Challenges	Implied Problems
C10: Product inconsistent with business model	Absence of strategy and business model for business solution innovation. Company X setup for product business. No training and education of staff to manage and develop business solutions	Constant confusion of personnel and lack of motivation for product and sales organization
C11: Success-critical bundling of P2 with service offering not possible	Required business model for selling business solutions conflicted with company's traditional product business model	Long and tough price negotiations with customers
C12: Solution requirements not prioritized	Lack of solution development process	Delays
C13: Layoffs in Company X	Cost-cutting of Company X at their local office in a country	Push to sell P2 reduced. Competence lost

Table 12
Determinants of success for P2 V2 (see Fig. 2).

Determinant category	Determinant of innovation	Observations
Internal collaboration	D19: Team work quality [66]	"Excellent team to work with great spirit, great experience/competence. We all pitched in as one group"
Networking	D20: Inter firm relationship [56]	"Expertise from Operator O and Company Y made the solution to fly. Knowledge of technology and economic factors..." stated by the product manager of P2 V2
External environment	D10: A local context that encourages investment in innovation related activity [43]	"Focus on one market only and it was a non-saturated market (an emerging) voice"
	D21: Collaboration with suppliers and customers [49]	"...excellent cooperation with stakeholders including Company X SA and Company Y, EMA and supplier services in Madrid Spain..." according to the product manager
Strategy	Strategic intention[a]	Absence of concrete objectives and business model for business solution innovation (see challenge C10)
Knowledge management	Training and education of personnel[a]	People within Company X were not educated to develop and manage the new type of innovation (i.e. business solution). See challenges C10, C11 and C12

[a] Confirmed absence of determinant.

price negotiations were long and tough, and P2 was not effectively sold.

An additional challenge was internal. Company X reduced staff at the office close to company Y. This reduced effective collaboration in the joint-venture. Also, the staff of P2 V2 was replaced by consultants for subsequent releases. This resulted in competence and knowledge loss.

Table 12 shows the determinants for P2 V2. *Excellent team work*, a *strong inter-firm relationship*, *collaboration with suppliers*, and an *untapped potential market* were the key determinants that enabled P2 V2. However, no determinant was stated by the study participants that mitigated the challenges surrounding the difficulties due to the mismatch of P2 V2 with company X legacy. The lack of such a determinant limited P2 V2 success.

4.3. P3 – Product characterization and innovation process

P3 was realized as a new feature of a product F. F supports product and portfolio management by enabling executives and teams to make business decisions. It is already a commercial success. P3 offers a simple and practical approach for calculating return-on-investment (ROI) of software and system development projects. The integration of P3 into F allowed enhancing business decisions with ROI calculations.

P3 was a single innovation project that was initiated by an intrapreneur. P3 was successfully launched as an integrated feature in an existing product (F) and has been very well received by the customers. Fig. 3 gives an overview.

4.3.1. P3 – Innovation activities, challenges, and determinants for innovation success

4.3.1.1. Activity 1 – Opportunity recognition. An intrapreneur built an approach to compute the return of planned investments based on a model of value and uncertainty. General management appreciated the idea and encouraged the intrapreneur to realize it.

4.3.1.2. Activity 2 – Initial screening. Company Z did not have any formal mechanism for idea screening. The intrapreneur of the idea stated: "one needs to convince product managers, executives, developers to see if it is feasible." The product manager also confirmed: "We do not have a disciplined process for this. The key idea is that it is a marketplace of ideas. You need to nurture the idea based on what you are hearing. You get to a virtual cycle, where people like it, improve it, and like it more. You improve it and get evidence that it works."

4.3.1.3. Activity 3 – Strategic planning. Internal stakeholders, including the product manager for Product F, and external customers evaluated the idea. The product manager compared P3 with competing ideas and selected P3 for enhancing F. The customers showed interest in the idea.

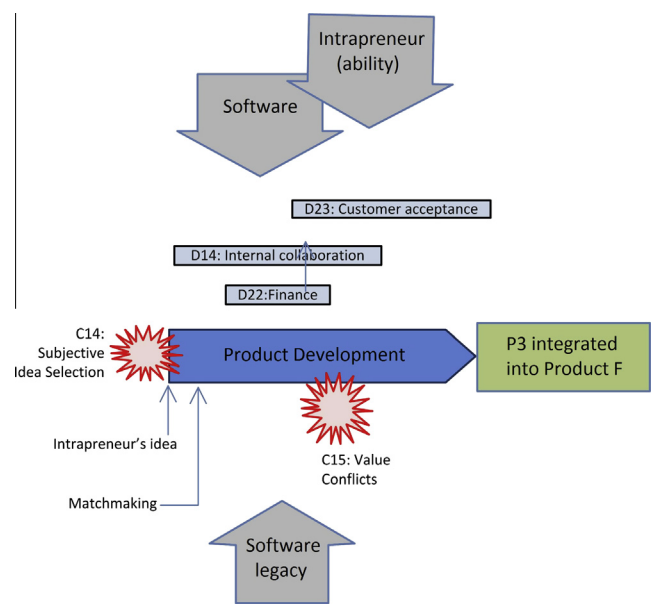

Fig. 3. Project that transformed the initial idea into the software product P3.

