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Flexibilization of Service Processes: Toward an Economic Optimization Model

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FLEXIBILIZATION OF SERVICE PROCESSES: TOWARD AN ECONOMIC OPTIMIZATION MODEL

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Abstract

Although the importance of flexibility has long been recognized in the service industry, scholars and practitioners alike still struggle to express the value of flexible services in economic terms. We perceive that many service providers tend to strive for very flexible service processes no matter in which ecosystem they are embedded. They invest huge amounts of money in flexibilization projects without being able to justify their decisions in line with economic criteria. Scholars, in contrast, advise against investing as much as possible in flexibilization. Concrete recommendations, however, are missing. Especially insights into the positive economic effects of flexible service processes require more attention. Against this backdrop, we propose an economic optimization model as a first step to capture the general relationships that govern the flexibilization of service processes. The optimization model enables service providers to estimate appropriate levels of volume and functional flexibility and to select flexibilization projects accordingly. We also provide first insights into the applicability of the optimization model via a demonstration example.

Keywords: service management, services, flexibility, business process management, optimization model

1 Introduction

In all industrial nations, services are the biggest and most strongly growing business sector. In Germany, for instance, 74% of all workers were employed in the service sector and the service sector accounted for 71% of the gross domestic product in 2010 (OECD 2012). As today's business environment is characterized by increasing requests for individualized services and high demand uncertainty, flexibility becomes ever more important (Gong and Janssen 2010; Goyal and Netessine 2011). However, more flexibility is not necessarily better (He et al. 2011). Rather, flexibility has no value per se! Numerous service providers (SPs) nevertheless tend to strive for very flexible processes and invest huge amounts of money seemingly independent of their ecosystem. Justifying such investments in line with economic criteria is challenging for practitioners and scholars alike. Thus, an economic analysis of investments in the flexibilization of service processes is worthwhile.

Although business process flexibility in general is of high interest for scholars of various disciplines, there is only little research on its economic valuation. Only lately attention has been paid to quantitative approaches to valuating business process flexibility. The first approaches proposed by Gebauer and Schober (2006) and Schober and Gebauer (2008) use decision tree analysis and real options theory to determine how much to spend on the flexibility of information systems while considering the uncertainty, variability, and time-criticality of the business processes involved. They treat flexibility as cost reductions, but do not consider positive effects, e.g., increased volume of sales. Braunwarth et al. (2010) investigate a particular form of flexibility, i.e., the ability to set the degree of automation dynamically at run time based on the current workload. Braunwarth and Ullrich (2010) present another real options based model to valuate flexibility. In their paper, they focus on the integration of external SPs to deal with excess demand. They deal with service processes without direct customer contact, a property that holds true for a small fraction of service processes only. To sum up: Despite the importance of flexible business processes in general and service processes in particular, scholars and practitioners still struggle when valuating flexibility in an economic manner. What is missing is a valuation and decision framework that helps deal with different flexibilization projects (FPs) considering both positive and negative economic effects of flexible service processes. Therefore, we deal with the following research question: *How much should a SP invest in the flexibilization of its services process?*

As a first step to answer this question, we propose an economic optimization model to capture the general relationships that govern the flexibilization of service processes. Based on a cash flow analysis, the model enables SPs to estimate appropriate levels of flexibility and to select FPs accordingly. Thereby, we deliberately argue from a high level of abstraction and emphasize positive economic effects. We also focus on two distinct kinds of flexibility, namely volume flexibility and functional flexibility.

The remainder of this paper is structured as follows: In section 2, we sketch the theoretical background regarding the services domain and business process flexibility. Section 3 presents the economic optimization model. In section 4, we provide first insights into the applicability of the optimization model via a demonstration example. We conclude in section 5 with a brief summary, limitations, and an outlook.

