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Capability development with process maturity models - Decision framework and economic analysis

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Abstract: Despite the need for sustaining competitive advantage, scholars and practitioners struggle when deciding which organizational capabilities they should develop to which extent. Today, inconsistent recommendations bear the risk of misallocating corporate funds. Despite recent advances, further research needs to be conducted with respect to how uncertainty can be considered in capability development decisions and whether the cutting of capabilities is a feasible option. Against this background, we propose a conceptual framework for structuring capability development decisions. Due to the close relationship between capability development and business process management, the framework builds on process maturity models and the principles of value-based business process management. We also conduct an economic analysis to disclose general relationships that govern capability development based on process maturity models.

Keywords: business process management, capability development, decision framework, maturity models, process change, process maturity models, value-based management

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1 Introduction

Capability development is an essential task of organizational design and corporate decision-making, particularly in a world where numerous organizations face strong competition and a progressively dynamic environment (Pavlou & El Sawy, 2011; Wernerfelt, 1984). Despite elaborate theoretical underpinnings such as the resource-based view of the firm and dynamic capability theory, scholars and practitioners still struggle when deciding which capabilities they should develop to which extent in order to sustain competitive advantage. In fact, capability development is closely related to business process management (BPM) because capabilities and processes refer to the same phenomenon (Ortbach, Plattfaut, Pöppelbuß, & Niehaves, 2012; van Looy, de Backer, & Poels, 2011). As BPM has considerably matured over the last decades and evolved into a widely adopted approach of organizational design (Gartner, 2010; Luftman & Derksen, 2012; van der Aalst 2013), it is worthwhile to investigate how tools from the BPM area can be used for capability development.

One of the most popular tools from the BPM area that support capability development are process maturity models (Pöppelbuß, Niehaves, Simons, & Becker, 2011). Although process maturity models recommend which capabilities an organization should develop, most of them do not help assess the extent to which capabilities should be developed. Some process maturity models recommend striving for the highest extent (Plattfaut, Niehaves, Pöppelbuß, & Becker, 2011). Thereby, they adopt a lifecycle theory of evolution where a predefined sequence of developmental stages has to be traversed in a complete, linear, and irreversible manner (van de Ven & Poole, 1995). Other process maturity models advise against the pursuit of the highest extent, but lack more concrete insights. As a matter of fact, ever more organizations aim to develop their capabilities to the highest extent to differentiate themselves from competitors or to give in to the demands of customers (de Bruin, Freeze, Kulkarni, & Rosemann, 2005). Hence, there is confusion and a lack of guidance in industry about which capabilities an organization should develop to which extent.

Despite an extensive knowledge base related to maturity models in general and process maturity models in particular, the literature does not provide clarity either. Röglinger and Kamprath (2012) investigate capability development decisions based on process maturity models and analyse which capability increases cause the highest value contribution. They uncovered developing capabilities to the highest extent as a border solution. Plattfaut et al. (2011) reached similar conclusions based on a multiple case study. As for future research, Röglinger and Kamprath recommend incorporating uncertainty into capability development decisions and investigating whether the cutting of capabilities is a feasible option. Plattfaut et al. (2011) also recommend further research regarding the cutting of capabilities. Picking up these recommendations, we address the following research questions (RQ):

RQ1: How can decisions related to capability development be structured?

RQ2: How can the relationships that govern capability development based on process maturity models be identified?

To answer both questions, we propose a decision framework, which extends the prior work of Röglinger and Kamprath (2012), and analyse the objective function of this framework. This endeavour seems worthwhile because organizations are likely to have exceeded the economically reasonable extent to which their capabilities should be developed (Buhl, Röglinger, Stöckl, & Braunwarth, 2011). Cutting capabilities may thus shape up as a neglected lever of company value. Moreover, the feasibility of capability cutting would challenge the lifecycle theory as the dominating underpinning for maturity models. This, in turn, would advance the theoretical knowledge related to capability development. The paper at hand is conceptual in nature, i.e. it follows an axiomatic and deductive approach, which allows for a formal representation of the decision problem and analysis of trade-offs (Meredith, Raturi, Amoako-Gyampah, & Kaplan, 1989). The decision framework does not intend to provide concrete decision support.

The paper is structured as follows: First, we provide the theoretical background necessary to understand the decision framework. We then introduce the decision framework and analyse its objective function to answer both research questions. We conclude by summarizing the results, discussing limitations, and pointing to implications.

2 Theoretical background

To put the decision framework on a solid foundation, we first elaborate on the close relationship between capability development and processes process management. We then outline the foundations of process maturity models and value-based BPM, two domains that shape the decision framework.

2.1 Capability development and business process management

Capability development is closely related to the resource-based view of the firm and dynamic capability theory. In terms of the resource-based view, organizations are collections of resources that achieve competitive advantage if their resource configuration is valuable, rare, imperfectly imitable, and non-substitutable (Barney, 2000; Penrose, 1959; Wernerfelt, 1984). Resources are anything which could be thought of as a strength or a weakness (Wernerfelt, 1984). They split into assets and capabilities. While assets are anything tangible or intangible that can be used by an organization, capabilities refer to the ability to perform a coordinated set of tasks for achieving a particular result (Helfat & Peteraf, 2003). That is why capabilities are also defined as collections of routines or repeatable patterns of actions in the use of assets (Wade & Hulland, 2004; Winter, 2003). According to dynamic capability theory, stable resource configurations do not guarantee sustainable competitive advantage because changes in the organisation's environment require changes in the resource configuration (Collis, 1994; Teece, Pisano, & Shuen, 1997). Thus, an organization needs capabilities that facilitate and govern change. Dynamic capability theory extends the resource-based view in that it distinguishes between operational and dynamic capabilities (Pavlou & El Sawy, 2011). Operational capabilities refer to the basic functioning of an organization and its ability to make a daily living (Winter, 2003; Zollo & Winter, 2002). Dynamic capabilities help integrate, build, and reconfigure operational capabilities to increase their fit with the organization’s environment and to improve effectiveness (Teece & Pisano, 1994; Zollo & Winter, 2002). As such, dynamic capabilities affect the output of an organization only transitively through their effect on operational capabilities (Helfat & Peteraf, 2003).

BPM combines knowledge from information technology and management sciences and applies this to processes (van der Aalst, 2013; Weske, 2007). A process is a structured set of activities designed to produce a specific output (Davenport, 1993). From a lifecycle perspective, BPM includes the identification, definition, and modelling of processes, their implementation and execution, monitoring and control, and continuous improvement (Dumas, La Rosa, Mendling, & Reijers, 2013; Hammer, 2010). Moreover, successful BPM grounds on the interplay of culture, governance, information technology, methods, people, and strategic alignment (Rosemann & vom Brocke, 2010). Processes can be categorized into core, support, and management processes (Armistead, Pritchard, & Machin, 1999; Harmon, 2010). Core processes, which are also referred to as operational or business processes, generate products or services that are of value to customers. Support processes ensure that the core processes continue to function. Management processes entail the planning, organization, communication, monitoring, and controlling of activities.

Although capability development and BPM have developed independently, BPM researchers increasingly revert to the resource-based view and dynamic capability theory to strengthen the theoretical foundations of BPM (Benner, 2009; Niehaves, Plattfaut, & Sarker, 2011; Trkman, 2010). The reason is that processes and capabilities deal with the same phenomenon, namely a coordinated set of tasks and their execution in a predictable and consistent manner (van Looy, 2011). One difference, if at all, is that processes focus more on "how", while capabilities put more emphasis on "what" (Sharp, 2013). Another similarity is that capabilities and processes are structured hierarchically in terms of capability and process areas, where each area includes several capabilities or processes respectively (Dumas et al., 2013; Ortbach et al., 2012). In the literature, processes and their execution are usually equated with operational capabilities, whereas BPM is associated with dynamic capabilities (Niehaves et al., 2011). In line with the classification of process types shown above, we consider core and support processes as the operational capabilities of an organization. This is because both process types make up an organization's value creation. Management processes define an organization's dynamic capabilities. In this sense, BPM, as a particular management process, is a dynamic capability.