4.3.1.4. Activity 4 – Idea development and solution screening. P3 was prototyped and integrated into F. The research department and the product F-owning division jointly funded the prototyping project. It evolved P3 and showed it simplicity, novelty, and market relevance: "*This is the beginning of evolutionary theory. You expect mutations to fail. You expect to amplify the others.*" as explained by the intrapreneur.

4.3.1.5. Activity 5 – Business and marketing opportunity analysis. The company's standard process for business and market opportunity analysis was used. The prototype for P3 confirmed customer interest. One customer agreed to pilot test it. No formal business case was developed for P3.

4.3.1.6. Activity 6 – Technical development. Formal approval of the prototype by the customer initiated hand-over of P3 from research to development. A standard development process was then used.

4.3.1.7. Activity 7 – Product testing. product testing was performed using the company's standards.

4.3.1.8. Activity 8 – Product commercialization. Product commercialization was started according to the company's standard approach. It was still ongoing during the data collection.

4.3.1.9. Influence of Context. P3 was part of an innovation program that avoided major challenges. The study participants perceived the challenges to be on the level of the innovation program instead of the product level. Table 13 gives an overview of the challenges, causes and implied problems.

Funding decisions were perceived to be suboptimal. The innovator's personal qualities and capabilities, rather than investment analysis determined idea selection. No objective selection process was in place that would have enabled ideas of high impact from people without intrapreneur qualities to grow and spread. In addition, too many projects got funding.

A cultural gap existed between research and development units. Researchers perceived product quality differently than developers. Researchers were interested in demonstrating a slick product. Developers wanted to design an architecture that eased product maintenance.

Table 14 shows the determinants for P3. The intrapreneur helped to bridge the gap between the research and actual development teams by bringing them close together during pre-project development activities. In addition, company Z did *extensive investment* in research. The comfortable budget reduced the impact of the issue that too many projects got funding.

It was unavoidable for the project teams of P1 and P2 to run into challenges. The planning challenges rose as an allowance was not given for the novelty of the idea, thus failing to take estimation accuracy into account. Estimations and predictions are normally based on experiences from similar projects [68], however, given that innovation per definition is differentiated (in some way at least) from previous ventures, overestimation might be prudent. In essence, the product development teams' lack of knowledge, and inadequate time to perform idea development and solution screening, strategic planning and business and market opportunity analysis was a result of underestimation, and the 70/30 rule can be applied as a possible solution.

Structured innovation programs help organizations to capture knowledge and experience, improve the innovation process, and setup favorable conditions for realizing new ideas [69]. P3, in contrast to P1 and P2, benefitted from such a program. P3 did not encounter any significant challenge. The program guided the conception, evaluation, and implementation of the product idea. Portfolio decisions during idea evaluation made sufficient resources available for product implementation. The program matched the idea author with a relevant development unit. The developers from that unit were experienced in the kind of product that was conceived. Their estimates ensured sufficient time for implementing the product. However, for P3 challenges were observed at the company level, i.e. the challenges shifted from estimation, planning and quality problems to difficulties in the correctness and fairness of portfolio decision-making and collaboration across organizational units (see Section 4.3.1).

5. Analysis and discussion

This section answers the research questions presented in Table 2 by comparing the observed practice with state-of-art in *really new* product innovation and by discussing contextual factors that affected the innovations cases we studied.

5.1. RQ1 – Comparison of innovation state-of-the-art and practice

State-of-the-art of *really new* product development was implemented fragmentarily in the three studied cases. Except for *opportunity recognition* and *technical implementation*, none of the activities that are considered success-relevant were implemented at the expected degree. No obvious practice pattern explains the difference between product success and failure. Table 15 gives an overview of the similarities and differences between the innovation practice we observed and state-of-the-art [3,6].

Activity 1 – Opportunity recognition. Opportunities were recognized in all cases. The sources differed for the studied cases, but all of them corresponded to one of the variety of sources that [6] suggested to be relevant. Demand from the customer was the enabler for product P1 and technology-push for P2 and P3. However, P1 had limited scalability, and P2 did not reach wider market. The mix of idea sources within and across cases contradicts with the findings of studies [43,54,55] that report market demand as

Table 13
Challenges of P3 and their causes and implied problems (see Fig. 3).

