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Martin Lehnert, Alexander Linhart, Maximilian Röglinger

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WI-441

University of Augsburg, D-86135 Augsburg
Visitors: Universitätsstr. 12, 86159 Augsburg
Phone: +49 821 598-4801 (Fax: -4899)

University of Bayreuth, D-95440 Bayreuth
Visitors: F.-v.-Schiller-Str. 2a, 95444 Bayreuth
Phone: +49 921 55-4710 (Fax: -844710)

www.fim-rc.de

CHOPPING DOWN TREES VS. SHARPENING THE AXE – BALANCING THE DEVELOPMENT OF BPM CAPABILITIES WITH PROCESS IMPROVEMENT

Martin Lehnert, Alexander Linhart, Maximilian Röglinger
University of Augsburg, FIM Research Center, Augsburg, Germany
{martin.lehnert,alexander.linhart,maximilian.roeglinger}@fim-rc.de

Abstract. The management and improvement of business processes is an evergreen topic of organizational design. With many techniques and tools for process modeling, execution, and improvement being available, research pays progressively more attention to the organizational impact of business process management (BPM) and the development of BPM capabilities. Despite knowledge about the capabilities required for successful BPM, there is a lack of guidance on how these BPM capabilities should be developed and balanced with the improvement of individual business processes. As a first step to address this research gap, we propose a decision model that enables valuating and selecting BPM roadmaps, i.e., portfolios of scheduled projects with different effects on business processes and BPM capabilities. The decision model is grounded in the literature related to project portfolio selection, process performance measurement, and value-based management. We also provide an extensive demonstration example to illustrate how the decision model can be applied.

Keywords: Business Process Management Capabilities · Process Improvement · Value-based Decision-Making.

1 Introduction

Process orientation is a widely adopted paradigm of organizational design and a recognized source of corporate performance [1, 2]. As a result, business process management (BPM) receives constant attention from industry and academia [3, 4]. As many techniques and tools for process modeling, execution, and improvement are available [5], BPM research is shifting its focus toward the organizational impact of BPM and the development of BPM capabilities [6]. This shift makes emerge novel research questions at the intersection of traditional BPM research and BPM research focused on capability development. In this paper, we investigate one of these novel research questions from a project management perspective, namely how the development of BPM capabilities should be balanced with the improvement of individual business processes.

The BPM literature contains many process improvement approaches [7, 8]. Most improvement approaches, by nature, take on a single-process perspective and neglect how to balance the improvement of a single process with the improvement of other processes or the development of BPM capabilities. From a capability perspective, recent research analyzed which capabilities are necessary for successful BPM. For instance, Rosemann and vom Brocke [9] proposed a framework of six factors (e.g., people, information technology, methods, culture, and governance) each of which is supported by a set of capability areas (e.g., process design, process education, or process improvement planning). A similar framework is authored by van Looy et al. [10]. Jurisch et al. [11] identified which capabilities an organization needs to succeed in process change. Though compiling and structuring BPM capabilities, no approach indicates how these capabilities should be developed. The literature related to the BPM capability areas "process improvement planning" and "process program and project planning" provides no guidance either. A tool that is supposed to provide guidance are process and BPM maturity models [12]. While process maturity models deal with the condition of processes in general or distinct process types, BPM maturity models focus on BPM capabilities [9]. However, maturity models are criticized for adhering to a one-size-fits-all approach, i.e., they typically support a single path of maturation that has to be traversed completely and irreversibly without any possibility for customization [6]. Moreover, maturity models are not suited for decision-making purposes [12]. Other authors take on a project management perspective by using project portfolio selection (PPS) techniques [13]. As process improvement and the development of BPM capabilities are achieved via projects, a project management perspective promises to be a sensible option for balancing both endeavors and for providing more flexible guidance than maturity models do. However, existing quantitative approaches based on PPS only deal with areas of BPM that have nothing to do with BPM capabilities.

The preceding analysis reveals the following research gap: First, organizations require more guidance on how they should develop BPM capabilities. Second, they lack approaches that assist with balancing the development of BPM capabilities and the improvement of individual business processes. From a project management perspective, this research gap refers to a PPS and a project scheduling problem. Therefore, our research question is as follows: *Which projects should an organization implement and in which order should it implement these projects to balance the development of BPM capabilities with the improvement of individual business processes?*

As a first step to answer this question, we propose a decision model for valuating and selecting BPM roadmaps in line with economic principles. A BPM roadmap is a portfolio of scheduled projects with different effects on business processes and BPM capabilities. Thereby, a BPM roadmap indicates which process- or BPM-level projects need to be implemented in which order. As the decision model shows characteristics of a model and a method, we adopt a design science research approach [14]. In line with existing reference processes [15], we cover the following phases of design science research: identification of and motivation for the research problem, objectives of a solution, design and development, and evaluation. In the design and development as well as in the evaluation phase, several industry partners were involved, i.e., an IT service provider, a financial service provider, and an IT consultancy.