2.2 Process maturity models

Maturity models are a tool for capability development that has become increasingly popular over the last decades (Harmon, 2009; Pöppelbuß et al., 2011). Based on the assumption of predictable patterns of evolution and change, maturity models foster the development of capabilities along a path of predefined stages (Mettler, 2011). Maturity models contain several capability areas, which are also referred to as process areas or enablers (Hammer, 2007; Weber, Curtis, & Gardiner, 2008). Moreover, they distinguish two layers of capability development, namely the capability area layer and the organizational layer (de Bruin et al., 2005). The capability area layer focuses on capability areas. Each capability area has a capability level that expresses the extent to which that capability is developed, i.e. how predictably and consistently the results of the underlying processes are achieved (Rosemann & de Bruin, 2005; van Looy et al., 2011). The organizational layer focuses on maturity, i.e. the interplay and aggregated effect of all capability areas (van Looy et al., 2011). The extent to which an organization has explicitly and consistently developed its capabilities is captured in terms of a maturity level, a figure that results from aggregating the capability levels of all capability areas. Some maturity models guide capability development by proposing improvement measures as good or best practices. The majority of maturity models, however, only contain a set of capability areas and descriptions of capability and maturity levels, and leave the identification of improvement measures to the model user (Curtis & Alden, 2007).

In the BPM domain, there are process maturity models and BPM maturity models (Rosemann & vom Brocke, 2010), although this distinction is not perfectly precise (Röglinger, Pöppelbuß, & Becker, 2012). BPM maturity models focus on the development of BPM as a particular dynamic capability (Rosemann & de Bruin, 2005). They aim to provide a holistic assessment of all areas relevant to BPM (Rohloff, 2009) and, as such, cover capability areas that relate to culture, governance, information technology, methods, people, and strategic alignment (Rosemann & vom Brocke, 2010). Process maturity models deal with processes in general or processes from a particular domain (de Bruin & Rosemann, 2007). For example, the Capability Maturity Model (CMM) covers software engineering processes, the Capability Maturity Model Integration for Services (CMMI-SVC) deals with service processes, and the COBIT maturity model addresses IT Governance processes (IT Governance Institute, 2010; Paulk, Curtis, Chrissis, & Weber, 1993; Software Engineering Institute, 2009). In this paper, we focus on process maturity models.

What is special about process maturity models is that they do not directly focus on operational capabilities in terms of an organization's core processes. This is reasonable because these capabilities are supposed to be valuable, rare, imperfectly imitable, and non-substitutable. Instead, process maturity models deal with operational capabilities that represent support processes or to dynamic capabilities that relate to specific management processes. For example, the capability area "Incident Resolution and Prevention" from CMMI-SVC relates to a support process, whereas the capability area "Strategic Service Management" refers to a management process (Software Engineering Institute, 2009). Process maturity models intend to make an organization's core processes reliable and to ensure that their output is of a high quality, even in the event of stressful situations, by developing the capabilities representing management and support processes. Capability development means making management and support processes more defined, managed, measured, controlled, and reflective (Paulk et al., 1993).

The most popular process maturity models are those belonging to the CMMI family (Paulk et al., 1993). Like maturity models in general, the CMMI models support capability development on two layers. As capability areas are termed process areas in CMMI, we call the capability area layer process area layer. The CMMI models enable two improvement paths, namely continuous and staged representation. In the continuous representation, capability development starts with the process area. An organization selects process areas and implements predefined improvement measures to a desired extent. In the staged representation, capability development focuses on maturity and is driven top-down from the organizational layer. The idea is to implement improvement measures of previously defined groups of process areas according to some rules predefined in CMMI. The decision framework proposed in the next section draws on the CMMI blueprint and nomenclature, because of the quasi-standard nature of CMMI models. However, we abstract from CMMI peculiarities wherever reasonable. The decision framework also follows the continuous representation.

2.3 Value-based business process management

Value-based BPM is a paradigm where all process-related activities and decisions are valued according to their contribution to the company value. As such, it applies the principles of value-based management to BPM. We first sketch these principles and then show how they fit process decision-making.

As a substantiation and extension of the shareholder value approach, value-based management sets the maximizing of the long-term, sustainable company value as the primary objective for all business activities (Koller, Goedhart, & Wessels, 2010). Its foundations trace back to Rappaport (1986) and were developed further by Stewart and Stern (1991) and Copeland et al. (1990). The company value is determined based on future cash flows (Rappaport, 1986). Value-based management can only be claimed to be implemented if all activities and decisions on all management levels align with the objective of maximizing 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. Decisions that comply with value-based management must be based on cash flows, consider risks, and incorporate the time value of money (Buhl et al., 2011)

There is a set of objective functions that are typically used for value-based decision-making. They are structured along two dimensions: decision situation and tax perspective. The decision situation can accept certainty and risk with risk-neutral or risk-averse decision-makers as values. The tax perspective distinguishes before taxes and after taxes. We exclude the tax perspective from the further discussion. Concerning certainty, the cash flow of a decision alternative contains deterministic periodic payment surpluses. These surpluses result from cash inflows and cash outflows. Decision alternatives can be valued using the net present value (NPV) (Martin, Petty, & Wallace, 2009). Concerning risk, the cash flow encompasses stochastic periodic payment surpluses. When it comes to valuation, the stochastic payment surpluses need to be replaced by a deterministic figure that provides decision makers with the same utility as its stochastic counterpart. The valuation method depends on the risk attitude. The elaborations below assume that decision makers have a constant risk aversion and aim to maximize their expected utility in line with the Bernoulli principle. As for risk-neutral decision makers, decision alternatives can be valued based on the expected NPV of the stochastic cash flow. If decision makers are risk-averse, the certainty equivalent method is considered the most theoretically well-founded valuation method (Berger, 2010). Decision makers first condense the stochastic payment surpluses into a stochastic NPV and then determine the respective certainty equivalent. In case of a normally distributed stochastic NPV and an exponential Bernoulli utility function, the certainty equivalent equals the risk-adjusted expected value of the stochastic NPV (Berger, 2010). The corresponding preference function is shown in Equation (1).

$$\Phi\left(\widetilde{CF}\right) = \mu\left(\widetilde{CF}\right) - \frac{\alpha}{2}\sigma^2\left(\widetilde{CF}\right) \tag{1}$$

Here, $\widetilde{CF}$ is the stochastic NPV, whereas the parameters $\mu\left(\widetilde{CF}\right)$ and $\sigma^2\left(\widetilde{CF}\right)$ denote the expected value and variance. The constant α captures the decision makers' extent of risk aversion (Freund, 1956). Bamberg and Spremann (1981) show how α can be determined. For risk-averse decision makers, the constant α takes positive values (Pratt, 1964).

The objective functions from also apply to process decision-making (Buhl et al., 2011). With the uncertainty of capability development decisions being part of our research questions, we justify when and why the prerequisites for using the preference function from Equation (1) hold true for process decision-making. In general, the payment surplus of a single process instance follows an arbitrary distribution, depending on the involved tasks and control-flow patterns (Bolsinger, Bewernik, & Buhl, 2011). The payment surpluses, however, are identically distributed as all process instances follow the same process model. Based on the assumption that process instances are executed independently from one another and that there are sufficiently many instances per period, it follows from the central limit theorem that the stochastic periodic payment surpluses are approximately normally distributed, regardless of how the payment surpluses of the process instances are distributed (Feller, 1968). Since processes are designed to be executed repeatedly, there are generally sufficiently many process instances to apply the central limit theorem. With the normal distribution being invariant toward convolution, the stochastic NPV is approximately normally distributed as well (Chernoff & Moses, 1959). Since it can be reasonably assumed that executives are risk-averse, and that an exponential Bernoulli utility function is used for process decision-making, the preference function shown in Equation (1) also applies to process decision-making.

3 Decision framework

3.1 General setting

We investigate an organization that already uses a process maturity model for capability development and where the management already selected the relevant process areas. Accordingly, we are interested in capability and maturity level changes, not in absolute values.