Challenges	Causes for Challenges	Implied Problems
C14: Subjective idea selection that depends on personality of innovator as a champion for the idea	Lacking explicit criteria and investment analysis of the innovative idea	Too many ideas that may not be good, get funding
C15: Conflicting values between research and development	Lack of collaboration between research and development groups	Delayed project

Table 14
Determinants of success for P3 (see Fig. 3).

Determinant category	Determinant of innovation	Observations
Individual	D17: Entrepreneurship [67]	Within Company Z, innovation is encouraged by fostering staff as part of their career growth. The company has created a culture where individual developers/engineers can be identified and moved forward. However, those who do not show potential are eliminated. They have mentoring programs to identify future leaders, known as distinguished engineers. The idea is to observe people who have innovative ideas, and then select and encourage them. The selection of distinguished engineers is made through a joint collaboration between line management and the human resource department. The ideas proposed by the distinguished engineers get attention from the community and they easily get permission to push bigger ideas
Financial	D22: Finance (funding the innovation project) [55]	"Investment in research"
Customer orientation	D23: Customer acceptance	Extensive testing of ideas with customers
Internal collaboration	Technology transfer[a]	Gap between research and development departments (see challenge C14)

[a] Confirmed absence of determinant

the major determinant of innovation success. The studied cases suggest that the source for spotting an opportunity can be everywhere. However, having a product against market demand does not automatically prescribe success rather quality of the product and its reach to wider market are also needed. The studied cases indicate that technology push innovations need to be very carefully analyzed, as they risk initial failure.

Activity 2 – Initial screening was done informally in each of the three cases under the leadership of an individual that acted as product champion. Informal screening practice has been observed earlier [70], but our findings contradict with the recommended use of formal techniques and criteria [6]. This informal one person process relied on the expert judgment of an individual (e.g. the product champions that acted as proponent for the product ideas) seems to be the norm in our cases. This contradicts studies that report domination of group decisions during screening [6]. In our cases the multiple competences could have been involved informally. However, the actual screening was not a collaborative effort, rather a championing of sorts.

The screening and evaluation of ideas can be a pivotal activity, as it enables the selection of ideas with the greatest potential, and with resources being limited only a limited number of ideas can be chosen for realization. The screening and selection process in an organization can also be helpful in the identification and refinement of ideas, as reported by Gorschek et al. [71], where screening in essence was simultaneous refinement, alleviating issues such as challenges in commercialization [72] at an early stage. For our cases, it should be observed that since we only studied "successful" cases (or cases with limited success initially), which do not preclude the importance of formalized innovation candidate screening. Instead, our findings show that it is not a pre-requisite for success – specifically for cases where the idea for the product results in a response to an explicit demand from the customer (see Table 15, columns 3 and 4).

Activity 3 – Strategic planning was not performed for P1 and P2 but was formally carried out for P3. Strategic planning is considered success-critical for *really new* products, even-though informal or partial practice has been observed before [3]. Within strategic planning, resource planning is considered particularly important for successful product development [73]. The product ideas for P1 and P2 were not assessed and integrated with the companies' strategies, however. Although this omission did not prevent P1 success, it did create uncertainty and difficulties in the projects. For P2, the lack of strategic planning led to ignorance of the P2 business model incompatibility with company X legacy. Inadequate knowledge and setup of the company would require creative destruction of development processes and of policies and practices for marketing and sales [74,75]. Such change did not happen in the cases, however. Also the resources for the innovation projects for P1 and P2 were not adequately planned. For P1, too few resources were planned and allocated. P2 V2 could not be sold effectively. Knowledge management problems made evolution of P2 V2 difficult. Our cases show that if proper strategic planning is not performed, the company may have problems due to incompatibility of the innovative product idea with the current business and with the software legacy within the company. For P1, this incompatibility was catered for by extremely capable team. For P2, the problem was tried to be mitigated by initiatives to educate people.

Activity 4 – Idea development and solution screening was done to some degree in all cases except for P1 V1. For P1 V2 there was quick prototyping, for P2 V1 there were limited pilot tests, for P2 V2 there were pre-studies, and for P3 there were formal prototype tests with customers. These practices revealed customer needs and pointed to adequate solutions for the corresponding product ideas. The pilot tests for P2 V1 gave insights about consumer behavior and product sales problems. The insights were used to adapt the sales approach that then included a live demonstration of the dynamic discounting during sales meetings. The pre-studies performed for P2 V2 enabled smooth integration of P2 V1 with other products. The testing of a P3 prototype with customers gave company Z confidence in the market potential of the idea. Such confidence is necessary for developing new products [76]. For P1 V1, adaptation of an already existing solution was perceived enough in the context of time pressure. The importance of this activity for the observed cases contradicts studies that deny its effect on product success [3]. From the studied cases, it can be concluded that idea development and solution screening needs to be done to gain insights into customers' needs and behaviors.