2 Theoretical Background

2.1 Services, Service Processes, and the Impact of Time

Services are typically defined via constitutive criteria. The most fundamental criteria include immateriality, inseparability of production and consumption, and the integration of customers into the value creation process (Johnston et al. 2012). Thus, services are typically referred to as an intangible personal experience that cannot be stored or transferred (Fitzsimmons and Fitzsimmons 2010). As services cannot be physically stored, the customers' time has to serve as a buffer to cope with deviations of supply and demand. That is why time plays a crucial role in service delivery.

From a process perspective, value creation with services splits into three phases (Alter 2010): First, SPs create awareness for their services and customers become aware of their need. Second, both parties negotiate their commitments. Third, SPs and customers co-create the service. In this paper, we focus on the third phase and take on an SP's perspective. For an economic analysis of flexibility, we furthermore use a classification schema that classes service process instances into runners, repeaters, and strangers (Johnston et al. 2012). Runners denote standard activities found in high volume operations. Repeaters are also standard activities, but more complex and less frequent. Strangers are non-standard activities caused by (unplanned) extraordinary requests that are usually associated with a unique project or activity. While runners and repeaters can be performed immediately, strangers require additional set-up and preparation.

Services are typically reckoned time-sensitive. From a single customer's perspective, a service only generates value if it is delivered within a certain period of time. From an SP's perspective, the value of a service decreases with the time it takes to deliver the service. This is because customers usually have different preferences regarding time. In a competitive market, excessive waiting – or even the expectation of long waiting – may lead to lost sales (Fitzsimmons and Fitzsimmons 2010). That is, customers either leave before they are served or reconsider their need. From a customer perspective, only one period of time needs to be considered, which we call total service time. This period starts when the customer requests a service and ends when the service is delivered. From an SP perspective, however, total service time splits into three distinct parts, namely waiting time, set-up time, and processing time. Customers have to wait if demand exceeds capacity (Gross et al. 2008). Analogous to queuing theory, the SP has not yet started to handle the customer's request in this period of time. The set-up time is relevant for strangers only. It refers to the period where the SP has not yet started to execute the request, but is already preparing employees, devices, machines, processes, or systems (Cheng and Podolsky 1996). Finally, processing time relates to the period where the service is produced in collaboration with the customer (Curry and Feldman 2011). We get back to this classification schema when we present the economic model. We admit that the amount of customers willing to pay for a service may also depend on other criteria, e.g., the quality of the service or past experiences. Those criteria are mainly discussed in the marketing literature (e.g., Kumar et al. 2010; Montoya et al. 2010) and treated as constant here.

2.2 Flexibility of business processes

In order to determine its value, flexibility needs to be understood in more detail. In literature, flexibility is considered as an academically immature concept (Chanopas et al. 2006; Saleh 2009). Sethi and Sethi (1990), for example, compiled more than 50 definitions of different kinds of flexibility from the manufacturing context. Typically, flexibility refers to distinct objects (e.g., business processes, infrastructure, or information systems) or types (e.g. strategic, operational). In this paper, we define flexibility as "the capability of a system to react to or to anticipate system or environmental changes by adapting its structure and/or its behavior considering given objectives" (Wagner et al. 2011, p. 811).

We analyze the operational flexibility of service processes and focus on two particular kinds, namely volume flexibility and functional flexibility. Volume flexibility enables to cope with uncertain demand, particularly excess demand. Functional flexibility helps deal with increasing service variety that is rooted in the demand for individualized treatment and becomes manifest in (unplanned) extraordinary requests, i.e., strangers. Note that functional flexibility does not improve the ability to handle a specific stranger. Rather, it yields better capabilities for coping with strangers in general. Volume and functional flexibility are also known from labor and service management research where they are referred to as numerical flexibility and new product flexibility respectively (Johnston et al. 2012; OECD 1998). As many other types of flexibility can be transformed into volume and functional flexibility, our focus is not too restrictive. Other ways of classifying flexibility can be found in Snowdon et al. (2007), Soffer (2005), or Kumar and Narasipuram (2006).