Like the CMMI models, we consider the process area layer and the organizational layer of capability development. In the process area layer, capabilities can be strengthened by implementing additional improvement measures. Capabilities can be cut by withdrawing already implemented improvement measures. The strengthening of capabilities is reflected by an increase of the capability levels of the related process areas, the cutting of capabilities is reflected by a decrease of the related capability levels. In the organizational layer, the maturity level can be interpreted from an internal and external perspective. From an internal perspective, the maturity level reflects the reliability of the organization's core processes and the quality of their output. From an external perspective, customers usually do not know the internal structure of an organization, or they know only parts of it. Therefore, customers treat the organization as a black box and attribute their satisfaction to the organization as a whole. Taken together, the maturity level serves as proxy for both the organization's internal condition and customer satisfaction. We use the maturity level as an auxiliary quantity to measure the effects of capability development on the organizational layer. We make the following assumptions:

(A.1) The organization implements $n \in \mathbb{N}$ process areas A_i $(i = 1, \dots, n)$ of the used process maturity model. Each process area has a capability level $c_i^{\mathrm{cur}} \in \mathbb{R}_0^+$ $\left(c_i^{\min} \leq c_i^{\mathrm{cur}} \leq c_i^{\max}\right)$ where $c_i^{\min} \in \mathbb{R}_0^+$ represents the lowest capability level at which the corresponding capabilities are still present in the organization, and $c_i^{\max} \in \mathbb{R}^+$ $\left(c_i^{\min} < c_i^{\max}\right)$ is the highest capability level possible. A capability level can be changed by Δc_i $\left(c_i^{\min} - c_i^{\mathrm{cur}} \leq \Delta c_i \leq c_i^{\max} - c_i^{\mathrm{cur}}\right)$.

(A.2) The organization has a maturity level $m^{\mathrm{cur}} \in \mathbb{R}_0^+$ that can change about $\Delta m \in \mathbb{R}$. Maturity level changes results from aggregating the capability level changes on the process area layer using the aggregation function $\Delta m = f(\overrightarrow{\Delta c})$ with $\overrightarrow{\Delta c} = (\Delta c_1, \dots, \Delta c_n)^{\mathrm{T}}$.

3.2 Economic effects of maturity level changes

In line with value-based BPM, capability level changes are investments with a multi-period cash flow. Accordingly, we divide the cash flow along two dimensions: investment vs. operations phase, and process area layer vs. organizational layer. The resulting components include investment outflows per process area, changed operational outflows per process area, and changed operational inflows on the organizational layer. There is no cash flow component on the organizational layer for the investment phase because the implementation and withdrawal of improvement measures take place on the process area layer. Such a cash flow component may occur in the context of BPM maturity models, such as during the rollout of a process modelling tool or the establishment of a process centre of excellence.

3.2.1 Investment outflows per process area

Investment outflows result from implementing and withdrawing improvement measures. To increase a capability level, additional improvement measures must be implemented. Since no statement is possible about whether or not improvement measures assigned to lower capability levels are less complex than those assigned to higher capability levels, or vice versa, we treat improvement measures as equally expensive. Nevertheless, the more a capability level is increased, the more expensive the coordination overhead of the change project is. Additional improvement measures also must be integrated with the already implemented ones. Typically, the coordination and integration overhead increases over-proportionally with the size of a change project (Boehm, Abts, & Chulani, 2000; Verhoef, 2005). Thus, the investment outflows for capability level increases consist of a proportional and an over-proportional part. We account for these characteristics by using a strictly increasing and strictly convex function.

To decrease a capability level, improvement measures must be withdrawn. Analogous to capability level increases, we treat the withdrawal of improvement measures as equally expensive, including a constant effort to disintegrate the withdrawn improvement measures from the remaining ones. The argument regarding the coordination overhead applies to capability level decreases as well. Therefore, the investment outflows for capability level decreases consist of a proportional and an over-proportional part. We account for these characteristics by using a strictly decreasing and strictly convex function, although the concrete monotonicity and curvature will, in general, differ from that for capability level increases.

We treat the investment outflows as certain because the implementation or withdrawal of improvement measures takes place entirely within a distinct process area. It neither depends on the organization's core processes nor on its environment. Despite a variety of project risks, there is consensus that estimations of cash outflows have greater precision than estimations of cash inflows. Therefore, we decided not to incorporate risk regarding the investment outflows. In line with value-based BPM, we condense the investment outflows per period into a single figure by means of their NPV. Henceforth, we refer to the NPV of the investment outflows as investment outflows. We make the following assumptions:

(A.3) The investment outflows related to a process area A_i are denoted by the piecewise defined function $O_i^{\mathrm{inv}}(\Delta c_i) \in \mathbb{R}_0^+$, which is strictly increasing for capability level increases ($\Delta c_i \geq 0$) and strictly decreasing for capability level decreases ($\Delta c_i \leq 0$). It holds that $O_i^{\mathrm{inv}}(0) = 0$. $O_i^{\mathrm{inv}}(\Delta c_i)$ is continuously differentiable twice (except for $\Delta c_i = 0$) and strictly convex in its domain of definition. The derivations are $O_i^{\mathrm{inv}\,\prime}(\Delta c_i) > 0$ and $O_i^{\mathrm{inv}\,\prime\prime}(\Delta c_i) > 0$ for $\Delta c_i \geq 0^+$, $O_i^{\mathrm{inv}\,\prime}(\Delta c_i) < 0$ and $O_i^{\mathrm{inv}\,\prime\prime}(\Delta c_i) > 0$ for $\Delta c_i \leq 0^-$, and not defined at $\Delta c_i = 0$.

3.2.2 Changed operational outflows per process area

Operational outflows incur for operating the management and support processes enclosed in the process areas. If there is a capability level increase, more improvement measures are implemented, which makes process areas more complex to operate. If there is a capability level decrease, improvement measures are withdrawn and process areas become less complex to operate. Analogous to the investment outflows, we treat the operation effort as equally high for all improvement measures. The overhead of coordinating the operation of the implemented improvement measures also increases over-proportionally with the number of additionally implemented improvement measures. Likewise, it decreases if improvement measures are withdrawn. That is, when withdrawing an improvement measure, the operational outflows decrease by the same value by which they increased when the improvement measure was implemented. All this leads to changed operational outflows that consist of a proportional and an over-proportional part. The most important difference between the investment outflows and the changed operational outflows is that the investment outflows take positive values for any capability level changes. The changed operational outflows, however, take positive values for capability level increases and negative values for decreases. We account for these characteristics by using a function that is strictly increasing and strictly convex in its domain of definition.

We treat the changed operational outflows as certain for the same reasons as the investment outflows. In line with value-based BPM, we condense the changed operational outflows per period into a single figure by calculating their NPV. Henceforth, we refer to the NPV of the changed operational outflows as changed operational outflows.

(A.4) The changed operational outflows related to a process area A_i are denoted by the function $\Delta O_i^{\mathrm{op}}(\Delta c_i) \in \mathbb{R}$. The function is strictly increasing, strictly convex, and continuously differentiable twice with $\Delta O_i^{\mathrm{op}\,\prime}(\Delta c_i) > 0$ and $\Delta O_i^{\mathrm{op}\,\prime\prime}(\Delta c_i) > 0$ in its domain of definition. It holds that $\Delta O_i^{\mathrm{op}}(0) = 0$.

3.2.3 Changed operational inflows on the organizational layer

Operational inflows result from selling the output of the organization's core processes to customers. Therefore, the operational inflows relate to the organizational layer and depend on the maturity level. Operational inflows also depend on both the organization's internal condition and its environment. One of the most influential environmental factors is the risky demand for the output of the core processes (Buhl et al., 2011). On the one hand, risky demand depends on the customers' satisfaction with the organization as a whole, which in turn is driven by the reliability of the core processes and the quality of their output (Anderson & Sullivan, 1993). On the other hand, risky demand depends on influences from outside the organization, such as the customers' willingness to pay, competitor behaviour, or industry trends (Sodhi, 2005). While the customers' satisfaction and the organization's internal condition can be changed by capability development and thus are reflected in the changed maturity level, the external influences are not sensitive to capability development.

To account for their risky nature in line with value-based BPM, we treat the periodic operational inflows as normally distributed random variables. The inflows are assumed to fluctuate only such strong that the application of the central limit theorem is justified. For further analysis, we rely on the stochastic NPV of the periodic operational inflows and the certainty equivalent of the stochastic NPV. Henceforth, we refer to the stochastic NPV as operational inflows and to the changes in the certainty equivalent as risk-adjusted changed operational inflows.