Activity 5 – Business and market opportunity analysis concerns the execution of required marketing tasks for converting new product ideas into well-defined sets of features that satisfy customer needs. Interestingly, the activity of business and market opportunity analysis was partially performed for P1 and P2, and explicitly for P3. The challenge in relation to opportunity analysis for innovations is that customer needs are not well-defined upfront and introducing the products involves extensive customer education and iterative learning from the market [3]. In this case, a traditional business and market opportunity analysis was seen as a wasted effort, a point strongly argued by Song and Montoya-Weiss [3]. In contrast Cooper found that this activity is significantly related to product success, arguing that it helps to estimate competitive situation, market size, customer wants/needs/preferences, and customer reaction to the proposed product/product concept [6].

While developing P1, incorrect assumptions were made about product use due to absence of detailed business and market opportunity analysis. Consequently, Company X had to face a lot of customer complaints with respect to the scalability and reliability of P1 V1 (see Challenge C3, Fig. 1 and Table 6). However, the customer use of P1 V1 and the corresponding issues can be regarded as market learning. This interpretation encouraged the team to develop the scalable and reliable product P1 V2. However, this product test was not deliberate. On the other hand, when developing P2, Company Y deliberately developed prototypes and used them for extensive market research. That market research showed that customers needed continuous support during product use and risk has to be shared with the customers through an appropriate business model. For P2, Company X, in contrast to Company Y, did not perform a business and market opportunity analysis to identify what is needed in the business solution to make it a success. Subsequently, they faced a number of challenges related to bundling the right services and pricing model in the business solution (see C11 in Fig. 2). Uncertainties regarding target markets, product technologies and/or product support systems make it challenging for managers to anticipate factors and their effects on the outcome [3]. This phenomenon was observed specifically for P2, where uncertainties and subsequent risks also make it difficult to sell the idea to internal stakeholders and customers. Every innovative idea involves uncertainty and risks to some extent, however, our study shows that there is a need to identify uncertainties and inherent risks by performing business and market opportunity analysis, and develop strategies how to address them in order to make the innovation a success.

Activity 6 – Technical development, Activity 7 – P*roduct testing*, and *Activity 8 – Product commercialization* were performed in all cases, except for the omission of extensive tests in P1 V1. These activities are considered part of the normal product development process [73], and they were so in all three companies. Failure to perform product testing can be detrimental [6]. Time-to-market pressure made company X to omit this activity for P1 V1. This omission contributed to the scalability and reliability problems of P1 V1. An upfront investment in testing would have been

Table 15
Comparison of activities that influence the success of *really new* products.

Activities and practices within them	Success-influencing [6]	Success-influencing [3]	P1V1 (Limited success)	P1V2 (Success)	P2V1 (Limited success)	P2V2 (Success)	P3 (Ongoing)
Activity 1 – Opportunity recognition	Strongly related**	N/A	Customer request	Customer complaints	Service department	Management	R&D intrapreneur
External sources (e.g. customer)			X	X	Not done	Not done	Not done
Internal sources (e.g. R&D)			Not done	Not done	X	X	X
Activity 2 – Initial screening	Strongly related	N/A	Informal	Informal	Informal	Informal	Informal
Checklist-based group decision			Not done	Not done	Not done	Not done	Not done
Informal individual decision			X*	X	X	X	X
Activity 3 – Strategic planning	Significantly related***	Positive impact	Not done	Not done	Not done	Not done	Formal
Comparison with strategic objectives			Not done	Not done	Not done	Not done	X
Resource assessment and planning			Not done	Not done	Not done	Not done	X
Preliminary market assessment			Not done	Not done	Not done	Not done	X
Activity 4 – Idea development and solution screening	Strongly related	Considered not success critical	Not done	Informal	Informal	Informal	Formal
Technical assessment in pre-study			Not done	Not done	Not done	X	Not done
Product specification and design			Not done	Not done	Not done	Not done	Not done
Model development (prototype)			Not done	X	Not done	Not done	Not done
Pilot test			Not done	Not done	X	Not done	Not done
Formal kill decisions at stage gates			Not done	Not done	Not done	Not done	X
Activity 5 – Business and market opportunity analysis	Significantly related	Negative impact	Partial	Partial	Not done	Partial	Formal
Quick business case for project			X	X	Not done	X	Not done
Business case for productization			Not done	Not done	Not done	Not done	X
Detailed market study			Not done	Not done	Not done	Not done	Not done
Market requirements specification			Not done	Not done	Not done	Not done	X
Requiring idea adoption by product team and customers			Not done	Not done	Not done	Not done	X
Activity 6 – Technical development	Strongly related	Positive impact	Ad-hoc	High quality	High quality	High quality	High quality
Design, development, test and built			X	X	X	X	X
Activity 7 – Product testing	Significantly related	Not success-critical	Minimal	Standard	Formal	Standard	Standard
Incremental product testing			Not done	X	X	Not done	Not done
Market-based testing			Not done	Not done	Not done	X	Not done
Specifications check			Not done	Not done	Not done	Not done	Not done
In-house alpha and beta tests			Not done	Not done	Not done	Not done	X
Field tests			Not done	Not done	X	Not done	Not done
Activity 8 – Product commercialization	Significantly related	Positive impact	Standard	Standard	Standard	Standard	N/A
Publicity and promotion			Not done	Not done	X	Not done	N/A
Training and education of sales staff			Not done	Not done	Not done	Not done	N/A
Supply and channel preparation			Not done	Not done	X	Not done	N/A
Product support			Not done	Not done	X	Not done	N/A