The paper is organized as follows: As the decision model is located at the intersection of BPM and project management, we sketch the foundations of BPM, process performance measurement, PPS, and value-based management as theoretical background in section 2. We also derive requirements that a solution to the research question should meet (*objectives of a solution*). In section 3, we propose the decision model (*design and development*). In section 4, we report on the evaluation steps conducted so far, particularly on a demonstration example that builds on a prototypical implementation of the decision model and uses the case of an IT service provider (*evaluation*). We conclude by summing up key results, limitations, and pointing to future research.

2 Theoretical background and Requirements

2.1 Business Process Management and Process Performance Measurement

BPM is "the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and to take advantage of improvement opportunities" [3]. Therefore, BPM combines knowledge from information technology and management sciences [5]. From a lifecycle perspective, BPM includes the identification, definition, modeling, implementation and execution, monitoring and control as well as continuous improvement of processes [3]. BPM deals with all processes of an organization and, thus, constitutes an infrastructure for efficient work [16].

BPM is closely related to capability development, a field that builds on the resource-based view and dynamic capability theory. According to the resource-based view, capabilities refer to the ability to perform a coordinated set of tasks for achieving a particular result [17]. From a dynamic capability theory perspective, capabilities split into operational and dynamic capabilities [18]. Operational capabilities refer to the basic functioning of an organization [19]. Dynamic capabilities help integrate, build, and reconfigure operational capabilities to increase their fit with the environment as well as their effectiveness and efficiency [20]. Processes and their execution are equated with operational capabilities, whereas BPM is treated as a dynamic capability [21].

As for the BPM lifecycle stages monitoring and control as well as improvement, performance indicators are essential for assessing the performance of a process and the effects of redesign projects [3]. Process performance indicators can be grouped according to the Devil's Quadrangle, a framework that consists of the dimensions time, cost, quality, and flexibility [22]. The Devil's Quadrangle earned its name from the fact that improving one dimension has a weakening effect on at least one other dimension [22]. Thereby, it discloses the trade-offs that have to be resolved during process improvement [22]. To apply the Devil's Quadrangle, its dimensions must be operationalized by performance indicators that account for the peculiarities of the context at hand [3]. As for time, a common indicator is the cycle time, i.e., the time for handling a process instance end-to-end [23]. Typical cost indicators are turnover, yield, or revenue. Quality splits into internal and external quality that can be measured in terms of error rates and customer satisfaction, respectively. Flexibility can be measured via waiting or set-up times [24]. Although there are further non-monetary performance dimensions, we focus on the dimensions of the Devil's Quadrangle. We derive the following requirements:

(R.1) *Capability development*: To determine an optimal BPM roadmap, (a) there must be projects that affect an organization's operational capabilities, i.e., its business processes, and projects that help develop BPM as a dynamic capability. Moreover, (b) there must be projects that influence a single business process and projects that affect multiple business processes.

(R.2) *Process performance measurement*: To evaluate the projects contained in a BPM roadmap, (a) the performance of all processes has to be measured according to typical performance dimensions such as those from the Devil's Quadrangle. (b) It must be possible to operationalize each dimension by one or more performance indicators.

2.2 Project Portfolio Selection

PPS is the activity "involved in selecting a portfolio, from available project proposals […], that meets the organization's stated objectives in a desirable manner without exceeding available resources or violating other constraints" [25]. The PPS process includes five stages: pre-screening, individual project analysis, screening, optimal portfolio selection, and portfolio adjustment [25]. In the pre-screening stage, projects are checked with respect to whether they align with the organization's strategy and/or are mandatory. During individual project analysis, each project is evaluated stand-alone regarding pre-defined criteria. In the screening stage, all projects are eliminated that do not satisfy the pre-defined criteria. The optimal portfolio selection stage determines the project portfolio that meets pre-defined criteria best. This requires a decision model that integrates all criteria and considers interactions among projects [26]. Finally, decision makers may adjust the optimal portfolio based on their knowledge and experience.