(A.5) The operational inflows on the organizational layer are a normally distributed random variable, $\tilde{I}^{\mathrm{op}} \sim N(\mu_{\tilde{I}^{\mathrm{op}}}; \sigma^2_{\tilde{I}^{\mathrm{op}}})$, with $\mu_{\tilde{I}^{\mathrm{op}}}$ as the expected value and $\sigma^2_{\tilde{I}^{\mathrm{op}}}$ as variance. The involved decision makers are risk-averse and have an exponential Bernoulli utility function. Changing the maturity level influences the expected value by $\Delta\mu_{\tilde{I}^{\mathrm{op}}}(\Delta m)$ and the variance by $\Delta\sigma^2_{\tilde{I}^{\mathrm{op}}}(\Delta m)$. The risk-adjusted changed operational inflows $\Delta\Phi_{\tilde{I}^{\mathrm{op}}}(\Delta m)$ are shown in Equation (2) where $\alpha \in \mathbb{R}^+$ represents the decision makers' constant risk aversion.

$$\Delta\Phi_{\tilde{I}^{\mathrm{op}}}(\Delta m) = \Delta\mu_{\tilde{I}^{\mathrm{op}}}(\Delta m) - \frac{\alpha}{2}\Delta\sigma^2_{\tilde{I}^{\mathrm{op}}}(\Delta m) \tag{2}$$

The expected value indicates how many operational inflows result on average from selling the output of the organization's core processes. If the core processes become more reliable and the quality of their output increases, customer satisfaction will improve and the customer base will consist of more regular customers with a stable, higher-than-average demand (Anderson & Sullivan, 1993). The reason is that customer satisfaction drives loyalty and retention (Rust & Zahorik, 1993). In this case, it is reasonable to expect more operational inflows on average (Gruca & Rego, 2005). Less operational inflows can be expected if the internal condition of the organization worsens. This is because customers migrate in case of dissatisfaction. The customer base then comprises more occasional customers featuring an irregular, below-average demand. In sum, the changed expected value of the operational inflows takes positive values and increases if the maturity level increases. It takes negative values and decreases if the maturity level decreases. In line with Gossen's law of diminishing marginal utility, customers are supposed to become less and less sensitive to improvements in quality and reliability. Thus, the changes in the expected value are governed by a saturation effect and thus under-proportional (Varian, 2005). Analogous to the changed operational outflows, when the maturity level is decreased, the changed expected value of the operational inflows goes down by the same amount by which it increased when the maturity level increased. We account for these characteristics by using a function that is strictly increasing and strictly concave in its domain of definition.

The variance of the operational inflows reflects how reliable the internal condition of the organization and how volatile the demand is. As a higher maturity level leads to more regular customers in the organization's customer base, the demand for the output of the organization's core processes becomes not only higher, but also less volatile. That is, the changed variance takes negative values and decreases if the maturity level increases (Gruca & Rego, 2005). It takes positive values and increases if the maturity level decreases. As we focus on the cash flow effects caused by maturity level changes, we do not account for those parts of risky demand that depend on influences from the organization's environment. That is, if we took an absolute perspective, the variance would converge toward a positive lower limit. This lower limit represents the demand risk with which the organization had to cope in case its core processes were perfectly reliable and the customers were perfectly satisfied. In our delta analysis, the changed variance converges toward a negative lower limit. Analogous to the expected value, the law of diminishing marginal returns can be assumed to apply to risk mitigation. We account for these characteristics using a function that is strictly decreasing and strictly convex in its domain of definition.

To summarize, increasing the maturity level shifts the distribution of the operational inflows to the right and shrinks it. Decreasing the maturity level shifts the distribution to the left and stretches it. We make the following assumption:

(A.6) The changed expected value of the operational inflows is strictly increasing, strictly concave, and continuously differentiable twice with $\Delta\mu'_{\tilde{I}^{\mathrm{op}}}(\Delta m) > 0$ and $\Delta\mu''_{\tilde{I}^{\mathrm{op}}}(\Delta m) < 0$. The changed variance is strictly decreasing, strictly convex, and continuously differentiable twice with $\Delta\sigma^{2\,\prime}_{\tilde{I}^{\mathrm{op}}}(\Delta m) < 0$ and $\Delta\sigma^{2\,\prime\prime}_{\tilde{I}^{\mathrm{op}}}(\Delta m) > 0$. It holds that $\Delta\mu_{\tilde{I}^{\mathrm{op}}}(0) = 0$ and $\Delta\sigma^{2}_{\tilde{I}^{\mathrm{op}}}(0) = 0$.

3.3 Objective function

In line with value-based management, the organization strives to maximize its long-term, sustainable company value. Therefore, it intends to maximize the changed cash flow NPV on the organizational layer . Henceforth, we refer to the changed cash flow NPV as changed cash flow. It is a proxy for the value contribution of the organization's capability development endeavours. This leads to the objective function shown in Equation (3).

$$\text{MAX}: \Delta CF(\overrightarrow{\Delta c}) = \Delta\Phi_{\tilde{I}^{\text{op}}}(f(\overrightarrow{\Delta c})) - \sum_{i=1}^{n} \Delta O_i^{\text{op}}(\Delta c_i) - \sum_{i=1}^{n} O_i^{\text{inv}}(\Delta c_i) \tag{3}$$

4 Economic analysis

We now infer general relationships from the objective function of the decision framework. We start with the single process area case and then generalize the findings for the multiple process area case.

4.1 Analysis of the single process area case

In the single process area case, there is only one process area, say A_1. Thus, the capability level on the process area layer equals the maturity level on the organizational layer. We use a simplified version of the changed cash flow as objective function (Equation 4).

$$\text{MAX}: \Delta CF(\Delta c_1) = \Delta\Phi_{\tilde{I}^{\text{op}}}(\Delta c_1) - \Delta O_1^{\text{op}}(\Delta c_1) - O_1^{\text{inv}}(\Delta c_1) \tag{4}$$

Below, we derive the characteristics of the changed cash flow based on its components. The risk-adjusted changed operational inflows, $\Delta\Phi_{\tilde{I}^{\text{op}}}(\Delta m_1)$, depend on the characteristics of the changed expected value and the changed variance (A.5). Accordingly, they are strictly increasing and strictly concave in their domain of definition (Equations 5 and 6). They take positive values for capability level increases and negative values for capability level decreases.

$$\Delta\Phi'_{\tilde{I}^{\text{op}}}(\Delta c_1) = \underbrace{\underbrace{\Delta\mu'_{\tilde{I}^{\text{op}}}(\Delta c_1)}_{\substack{>0 \text{ always} \\ (\text{A.6})}} - \underbrace{\frac{\alpha}{2}}_{\substack{>0 \text{ always} \\ (\text{A.5})}} \underbrace{\Delta\sigma^{2\,\prime}_{\tilde{I}^{\text{op}}}(\Delta c_1)}_{\substack{<0 \text{ always} \\ (\text{A.6})}}}_{>0 \text{ always}} \tag{5}$$

$$\Delta\Phi''_{\tilde{I}^{\text{op}}}(\Delta c_1) = \underbrace{\underbrace{\Delta\mu''_{\tilde{I}^{\text{op}}}(\Delta c_1)}_{\substack{<0 \text{ always} \\ (\text{A.6})}} - \underbrace{\frac{\alpha}{2}}_{\substack{>0 \text{ always} \\ (\text{A.5})}} \underbrace{\Delta\sigma^{2\,\prime\prime}_{\tilde{I}^{\text{op}}}}_{\substack{>0 \text{ always} \\ (\text{A.6})}}(\Delta c_1)}_{<0 \text{ always}} \tag{6}$$

The investment outflows, $O_1^{\text{inv}}(\Delta c_1)$, are modelled as a piecewise defined function (A.3) with a junction point at $\Delta c_1 = 0$. Their first derivation has a jump discontinuity at the junction point because it takes negative values for capability level decreases, positive values for capability level increases, and is not defined at the junction point itself. Thus, the investment outflows have an inflection point there. The jump discontinuity crosses the abscissa from the bottom to the top. The distance of the jump discontinuity depends on the slope of the first derivation for an infinitesimally small maturity level decrease and increase.