* X in a cell indicates the practice in that corresponding row was carried out for the product in the corresponding column.
** Strongly related when level of significance (based on two-tailed t test performed in [6]) is $\geqslant 0.01$.
*** Significantly related when level of significance (based on two-tailed t test performed in [6]) is >0.01 and $\geqslant 0.05$.

beneficial. This upfront investment should be measured in relation to the cost of the wasted effort.

Analogously, determinants for innovation success were present only fragmentarily in the three studied cases. Again, no obvious pattern explains the difference between product success and failure. For example, while some determinants (for example, basic research infrastructure, human capital, flexibility and leadership) were present in the development of P1, none of these could be identified in the development of P2 and P3. Table 16 gives an overview.

Overall, our data points to the following answer of RQ1. The state-of-practice for the three case products does not compare to the state-of-the-art in really new product development. Few activities were implemented at the expected degree, and only a fraction of the determinants for innovation success were present. No obvious pattern with respect to the eight development activities or with respect to the determinants for innovation success explains the difference between product success and failure.

The results from our findings contradict some previous work [3,6] that suggests more comprehensive adoption of innovation activities and practices. Moreover, in the studied cases no formal innovation process existed whereas some recent surveys [17,18] have reported that a formal innovation process is a norm in most companies they surveyed.

There could be several reasons for these differences in findings. Since we studied only three "successful" cases, it was not possible to find a pattern of activities that led to success, thus our study is more focused on how a good idea is refined to possible become an innovation. Another possible reason could also be that software industry (which is our focused domain) has not matured enough to formalize their innovation process as compared to traditional product development industry. One central aspect that should be brought forward is that we have conducted in-depth case studies, talking to the "doers" in each company to get a "real and actual" account of events. The companies we worked with had some innovation processes and practices that were official, but in the cases we studied they were not utilized or seen as beneficial – thus there is a need to differentiate between the official process (how things should be done) and the actual used process (how things are done [77]).

Table 16
Overview of determinants across products and versions.

Determinant category	Determinant of innovation	P1 V1	P1 V2	P2 V1	P2 V2	P3
Organizational resources	D1: Research infrastructure	X	X			
	D2: Human capital	X	X			
	D3: Technology capabilities	X	X			
Customer orientation	D4: Customer orientation	X				
Communication	D5: Communication	X	X			
Culture	D6: Flexibility	X	X			
	D12: Incentive provision		X			
Leadership	D7: Leadership	X	X			
External collaboration	D8: Cooperation with customers	X	X			
Market	D9: Demand pull	X	X			
External environment	D10: A local context that encourages investment in innovation-related activity	X			X	
Empowerment	D11: Skilled people have ownership to innovate in their area		X			
Risk	D13: Willingness to take a risk		X			
Internal collaboration	D14: Specialized knowledge consolidated across business divisions, technical disciplines, product technologies, and target markets from within the enterprise			X		
Technology	D15: Knowledge and experience in science and engineering			X		
R&D	D16: Experimentation and pilot test			X		
Individual	D17: Entrepreneurship			X		X
Market	D18: Market research					
Internal collaboration	D19: Team work quality				X	
Networking	D20: Inter firm relationship				X	
	D21: Collaboration with suppliers and customers				X	
Financial	D22:Finance					X
Customer orientation	D23: Customer acceptance					X

X in a cell indicates the determinant existed for the product in the corresponding column.

In addition, the varying degree of implementation of certain innovation activities, and omission of others, may have been affected by a number of contextual factors. Context may explain the seemingly random presence and absence of determinants as not every determinant is needed in every context. This perspective will be discussed in section 5.2.