Considering interactions among projects is a challenging, but necessary requirement for making reasonable PPS decisions [27]. The current literature focuses on interactions among information technology/information systems (IT/IS) projects as IT/IS projects typically involve higher-order interactions between three or more projects, whereas, in the capital budgeting or R&D context, mostly interactions between two projects are considered [28]. Higher-order interactions among IT/IS projects can be classified according to three dimensions, i.e., inter-temporal vs. intra-temporal, deterministic vs. stochastic, and scheduling vs. no scheduling [26]. Intra-temporal interactions affect the planning of single portfolios, whereas inter-temporal interactions influence today's decision-making based on potential follow-up projects [29]. Inter-temporal interactions result from effects that depend on the sequence in which projects are implemented [30]. Interactions are deterministic if all parameters are assumed to be known with certainty or were estimated as a single value. If parameters are uncertain and follow some probability distribution, interactions are considered as stochastic [31]. Scheduling interactions occur if projects may start at different points. Otherwise, there are no scheduling interactions. Against this background, we derive the following requirement:

(R.3) *Project portfolio selection*: To determine an optimal BPM roadmap, it is necessary (a) to consider only projects that affect processes or BPM capabilities and align with corporate strategy, (b) to evaluate these projects stand-alone prior to portfolio selection, (c) to consider interactions among these projects.

2.3 Value-based Management

Value-based management, as a substantiation and extension of the shareholder value concept, sets the maximizing of the long-term, sustainable company value as the primary objective for all business activities [32]. The company value is determined based on future cash flows [33]. Value-based management can only be claimed to be implemented if all business activities and decisions on all management levels are aligned with the objective of maximizing the company value. Therefore, companies must not only be able to quantify the company value on the aggregate level, but also the value contribution of individual activities or decisions.

There is a set of objective functions that are used for making decisions in line with value-based management [34]. In case of certainty, decisions can be based on the net present value (NPV) of the future cash flows [35]. In case of risk with risk-neutral decision makers, decisions can be made based on the expected NPV. If the decision makers are risk-averse, decision alternatives can be valuated using the certainty equivalent method or a risk-adjusted interest rate [36]. To comply with value-based management, decisions must be based on cash flows, consider risks, and incorporate the time value of money [34]. This leads to the following requirement:

(R.4) *Value-based management*: The optimal BPM roadmap is the roadmap with the highest value contribution. To determine the value contribution of a BPM roadmap, one has to account (a) for the cash flow effects of the BPM roadmap, (b) the decision makers' risk attitude, and (c) the time value of money.

3 Decision Model

3.1 General Setting and Basic Assumptions

We consider an organization with multiple business processes. The output of each process is of value to the organization's customers. The demand for each process output depends on quality and time, not on the price. Each performance dimension can be operationalized in terms of case-specific indicators. The organization aims to select the optimal BPM roadmap, i.e., the roadmap with the highest value contribution, from a set of pre-defined project candidates. It thus determines which project candidates should be implemented in which order. The project candidates have been checked for appropriate strategic fit in the pre-screening stage of the PPS process. To unambiguously analyze inter-temporal interactions among projects and processes, only one project can be implemented per period. All projects can be finished within one period such that their effects become manifest at the beginning of the next period. In this context, periods can also be quite short (e.g., quarters or months). When selecting the optimal BPM roadmap, the organization also has to set the relevant planning horizon. If the number of project candidates exceeds the planning horizon, the organization has to make a PPS and a project scheduling decision at the same time. Otherwise, there is only a scheduling decision. Due to the inter-temporal interactions among projects and processes, the absolute effect of a project depends on the projects that have been implemented in prior periods, a phenomenon that is referred to as path dependence [37]. As a result, implementing the same projects in different sequences leads to different absolute effects of each project and to BPM roadmaps with different value contributions. As it is very complex and costly to estimate ex ante the absolute effects of each project candidate considering all possible sequences of implementation [38], we assume that the effects have been assessed in terms of relative numbers independent from other projects during the individual project analysis stage of the PPS process. This setting translates into the following assumptions:

(A.1) Each process $i \in I$ from the set of processes under investigation has a distinct quality $q_{i,y} \in \mathbb{R}^+$ and time $t_{i,y} \in \mathbb{R}^+$ for each period y of the planning horizon $Y \in \mathbb{N}$. The sales price $p_i \in \mathbb{R}^+$ for the output of process i is constant.

(A.2) The demand $n_i(q_{i,y}, t_{i,y}) \in \mathbb{R}^+$ for the output of process i is deterministic and depends on the quality $q_{i,y}$ and time $t_{i,y}$. The demands for different outputs are independent. The customers' sensitivity toward quality and time is constant throughout the planning horizon.

(A.3) One project can be implemented per period. All projects can be finished within one period.

(A.4) The effects of all project candidates have been determined in the individual project analysis stage of the PPS process. These effects are expressed in terms of relative numbers and independent from other projects.