To become more flexible, SPs have to implement FPs. Projects that increase volume flexibility include adjustments of work force size for example by using part time employees or flexible employment contracts (Cappelli and Neumark 2004; Van Jaarsveld et al. 2009). Standardization, short-time outsourcing, capacity sharing, and increased customer participation are considered reasonable, too (Fitzsimmons and Fitzsimmons 2010). Braunwarth et al. (2010) propose an algorithm that allows for adjusting the degree of automation dynamically at runtime. Projects that foster functional flexibility include multi-skilling, wide-skilling, extensive training, and re-training (OECD 1998). Moreover, using information systems and advanced approaches to business process design, e.g., configurable reference process models, have to be considered as well (Iravani et al. 2005).

3 Optimization model

3.1 General Setting

We consider a single service process. To cope with uncertain demand and strangers, appropriate levels of volume flexibility $f_{\text{vol}} \in [0; 1]$ and functional flexibility $f_{\text{fun}} \in [0; 1]$ have to be determined. As flexibility results from FPs, f_{vol} and f_{fun} can also be interpreted as the share of pre-selected and pre-ordered volume and functional FPs that must be implemented to attain the desired levels of flexibility. In the status quo, no FPs are implemented. We assume:

(A1) There is a pre-defined and pre-ordered set of volume and functional FPs, each. All pre-selected FPs fit the service process at hand. Moreover, FPs are infinitely divisible.

In line with value-based business process management, we use an objective function based on cash flows to determine the optimal levels of volume and functional flexibility (Buhl et al. 2011). To keep the complexity of the model manageable and to preserve analytic solvability, we analyze a single period of time only. Nevertheless, the general relationships that govern the flexibilization of service processes are still captured. The cash flow splits into cash inflows $I \in \mathbb{R}_0^+$ and cash outflows $O \in \mathbb{R}_0^+$. Both depend on volume and functional flexibility. Thus, we get the following objective function that should be maximized:

$$\text{MAX: } CF(f_{\text{vol}}, f_{\text{fun}}) = I(f_{\text{vol}}, f_{\text{fun}}) - O(f_{\text{vol}}, f_{\text{fun}}) \tag{1}$$

Below, we first analyze the cash inflows and outflows – with an emphasis on inflows as positive economic effects of service flexibilization, then concretize the objective function, and solve the optimization model.

3.2 Analysis of cash inflows

The basic idea for analyzing the cash inflows is as follows: (1) more flexibility shortens the total service time (i.e., the time between service request and delivery), (2) a shorter total service time increases the number of realized consumer requests, and (3) realized consumer requests directly translate into cash inflows. We analyze the cash inflows along this sequence in reversed order: We first present the cash inflow components we consider and how total service time impacts the amount of realized consumer requests. Second, we analyze how flexibility influences total service time.

3.2.1 The impact of total service time

The cash inflows of the service process result from realizing consumer requests. From a conceptual perspective, consumer requests split into three groups that sum up to the service's market potential (Figure 1a). The bottom-most group represents requests from consumers who are interested in the service and happy with the current total service time. The group in the middle includes requests whose realization depends on how much the total service time can be shortened by means of flexibilization. Such requests relate to consumers who are interested in the service, but unhappy with the current total service time. The top-most group encloses consumer requests that are never realized, i.e., even if the total service time became zero. Such requests stem from consumers who are not interested in the service because they are locked-in with competitors or desire service variants that the SP is not able or willing to offer. In the real world, the size and existence of these groups depends on the service process under investigation. Henceforth, we consider the two bottom-most groups and refer to them as the highest amount of consumer requests the SP can realize, $x_{\max} \in \mathbb{R}^+$.

