ROADMAP TO FLEXIBLE SERVICE PROCESSES – A PROJECT PORTFOLIO SELECTION AND SCHEDULING APPROACH

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Abstract

Process flexibility has evolved into a desired corporate capability as it promises to cope with demand uncertainty and variety. Particularly service processes have a high intrinsic need for flexibility. Many approaches have been proposed to determine the business value and an appropriate level of flexibility for service processes. Most of these approaches focus on a distinct flexibility type and on single projects for implementing flexible service processes. The question how to reasonably combine flexibility projects has not been addressed yet. Moreover, most approaches do not conduct a full-fledged economic analysis of process flexibility. We therefore propose a decision model that helps determine an optimal flexibility roadmap, i.e., a scheduled portfolio of flexibility projects with different effects on service processes. The decision model accounts for different request types (i.e., runners, repeaters, and strangers), different capacity types (i.e., internal, external, dedicated, and flexible), different flexibility types (i.e., volume and functional), and related project archetypes. The decision model was evaluated using feature comparison, prototype construction, and a demonstration example including an extensive scenario analysis.

Keywords: Service processes, process flexibility, decision model, value-based management.

1 Introduction

Services are the biggest and most strongly growing business sector in all industrial nations (Fitzsimmons and Fitzsimmons, 2013; OECD Publishing, 2012). Nevertheless, services are particularly susceptible to demand uncertainty and variety, two challenges flexible service processes promise to address (Goyal and Netessine, 2011). With flexibility becoming an ever more desired corporate capability, service providers heavily invest in flexibility (Neuhuber et al., 2013). More flexible service processes, however, are not necessarily better (He et al., 2012). Rather, the appropriate level of service process flexibility depends on the characteristics of the service processes under investigation, their business environment, and the economic effects of investing in service process flexibility (van Biesebroeck, 2007).

Beyond technical and conceptual advances, many approaches have been proposed to valuate and determine an appropriate level of service process flexibility (Kumar and Stylianou, 2014). Braunwarth et al. (2010) help insurance companies determine whether claims should be handled automated and standardized or manually and flexibly. Their optimization model relies on the expected present value of the short-time cash effects and the long-term effects on customer satisfaction in terms of changes in the customer equity. Due to its focus on runtime decision support, the model neglects investments in flexibility. Afflerbach et al. (2014) consider a superior and an inferior service process in terms of profit margin. Accounting for cash flows as well as for process characteristics such as risky demand, criticality, similarity, and variability, their optimization model analyses which fractions of flexible capacity maximize the risk-adjusted expected net present value (NPV) of both processes. Dorsch and Häckel (2014) consider service processes parts of which can be outsourced via different models of capacity supply. Using discrete event simulation, they investigate how to combine different models of capacity supply to cope with risky demand in a manner that minimizes the total cost of service operations. Dorsch and Häckel focus on cost-driven service processes, a restriction that covers a small subset of services only. Neuhuber et al. (2013) help service providers determine the optimal level of volume and functional flexibility. Despite its focus on the positive economic effects of process flexibility, Neuhuber et al.'s model is restricted to a single period and to deterministic cash flows. Moreover, the flexibility of service processes is measured in terms of two flexibility levels between zero and one, a formalization that can hardly be assessed in real-world scenarios and requires flexibility projects to be ordered in advance. Schober and Gebauer (2011) present a real options-based model for valuating information systems flexibility while considering uncertainty, variability as well as time-criticality as properties of the involved processes. They take on a stochastic perspective in order not to underestimate the value of flexibility. Nevertheless, they only cover the cost effects of flexibility. The literature on project portfolio selection (PPS) also contains real options-based approaches that deal with flexibility (Benaroch and Kauffman, 1999; Huchzermeier and Loch, 2001). These approaches do not directly address service process flexibility. Moreover, they focus on determining the value added of flexibility in planning or the value of risk mainly based on single objective models, neglecting for example intra-temporal interactions among projects or mandatory projects (Frey and Buxmann, 2012).

This analysis reveals the following research gap: First, most approaches do not conduct a holistic economic analysis of service process flexibility. Most approaches that incorporate positive effects do this in hard-to-measure way or neglect their stochastic and long-term nature. Second, most approaches focus on a single flexibility type, mostly volume flexibility, and conduct detailed analyses regarding a single flexibility project (e.g., outsourcing or capacity reallocation). The challenge of how to combine projects that refer to different flexibility types has not been addressed yet. Approaches that consider multiple flexibility types and projects stay on a high level of abstraction. The resulting research question is as follows: *Which flexibility projects should a service provider implement in which order to achieve an appropriate level of flexibility for its service processes in line with economic principles?*

As a first step to answer this question, we propose a decision model for valuating flexibility roadmaps in line with the principles of project portfolio selection and value-based management (VBM). A flexibility roadmap is a scheduled portfolio of flexibility projects. Flexibility projects refer to volume or functional flexibility and differently affect a service provider's capacity configuration as well as the performance of the service process under consideration. As the decision model shows characteristics of a model and a method, we adopt the design science research paradigm and cover the following phases: identification of and motivation for the research problem, objectives of a solution, design and development, and evaluation (Peffers et al., 2008). In the design and development phase, we use normative analytical modelling to build the decision model (Meredith et al., 1989). With this paper, we also extend our prior research on business process flexibility and the development of business process management capabilities (Afflerbach et al., 2014; Lehnert et al., 2014).

The paper is organized as follows: First, we sketch the foundations of service process flexibility, PPS, and VBM as theoretical background, and derive respective requirements. We then introduce the decision model and report on feature comparison, prototype construction, and a demonstration example. We conclude by presenting key results, limitations, and issues for future research.

2 Theoretical Background and Requirements

2.1 Flexible service processes

Services are intangible experiences typically defined via criteria such as immateriality, inseparability of production and consumption, and integration of customers in the value creation process (Fitzsimmons and Fitzsimmons, 2013). We focus on information-intensive services that contain many information processing tasks and, thus, have a high potential for IT support and automation (Apte and Mason, 1995; Porter and Millar, 1985). The service value creation process splits into three phases (Alter, 2010). Service providers first create awareness for their services and customers become aware of their need. Both parties then negotiate their commitments and co-create the service. The last phase is called service delivery. Service requests split into runners, repeaters, and strangers (Johnston et al., 2012), a classification that complies with the standard, routine, and non-routine process scheme proposed by Lillrank (2003). Runners are standard activities with well-defined inputs and outputs found in high volume operations. Repeaters are routine activities composed of standard activities. Neither runners nor repeaters require substantial changes in the service process before or during execution, which is why they can be processed similarly (Neuhuber et al., 2013). Strangers are non-standard activities triggered by extraordinary requests whose input and output variety cannot be entirely captured before execution. Strangers thus require preparatory activities and changes in the service process before and during execution.