To identify the BPM roadmap with the highest value contribution, all roadmap candidates r must be evaluated. The value contribution of a BPM roadmap is measured in terms of its NPV_r, i.e., the sum of all discounted periodic cash flows using a risk-adjusted interest rate $z \in \mathbb{R}_0^+$. For each period of the planning horizon, the periodic cash flows split into investment outflows $O_y^{\text{inv}} \in \mathbb{R}^+$ for implementing the respective project of the roadmap and into operating cash flow from executing the organization's business processes. For a specific period and process, the operating cash flow results from the demand that realizes for the quality and time of the process in that period as well as from a contribution margin, which in turn depends on the price of the process output and the respective periodic operating outflows $O_{i,y}^{\text{op}} \in \mathbb{R}^+$. The investment outflows are assumed to be due at the beginning of each period. The operating cash flow is due at the end of each period. This leads to the following objective function:

$$\max_r : NPV_r = -\sum_{y=0}^{Y} \frac{O_y^{\text{inv}}}{(1+z)^y} + \sum_{i=1}^{|I|} \sum_{y=0}^{Y} \frac{n_i(q_{i,y}, t_{i,y}) \cdot [p_i - O_{i,y}^{\text{op}}]}{(1+z)^{y+1}} \tag{1}$$

The remainder of this section is structured along Figure 1, which illustrates how the project archetypes used in our decision model affect the organization's business processes and BPM capabilities as well as the components of the objective function. For increased readability, Figure 1 focuses on one process and a single period.

3.2 Project Archetypes and their Effects

We distinguish two project archetypes, i.e., process-level and BPM-level projects. Thereby, we deliberately abstract from the large number of projects that may occur in real-world settings as we aim to analyze project effects in general. Process-level projects help develop the organization's operational capabilities by improving a particular business process [19]. BPM-level projects aim at building up BPM as a special dynamic capability that reflects the ability to change existing processes [21]. Due to this effect on dynamic capabilities, BPM-level projects have two different effects on the organization's operational capabilities. Both effects may occur separately or simultaneously, depending on the concrete project at hand. First, BPM-level projects can directly affect operational capabilities as from the next period. In contrast to process-level projects and in line with the infrastructure character of BPM, BPM-level projects influence all business processes [16]. Second, BPM-level projects can affect operational capabilities indirectly by facilitating the implementation of process-level projects in the future.

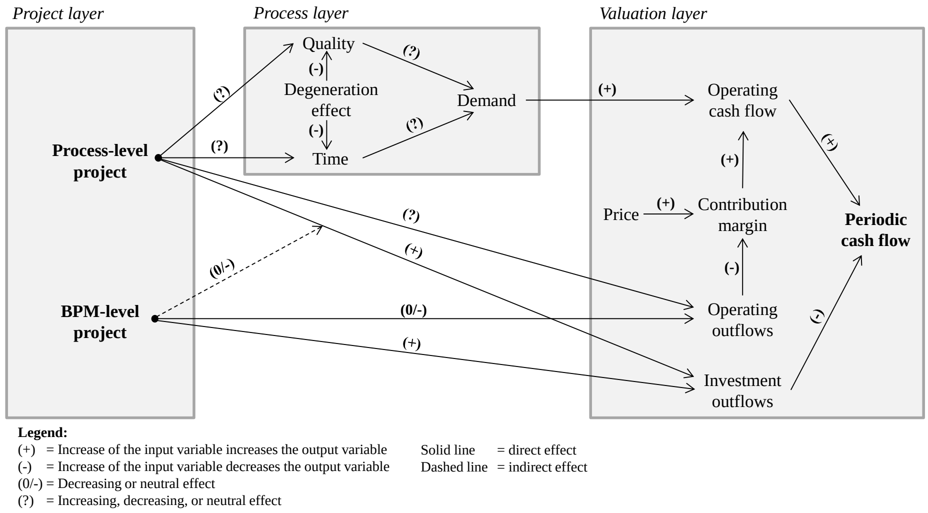

Fig. 1. Effects among projects and processes

Process-level projects improve a distinct business process in terms of quality, time, and operating outflows – a value-based substitute for cost – as dimensions of the Devil's Quadrangle [3]. Flexibility is covered indirectly via reduced waiting or set-up times [24]. Depending on the project at hand, each dimension may be influenced positively or negatively or remain unchanged. This allows for covering many different effect constellations. For instance, there are projects that improve the quality of a process, while increasing time with potentially no effect on the operating outflows. Other projects reduce the operating outflows while leaving quality and time unchanged. In addition, all process-level projects cause investment outflows. An example is the hiring of additional workers in the claim settlement process of an insurance company. This project increases the operating outflows of the claim settlement process, reduces the average cycle time, and increases quality in terms of fewer mistakes and undetected cases of fraud. Moreover, consider the adoption of a workflow management system for the claim settlement process. This project reduces the average cycle time due to enhanced resource allocation and increases quality in terms of customer satisfaction. The project also increases the operating outflows of the process due to higher maintenance effort.