The changed cash flow, $\Delta CF(\Delta c_1)$, inherits the inflection point at the junction point from the investment outflows. Moreover, the derivations of the changed cash flow are undefined at the junction point and have a jump discontinuity there. As the investment outflows negatively affect the changed cash flow, the jump discontinuity goes from the top to the bottom. Although the distance of the jump discontinuity is the same as for the investment outflows, its position on the ordinate also depends on the other cash flow components. Thus, it does not necessarily cross the abscissa.

Further characteristics of the changed cash flow can be deduced from a more detailed analysis of its derivations (Equations 7 and 8). Based on the characteristics of the other cash flow components, the sign of its first derivation is ambiguous. Without additional knowledge, no statement can be made about monotonicity. Since the second derivation takes negative values for all capability level changes, except for the junction point, the changed cash flow is strictly concave in its domain of definition. Accordingly, the first derivation is strictly decreasing in its domain of definition. As a result, it can intersect the abscissa never or once. If the first derivation intersects the abscissa in its domain of definition, the changed cash flow has an extremum at the intersection point. As the sign of the first derivation changes from positive to negative, the extremum is a global maximum. We refer to this case as an inner solution. If the first derivation does not intersect the abscissa or only touches it in its domain of definition, we have a left or right border solution. The first derivation may also take a positive value for an infinitesimally small capability level decrease and a negative value for an infinitesimally small capability level increase. The changed cash flow then reaches its maximum at the junction point. As for monotonicity, we now know that the changed cash flow is strictly increasing to a global maximum and strictly decreasing beyond.

$$CF'(\Delta c_1) = \underbrace{\underbrace{\Delta\Phi'_{\bar{I}^{\mathrm{op}}}(\Delta c_1)}_{\substack{>0\text{ always}\\ \text{(Equation 5)}}} - \underbrace{O_1^{\mathrm{op}\,\prime}(\Delta c_1)}_{\substack{>0\text{ always}\\ \text{(A.4)}}} - \underbrace{O_1^{\mathrm{inv}\,\prime}(\Delta c_1)}_{\substack{>0\text{ for }\Delta c_1\geq 0^+,\\ <0\text{ for }\Delta c_1\leq 0^-,\\ \text{undefined at }\Delta c_1=0\\ \text{(A.3)}}}}_{\substack{\text{ambiguous for }\Delta c_1\neq 0,\\ \text{undefined at }\Delta c_1=0}} \tag{7}$$

$$CF''(\Delta c_1) = \underbrace{\underbrace{\Delta\Phi''_{\bar{I}^{\mathrm{op}}}(\Delta c_1)}_{\substack{<0\text{ always}\\ \text{(Equation 6)}}} - \underbrace{O_1^{\mathrm{op}\,\prime\prime}(\Delta c_1)}_{\substack{>0\text{ always}\\ \text{(A.4)}}} - \underbrace{O_1^{\mathrm{inv}\,\prime\prime}(\Delta c_1)}_{\substack{>0\text{ for }\Delta c_1\neq 0,\\ \text{undefined at }\Delta c_1=0\\ \text{(A.3)}}}}_{\substack{<0\text{ for }\Delta c_1\neq 0,\\ \text{undefined at }\Delta c_1=0}} \tag{8}$$

4.2 Interpretation of the single process area case

The insights gained from analysing the changed cash flow enable identifying general relationships. We consider three situations where the capabilities related to the single process area is developed either to the (1) lowest extent, (2) highest extent, or (3) to an intermediate extent.

4.2.1 Situation 1: capabilities developed to the lowest extent

If the capabilities related to the single process area are developed to the lowest extent, the capability level can be increased or left unchanged. The only positive effect on the changed cash flow is that the changed risk-adjusted operational inflows increase if the capability level is increased. We distinguish between a left and right border solution, and an inner solution (Figure 1).

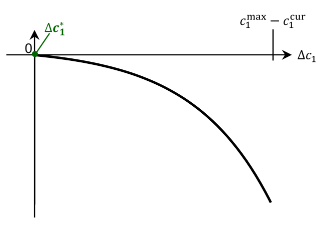
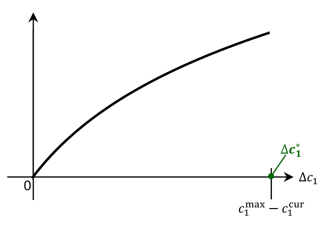
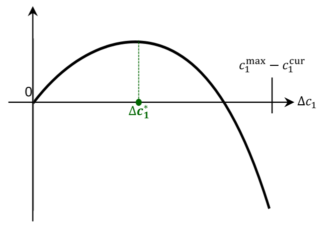
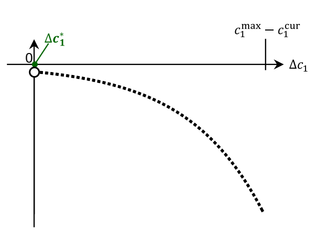
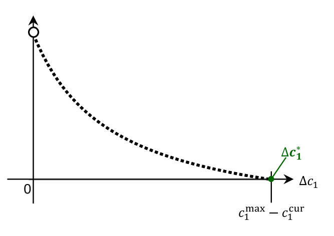
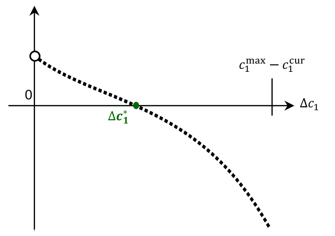
SITUATION 1 $c_1^{\text{cur}} = c_1^{\text{min}}$	**Left border solution**	**Right border solution**	**Inner solution**
Changed cash flow $\Delta \boldsymbol{CF}(\Delta \boldsymbol{c_1})$			
Marginal changed cash flow $\boldsymbol{CF'}(\Delta \boldsymbol{c_1})$			
Optimal capability level change	$\Delta c_1^* = 0$	$\Delta c_1^* = c_1^{\text{max}} - c_1^{\text{cur}}$	Δc_1^* to be calculated

Figure 1. Interpretation of situation 1

A left border solution means that the highest changed cash flow results from leaving the capability level unchanged. The marginal investment outflows and the marginal changed operational outflows, together, exceed the marginal changed risk-adjusted operational inflows already for an infinitesimally small capability level increase. The marginal changed cash flow runs below the abscissa in its domain of definition. Consequently, the changed cash flow is strictly decreasing. No improvement measures should be implemented to strengthen the capabilities.

In a right border solution, the highest changed cash flow results from the highest capability level increase. The marginal changed risk-adjusted operational inflows exceed or equal the marginal investment outflows and the marginal changed operational outflows if the potential of strengthening the capabilities is fully tapped. The marginal changed cash flow runs above the abscissa in its domain of definition. It may touch the abscissa at the point of the highest possible capability level increase. The changed cash flow is strictly increasing. All improvement measures provided by the process maturity model should be implemented.

An inner solution occurs if the highest changed cash flow results from a capability level increase between the lowest and the highest possible increase. At first, the marginal changed risk-adjusted operational inflows exceed the marginal investment outflows and the marginal changed operational outflows. When both effects cancel each other out, the optimal capability level increase is reached. Beyond this point, the marginal investment outflows and the marginal changed operational outflows, together, exceed the marginal changed risk-adjusted operational inflows. The marginal changed cash flow initially runs above the abscissa, intersects it at the point of the optimal capability level increase, and then runs below it beyond. The capability level should be increased by the optimal capability level change. Improvement measures should be implemented as long as the marginal changed cash flow is positive.

4.2.2 Situation 2: capabilities developed to the highest extent

If the capabilities related to the single process area are developed to the highest extent, the capability level can be decreased or left unchanged. In this situation, the only positive effect on the changed cash flow is that the changed operational outflows decrease if the capability level is decreased. Again, we discuss border solutions and an inner solution (Figure 2).