5.2. RQ2 – Contextual factors and innovation practice

Overall, our data points to the following answer of RQ2. Contextual factors affected the state-of-practice for the three case products. Each team's activities were the result of pragmatic attempts to maximize the likelihood of innovation success in the respective situations. Belief in the flexibility of software encouraged the projects to quickly deliver a product good-enough for the initial customers. Threat of company survival reinforced that practice. Technology and human legacy enabled such quick composition of a product. Lack of innovation-enabling legacy implied efforts to build such a legacy. Business legacy made it easy for products to reach customers. The champions' belief in the product and entrepreneurial qualities, finally, created the tenacity necessary to sustain the innovation over periods of crisis.

If innovation success had been determined by a set of universal activities/best practices, the success of P1, P2, and P3 would have depended on how many of activities/best practices suggested by [3,6,17,18] were adopted. The studied cases, however, confirmed the view that successful innovation practice is determined by contextual factors [12,13].

Except for the nature of the innovation and market, the contextual factors differed from those suggested by [12,13], however. As [12] predicts, the substantial novelty of the products made their creation difficult, and business legacy reduced market uncertainty and eased innovation. Opposed to the predictions of [12] related to the nature of technology, it was not relevant whether well-established standards and practice existed. In addition to the factors suggested by [12], our cases exhibited the following contextual factors playing their role in the context of software innovation practice: the special characteristics of software, threat to survival, software and business legacy, and the power and ability of the product champion. This discovery of additional contextual factors indicates that more research is needed to saturate the understanding of contextual factors that affect software innovation practice.

Figs. 1–3 provide an overview of the contextual factors for each innovation. The remainder of this subsection explains the contextual factors and their role in enabling software product innovation in detail.

5.2.1. The effect of inherent software properties on innovation

Software allows easy integration with other systems [78], has a relatively low-cost of development and production [79,80], and is flexible to change and evolve [79]. We hypothesize that if software has an effect on innovation, the characteristics of software should explain the choice of innovation practices used in P1, P2, and P3. Each of these characteristics is detailed below along with the effects on the choice of activities and determinants.

Low-cost: The lack of physical shape (it is in essence a virtual non-physical artifact) allows software to be easily designed and produced [81]. The development can focus on the design of functionality and logic structure only, ignoring the interdependencies with design and ramp-up of the production processes [82]. Similarly, prototyping does not require the creation of a physical product to simulate the functionality and value of a product. This enables quick prototyping to test the feasibility and acceptance of the idea [83]. In case of P1 V2, it was low cost and quick to develop and test different possible solutions before selecting the best one (see Section 4.1.2). The simplicity of creating prototypes, once the technical solution was evident, enabled the creation of a prototype for P2 (see Section 4.2.1). A small team was able to

create the prototype and pilot it based on data from Operator O. Also in the case of P3, the low cost of prototyping enabled testing of the idea with customers prior to the commencement of the product development project (see Section 4.3.1). The positive feedback received by these customers convinced the business unit to productize the idea fully.

The low cost of software production encourages pilot testing [59] and customer collaboration [53]. The low cost of software prototyping affected the use of the corresponding determinants for innovation success of the initial versions of P2 and P3. In both cases the low cost enabled the initial experimentation, pilot testing, and early and extensive collaboration with the respective customers. This allowed Company Y and Company Z to understand customer needs and evaluate the acceptance of the product idea.

Flexibility: Software can be changed or updated relatively easily by using patches or release updates [79]. This flexibility makes incremental product development possible by reducing the importance of accurate a-priori product development decisions. This is especially true for pure software solutions since there are few dependencies to physical artifacts that demand traditional production. Decisions can be corrected with appropriate refactoring. The ease of change enables frequent releases, which then facilitates incremental development, testing, and continuous learning. P1 V1 was developed with this flexibility in mind. As a consequence, the product development team accepted faulty assumptions about how users and the market would react to the product and did not invest in market studies. The development effort also assumed that the errors and quality problems of the solution could be easily corrected, and they only did minimal testing. The omission of these practices allowed for the early release of P1 V1. It turned out that flexibility of the constructed software product was limited, however. The limitations of the technologies used in P1 V1 did not allow for updates, but required re-building everything from scratch to handle quality issues. For P2, the ease of making changes in software enabled incremental improvements in P2 by testing the product through pilots and multiple releases in the market (P2 V1). The flexibility of software did not play an important role in P3.

Software flexibility allowed for early product release. This practice reduced the importance of the determinants of innovation success related to upfront market research and planning, confirming the view of [72]. Also it gave the innovation projects market feedback iteratively. Both P1 and P2 benefited from this early testing of the product in a full-scale real-world environment, confirming the view of [59]. It also increased customer orientation for later releases of the products. The products rapidly reached a break-even point and provided a high return on investment because the initial customers could be invoiced early, confirming the view of [84]. The income that P1 V1 generated eased the situation of Company X at the time. The income that P2 V1 generated enabled the continuation of the startup (Company Y). The massive effort for evolving P1 V1 into P1 V2, however, shows that software flexibility has its limits. The use of software flexibility for shortcutting the development process worked for evolutionary changes, but turned out to be a double-edged sword for radical change.