BPM-level projects that only have a direct effect on the organization's operational capabilities make all business processes under investigation more cost-efficient [20], e.g., due to a better process culture and awareness. As an example, consider extensive process manager trainings that increase the coordination among processes and ensure an end-to-end mindset. As a result, the operating outflows are likely to drop despite additional periodic training effort. BPM-level projects that only have an indirect effect on operational capabilities make it easier to implement process-level projects. This effect becomes manifest in reduced investment outflows of future process-level projects. That is, implementing such BPM-level projects without subsequent process-level projects only causes investment outflows. As an example, consider training employees in business process reengineering (BPR) methods [39] or process redesign patterns [22]. Based on such trainings, employees are able to implement future process-level projects more easily. Analogous examples that relate to the BPM success factor IT are the adoption of a process modeling or simulation tool. Finally, there are BPM-level projects that combine the direct and indirect effect on operational capabilities. Such projects do not only help implement future process-level projects, but also make all business processes under investigation more cost-efficient as from the next period. Consider, for example, Six Sigma trainings. On the one hand, Six Sigma provides many tools that facilitate process improvement. On the other hand, as an approach to continuous process improvement, Six Sigma sensitizes people to looking for more efficient ways of conducting their daily work. What is common to all BPM-level projects is that they cause investment outflows. We make the following assumptions:

(A.5) Process-level projects enhance the organization's operational capabilities by improving a single process in terms of time, quality, and operating outflows. Considering a distinct project s, u_s denotes the project's relative effect on quality, e_s the relative effect on time, and m_s the relative of effect on the operating outflows. Process-level projects also cause investment outflows $O_s^{\text{inv}} \in \mathbb{R}^+$.

(A.6) BPM-level projects enhance operational capabilities directly and/or indirectly. As for the direct effect, a_s denotes a project's relative effect on the operating outflows of all business processes under investigation. As for the indirect effect, b_s denotes the relative effect on the investment outflows of all process-level projects implemented in future periods. BPM-level projects cause investment outflows $O_s^{\text{inv}} \in \mathbb{R}^+$.

3.3 Integrating the Project Effects into the Objective Function

With the knowledge about the project archetypes and their effects, we operationalize the objective function (Equation 1). For each period of the planning horizon, we determine the quality, time, and investment outflows as well as the operating outflows of all business processes.

The investment outflows O_y^{inv} in period y depend on which process- or BPM-level project is scheduled for that period (Equation 2). As one project can be implemented per period and each project is finished within one period (A.3), there is a one-to-one relationship between periods and projects. Thus, the index y refers to exactly one project. We use the index s to denote the project that is scheduled for period y in the BPM roadmap r under investigation. If a BPM-level project is scheduled for period y, the investment outflows in that period equal O_s^{inv} as the investment outflows of BPM-level projects are independent of other projects. If a process-level project is scheduled for period y, the investment outflows do not only depend on O_s^{inv}, but also on the indirect effects $b_j \in]0;1]$ of all BPM-level projects that have been implemented until period $y-1$ (A.6). The set of these BPM-level projects is denoted by $BPM_{r,y-1}$. In our model, the effects b_j are linked multiplicatively due to their relative character (A.4). The combination of multiplicatively linked effects and the discounting of periodic cash effects allows for incorporating inter-temporal interactions. If no project is scheduled for period y, a case that only occurs if the planning horizon exceeds the number of projects in the BPM roadmap, the investment outflows in that period are zero.

$$O_y^{\text{inv}} = \begin{cases} O_s^{\text{inv}} & \text{if a BPM-level project is scheduled for } y \\ O_s^{\text{inv}} \cdot \prod_{j \in BPM_{r,y-1}} b_j & \text{if a process-level project is scheduled for } y \\ 0 & \text{if no project is scheduled for } y \end{cases} \tag{2}$$

The operating outflows $O_{i,y}^{\text{op}}$ of business process i in period y depend on the BPM-level and the process-level projects that have been implemented until period $y-1$ (Equation 3). Therefore, the set of previously implemented BPM-level projects, $BPM_{r,y-1}$, and the set of previously implemented process-level projects with an effect on business process i, $PLP_{r,i,y-1}$, have to be considered. Thereby, the effect m_j belongs to process-level projects, whereas a_j refers to the direct cost-efficiency effects of BPM-level projects. As process-level projects may have a positive, negative, or neutral effect on the operating outflows, m_j can take values from the interval $]0;\infty[$ where $m_j = 1$ denotes a neutral effect. As BPM-level projects only reduce the operating outflows (A.6), the effect a_j can take values from the interval $]0;1]$. As all project effects are relative, we also need the operating outflows of business process i at the decision point ($y = 0$) to calibrate the height of the operating outflows. The operating outflows at the decision point can be reasonably assumed to be known as we consider existing business processes [34].