The performance of business processes in general and of service processes in particular can be assessed in terms of time, cost, quality, and flexibility, the dimensions of the Devil's Quadrangle (Dumas et al., 2013). The Devil's Quadrangle is also used for assessing the effects of process redesign projects, including flexibility projects. Each dimension of the Devil's Quadrangle must be operationalized by specific performance indicators. A prominent time indicator is cycle time, i.e., the time required to handle a request end-to-end. We refer to the cycle time as total service time. Indicators of the cost dimension, which also includes positive economic effects, are turnover, revenue, cash inflows or outflows. Quality splits into internal and external quality that can be measured in terms of error rates and customer satisfaction, respectively. Internal and external quality are closely related to the time dimension, as customer satisfaction is driven by expectations and experiences about time and error-induced rework increases the total service time (Anderson et al., 1994; Ray and Jewkes, 2004). The flexibility of a service process can be measured in terms of time as well (Neuhuber et al., 2013).

The preceding discussion in mind, time is a critical performance dimension of service processes. From a single customer's perspective, a service creates value if it is delivered within a certain time. From the service provider's perspective, the value of a service decreases with the total service time as customers have different preferences regarding time. In line with the effect of time on customer satisfaction, excessive total service time – or the expectation thereof – may decrease demand (Fitzsimmons and Fitzsimmons, 2013). The total service time splits into waiting, set-up, and processing time. Customers must wait if demand exceeds capacity (Gross et al., 2008). The set-up time refers to the period of time where the service provider has not yet started to process the request, but is already preparing employees, devices, machines, processes, or systems (Cheng and Podolsky, 1996). Set-up time has to be considered for complex requests, such as strangers. The processing time relates to the period where the service is co-created with the customer (Curry and Feldman, 2011).

Flexibility refers to the ability of a "system to react to or to anticipate system or environmental changes by adapting its structure and/or its behaviour considering given objectives" (Wagner et al., 2011, p. 811). Process flexibility is a hybrid form of volume and functional flexibility, allowing processes to cope with risky demand and create different as well as unplanned outputs (Afflerbach et al., 2014). This definition also applies to services processes (Johnston et al., 2012). Volume flexibility enables to "increase or decrease production above and below the installed capacity" (Goyal and Netessine, 2011, p. 182). Functional flexibility enables delivering the desired output variety (Anupindi et al., 2012). This definition of process flexibility requires adopting a broad process understanding that, following Alter's (2013) work system model, includes the resources and people involved in process execution.

When implementing process flexibility, it is worthwhile to analyse how volume and functional flexibility can be achieved. Mainly studied from a capacity and revenue management perspective, volume flexibility includes demand- and supply-side measures. While demand-side measures segment and deskew demand, supply-side measures focus on hedging and turning fixed into variable costs. Exemplary demand-side measures are dynamic pricing, reservation systems, and incentives on off-peak demand (Jerath et al., 2010). Supply-side measures include increased customer integration, enhanced process efficiency, service process automation, capacity sharing, outsourcing of excess demand, IT-based cross-training, and off work shift scheduling (Fitzsimmons and Fitzsimmons, 2013; Jack and Raturi, 2002). Functional flexibility has a rich tradition in workflow management (Reichert and Weber, 2012). Strategies for implementing functional flexibility are flexibility-by-design, flexibility-by-deviation, flexibility-by-underspecification, and flexibility-by-change (Schonenberg et al., 2008). Flexibility-by-design allows for choosing among predefined execution paths, whereas flexibility-by-deviation enables temporarily adapting a process at runtime. Flexibility-by-underspecification allows for completing a process at runtime. Flexibility-by-change enables to cope with events that cannot be addressed by temporary deviations. From a process design perspective, functional flexibility is established via configurable process models and modular design (Gottschalk et al., 2007). From a resource perspective, functional flexibility is achieved via extensive training, multi-purpose machines, process-aware information systems, and service-oriented architectures. Against this background, we derive the following requirement:

(R.1) *Service process flexibility*: To determine the optimal flexibility roadmap, (a) projects referring to functional and volume flexibility must be considered. Furthermore, (b) drivers that cover relevant characteristics of the service process under consideration and its environment must be included.

2.2 Project portfolio selection

The literature includes many approaches to PPS (Lee and Kim, 2000; Yu et al. 2012) and project scheduling (Carazo et al., 2010; Perez and Gomez, 2014). Some approaches are qualitative, others are quantitative (Frey and Buxmann, 2012). Qualitative approaches typically propose reference processes, instead of concrete methods (Archer and Ghasemzadeh, 1999; Jefferey and Leliveld, 2004). 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" (Archer and Ghasemzadeh, 1999, p. 208). The PPS process includes five stages: pre-screening, individual project analysis, screening, optimal portfolio selection, and portfolio adjustment (Archer and Ghasemzadeh, 1999). In the pre-screening stage, projects are checked with respect to whether they align with the organization's strategy. 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 the pre-defined criteria best.

Considering interactions is challenging, but necessary for making PPS decisions (Frey and Buxmann, 2012; Lee and Kim, 2001). 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 (Kundisch and Meier, 2011). Intra-temporal interactions affect the planning of single portfolios, whereas inter-temporal interactions influence today's decision-making based on potential follow-up projects (Gear and Cowie, 1980). Inter-temporal interactions result from effects that depend on the sequence in which projects are implemented (Bardhan et al., 2004). Interactions are deterministic if all parameters are assumed to be known with certainty or were estimated as single values. If parameters are uncertain and follow some probability distribution, interactions are considered stochastic (Medaglia et al., 2007). Scheduling interactions occur if projects may start at different points. Therefore, we derive the following requirement:

(R.2) *Project portfolio selection*: To determine the optimal flexibility roadmap, it is necessary (a) to evaluate available flexibility projects stand-alone prior to portfolio selection and (b) to consider interactions among these projects.