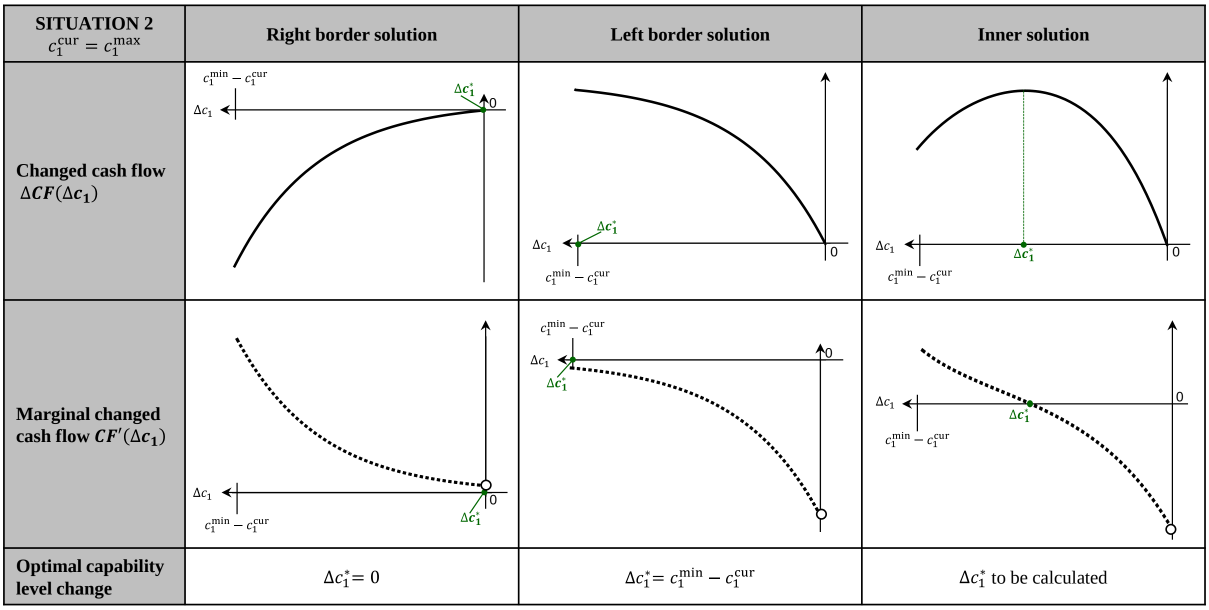


Figure 2. Interpretation of situation 2

A right border solution occurs if the highest changed cash flow results from leaving the capability level unchanged. The absolute values of the marginal investment outflows and the marginal changed risk-adjusted operational inflows, together, exceed the absolute value of the marginal changed operational outflows already for an infinitesimally small capability level decrease. The marginal changed cash flow runs above the abscissa in its domain of definition. The changed cash flow is strictly increasing. No improvement measures should be withdrawn to cut the capabilities.

In a left border solution, the highest changed cash flow results from the highest capability level decrease. Here, the absolute value of the marginal changed operational outflows exceeds or equals the joint absolute value of the marginal investment outflows and the marginal changed risk-adjusted operational inflows if the potential for cutting the capabilities is fully tapped. The marginal changed cash flow runs below the abscissa it in its domain of definition. However, it may touch the abscissa at the point of the highest possible capability level decrease. The highest changed cash flow is strictly decreasing. All implemented improvement measures should be withdrawn.

An inner solution occurs if the highest changed cash flow results from a capability level decrease between the lowest and highest possible decrease. When viewing from the right to the left, the absolute value of the marginal changed operational outflows first exceeds the joint absolute value of the marginal investment outflows and the marginal changed risk-adjusted operational inflows. When both effects cancel each other out, the optimal capability level decrease is reached. Beyond this point, the joint absolute value of the marginal investment outflows and the marginal changed risk-adjusted operational inflows exceed the absolute value of the marginal changed operational outflows. The marginal changed cash flow initially runs below the abscissa, intersects it at the point of the optimal capability level decrease, and runs above it beyond. The capability level should be reduced by the optimal capability level decrease. Improvement measures should be withdrawn as long as the marginal changed cash flow is negative.

4.2.3 Situation 3: capabilities developed to an intermediate extent

If the capabilities related to the single process area are developed to an intermediate extent, the capability level can be increased, decreased, or left unchanged. We therefore distinguish between border solutions (Figure 3) and inner solutions (Figure 4) again. What is special about this situation is the inner solutions because they depend on the jump discontinuity of the marginal changed cash flow. As the left and right border solutions are analogous to the previous sections, we focus on the inner solutions here.

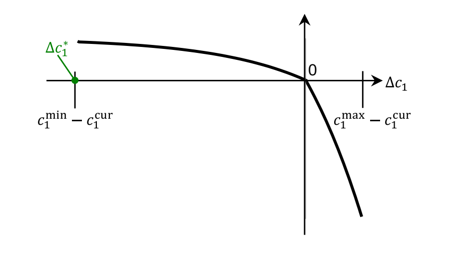
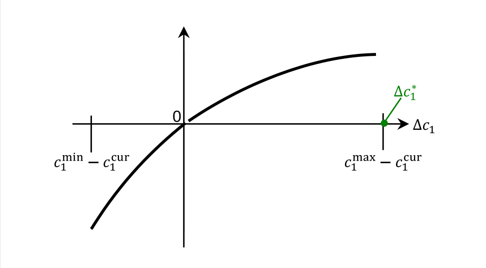
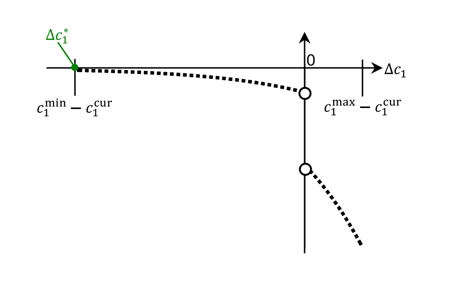
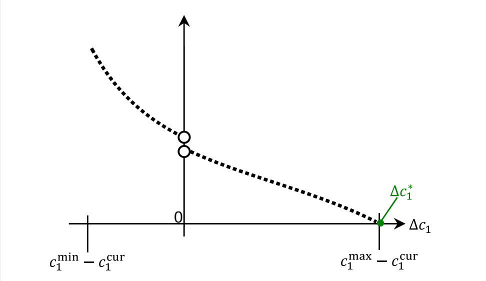
SITUATION 3 $c_1^{\min} < c_1^{\mathrm{cur}} < c_1^{\max}$	**Left border solution**	**Right border solution**
Changed cash flow $\Delta \boldsymbol{CF}(\Delta \boldsymbol{c_1})$		
Marginal changed cash flow $\boldsymbol{CF}'(\Delta \boldsymbol{c_1})$		
Optimal capability level change	$\Delta c_1^* = c_1^{\min} - c_1^{\mathrm{cur}}$	$\Delta c_1^* = c_1^{\max} - c_1^{\mathrm{cur}}$

Figure 3. Interpretation of situation 3 (border solutions)

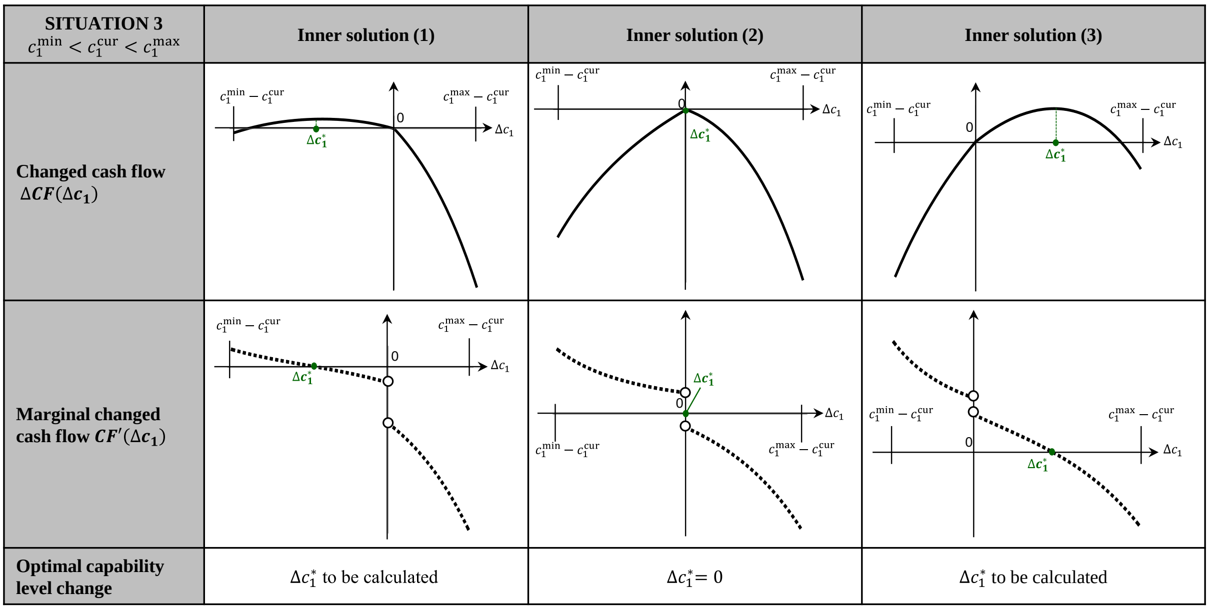


Figure 4. Interpretation of situation 3 (inner solutions)

An inner solution occurs if the highest changed cash flow results from a capability level change between the highest decrease and the highest increase. There are three alternatives: In the first case, the absolute value of the marginal changed operational outflows exceeds the joint absolute value of the marginal investment outflows and the marginal changed risk-adjusted operational inflows at the point of the highest possible capability level decrease, but not for an infinitesimally small capability level decrease. Correspondingly, the marginal changed cash flow intersects the abscissa for some optimal capability level decrease. When viewed from right to the left, improvement measures should be withdrawn to cut the capabilities as long as the marginal changed cash flow is negative.