$$O_{i,y}^{\text{op}} = O_{i,0}^{\text{op}} \cdot \prod_{j \in PLP_{r,i,y-1}} m_j \cdot \prod_{j \in BPM_{r,y-1}} a_j \tag{3}$$

The quality $q_{i,y}$ of business process i in period y depends on the quality of this process at the decision point ($y = 0$) and on all previously implemented process-level projects that focus on this process (Equation 4). For the quality of process i at the decision point, the same argumentation holds true as for the operating outflows. The relative effect of a process-level project on quality is denoted by u_j. This effect takes values from the interval $]0;\infty[$ as process level-projects may have a positive, negative, or neutral effect on quality. Like all other effects, quality effects are linked multiplicatively. Quality usually has an upper boundary [3]. For example, an error rate ranges from 0 to 100 % or a customer satisfaction index may have maximum of 10. To account for this property, we incorporated an upper quality boundary $q^{\max} \in \mathbb{R}^+$. Against this backdrop, it may be the case that investment outflows are wasted if a process-level project with a high quality effect is implemented when the quality of a process is already very close to its upper boundary. In line with the quality management literature, one has to continuously invest to maintain a once-achieved quality level. That is, whenever the organization conducts a BPM-level project or a process-level project that focuses on another process, the quality of process i drops. We therefore integrated a process-specific degeneration effect d_i that takes values from the interval $]0; 1]$. The degeneration effect penalizes if the organization focuses too much on a distinct process or on building up BPM. The exponent of the degeneration effect in Equation (4) indicates the number of periods in which, up to the current period y, the organization did not conduct process-level projects that focus on process i. The extent of the degeneration effect depends on different process characteristics (e.g., complexity, or employee fluctuation).

$$q_{i,y} = \min\left(\left(q_{i,0} \cdot d_i^{y-|PLP_{r,i,y-1}|} \cdot \prod_{j \in PLP_{r,i,y-1}} u_j\right); q^{\max}\right) \tag{4}$$

Time and quality can be treated similarly. The difference is that time has no upper boundary and another polarity than quality. The time $t_{i,y}$ of business process i in period y depends on the time of the process at the decision point ($y = 0$) and on all previously implemented process-level projects that focus on this process (Equation 5). The relative time effect of a process-level project is denoted by e_j. This effect takes values from the interval $]0; \infty[$ as process level-projects may have a positive, negative, or neutral effect on time. Analogous to quality, we incorporated a degeneration effect v_i that occurs in all periods where the organization does not conduct process-level projects that focus on process i. As time has a different polarity than quality, the degeneration effect takes values from the interval $[1; \infty[$.

$$t_{i,y} = t_{i,0} \cdot v_i^{y-|PLP_{r,i,y-1}|} \cdot \prod_{j \in PLP_{r,i,y-1}} e_j \tag{5}$$

Having operationalized the objective function using the effects of process-level and BPM-level projects, the decision model can now be employed to valuate and compare roadmaps in terms of their value contribution to identify the optimal BPM roadmap.

4 Evaluation

To evaluate the decision model, we discuss its characteristics against the requirements from the literature. We also built a prototype and provide a demonstration example using the case of an IT service provider. Finally, we are currently applying the decision model in an industry project. We will report on the insights in our future research.

4.1 Feature Comparison

Regarding feature comparison, the characteristics of our decision model are compared with the requirements we derived from the literature in section 2 (Table 1). The requirements that represent the capability development and the process performance measurement perspectives are met to the full extent. The requirements that account for the PPS and the value-based management perspectives are covered partly. The resulting need for future research is outlined in the conclusion.

Table 1. Results of feature comparison.

RQ	Features of the model
(R.1)	The decision model builds on process-level projects, which affect only one business process, and BPM-level projects, which affect all business processes under consideration (R.1b). Process-level projects enhance an organization's operational capabilities, whereas BPM-level projects build up BPM as a dynamic capability. They affect operational capabilities directly by making all business processes more cost-efficient and/or indirectly by facilitating the implementation of process-level projects in the future (R.1a).
(R.2)	The decision model aligns with the Devil's Quadrangle. It directly accounts for the performance dimensions time, quality, and cost, and indirectly for flexibility (R.2a). As value-based substitutes for cost, the decision model relies on operating cash outflows and investment outflows. Each dimension can be operationalized via different performance indicators (R.2b).
(R.3)	We consider a set of pre-defined project candidates. We assume that, in the pre-screening stage of the PPS process, all project candidates were checked for appropriate strategic fit (R.3a) and that, in the individual project analysis stage, the relative effects all of project candidates have been determined as single values independent from other projects (R.3b). The absolute effects of a project depend on the projects that have been implemented in prior periods. Thus, we consider deterministic, scheduling, and inter-temporal interactions among projects (R.3c).
(R.4)	The value contribution of a BPM roadmap is based on its NPV, an appropriate quantity in case of deterministic interactions. The NPV considers all cash effects that result from process- and BPM-level projects as well as from process execution (R.4a). We account for the decision makers' risk attitude using a risk-adjusted interest rate (R.4b). As BPM roadmaps comprise multiple projects implemented at different points in time, we also consider a multi-period planning horizon. The risk-adjusted interest rate also accounts for the time value of money (R.4c).