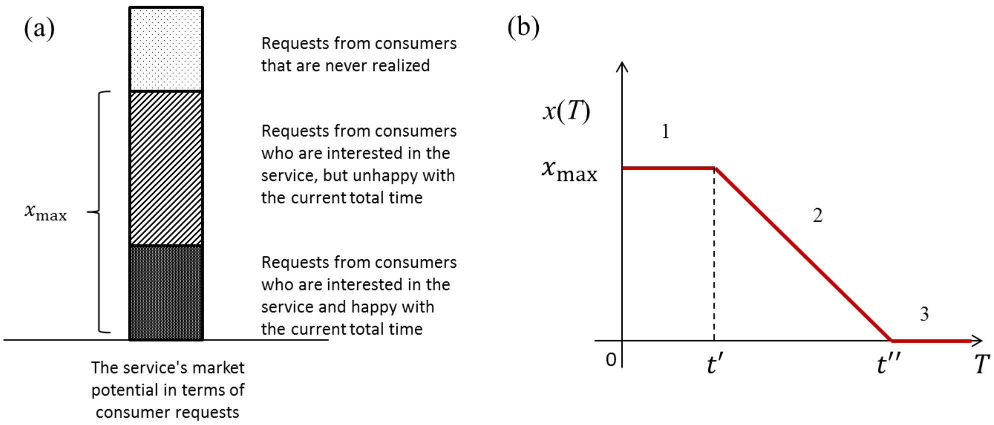

Figure 1: (a) Grouping of consumer requests
(b) Amount of realized consumer requests depending on the total service time

The amount of realized consumer requests depends on the total service time $T \in \mathbb{R}^+$, a relationship that we capture by means of the function $x(T) \in [0; x_{\max}]$. In line with the argumentation from above, the function $x(T)$ is piece-wise defined and monotonically decreasing (Figure 2b). The corresponding cash inflows are calculated by multiplying $x(T)$ with the profit contribution per request $p \in \mathbb{R}^+$. In part 1 of $x(T)$, the total service time falls short of a critical value (t') where all interested consumers are happy with the total service time. Therefore, the highest amount of consumer requests is realized and no additional requests can be realized. Reducing the total service time does not increase the cash inflows in this part. In part 3, the total service time exceeds a critical value (t'') where no consumers are willing to pay for the service anymore. Reducing the total service time by means of flexibilization is only reasonable if the total time can attain a value smaller than t''. In part 2, the total service time takes a value between t' and t''. Thus, a fraction of the highest amount of consumer requests is realized. This fraction decreases when the total service time increases. We assume:

(A2) The highest amount of consumer requests and the profit contribution are fixed and known. The amount of realized consumer requests only depends on the total service time. All consumer requests are treated as homogenous regarding their profit contribution. The consumers' preferences regarding total service time are uniformly distributed between t' and t''.

Based on this assumption, we can model $x(T)$ as follows:

$$x(T) = \begin{cases} x_{\max} & \text{for } 0 \leq T \leq t' \quad \text{(part 1)} \\ \frac{x_{\max}}{t'-t''} \cdot (T - t'') & \text{for } t' < T < t'' \quad \text{(part 2)} \\ 0 & \text{for } t'' \leq T \quad \text{(part 3)} \end{cases} \tag{2}$$

3.2.2 The impact of flexibility

The total service time of a service process depends on how flexible the process is. Therefore, we examine which kind of flexibility drives which component of the total service time. The waiting time $T_{\text{wait}} \in \mathbb{R}^+$ does not only depend on the current workload, but also on how easily the SP is able to cope with demand fluctuations, particularly with the excess of expected demand. For this reason, waiting time is driven by volume flexibility. The set-up time $T_{\text{set-up}} \in \mathbb{R}^+$ indicates how easily the SP deals with strangers. It is thus influenced by functional flexibility. Moreover, set-up time is not influenced by volume flexibility and waiting time is not driven by functional flexibility. As neither volume nor functional flexibility influence the service itself, the processing time $T_{\text{proc}} \in \mathbb{R}^+$ is independent of any kind of flexibility we consider.