5.2.2. Threat to survival and its effect on innovation practice

For P1, threats to the survival of Company X's local office shifted the focus of the development project to deliver a good-enough product quickly instead of capitalizing on innovation success determinants such as following an innovation strategy, innovation portfolio planning, and the creation of new technologies. These activities would have delayed the delivery of P1 V1. Moreover, if the team had done extensive market research at the time, recruited new resources and had complied with the traditional development processes, they would have missed the market window. Instead, skilled human capital got together as a team and resorted to an "agile way of working", ignoring the validation of assumptions relating to market demand and minimizing product testing. These shortcuts enabled the team to deliver P1 V1. The release of P1 V1 with minimal quality helped the company to mitigate the survival threat in the short run, by delivering the product to the requesting customer, and later with the release of P1 V2 they addressed the quality problems as well. We could identify only little previous research on the relationship between the probability of survival and the innovative activities carried out within the company [85,86].

5.2.3. The effect of software legacy on innovation

Companies accumulate substantial amounts of legacy over time. Legacy is, in essence, a side effect of development, and includes: (i) technology and solutions [87], (ii) employees and their social networks, and (iii) knowledge and processes [88]. Some companies struggle with the question of how to take advantage of legacy, especially if it comprises outdated design techniques and technologies [87,89–92]. Low quality legacy requires re-engineering or re-development of old technologies and solutions [89,90]. High quality legacy is considered by some companies as the company's capital and a major source of competitiveness [88,93,94]. In essence legacy can be used to enable innovation, design and development. The existence of innovation-enabling legacy can reduce solution development effort and uncertainty regarding performance and risk. Legacy, can thus enable, and simultaneously hinder the development of innovative products.

In the studied cases, software legacy was leveraged if the capabilities of that legacy matched market needs and the use of legacy mitigated uncertainty and risk to a certain extent. Technology and human legacy enabled the development of P1 V1. The presence of an existing solution, used for other applications, and the knowledge of employees enabled Company X to quickly design and build P1 V1. P1 V1 then became a new legacy baseline. P1 V2 was the only product of our three cases that was developed without using an existing legacy. The legacy created with P1 V1 was destroyed by re-developing P1 with replaced technologies and solutions to address discovered scalability and reliability issues. Additionally, the development process was also discarded and replaced as the project teams believed it would hinder the fast delivery of the product.

Infrastructure, human capital and personal relationships enabled the initial development of P2. Access to a real operating environment and the knowledge and competence of the people allowed for a prototype of the idea and its pilot testing. The legacy that was created with that prototyping effort allowed the establishing of a start-up – Company Y. In order to gain larger market share, the entrepreneur of Company Y used his personal network to win collaboration with Company X that possessed the required market legacy (customer networks). The joint venture then had the necessary product and technology legacy to successfully productize P2.

Similarly, P3 could not be developed by the intrapreneur independently. The institutionalized innovation process enabled the innovator of P3 to expose his initial ideas to other employees that possessed software legacy, the product F, required to productize P3. P3 was built by integrating it into that product.

The innovation projects leveraged on software legacy, but such leverage did not come free. In order to capitalize on software legacy a number of well-known practices were needed. These included networking [56], internal collaboration [62], and an inter-firm relationship [47]. For P1, matchmaking was enabled by internal collaboration within the company and business networks. For P2 V2, matchmaking was enabled by the personal network of the entrepreneur who acquired the necessary relationships during his time at Operator O. Such personal network use is suggested by [54]. For P3, matchmaking was enabled by the company-internal

market place, where ideas were presented to stakeholders within the company and internal collaborations were identified.

5.2.4. The effect of business legacy on innovation practice

Companies do not only accumulate technology-oriented legacy, but also business legacy. Such business legacy includes knowledge about users, customers, and markets, relationships with their customer, and the alignment of products and services with market needs. Business legacy may be positive and reduce market-related uncertainty and risk as it allows a company to be aware of true market needs and how the market reacts to a product, which affects the evolution of the product. A lack of an innovation-enabling business legacy implies new business developments to build such a legacy. This prolongs the innovation project or increases uncertainty regarding market success and risk. On the other hand, the business legacy may be negative and hinder innovation success. A company might have to adapt to new markets and develop a new marketing approach if the innovation diverges from the company's previous offerings – this in itself could be a hindrance, but if nothing else mandating an additional investment.