In the second case, the marginal investment outflows and the marginal changed operational outflows, together, exceed the marginal changed risk-adjusted operational inflows for an infinitesimally small capability level increase. In addition, the joint absolute value of the marginal investment outflows and the marginal changed risk-adjusted operational inflows exceeds the absolute value of the marginal changed operational outflows for an infinitesimally small capability level decrease. Therefore, the changed cash flow reaches its maximum at the inflection point. No changes are recommended.

In the third case, the marginal changed risk-adjusted operational inflows exceed the marginal investment outflows and the marginal changed operational outflows for an infinitesimally small capability level increase, but not at the point of the highest possible capability level increase. The marginal changed cash flow therefore intersects the abscissa for some optimal capability level increase. Improvement measures should be implemented to strengthen the capabilities as long as the marginal changed cash flow is positive.

4.3 Multiple process area case

The difference between the multiple and the single process area case is that the change on the process area layer cannot be equalled the change on the organizational layer anymore. This is because the changes in multiple capability levels need to be aggregated into a single maturity level change. When analysing the multiple process area case, it is worthwhile to investigate how the insights from the single process area case can be generalized.

For the further analysis, we use the aggregation function proposed by Röglinger and Kamprath (2012) (Equation 9). It can be applied here because we assumed in the decision framework that the capability levels of the preselected process areas may only be reduced such far that the related capabilities are still present in the organization. The aggregation function considers that different capabilities can be differently important for the organization. It also allows for simple synergetic effects. In Equation (9), the $s_{ij} \in \mathbb{R}_0^+$ represent the strength of the synergetic effects between the capabilities covered by the process areas A_i and A_j, the $s_{ii} \in \mathbb{R}^+$ denote how important the capability area covered by process areas A_i is $(i, j \leq n, i \neq j)$.

$$\Delta m = f\left(\overrightarrow{\Delta c}\right) = \sum_{i=1}^{n} \Delta c_i \cdot s_{ii} + \sum_{i<j}^{n} (\Delta c_i + \Delta c_j) \cdot s_{ij} \tag{9}$$

The changed cash flow, $\Delta CF\left(\overrightarrow{\Delta c}\right)$, has multiple partial first and partial second derivations (Equation 3). We seek the optimal vector of capability level changes. An analysis of the changed cash flow shows that its partial first and second derivations do not only depend on the cash flow components, as seen in the single process area case, but also on the aggregation function (Equations 10 and 11). Considering the characteristics of the aggregation function, the partial second derivations of the changed cash flow take negative values in their domain of definition, except for the junction points of the process area-specific investment outflows. Therefore, the partial first derivations are strictly decreasing in their domain of definition with respect to each capability level change. Nevertheless, their sign is ambiguous. Röglinger and Kamprath (2012) showed that the Hessian matrix is negative definite for objective functions like that from Equation (3) and for an aggregation function like that from Equation (9). Therefore, the changed cash flow is strictly concave as in the single process area case. Thus, if there is a vector of capability level changes for which all partial first derivations become zero, this vector marks the global maximum of the changed cash flow. It also represents the optimal capability level changes by which the capabilities under investigation should be cut or strengthened.

$$\frac{\partial \Delta CF\left(\overrightarrow{\Delta c}\right)}{\partial \Delta c_i} = \underbrace{\underbrace{\underbrace{\frac{\partial \Delta \Phi_I{}^{\text{op}}(\Delta m)}{\partial \Delta m}}_{\substack{>0 \text{ always} \\ \text{(Equation 5)}}} \cdot \underbrace{\frac{\partial f\left(\overrightarrow{\Delta c}\right)}{\partial \Delta c_i}}_{\substack{>0 \text{ always} \\ \text{(Equation 9)}}}}_{>0} - \underbrace{\frac{\partial \Delta O_i^{\text{op}}(\Delta c_i)}{\partial \Delta c_i}}_{\substack{>0 \text{ always} \\ \text{(A.4)}}} - \underbrace{\frac{\partial O_i^{\text{inv}}(\Delta c_i)}{\partial \Delta c_i}}_{\substack{>0 \text{ for } \Delta c_i \geq 0^+, \\ <0 \text{ for } \Delta c_i \leq 0^-, \\ \text{undefined at } \Delta c_i = 0 \\ \text{(A.3)}}}}_{\substack{\text{ambiguous for } \Delta c_i \neq 0, \\ \text{undefined at } \Delta c_i = 0}} \tag{10}$$

a) Differentiation with respect to two capability level changes $(i, j \leq n, i \neq j)$

$$\frac{\partial^2 \Delta CF\left(\overrightarrow{\Delta c}\right)}{\partial \Delta c_i \partial \Delta c_j} = \underbrace{\underbrace{\frac{\partial^2 \Delta \Phi_I{}^{\text{op}}(\Delta m)}{(\partial \Delta m)^2}}_{\substack{<0 \text{ always} \\ \text{(Equation 6)}}} \cdot \underbrace{\frac{\partial f\left(\overrightarrow{\Delta c}\right)}{\partial \Delta c_j}}_{\substack{>0 \text{ always} \\ \text{(Equation 9)}}} \cdot \underbrace{\frac{\partial f\left(\overrightarrow{\Delta c}\right)}{\partial \Delta c_i}}_{\substack{>0 \text{ always} \\ \text{(Equation 9)}}}}_{<0 \text{ always}} \tag{11}$$

b) Differentiation with respect to one capability level change $(i \leq n)$

$$\frac{\partial^2 \Delta CF\left(\overrightarrow{\Delta c}\right)}{(\partial \Delta c)^2} = \underbrace{\underbrace{\underbrace{\frac{\partial^2 \Delta \Phi_{I^{\mathrm{op}}}(\Delta m)}{(\partial \Delta m)^2}}_{\substack{<0 \text{ always} \\ \text{(Equation 6)}}} \cdot \underbrace{\left(\frac{\partial f\left(\overrightarrow{\Delta c}\right)}{\partial \Delta c_i}\right)^2}_{\substack{>0 \text{ always} \\ \text{due to} \\ \text{exponent}}}}_{<0 \text{ always}} - \underbrace{\frac{\partial^2 \Delta O_i^{\mathrm{op}}(\Delta c_i)}{(\partial \Delta c_i)^2}}_{\substack{>0 \text{ always} \\ \text{(Equation 4)}}} - \underbrace{\frac{\partial^2 O_i^{\mathrm{inv}}(\Delta c_i)}{(\partial \Delta c_i)^2}}_{\substack{>0 \text{ for } \Delta c_i \neq 0, \\ \text{undefined at } \Delta c_i = 0 \\ \text{(A.3)}}}}_{\substack{<0 \; for \; \Delta c_i \neq 0, \\ \text{undefined at } \Delta c_i = 0}}$$