Below, we outline how volume and functional flexibility drive waiting time and set-up time. All time values we consider have to be interpreted as average values. In line with the argumentation so far, more functional flexibility implies less set-up time. That is, functional flexibility leads to monotonically increasing time savings $TS_{\text{set-up}}(f_{\text{fun}})$ compared to the actual set-up time $T_{\text{set-up,act}} \in \mathbb{R}^+$. In line with the theory of diminishing marginal utility, we treat the time savings as under-proportional (Mukherjee 2007). This is because implementing an additional FP has a higher relative impact on the set-up time if a small fraction of the pre-defined FPs has already been implemented compared to the case where almost all pre-defined FPs have been implemented. As we consider a SP that is currently not able to handle strangers within an appropriate set-up time, the high relative impact can be observed when the first FP is implemented. We use a power function that is strictly monotonically increasing and strictly concave to model the properties of the time savings related to set-up time.

$$T_{\text{set-up}}(f_{\text{fun}}) = T_{\text{set-up,act}} - {f_{\text{fun}}}^{\alpha} \cdot TS_{\text{set-up,max}} \text{ (with } TS_{\text{set-up,max}} \leq T_{\text{set-up,act}}) \qquad (3)$$

The parameter $\alpha \in (0; 1)$ is responsible for the strictly concave course of the time savings. Its value has to be determined outside the optimization model. A key influencing factor of α is the variability of strangers. Therefore, α takes a value close to 0 if the service process faces a small number of distinct strangers with diverse frequencies. It takes a value close to 1 if many different strangers need to be performed with about the same frequency. Gebauer and Schober (2006) rely on the same parameter for modeling the overall process variability. They operationalize it by means of the Lorenz curve concept.

Analogous to functional flexibility, volume flexibility shortens the waiting time of the service process, i.e., it leads to time savings $TS_{\text{wait}}(f_{\text{vol}})$ compared to the actual waiting time $T_{\text{wait,act}} \in \mathbb{R}^+$. These time savings have the same properties as the time savings that result from functional flexibility. Thus, we model the time savings resulting from volume flexibility analogous to formula (3).

$$T_{\text{wait}}(f_{\text{vol}}) = T_{\text{vol,wait}} - {f_{\text{vol}}}^{\beta} \cdot TS_{\text{wait,max}} \text{ (with } TS_{\text{wait,max}} \leq T_{\text{wait,act}}) \qquad (4)$$

A key influencing factor of $\beta \in (0; 1)$ is the frequency of unexpected demand peaks of a service process. The parameter is considered to take small values if the SP needs to handle only a few unexpected demand peaks, while it is considered to be high when many unexpected demand peaks occur. Summing up, the total service time can be determined by adding up processing time, set-up time, and waiting time. It needs to be considered that the set-up time is zero for runners and repeaters. Therefore, we split the amount of consumer requests into a share of runners and repeaters and a share of strangers.

(A3) All values needed for calculating the time savings are fixed and known. The same holds true for the share of the service process instances that are runners and repeaters $\delta \in [0,1]$.

As SPs typically face much more runners and repeaters than strangers, the parameter δ most likely takes values close to 1. Considering (A3), we calculate the total service time as follows:

$$T(f_{\text{vol}}, f_{\text{fun}}) = T_{\text{proc}} + (1-\delta) \cdot \left[T_{\text{set-up}}(f_{\text{fun}}) + T_{\text{wait}}(f_{\text{vol}})\right] + \delta \cdot T_{\text{wait}}(f_{\text{vol}}) \qquad (5)$$

3.3 Analysis of cash outflows

Investments in service process flexibilization also imply cash outflows. Cash outflows result from (a) the implementation of FPs, (b) administration, communication, and project management activities during the implementation of FPs, (c) support and maintenance activities throughout service execution, and (d) handling consumer request. Only the categories (a) to (c) depend on volume and functional flexibility. Category (d) depends on the amount of realized consumer requests and is already included in the profit contribution we defined above. The higher the levels of volume and functional flexibility, the more cash outflows occur. Moreover, the cash outflows for administration, communication, and project management activities during the implementation of FPs as well as the cash outflows for support and maintenance activities throughout service execution typically increase in an over-proportional manner (Verhoef 2002). We account for these characteristics using a strictly monotonically increasing and strictly convex function, which is quite similar to the functions we used for modeling the time savings.