2.3 Value-based management

Building on the work of Rappaport (1986), Copeland et al. (1990), and Stewart (1991), VBM sets the maximizing of the long-term company value as the primary objective for all business activities. The company value is based on future cash flows (Rappaport, 1986). To claim value-based management to be implemented, companies must not only be able to quantify the company value on the aggregate level, but also the value contribution of single activities and decisions. In addition, decisions must be based on cash flows, consider risks, and incorporate the time value of money to comply with the principles of VBM (Buhl et al., 2011). Depending on the decision situation and the decision makers' risk attitude, there are accepted objective functions for value-based decision-making (Berger, 2010). In case of certainty, decisions can be made based on the NPV of future cash flows. In case of risk with risk-neutral decision makers, decisions can be made based on the expected NPV. In case of risk-averse decision makers, decision alternatives can be valuated using the risk-adjusted expected value of the NPV or using a risk-adjusted interest rate. This leads to the following requirement:

(R.3) *Value-based management*: The optimal flexibility roadmap is the roadmap with the highest value contribution. To determine the value contribution of a flexibility roadmap, one has to account (a) for the cash flow effects of the projects included in the roadmap, (b) for the decision makers' risk attitude, and (c) for the time value of money.

3 Decision Model

When introducing the decision model, we first outline the general setting including request and capacity types as well as indicators for the performance of the service process under investigation. We then present the project archetypes and integrate all effects into an economic objective function.

3.1 Request and capacity types

As unit of analysis, we consider a single service process and focus on the service delivery phase from a supply-side perspective. In line with the characteristics of runners, repeaters, and strangers, we distinguish a joint service process variant for runners and repeaters (RR) and another variant for strangers (S). With all request types referring to the same service process, we express the relationship between both process variants in terms of the fraction of mandatory tasks $\beta \in]0;1]$ from the runner/repeater process variant that are also included in the stranger variant. If almost all tasks of the runner/repeater variant are mandatory, β is close to 1. Consider that β is a one-sided measure that takes on a runner/repeater perspective. It cannot take on the stranger perspective because strangers include additional and potentially request-specific tasks whose amount cannot be foreseen before execution (Johnston et al., 2012).

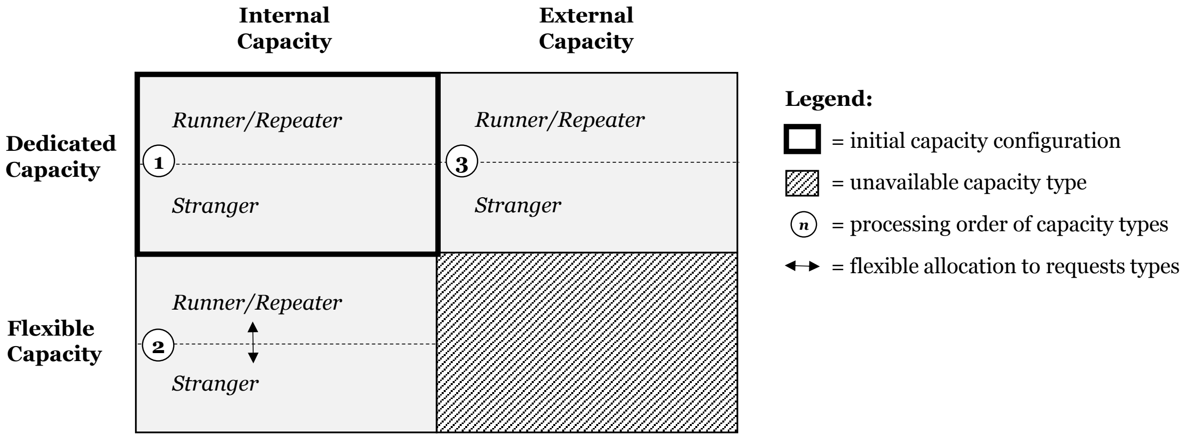

Figure 1. The service provider's capacity configuration.

In each period of the planning horizon, the service provider disposes of a distinct capacity configuration (Figure 1). Accounting for our focus on the supply side, the capacity configuration may include different capacity types, i.e., dedicated and flexible capacity as well as internal and external capacity. For our purposes, we neglect external flexible capacity. The capacity of a distinct type denotes the maximum number of related requests the service provider can serve per period. Internal and external capacity refer to the fact that service requests are served using the service provider's own resources or the resources of a third party (Dorsch and Häckel, 2014). Dedicated capacity is assigned to either runner/repeater or stranger requests (e.g., using specifically trained employees, special-purpose machines, or IT services). Flexible capacity can be used for handling both runner/repeater requests and strangers (e.g., using cross-trained employees, multi-purpose machines, and configurable IT services) (Jordan and Graves, 1995).

Assuming that one flexible capacity unit can handle one runner/repeater request, the exchange rate ε indicates how many units are needed to handle a stranger request (Afflerbach et al., 2014). As for external capacity, the service provider can choose between two models of capacity supply, i.e., non-scalable and scalable capacity (Aksin et al., 2008). In case of non-scalable capacity, the service provider increases its dedicated internal capacity for runner/repeater or stranger requests by a fixed amount of capacity units for which it pays a fixed amount of money. As for scalable capacity, the service provider increases its dedicated internal capacity for runner/repeater or stranger requests by a variable, but capped amount of capacity units. The amount of money the service provider must pay depends on how many capacity units it actually used in a distinct period. All capacity types can be changed by implementing flexibility projects. Table 1 summarizes the relevant mathematical variables. In addition, we assume:

A1: Each service request is handled entirely internally or externally. For each request type, the capacity allocation policy is: internal dedicated capacity, internal flexible capacity, external non-scalable or scalable capacity. In the initial period of the planning horizon $y = 0$, the capacity configuration only includes dedicated internal capacity.