4.2 Demonstration Example

For the demonstration example, we consider three service processes that an IT service provider offers to its customers. The demand for a distinct service depends on its quality and time. For the service provider, a planning period lasts one quarter. The interest rate is 2.5% per quarter. The first service is an incident management service that includes the operation of a ticket system and the provision of required service staff. Costumers pay a fixed service fee per ticket. The number of tickets has been identified as a main driver of the service's operational outflows. The quality of this service is measured as the fraction of tickets that is resolved to the customers' satisfaction. Time is operationalized as the average time for reacting upon a ticket. The second service is the operation of an Enterprise Resource Planning (ERP) system. Costumers pay a fixed license fee per quarter. The quality of the ERP service is expressed as the availability of the ERP system. Time is operationalized as the time necessary to implement minor changes in the ERP system or to conduct related customization. The third service is a backup service. Customers pay a fixed remuneration per license related to their average memory requirements. The perceived quality of this service depends on the agreed service level of the backup service, i.e., the number of backups per period and the number of periods for which backups are stored. For this service, time such as recovery time is not relevant from the customers' point of view.

We consider the three IT service processes just introduced (Table 2) and five different projects (Tables 3 and 4), thereof three BPM-level and two process-level projects. The projects and their effects used in this demonstration example were derived from projects that were implemented at those industry partners with which we discussed the decision model. Overall, we calculate four scenarios. For each project, we estimated the effects for an optimistic (opt.) and a pessimistic (pess.) scenario. We also consider two planning horizons, i.e., three and eight periods. As for the short planning horizon, the service provider has to solve a PPS and a project scheduling problem. As for the long planning horizon, the service provider has to solve a project scheduling problem. A planning horizon of eight periods leads to 120 different BPM roadmaps to be evaluated, whereas a planning horizon of three periods leads to 60 different BPM roadmaps.

Table 2. IT service processes considered in the demonstration example.

i	Name	$q_{i,0}$	$t_{i,0}$	p	$O_{i,0}^{\text{op}}$	d_i, v_i	n_i
1	Incident management service	95 %	60 min	2.50 €	1 €	10.00 %	$11{,}000 \cdot \left(\ln q + e^{\frac{1}{t}}\right)$
2	Operation of an ERP system	91 %	30 d	1,500 €	1,300 €	5.00 %	$200 \cdot \left(\ln q + e^{\frac{1}{t}}\right)$
3	Backup service	80 %	-	220 €	150 €	5.00 %	$1{,}200 \cdot \ln q$

Table 3. BPM-level projects considered in the demonstration example.

s	Name	Services influenced	O_s^{inv}	a_s		b_s	
				pess.	opt.	pess.	opt.
1	Training in BPR methods	All	25,000 €	-	-	0.95	0.8
2	Development of a process performance measurement system	All	100,000 €	0.95	0.85	-	-
3	Training in Six Sigma	All	35,000 €	0.99	0.9	0.95	0.8

Table 4. Process-level projects considered in the demonstration example.

s	Name	i	O_s^{inv}	e_s		u_s		m_s	
				pess.	opt.	pess.	opt.	pess.	opt.
4	Update ticket system	1	110,000 €	0.90	0.70	1.0	1.1	1.3	1.1
5	Increase backup frequency	3	35,000 €	-	-	1.1	1.3	1.2	0.9

The results of all scenarios are shown in Table 5. For each scenario, we list the indices of the included projects and the NPVs for the optimal and the worst BPM roadmaps (Table 5a and 5b). In each scenario, the NPV of the optimal BPM roadmap differs a lot from the NPV of the worst BPM roadmap. For example, in the optimistic scenario with a long planning horizon, the NPV of the optimal BPM roadmap is

1,584,657 € (25 %) higher than the NPV of the worst BPM roadmap. This result corroborates the proposition that the concrete set of projects and the inter-temporal interactions implied by the sequence of implementation greatly affect the value contribution.