$$O(f_{\text{vol}}, f_{\text{fun}}) = {f_{\text{vol}}}^{\varepsilon 1} \cdot c_{\text{vol,max}} + {f_{\text{fun}}}^{\varepsilon 2} \cdot c_{\text{fun,max}} \tag{6}$$

In this function, the cash outflow effects of volume and functional flexibility are modeled separately. Implementing all volume and functional FPs leads to the maximum cash outflows $c_{\text{vol,max}}$ and $c_{\text{fun,max}}$ respectively. Although a much more detailed analysis would have been possible, we look at cash outflows from a high level of abstraction because we put a special emphasis on the cash inflows as positive economic effects of service flexibilization. The parameters $\varepsilon 1 \in (1; \infty)$ and $\varepsilon 2 \in (1; \infty)$ are responsible for the cash outflow's strictly convex shape. Their values have to be determined outside the optimization model for example by relying on approaches to effort estimation. High values for $\varepsilon 1$ and $\varepsilon 2$ indicate that the service process has to deal with high project implementation and operational complexity respectively. Low values indicate the opposite. We assume:

(A4) All values needed for calculating the cash outflows are fixed and known.

3.4 Concretization of the objective function and determination of the optima

Based on the intermediate results, the objective function of the optimization model can be expressed more precisely. In line with value-based BPM, the SP strives to maximize the cash flow of the service process under investigation by increasing volume and functional flexibility. This leads to the following objective function:

$$CF(f_{\text{vol}}, f_{\text{fun}}) = \begin{cases} p \cdot x_{\max} - \left({f_{\text{vol}}}^{\varepsilon 1} \cdot c_{\text{vol,max}} + {f_{\text{fun}}}^{\varepsilon 2} \cdot c_{\text{fun,max}}\right) & \text{for } 0 \leq T(f_{\text{vol}}, f_{\text{fun}}) \leq t' \text{ (part 1)} \\ p \cdot \left[\frac{x_{\max}}{t' - t''} \cdot \left(T_{\text{proc}} + (1-\delta) \cdot \left[T_{\text{set-up}}(f_{\text{fun}}) + T_{\text{wait}}(f_{\text{vol}})\right] + \delta \cdot T_{\text{wait}}(f_{\text{vol}}) - t''\right)\right] - \left({f_{\text{vol}}}^{\varepsilon 1} \cdot c_{\text{vol,max}} + {f_{\text{fun}}}^{\varepsilon 2} \cdot c_{\text{fun,max}}\right) & \text{for } t' < T(f_{\text{vol}}, f_{\text{fun}}) < t'' \text{ (part 2)} \\ -\left({f_{\text{vol}}}^{\varepsilon 1} \cdot c_{\text{vol,max}} + {f_{\text{fun}}}^{\varepsilon 2} \cdot c_{\text{fun,max}}\right) & \text{for } t'' \leq T(f_{\text{vol}}, f_{\text{fun}}) \text{ (part 3)} \end{cases} \tag{7}$$

The objective function is piecewise-defined because it inherits the parts and junction points of the function $x(T)$ (see formula 2 and Figure 2b). We therefore label the parts of the objective function analogous to the parts of $x(T)$. Accordingly, part 1 includes all cases where the total service time takes values between zero and the critical value t' where all interested consumers are happy with the total service time, i.e., $0 \leq T(f_{\text{vol}}, f_{\text{fun}}) \leq t'$. All these cases yield the highest amount of consumer requests and thus the highest cash inflows possible. The corresponding cash outflows, however, depend on the levels of volume and functional flexibility. Part 3 encompasses all cases where the total service time takes values beyond the critical value t'' where no consumers are willing to pay for the service anymore, i.e., $t'' \leq T(f_{\text{vol}}, f_{\text{fun}})$. Hence, no consumer requests and cash inflows are realized. Just like in part 1, the cash outflows depend on the levels of volume and functional flexibility. Finally, part 2 encloses all cases where the total service time takes values between t' and t'', i.e., $t' < T(f_{\text{vol}}, f_{\text{fun}}) < t''$. Here, the cash inflows and the outflows depend on the levels of volume and functional flexibility.