Capacity type	Request type	Capacity	Total service time	Variable cash outflows	Fixed cash outflows
Internal dedicated	RR	$C_{\mathrm{RR},y}^{\mathrm{int}}$	$t_{\mathrm{RR},y}^{\mathrm{int}}$	$v_{\mathrm{RR},y}^{\mathrm{int}}$	$f_{\mathrm{RR},y}^{\mathrm{int}}$
	S	$C_{\mathrm{S},y}^{\mathrm{int}}$	$t_{\mathrm{S},y}^{\mathrm{int}}$	$v_{\mathrm{S},y}^{\mathrm{int}}$	$f_{\mathrm{S},y}^{\mathrm{int}}$
External dedicated	RR	$C_{\mathrm{RR},y}^{\mathrm{ext}}$	$t_{\mathrm{RR},y}^{\mathrm{ext}}$	$v_{\mathrm{RR},y}^{\mathrm{ext}}$	$f_{\mathrm{RR},y}^{\mathrm{ext}}$
	S	$C_{S,y}^{ext}$	$t_{\mathrm{S},y}^{\mathrm{ext}}$	$v_{\mathrm{S},y}^{\mathrm{ext}}$	$f_{\mathrm{S},y}^{\mathrm{ext}}$
Flexible	RR + S	C_{y}^{flex}	t_{y}^{flex}	v_{y}^{flex}	f_{y}^{flex}

y: distinct period of the planning horizon

Table 1. Mathematical variables related to capacity types.

3.2 Performance of the service process

The performance of the runner/repeater and the stranger process variants is evaluated regarding the dimensions of the Devil's Quadrangle (Dumas et al., 2013). To capture the effects of flexibility, we cover the dimensions time and cost. Though acknowledging the importance of service quality, we refrain from modelling quality explicitly because external quality is already in parts driven by time. We also consider the internal quality of runner/repeater and stranger requests to be constant throughout the planning horizon and not to be affected by implemented flexibility projects. Below, we first introduce the performance effects that only depend on the request type. We then discuss performance effects that also depend on the capacity type. Relevant mathematical variables regarding the capacity types are shown in Table 1.

The cash inflows of the service process only depend on the request type. The service process creates inflows in terms of the sales price. The sales price is p_{RR} for runner/repeater requests and p_{S} for stranger requests. The cash inflows of strangers exceed those of runner/repeater requests as customers are willing to pay a premium for more complex services ($p_{\mathrm{RR}} < p_{\mathrm{S}}$). In line with our focus on the supply side of service delivery, we consider the sales prices as given and constant.

The total service time as well as the variable and fixed outflows depend on both the request type and the capacity type. As runner/repeater requests occur more often and are more predictable than strangers, we use the runner/repeater process variant of the service process as benchmark. As for internal dedicated capacity, runner/repeater requests have a total service time and cause variable outflows per execution (e.g., for people and usage of IT services). Internal dedicated capacity for runner/repeater requests also leads to fixed outflows per period (e.g., for wages, resource consumption, and IT support). Depending on which flexibility projects have been implemented, the total service time, the capacity, the variable and the fixed outflows may take different values per period. Stranger requests require additional service time and cause additional variable outflows (e.g., for preparatory activities, additional tasks and resources, and for using more complex IT services) as well as fixed outflows (e.g., for better trained employees, maintenance of multi-purpose machines). As shown in Formula (1) and (2), the charges regarding time and variable outflows are additional to the total service time and variable outflows caused by the mandatory tasks of the runner/repeater process variant.

$$t_{\mathrm{S},y}^{\mathrm{int}} = \beta \cdot t_{\mathrm{RR},y}^{\mathrm{int}} + \Delta t_{\mathrm{S},y}^{\mathrm{int}} \tag{1}$$

$$v_{\mathrm{S},y}^{\mathrm{int}} = \beta \cdot v_{\mathrm{RR},y}^{\mathrm{int}} + \Delta v_{\mathrm{S},y}^{\mathrm{int}} \tag{2}$$

Flexible capacity leads to variable outflows. These outflows equal the cash outflows that occur for handling runner/repeater and stranger requests by means of internal dedicated capacity. The total service time basically equals the total service times in case of internal dedicated capacity. However, we include an overhead factor $\alpha \in [1; \infty[$ that arises because cross-trained employees typically do not have enough routine to execute service processes as fast and in the same quality as dedicated employees (Pinker and Shumsky, 2000). This leads to a total service time for flexible capacity as shown in Formula (3). Based on our knowledge about the total service times of runner/repeater requests and strangers that are handled via internal dedicated capacity, we can calculate the exchange rate as shown in Formula (4). Flexible capacity also leads to fixed outflows per period.

$$t_y^{\mathrm{flex}} = \begin{cases} \alpha \cdot t_{\mathrm{RR},y}^{\mathrm{int}} \text{ in case of a runner/repeater request} \\ \alpha \cdot \left(\beta \cdot t_{\mathrm{RR},y}^{\mathrm{int}} + \Delta t_{\mathrm{S},y}^{\mathrm{int}}\right) \text{ in case of a stranger request} \end{cases} \tag{3}$$

$$\varepsilon = \frac{\beta \cdot t_{\mathrm{RR},y}^{\mathrm{int}} + \Delta t_{\mathrm{S},y}^{\mathrm{int}}}{t_{\mathrm{RR},y}^{\mathrm{int}}} \tag{4}$$

Finally, the external capacity for handling runner/repeater requests causes fixed outflows, variable outflows, and has a total service time. The same holds true for external capacity that is dedicated to stranger requests. As these values are negotiated separately with the external service provider and specified in terms of service level agreements, the time and cash outflow values for external capacity are not derived from their internal counterparts.

Risky demand is an essential driver of service process flexibility. Complying with its effect on quality, the total service time transitively drives the demand. We model the periodic demand of the service process as a normally distributed random variable (Buhl et al., 2011; He et al., 2012). On the assumption that the service provider's customers make their purchase decisions only based on the total service time, the expected demand in a distinct period depends on the average total service time that could be observed by the service provider's customers in the previous period. We do not consider further inter-temporal demand effects, e.g., that customers whose requests cannot be served in a distinct period are such dissatisfied that they churn and place all future requests at another service provider – even if the average total service time decreases. That is, demand that cannot be served based on the service provider's capacity configuration is discarded without any further negative effects. Waiting time therefore plays a subordinate role in the total service time. Moreover, we do not distinguish between a total service time for runner/repeater and stranger requests because customers do not necessarily know whether their requests are treated as runner/repeaters or strangers from an internal service delivery perspective. Beyond risky demand, the proportion of stranger requests can vary in each period in line with the very nature of strangers. We treat the proportion of strangers as uniformly distributed between a service-specific lower and upper boundary. As, in a stable environment, the amount of strangers is much smaller than the amount of runner/repeater requests, the upper boundary of stranger requests relative to the demand is much smaller than one. Our considerations about the demand of the service process are summarized in assumption A.2. Based on these insights, we can derive the number of service requests to be handled as runners/repeaters or strangers in a distinct period as shown in Formula (5) and (6).