A ceteris paribus analysis provides further insights. Let $\overrightarrow{\Delta c}^{\text{c.p.}} = (\Delta c_1, \dots, \Delta c_i, \dots \Delta c_n)^{\mathrm{T}}$ denote the vector of capability level changes where all changes, except for Δc_i, take constant values. As the partial first derivations of the changed cash flow are strictly decreasing, the partial first derivation of $\Delta CF\left(\overrightarrow{\Delta c}^{\text{c.p.}}\right)$ with respect to Δc_i intersects the abscissa never or once, as in the single process area case. However, the intersection point generally differs from the intersection point of the corresponding single process area case because it also depends on how important each process area is and which interaction effects exist on the organizational layer. If the partial first derivation of $\Delta CF\left(\overrightarrow{\Delta c}^{\text{c.p.}}\right)$ with respect to Δc_i intersects the abscissa in its domain of definition, there is a process area-specific maximum at the intersection point because the sign of the first derivation changes from positive to negative. We refer to this situation as a partial inner solution with respect to Δc_i. If the partial first derivation of $\Delta CF\left(\overrightarrow{\Delta c}^{\text{c.p.}}\right)$ with respect to Δc_i does not intersect the abscissa in its domain of definition, we have a partial border solution. A partial left border solution with respect to Δc_i occurs if the corresponding partial first derivation of $\Delta CF\left(\overrightarrow{\Delta c}^{\text{c.p.}}\right)$ is negative or equals zero for the highest capability level decrease in case the capability is developed to an intermediate or the highest extent. The first derivation may also be negative already for infinitesimally small capability level increases in case the capability is developed to the lowest extent. There is a partial right border solution with respect to Δc_i if the corresponding partial first derivation of $\Delta CF\left(\overrightarrow{\Delta c}^{\text{c.p.}}\right)$ is positive or equals zero for the highest capability level increase in case the capability is developed to an intermediate or the lowest extent. The first derivation may also be positive for an infinitesimally small capability level decrease in case the capability is developed to the lowest extent. Finally, it may also be the case that the partial first derivation of $\Delta CF\left(\overrightarrow{\Delta c}^{\text{c.p.}}\right)$ with respect to Δc_i takes a positive value for an infinitesimally small capability level decrease and a negative value for an infinitesimally small capability level increase. This means that $\Delta CF\left(\overrightarrow{\Delta c}^{\text{c.p.}}\right)$ reaches its process area-specific maximum if the capability level remains unchanged. As for the monotonicity, we know that $\Delta CF\left(\overrightarrow{\Delta m}^{\text{c.p.}}\right)$ is strictly increasing to the process area-specific maximum and strictly decreasing beyond. These insights apply to all capabilities under investigation.

5 Discussion and conclusion

5.1 Summary

To structure capability development decisions (RQ1), we proposed a decision framework that builds on process maturity models and meets the principles of value-based BPM. Capabilities can be strengthened or cut by implementing or withdrawing improvement measures. The consequence is a multi-period cash flow that splits into investment outflows per process area, changed operational outflows per process area, and changed operational inflows on the organizational layer. All cash flow components represent net present values (NPVs) and are modelled through function types whose characteristics were derived from the economic literature. The framework accounts for the uncertainty of capability development decisions by dealing with the risky demand for the output of an organization's core processes in the operational inflows. We chose demand risks because they are one of the most influential risk categories of process decision-making, partly depend on the volatility of the core processes, and thus can be mitigated through capability development.

To identify general relationships that govern capability development based on process maturity models (RQ2), we analysed the objective function of the decision framework, i.e. the changed cash flow. In the single process area case, we distinguished three situations depending on whether, in the status quo, the capabilities covered by this single process area are developed to the lowest extent, the highest extent, or to an intermediate extent. For each situation, we discussed border and inner solutions. We found that concrete recommendations regarding the extent to which the capabilities should be developed depend on the risk/return characteristics of the cash flow components and the extent to which the capabilities are currently developed, i.e. the current capability level. Due to the similarities with the single process area case that are rooted in the aggregation function, the characteristics of the changed cash flow also apply to the multiple process area case. The situations and recommendations from the single process area case become partial situations and recommendations. The important difference is that the extent to which the capabilities covered by each process area should be developed also depends on synergetic effects among different capabilities and on how important capabilities are for the organization. The analysis showed that, with the proposed decision framework, a single configuration of capability level changes can be determined that maximizes the changed cash flow. The analysis also revealed that, from a maturity model perspective, the predefined sequence of capability levels can be traversed both incompletely and backwardly, a result that corroborates prior findings on the inadequacy of the lifecycle theory as the underpinning of maturity models.

One of the paper's main objectives was to investigate the cutting of capabilities. When cutting capabilities, the only positive effect on the changed cash flow is a decrease in the changed operational outflows. In the single process area case, it is reasonable to cut capabilities from an economic perspective as long as the absolute value of the marginal changed operational outflows exceed the joint absolute value of the marginal investment outflows and the marginal changed operational inflows. In other words, the reduction in the outflows for operating the implemented improvement measures must be higher than the divestment outflows for withdrawing the necessary improvement measures as well as the decrease in the expected inflows and the increase in demand risk, which result from more volatile core processes. This holds true for the multiple process area case, too. The analysis also revealed that, in general, the cutting of some capabilities should be combined with the strengthening of others. The deliberate cutting of capabilities can be a reasonable means for increasing company value.

5.2 Limitations

The decision framework and the analysis of its objective function are beset with limitations. Moreover, there are some challenges related to the practical application of the decision framework.

1. The cash flow components were modelled through function types that build on general properties regarding monotonicity and curvature. The consequence is that, in contrast to using concrete functions, no algebraic solutions could be provided for inner solutions. Thus, when applying the decision framework, organizations have to operationalize the function types by means of risk and re-

turn drivers that fit the particular setting at hand. We accepted this drawback because we assigned more utility to the larger scope of applicability that results from using function types.

2. In line with our conceptual approach, we made the assumptions underlying the decision framework explicit. The most important assumptions are those related to the properties of the cash flow components. It needs to be kept in mind that the identified relationships only hold true if the assumptions from which they were derived are fulfilled. Although the properties of the cash flow functions are rooted in the economic literature and prior research, it may be the case that they do not fit a particular setting. The proposed structuration of capability development decisions, in contrast, is independent of the assumptions.

3. In its current version, the decision framework accounts for the risky demand for the output of the organization's core processes. Further possibilities that could account for the risky nature of capability development have not been incorporated so far. The investment outflows and the changed operational outflows are treated as certain although there are related risk categories, such as project risks and operational risks. Correspondingly, interdependencies and diversification effects among cash flow components are neglected.

5.3 Implications

From a theoretical perspective, the limitations of the decision framework imply further research: One stream of future research relates to extending the decision framework. First, one could deal with other risk categories. One could also treat more cash flow components as stochastic to analyse more complex interdependencies and diversification effects. Another opportunity for extending the decision framework refers to investigating long- and short-term economic effects of capability development decisions. One should also have a look at the repeated strengthening and cutting of capabilities in order to adapt to a dynamic environment. Another stream of future research relates to enhancing the applicability of the decision framework to industry settings. For example, the cash flow components that so far consist of function types could be investigated in greater detail for typical settings. It seems worthwhile to identify generic risk and return drivers that operationalize the investment outflows, operational outflows, and operational inflows. A first step toward a deeper understanding of the cash flow components would be to conduct multiple case studies, such as in organizations that already use process maturity models.

From a managerial perspective, the decision framework may serve as foundation for business cases related to the development of organizational capabilities. Such business cases should consider the central ideas of the decision framework such as multiple layers of capability development, the distinction between an investment and operations phase, the incorporation of risk in the operational inflows, the different importance of individual capabilities as well as synergetic effects among different capabilities. Moreover, capability development decisions should rely on quantitative approaches and cash flows whenever possible. An appropriately documented process maturity model provided, the main challenge consists in adequately operationalizing the cash flow components and collecting suitable data. If estimating cash flow values is impossible or causes disproportionate effort, decision makers may also revert to non-monetary approaches. When applying the decision framework in industry settings it is not necessary to stick to all assumptions regarding the cash flow components that were made to identify the general relationships. However, if the assumptions hold true, business cases can be calculated much easier because border solutions can be identified by analysing a few critical values only. Regardless of whether the assumptions hold, the identified relationships raise the awareness for the fact that capabilities do not have to be developed to the highest extent, that cutting capabilities can increase the company value although it simultaneously causes an increase in demand risks, and that a combination of strengthening and cutting capabilities is likely to yield an optimal capability configuration.

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