The optimal levels of volume and functional flexibility can be determined by analyzing and optimizing the objective function step-by-step. We therefore revert to the three parts of the objective function as well as to two particular values of the total service time. These values are the total service time that is realized in case of no flexibilization, i.e., $T(0,0)$, and the total service time that is realized if the entire flexibilization potential is tapped, i.e., $T(1,1)$. We refer to these values as the maximum and minimum total service time respectively. Depending on the maximum and the minimum total service time, the objective function may include one, two, or all three parts outlined above. The reason is that the maximum and the minimum total service time may take values below t', beyond t'', or somewhere in between.

For each part of the objective function, a part-specific optimum can be determined. We refer to these optima as $CF_1^*(f_{\text{vol},1}^*, f_{\text{fun},1}^*)$ for part 1, $CF_2^*(f_{\text{vol},2}^*, f_{\text{fun},2}^*)$ for part 2, and $CF_3^*(f_{\text{vol},3}^*, f_{\text{fun},3}^*)$ for part 3. In part 3, more flexibility only increases the cash outflows. Thus, the objective function reaches its optimum if no flexibilization projects are implemented. That is, $f_{\text{vol},3}^* = 0$ and $f_{\text{fun},3}^* = 0$. Part 1 is similar to part 3. More flexibility only increases the cash outflows, while no cash inflows are realized. Therefore, the part-specific optimum results from those levels of volume and functional flexibility where the total service time equals t', i.e., $T\left(f_{\text{vol},1}^*, f_{\text{fun},1}^*\right) = t'$. Part 2 is a bit more complex. When the total service time falls short of the value where no consumers are willing to pay for the service (t''), cash inflows and cash outflows are increasing. Thus, the part-specific optimum depends on the parameters of the objective function. We therefore build the partial derivations of the objective function and use them to determine the optimal values of $f_{\text{vol},2}^*$ and $f_{\text{fun},2}^*$[1].

$$f_{\text{vol},2}^* = \left(\frac{(t''-t')\cdot c_{\text{vol,max}}\cdot \varepsilon 1}{p\cdot x_{\max}\cdot \beta \cdot TS_{\text{wait,max}}}\right)^{\frac{1}{\beta-\varepsilon 1}} \tag{8}$$

$$f_{\text{fun},2}^* = \left(\frac{(t''-t')\cdot c_{\text{fun,max}}\cdot \varepsilon 2}{p\cdot x_{\max}\cdot \alpha \cdot TS_{\text{prep,max}}\cdot (1-\delta)}\right)^{\frac{1}{\alpha-\varepsilon 2}} \tag{9}$$

As can be seen from formulae (8) and (9), the optimum of part 2 can be expressed analytically. With the objective function being strictly concave in part 2, the optimum is a maximum. Note that the optimum is only defined for combinations of $f_{\text{vol},2}^*$ and $f_{\text{fun},2}^*$ that yield a total service time between t' and t'', i.e., $\mathrm{t}' < T\left(f_{\text{vol},2}^*, f_{\text{fun},2}^*\right) < \mathrm{t}''$. It might happen that the formulae return values above or below these borders. In the first case, the optimum is located at junction point of part 1 and 2, i.e., where $T\left(f_{\text{vol},2}^*, f_{\text{fun},2}^*\right) = t'$. In the second case, the optimum is located at junction point of part 2 and 3, i.e., where $T\left(f_{\text{vol},2}^*, f_{\text{fun},2}^*\right) = t''$. The overall optimum results from comparing the part-specific optima as shown in formula (10).