A2: The periodic demand $\widetilde{D}_y \sim N(\mu_y; \sigma^2)$ is normally distributed. The expected demand depends on the average total service time of the previous period $t_{\text{total},y-1}$. With the function $g(t_{\text{total},y})$ translating the average total service time into an expected demand, it holds $\mu_y = g(t_{\text{total},y-1})$. The proportion of stranger requests $\tilde{X} \sim \mathcal{U}(a; b)$ follows a uniform distribution with a and b as service-specific lower and upper boundaries ($0 < a, b < 1, a < b, b \ll 1$).

$$\widetilde{D}_{\text{RR},y} = (1 - \tilde{X}) \cdot \widetilde{D}_y \tag{5}$$

$$\widetilde{D}_{\text{S},y} = \tilde{X} \cdot \widetilde{D}_y \tag{6}$$

The average total service time depends on how many runner/repeater and stranger requests are handled by which capacity type. As the number of runner/repeater and stranger requests may exceed the available capacity, we need the number of served requests as specified in Formula (7) and (8) to valuate flexibility projects. Thereby, $\widetilde{D}^{\text{flex}}_{\text{svd,RR},y}$ and $\widetilde{D}^{\text{flex}}_{\text{svd,S},y}$ represent the number of runner/repeater and stranger requests served via flexible capacity. On this foundation, we can calculate the average total service time as shown in Formula (9), where the variables d represent concrete demand realizations.

$$\widetilde{D}_{\text{svd,RR},y} = \widetilde{D}^{\text{int}}_{\text{svd,RR},y} + \widetilde{D}^{\text{flex}}_{\text{svd,RR},y} + \widetilde{D}^{\text{ext}}_{\text{svd,RR},y} \tag{7}$$

$$\widetilde{D}_{\text{svd,S},y} = \widetilde{D}^{\text{int}}_{\text{svd,S},y} + \widetilde{D}^{\text{flex}}_{\text{svd,S},y} + \widetilde{D}^{\text{ext}}_{\text{svd,S},y} \tag{8}$$

$$\begin{aligned} t_{\text{total},y} = \Big[& \big(d^{\text{int}}_{\text{svd,RR},y} + d^{\text{flex}}_{\text{svd,RR},y} \cdot \alpha\big) \cdot t^{\text{int}}_{\text{RR},y} + d^{\text{ext}}_{\text{svd,RR},y} \cdot t^{\text{ext}}_{\text{RR},y} \\ & + \big(d^{\text{int}}_{\text{svd,S},y} + d^{\text{flex}}_{\text{svd,S},y} \cdot \alpha\big) \cdot \big(\beta \cdot t^{\text{int}}_{\text{RR},y} + \Delta t^{\text{int}}_{\text{S},y}\big) + d^{\text{ext}}_{\text{svd,S},y} \cdot t^{\text{ext}}_{\text{S},y} \Big] \\ & \cdot \frac{1}{d^{\text{int}}_{\text{svd,RR},y} + d^{\text{flex}}_{\text{svd,RR},y} + d^{\text{ext}}_{\text{svd,RR},y} + d^{\text{int}}_{\text{svd,S},y} + d^{\text{flex}}_{\text{svd,S},y} + d^{\text{ext}}_{\text{svd,S},y}} \end{aligned} \tag{9}$$

3.3 Project archetypes

In line with our definition of process flexibility, we distinguish volume flexibility projects and functional flexibility projects. Volume flexibility projects enhance the service provider's ability to cope with fluctuating demand. As for internal capacity, volume flexibility projects can directly affect the total service time and the variable outflows related to the handling of runner/repeater requests. They thereby indirectly influence the total service time and variable outflows of the internal capacity dedicated to stranger requests (see Formula 1 and 2) as well as the total service time and the exchange rate of flexible capacity (see Formula 3 and 4). As for external capacity dedicated to runner/repeater and stranger requests, volume flexibility projects can directly influence the total service time and the variable outflows. Overall, volume flexibility projects can directly affect the fixed outflows and capacity of all capacity types. As far as direct effects are concerned, volume flexibility projects have relative effects on the performance indicators regarding internal dedicated capacity and absolute effects on the performance indicators related to all other capacity types. The reason is that, according to assumption A.1, only internal dedicated capacity is part of the service provider's initial capacity configuration. All other capacity types must be set up from scratch first. Moreover, it is very complex and costly to estimate ex ante the absolute effects of all project candidates considering all possible sequences of implementation (Project Management Institute, 2008). From a roadmap perspective, relative effects must be linked multiplicatively with the performance indicators of the service process, whereas absolute effects are linked additively (Lehnert et al., 2014). Depending on the project at hand, the effects of volume flexibility projects can be positive, negative, or neutral. This allows for covering many different constellations. For instance, there are volume flexibility projects such as process efficiency projects that only directly affect the dedicated internal capacity by reducing the total service time, while decreasing variable outflows with potentially no effect on fixed cash outflows. Other projects may reduce fixed outflows while leaving variable outflows and the total service time unchanged. It is also possible for a volume flexibility project to affect two capacity types. For example, a project can reduce internal dedicated capacity while adding external capacity. A concrete example is the introduction of flexible work contracts, a project that reduces fixed outflows and increases variable outflows. As another example, cross-training employees would positively affect volume flexibility as employees are enabled to handle both runner/repeater and stranger requests. Cross-training would therefore decrease dedicated capacity while adding flexible capacity. All volume flexibility projects cause investment outflows (e.g., for cross-training and related IT support, automating the service process, or integrating an external service provider into one's IT landscape).

Functional flexibility projects affect the service provider's ability to better handle stranger requests by means of internal capacity dedicated to strangers. Therefore, functional flexibility projects can directly influence the respective fixed outflows, the additional time, and the additional variable outflows needed to deal with stranger requests as well as the internal capacity dedicated to strangers (see Formula 1 and 2). Due to the effect on the additional time, functional flexibility projects indirectly affect the exchange rate (see Formula 4). Depending on the project at hand, the effects can again be positive, negative, or neutral. In each case, they are expressed in relative numbers because, according to assumption A.1, internal capacity dedicated capacity already exists in the initial capacity configuration. As an example from a resource perspective, consider the introduction of an enterprise wiki. Operating such a system reduces the variable outflows as well as the total service time while increasing dedicated capacity. All functional flexibility cause investment outflows (e.g., for establishing adequate IT support).