Apart from the differences in the planning horizon, the projects included in the optimal BPM roadmap and their sequence of implementation are very similar for all scenarios. In three scenarios, the first projects are the projects 2, 3, and 1, i.e., the BPM-level projects. In the fourth scenario, the first two projects are again projects 2 and 3. Project 1 is scheduled for period 4. Though appearing counter-intuitive at first sight, this result is reasonable from the short-term perspective as the projects 2 and 3 influence all processes and, in the case at hand, outperform the process-level projects. Project 1 is implemented in period 3, i.e., the last period of the short planning horizon, because it is much cheaper than the process-level projects. The same argumentation holds true for the long planning horizon. In the pessimistic case, the projects 4 and 5, which are scheduled for period 4 and 5, benefit from the indirect effects caused by projects 1 and 3. In the optimistic scenario, project 5 is scheduled for period 3 because it is rather cheap and has a comparatively strong effect on the quality and the operating outflows of the backup service. In fact, the demand for the backup service is very sensitive toward quality improvements, a circumstance that makes it reasonable from an economic perspective to implement project 5 two periods earlier than in the pessimistic case where its effects are much worse. It is also sensible to implement project 4 the last. The reason is that the quality of the incident management service already is very close to the upper boundary. Thus, project 4 is not fully effective. In addition, with all demand functions having diminishing marginal returns, quality improvements for the incident management service are less effective than for the backup service.

Table 5. Results of the demonstration example.

	5 periods	3 periods
Optimistic	Projects: 2, 3, 5, 1, 4 NPV: 7,892,429 €	Projects: 2, 3, 1 NPV: 2,579,570 €
Pessimistic	Projects: 2, 3, 1, 4, 5 NPV: 4,828,230 €	Projects: 2, 3, 1 NPV: 1,998,147 €

(a) Optimal BPM roadmaps

	5 periods	3 periods
Optimistic	Projects: 4, 1, 5, 3, 2 NPV: 6,307,772 €	Projects: 4, 1, 2 NPV: 1,689,518 €
Pessimistic	Projects: 5, 4, 1, 3, 2 NPV: 3,805,124 €	Projects: 5, 4, 2 NPV: 1,393,421 €

(b) Worst BPM roadmaps

5 Conclusion and Outlook

Located at the intersection of traditional BPM research and BPM research that focuses on capability development, we investigated the question which projects an organization should implement and in which order it should implement these projects to develop BPM capabilities in a way that is balanced with the improvement of individual business processes. To answer this question, we proposed a decision model that valuates BPM roadmaps, i.e., portfolios of scheduled projects with different effects on processes and

BPM capabilities, and selects the roadmap with the highest value contribution in a given planning horizon. The value contribution of a BPM roadmap is expressed in terms of its net present value. The decision model supports two project archetypes, namely process-level and BPM-level projects. Process-level projects help develop an organization's operational capabilities by improving a single process in terms of the dimensions of the Devil's Quadrangle (e.g., time, quality, and cost). BPM-level projects build up BPM as a dynamic capability. They affect an organization's operational capabilities directly by making all business processes more cost-efficient and/or indirectly by facilitating the implementation of process-level projects in the future. As for the evaluation, we discussed the decision model both with industry partners and with respect to the requirements from the literature. We also built a prototype and presented a demonstration example that was also discussed with industry partners.

As the decision model does not meet all requirements derived from the literature to the full extent, it is beset with limitations that may stimulate future research. First, some assumptions of the decision model simplify reality. For example, only one project can be implemented per period. Though being made to analyze the interactions among processes and projects more clearly in a first step, it is worthwhile to relax this assumption in the future. If more than one project can be implemented per period, it is necessary to account for intra-temporal interactions. In its current version, the decision model copes with simple intra-temporal interactions (e.g., budget restrictions or mandatory projects), but not with complex ones (e.g., input-output interactions). The decision model is also based on the assumption of deterministic interactions (e.g., regarding customer demands). Although the risk-adjusted discount rate used for calculating the value contribution of BPM roadmaps implicitly accounts for risks, future research should put more emphasis on stochastic interactions as for example the integration of risks with respective probabilities. Due to the interactions among projects and processes, we assumed that the absolute project effects depend on the previously implemented projects from the BPM roadmap. Thus, project effects were expressed in relative numbers and linked multiplicatively to determine the periodic cash effects. In practice, however, the effects of some projects may be independent of the previously implemented projects, a circumstance that would make an additive linking necessary. Therefore, the decision model should be extended correspondingly.

Second, although we were able to discuss the demonstration example with industry partners, the decision model would benefit from additional case studies. This would help gain more experience with estimating the needed parameters, which is a main difficulty of applying mathematical models. Case studies may also provide further insights into the behavior of the decision model and, for example complemented by additional experiments, serve as foundation for general recommendations for action. To efficiently determine the optimal BPM roadmap in settings of real-world complexity, further research should also search the quantitative project portfolio selection and project scheduling literature for suitable heuristic approaches that avoid the computational expensiveness of exhaustive enumeration.

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