Business legacy was essential for the development of P1 V2, P2 V2, and P3, and affected innovation success. A lack of such positive business legacy implied that such a legacy had to be built before product success was achieved. For P1 V1, faulty assumptions about market demand and subsequent quality problems acted as a learning effect. The new legacy was essential for designing the next version of the product P1 V2. Additional business legacy was created with P1 V1 in the form of relationships with potential customers. Also these were capitalized on once P1 V2 was released.

For P2 V2, however, business legacy was negative and hindered innovation success. The business model of Company X was inconsistent with the needs of product P2 V2, which led to confusions among stakeholders with respect to the required changes in the development processes, sales and marketing strategy. The business model could not be changed by the product organization and the problem still persists to this day.

In Company Z, the innovation process ensured that positive business legacy was created prior to actual product development. In order to create such legacy, the product idea was reviewed by customers. The knowledge gained by the resulting customer feedback was used to develop the value case of P3.

5.2.5. The effect of the power and ability of the champion in the innovation process

In the cases of P2 and P3, the champions' belief in the ideas and entrepreneurial qualities were the major determinants. The concept behind P2 was novel and risky. The entrepreneur tried to convince the management of telecommunication Operator O to productize the idea. However, after investing considerable effort with no results, the champion started his own company, Company Y, with a handful of employees from O. If the entrepreneur had not started his own company, the idea could have died at O. Later, the entrepreneur adopted a cooperative innovation strategy because he realized that his Company Y alone could not reach all the customers. Such cooperative innovation along with the corresponding motivations have been researched before [95]. The motivation for partnership is well acknowledged in literature, for example [96,97]. The "willingness" and "capability" of a partner are reported as an important criteria while choosing a partner [95]. Although P2 V2 was developed and marketed after the partnership between Company X and Company Y was established, the challenges faced by Company X while developing a new type of innovation certainly raises questions about the "capability" of the partner in this case [95]. The entrepreneur did not perform any formal capability analysis of the potential partners, but chose Company X as it had a larger foot print in the market, and the contact person at Company X was "willing" to develop P2.

In Company Z, entrepreneurship is part of a broader organizational process [98]. The structured innovation program in Company Z made it comparatively easy for the entrepreneur to sell his idea both internally to management and development team and externally to the customer. If telecommunication Operator O would have had a similar culture conducive to entrepreneurship, P2 could have been a part of O's portfolio and enhanced O's business volume as an exclusive internal product. In fact O did, more than a year later company Y was launched, identify the value of P2 and re-developed the technology internally.

6. Conclusion

This paper presents the results of an empirical study that examined innovation practice for three *really new* software products. Extensive data was collected that showed the contextual nature of product innovation process.

Innovation practices were determined through the study of three product innovations at three companies. Comparison of the challenges and success factors for all three cases was performed with respect to the literature on state-of-art of *really new* product innovation. Results indicate that innovation was not a blind application of universally applicable innovation activities and determinants. Instead, successful innovation required flexible adaptation to the situation at hand, pragmatic selection of activities, exploitation of existing determinants, and mitigation of challenges. This confirms the hypothesis that innovation practice is dependent on context. It calls for the creation of frameworks that enable the selection of activities and determinants for a given context – as one size does not fit all.

Qualitative analysis of the studied cases showed that innovation practice was affected by the specific characteristics of software as a technology, presence or absence of a threat to survival, existence of software and business legacy, and power and ability of the product champion. These observations about contextual influences of innovation practice challenge established models that claim innovation success to depend on a universal set of activities and determinants. Instead, they support more recent models that suggest that innovation practice is contextual. The study results not only confirm the latter view, but also extend it with contextual factors that were not discussed in the software intensive product development context prior to this study, namely the *inherent properties of software, survival threat*, the presence or absence of *software and business legacy* and *entrepreneurial power and capabilities*.

The discovery of new contextual factors, in addition to those that were known by prior research [12,13], implies that the understanding of the contextual nature of innovation processes has not stabilized yet. However, with our study the evidence base has become strong enough to initiate research that goes beyond a few revelatory cases and investigate contextual innovation at large. A large number of samples is needed to be convinced that all important contextual factors and their effects are identified. The present study, in conjunction with the mentioned prior work, can provide an initial theoretical lens for such research.

The results have the following implications for industry practitioners. Each innovation project needs to consider the existence and influence of contextual factors to ensure a successful outcome. The "best idea" and "best practice" do not suffice. A formal "innovation process/model" that spans from the initial idea-finding phase into product realization may have positive effect on a company as a whole. However, instead of following such a process, the studied projects implemented their own pragmatic activities. The influence of the context on appropriate innovation practice implies

a need for reflective thinking. Each step in an innovation project should be managed by identifying strengths, weaknesses, opportunities, and threats in the context of the project and addressing them with suitable means. The successful transformation of an innovation candidate into a product largely depends on such monitoring and action. The cases presented in this paper give examples of what factors to look for and how to address them.

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