3.4 Objective function

To increase the flexibility of the service process, the service provider can invest in flexibility projects. The service provider aims to select the optimal flexibility roadmap, i.e., the roadmap with the highest value contribution, from a set of pre-defined project candidates. The service provider thus determines which project candidates should be implemented in which order. We allow for only one flexibility project to be implemented per period, a feasible restriction as only one service process is considered. Moreover, all flexibility projects can be finished within one period such that their effects become manifest at the beginning of the next period (Lehnert et al., 2014). When determining the optimal flexibility roadmap, the service provider also has to set the relevant planning horizon Y. Due to the inter-temporal interactions among flexibility projects, capacity types, and request types, the effects of some flexibility projects depend on those projects that have been implemented in prior periods, i.e., implementing the same projects in different sequences leads to different effects and to roadmaps with different value contributions (Pierson, 2000). We assume:

A3: One project can be implemented per period. All projects can be finished within a single period. The effects of all project candidates have been determined in the individual project analysis stage of the PPS process. Moreover, the candidates have been checked for appropriate fit regarding the service process in the pre-screening stage.

To determine the value contribution of a flexibility roadmap r in line with the principles of PPS and VBM, we must compute the expected cash flows for each period of the planning horizon, discount these expected periodic cash flows using a risk-adjusted interest rate z, and then cumulate the discounted cash flows (Buhl et al., 2011). For each period, the cash flows split into investment outflows for implementing the respective project O_y^{inv}, fixed outflows, and an operating cash flows. The operating cash flows for runner/repeater as well as for stranger requests results from the served demand that realizes for the average total service time observed in the previous period and the capacity configuration available in the respective period as well as from a contribution margin. The contribution margin, in turn, depends on the price of the respective request type and the variable cash outflows. The investment outflows as well as all existing fixed cash outflows are due at the beginning of each period. The operating cash flows, in contrast, are due at the end of each period. This leads to the objective function shown in Formula (10). Note that the total service time is shown indirectly in Formula (10) because it is already included in the periodic demand, which in turn is reflected in the number of requests served per capacity type. Note as well that, if a roadmap contains multiple flexibility projects for a distinct capacity type not included in the initial capacity configuration, the effects of each project must be treated separately. For better readability, the objective function in Formula (10) only accounts for one project of these capacity types each.

$$
\begin{aligned}
&\max_{r} \widetilde{NPV}_r = \\
&-\sum_{y=0}^{Y} \frac{o_y^{\text{inv}}}{(1+z)^y} - \sum_{y=0}^{Y} \frac{f_{\text{RR},y}^{\text{int}} + f_{\text{S},y}^{\text{int}} + f_y^{\text{flex}} + f_{\text{RR},y}^{\text{ext}} + f_{\text{S},y}^{\text{ext}}}{(1+z)^y} \\
&+\sum_{y=0}^{Y} \frac{\left(p_{\text{RR}} - v_{\text{RR},y}^{\text{int}}\right) \cdot \left[E\left(\tilde{D}_{\text{svd,RR},y}^{\text{int}}\right) + E\left(\tilde{D}_{\text{svd,RR,flex},y}^{\text{int}}\right)\right]}{(1+z)^{y+1}} + \sum_{y=0}^{Y} \frac{\left(p_{\text{RR}} - v_{\text{RR},y}^{\text{ext}}\right) \cdot E\left(\tilde{D}_{\text{svd,RR},y}^{\text{ext}}\right)}{(1+z)^{y+1}} \\
&+\sum_{y=0}^{Y} \frac{\left(p_{\text{S}} - \left(\beta \cdot v_{\text{RR},y}^{\text{int}} + \Delta v_{\text{S},y}^{\text{int}}\right)\right) \cdot \left[E\left(\tilde{D}_{\text{svd,S},y}^{\text{int}}\right) + E\left(\tilde{D}_{\text{svd,S,flex},y}^{\text{int}}\right)\right]}{(1+z)^{y+1}} + \sum_{y=0}^{Y} \frac{\left(p_{\text{S}} - v_{\text{S},y}^{\text{ext}}\right) \cdot E\left(\tilde{D}_{\text{svd,S},y}^{\text{ext}}\right)}{(1+z)^{y+1}}
\end{aligned}
\tag{10}
$$

4 Evaluation

According to Venable et al. (2012), a variety of methods and patterns are available to evaluate artefacts in design-oriented research. To evaluate the decision model, we discuss the decision model against the requirements derived from the literature, implemented a simulation-based software prototype, and present a demonstration example. Due to space restrictions, we do not present the prototype here.

4.1 Feature comparison

The results of feature comparison are shown in Table 2. The requirements that relate to service process flexibility and VBM are met to the full extent. The requirement that accounts for PPS is covered partly. The resulting need for future research is outlined in the conclusion.

Requirement	Features of the model
(R.1) Service process flexibility	The decision model accounts for volume and functional flexibility projects (R.1a). It also considers characteristics related to the service process under investigation and the business environment (R.1b). As for the service process, we distinguish multiple request types, capacity types, and several dimensions of performance. As for the business environment, we account for risky demand as one of the most important flexibility drivers.
(R.2) Project portfolio selection	We consider a set of pre-defined project candidates. We assume that, in the pre-screening stage, all candidates were checked for appropriate strategic fit and that, in the individual project analysis stage, the relative and absolute effects all of candidates have been determined as single values independent from other projects (R.2a). The absolute effects of some projects depend on the projects that have been implemented in prior periods. With the periodic demand and the proportion of strangers per period, we consider stochastic, scheduling, and inter-temporal interactions (R.2b).
(R.3) Value-based management	The value contribution of a flexibility roadmap is based on the expected value of its stochastic NPV using a risk-adjusted interest rate for discounting. The stochastic NPV considers all cash effects that result from volume and functional flexibility projects as well as from service delivery (R.3a). We account for the decision makers' risk attitude when using a risk-adjusted interest rate (R.3b). As flexibility roadmaps comprise multiple projects implemented at different points in time, we also consider a multi-period planning horizon and the time value of money (R.3c).

Table 2. Results of feature comparison.

4.2 Demonstration example

For the demonstration example, we consider a fictitious service process that has a normally distributed periodic demand depending on the total service time (in hours) as shown in Formula (11).

$$
\tilde{D}_y \backsim N\left(1{,}000 \cdot e^{\frac{1}{t_{\text{total},y-1}}}; 150^2\right) \tag{11}
$$

The fraction of mandatory tasks that must be executed for runner/repeater and stranger requests amounts to $\beta = 0.6$. For the periodic proportion of strangers, we investigate two different scenarios, i.e., a small and one broad range, as modelled by the uniform distributions $\mathcal{U}(0.1; 0.2)$ and $\mathcal{U}(0; 0.3)$. We calculate the initial total service time in $y = 0$ based on a stranger proportion of $x = 0.15$. As initial capacity configuration, the service provider disposes of $C_{\mathrm{RR},0}^{\mathrm{int}} = 2{,}000$ units of dedicated internal capacity for runner/repeater requests and of $C_{\mathrm{S},0}^{\mathrm{int}} = 180$ units of dedicated internal capacity for stranger requests. The corresponding fixed outflows are $f_{\mathrm{RR},0}^{\mathrm{int}} = 60{,}000$ € and $f_{\mathrm{S},0}^{\mathrm{int}} = 30{,}000$ €. The variable outflows are $v_{\mathrm{RR},0}^{\mathrm{int}} = 80$ € and $\Delta v_{\mathrm{S},0}^{\mathrm{int}} = 100$ €. The service provider calculates with a total service time $t_{\mathrm{RR},0}^{\mathrm{int}} = 1$ h for handling runner/repeater requests using the available capacity as well as with an additional time of $\Delta t_{\mathrm{S},0}^{\mathrm{int}} = 1.1$ h for handling strangers. Customers are willing to pay $p_{\mathrm{RR}} = 200$ € for runner/repeater requests and $p_{\mathrm{S}} = 400$ € for stranger requests. We consider six different projects (Table 3), thereof five volume flexibility projects and one functional flexibility project. Four projects only have relative effects (exclusively depicted in Table 4) or absolute effects (exclusively depicted in Table 5). The other two projects have relative and absolute effects (Table 4 and Table **5**). The absolute capacity units of project 3 and 5 are calculated (calc.) based on the respective relative effects on the internal capacity during the application of the prototype. For all projects, we estimated optimistic (opt.) and pessimistic (pess.) effects. The difference between the optimistic and the pessimistic scenario is about 10%.

Project *n*	**Description**	**Type**	O^{inv}
1	Outsourcing excess demand of runner/repeater requests to an external service provider	Volume	1,000 €
2	Outsourcing excess demand of stranger requests to an external service provider	Volume	1,000 €
3	IT-based cross-training of employees	Volume	40,000 €
4	Increased process efficiency by means of standardization and automation	Volume	25,000 €
5	Shift from traditional to flexible employment contracts	Volume	30,000 €
6	Implementation and roll-out of an enterprise wiki	Functional	10,000 €

Table 3. Flexibility projects considered in the demonstration example.

Project *n*	**Scenario**	**Effect on**			
		$f_{\mathrm{RR}}^{\mathrm{int}}$	$C_{\mathrm{RR}}^{\mathrm{int}}$	$f_{\mathrm{S}}^{\mathrm{int}}$	$C_{\mathrm{S}}^{\mathrm{int}}$
3	pess.	0.95	0.88	-	-
	opt.	0.92	0.88	-	-
5	pess.	-	-	0.8	0.6
	opt.	-	-	0.72	0.67

Project *n*	**Scenario**	**Effect on**			
		$v_{\mathrm{RR}}^{\mathrm{int}}$	$t_{\mathrm{RR}}^{\mathrm{int}}$	$\Delta v_{\mathrm{S}}^{\mathrm{int}}$	$\Delta t_{\mathrm{S}}^{\mathrm{int}}$
4	pess.	1	0.96	-	-
	opt.	0.95	0.92	-	-
6	pess.	-	-	0.95	0.9
	opt.	-	-	0.85	0.75

Table 4. Relative effects of flexibility projects.

Project *n*	**Capacity**	**Scenario**	**Capacity units**	f_y	v_y^{ext}	t_y^{ext}	α
1	$C_{\mathrm{RR},y}^{\mathrm{ext}}$	pess.	320	0 €	125 €	1.2 h	-
		opt.	350	0 €	120 €	1.1 h	-
2	$C_{\mathrm{S},y}^{\mathrm{ext}}$	pess.	27	7,830 €	0 €	2.0 h	-
		opt.	30	8,400 €	0 €	1.8 h	-
3	C_y^{flex}	pess.	calc.	5,500 €	-	-	1.10
		opt.	calc.	5,000 €	-	-	1.05
5	$C_{\mathrm{S},y}^{\mathrm{ext}}$	pess.	calc.	0 €	255 €	1.85 h	-
		opt.	calc.	0 €	250 €	1.7 h	-

Table 5. Absolute effects of flexibility projects.

We assume that a planning period lasts one quarter and that the service provider uses a risk-adjusted discount rate of 10.4% per year and 2.5% per quarter for valuating investment decisions. For the planning horizon, we decided to analyse a short and a long planning horizon, i.e., three and eight periods.

As for the long planning horizon, we mainly face a project scheduling problem, while project selection becomes more important for the short planning horizon.

Concerning the planning horizon (short vs. long), the stranger range (small vs. broad), and the project effects (optimistic vs. pessimistic), we investigate eight scenarios. For each scenario, we determine the best and the worst roadmap. In sum, there are 229 roadmap candidates for the short planning horizon and 93,289 candidates for the long planning horizon. To determine the stochastic NPV of all roadmap candidates, we simulated 1,000 iterations per candidate using our software prototype. For all scenarios, Table 6 shows the best and the worst roadmaps in terms of the expected stochastic NPV followed by their relative value contribution. Each roadmap is depicted as a sequence of project indices, where “-” denotes that no project has been scheduled for the respective period.

		Short planning horizon		**Long planning horizon**	
		Small stranger range	**Broad stranger range**	**Small stranger range**	**Broad stranger range**
Best Case	**Opt.**	Project order: 1, 2, - NPV: 570,325 (3.59%)	Project order: 1, -, - NPV: 542,992 (3.90%)	Project order: 1, 4, 2, -, -, -, -, - NPV: 1,473,605 (6.65%)	Project order: 1, 4, 6, 2, -, -, -, - NPV: 1,395,534 (6.58%)
	Pess.	Project order: 1, 2, - NPV: 568,345 (3.23%)	Project order: 1, -, - NPV: 540,822 (3.48%)	Project order: 1, 2, -, -, -, -, -, - NPV: 1,449,779 (4.92%)	Project order: 1, -, -, -, -, -, -, - NPV: 1,369,483 (4.59%)
Worst Case	**Opt.**	Project order: 3, 5, 4 NPV: 401,304 (-27.11%)	Project order: 3, 5, 4 NPV: 382,831(-26.75%)	Project order: 3, 5, -, -, -, -, 6, 4 NPV: 1,085,480 (-21.44%)	Project order: 3, 5, -, -, -, -, 6, 4 NPV: 1,053,524 (-19.54%)
	Pess.	Project order: 3, 5, 4 NPV: 391,942 (-28.81%)	Project order: 3, 5, 4 NPV: 373,872 (-28.46%)	Project order: 3, 5, 4, -, -, -, 6, 1 NPV: 1,038,157 (-24.87%)	Project order: 3, 5, 4, -, -, -, 6, 1 NPV: 1,008,704 (-22.96%)

Table 6. Results of the demonstration example.

The results of applying the decision model to the demonstration example can be interpreted as follows:

1. In each scenario, the expected stochastic NPV of the best flexibility roadmap differs a lot from the value of the corresponding worst flexibility roadmap. For example, in the optimistic scenario with a long planning horizon and a small stranger range, the expected stochastic NPV is 388,125 € (26%) higher than the expected stochastic NPV of the worst flexibility roadmap. This result corroborates the proposition that the concrete selection of projects and the inter-temporal interactions implied by their sequence of implementation have a large impact on the value contribution.
2. Apart from the differences in the planning horizon, the projects included in the best flexibility roadmap and their sequence of implementation are similar for almost all scenarios. In all eight scenarios, project 1 is the first project being implemented. This is reasonable as the expected demand exceeds the initial capacity for runner/repeater requests in the initial period and project 1 adds dedicated external capacity for runner/repeater requests. Due to the fact that project 2 refers to external dedicated capacity for stranger requests, it is part of the best flexibility roadmap in all scenarios with a small stranger range. As for a broad stranger range, project 2 is only in the optimistic scenario with a long planning horizon part of the best flexibility roadmap as the proportion of stranger fluctuates more strongly. In the optimistic scenarios with a long planning horizon, project 4 that increases efficiency by means of standardization and automation is implemented. In all other scenarios, project 4 is not part of the best flexibility roadmap. In the optimistic scenarios with a short planning horizon, three periods are not enough to justify the investment outflows for implementing this project. In all pessimistic scenarios, the effects of project 4 are too weak. Project 6, which proposes the implementation of an enterprise wiki, is only implemented in the optimistic scenario with a long planning horizon and a broad stranger range. Project 6 mainly reduces additional time for handling stranger requests. As a result, stranger requests increase and it is reasonable to add dedicated external capacity for stranger requests by implementing project 2 thereafter. It is also notable that the projects 3 and 5 are not included in any best flexibility roadmap. Project 3, which refers to IT-based cross-training for employees, enables flexible capacity and therefore load balancing between runner/repeater and stranger requests. This flexible capacity goes along with higher cash outflows and longer total service

time compared to the already existing dedicated internal capacity. In our setting, flexible capacity does not lead to additional value contribution. The reason is that load balancing capabilities are not necessary because the expected demand exceeds the initial capacity in the initial period both for runner/repeater and stranger requests, and therefore no free capacity exists. Project 5 partially transforms internal dedicated capacity for stranger requests into external dedicated capacity for stranger requests. It is not included in a best flexibility roadmap for the same reason as project 3.

3. It can be seen in Table 6 that not only the sequence of implementation influences the value contribution of a flexibility roadmap. It is also reasonable from an economic point of view not to include all available project candidates.
4. Finally, as the flexibility projects included in the best flexibility roadmaps and the corresponding expected stochastic NPVs do not differ largely in the optimistic and the pessimistic scenarios (1.03% difference on average), we hypothesize that the decision model is robust against minor estimation errors. Such a hypothesis, however, must be checked in future research.

5 Conclusion

Against the increasing importance of flexible service processes, we investigated which flexibility projects a service provider should implement in which order to achieve an appropriate level of flexibility. To answer this question, we proposed a decision model that valuates flexibility roadmaps, i.e., portfolios of scheduled flexibility projects with different effects on service processes. The decision model helps select the roadmap with the highest value contribution in a given planning horizon. The value contribution of a flexibility roadmap is expressed in terms of the expected value of the roadmap’s stochastic net present value using a risk-adjusted interest rate. The decision model covers a single service process and focuses on how this process performs regarding time, flexibility, and cost. It also distinguishes runners, repeaters, and strangers as request types, handles multiple capacity types such as internal, external, dedicated, and flexible capacity, and considers a stochastic demand and proportion of strangers. As for the evaluation, we discussed the decision model against requirements derived from the literature, built a software prototype, and presented a demonstration that is example based on the prototype.

As the decision model does not meet all requirements to the full extent, its limitations should be subject to future research: As typical for modelling endeavours, some assumptions had to be made that simplify reality. For example, the decision model focuses on a single service process and allows for only one flexibility project per period. It is worthwhile to relax this assumption as, in industry, service processes are part of networks of multiple interconnected processes. One possibility of relaxing this assumption consists in adopting a single-project-per-period-and-process policy. If, across all service processes under investigation, more than one project can be implemented per period, it is necessary to account for intratemporal interactions (e.g., budget restrictions, mandatory projects, and input-output interactions). Moreover, the effects of flexibility projects are treated as static throughout the planning horizon, an assumption that could be relaxed in future research as well. The decision model would also benefit from real-world case studies to gain experience with estimating the needed parameters and to infer general insights into the behaviour of the decision model. Conducting case studies would also benefit from a software tool that extends the current prototype. Such a software tool should be able to handle more complex cases than illustrated in this paper and implement more sophisticated analysis capabilities (e.g., scenario analyses regarding different parameters).

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