$$CF(f_{\text{vol}}^*, f_{\text{fun}}^*) = \max\left[CF_1^*(f_{\text{vol},1}^*, f_{\text{fun},1}^*), CF_2^*(f_{\text{vol},2}^*, f_{\text{fun},2}^*), CF_3^*(f_{\text{vol},3}^*, f_{\text{fun},3}^*)\right] \tag{10}$$

Summing up, the overall optimum of the objective function can be determined as follows: First, one has to determine which parts of the objective function have to be considered. This is done by determining the maximum and minimum total time of the service process. Second, the relevant part-specific optima need to be compared and the highest value has to be chosen.

4 Demonstration example

Although the paper was intended to capture the general relationships of service process flexibilization and to derive economically well-founded recommendations on a high level of abstraction, we would also like to provide some guidance on how to apply the optimization model in reality. Thus, we present a demonstration example that illustrates the basic steps of application. As the parameters of the optimization model may be estimated differently and as estimation always leaves space for subjective influences, we suggest not to decide on service process flexibilization exclusively based on the recommendations of the optimiza-

[1] An appendix with a detailed mathematical derivation of formulae (8) and (9) can be requested from the authors.

tion model, but to triangulate its recommendations with other sources of information before. Indeed, the usefulness of the recommendations depends on how reliably the parameters can be estimated.

In line with the general setting introduced above, the example is about a SP that strives to make one of its processes more flexible by implementing volume and functional FPs. As a foundation, the SP has already selected and ordered functional and volume FPs that fit the service process under investigation (Table 1). The SP applies the optimization model to estimate the optimal levels of volume and functional flexibility in terms of cash flow and to determine the combination of FPs it should implement. Although the shares were modeled as continuous variables in the optimization model to allow for a general analysis, they take discrete values in reality. If one considers that volume and functional flexibility are independent, that the FPs related to each kind of flexibility build upon one another, and that the SP may also implement zero FPs, there are 25 feasible combinations of FPs.

Volume FP		Stand-alone impact on f_{vol}	$\boldsymbol{f}_{\textbf{vol}}$	Functional FP		Stand-alone impact on f_{fun}	$\boldsymbol{f}_{\textbf{fun}}$
1	Introduction of flexible employment contracts	+ 0.4	**0.4**	1	Introduction of a reference process model	+ 0.1	**0.1**
2	Introduction of a part time employee system	+ 0.1	**0.5**	2	Multi-skilling of employees	+ 0.3	**0.4**
3	Outsourcing of selected process activities	+ 0.2	**0.7**	3	Expert training of employees	+ 0.2	**0.6**
4	Dynamic optimization of the degree of automatization	+ 0.3	**1.0**	4	Extension of information system support (e.g., using a knowledge management system)	+ 0.4	**1.0**

Table 1: Pre-selected and pre-ordered lists of volume and functional flexibilization projects

Before determining the optimal combination of FPs, we analyze the SP's business environment and internal conditions. In our example, the SP has to cope with a huge amount of strangers. Only 40% of the requests are runners or repeaters, while 60% are strangers. The set-up time can be reduced by 30 minutes from 40 to 10 minutes, while the waiting time can be reduced by 80 minutes from 120 to 40 minutes. Correspondingly, implementing all volume FPs is more expensive than realizing all functional FPs. Finally, the consumers of the service process are quite tolerant regarding the total service time, which is why the SP deals with a fairly diverse consumer portfolio. The first consumers are not interested in the service anymore or leave for competitors when the total service time takes a value of more than 70 minutes. Only beyond a value of 130 minutes, no consumers are willing to pay for the service. Therefore, a small deviation of the total service time does not lead to a huge difference of realized consumer requests. Finally, it is estimated that 150 consumer requests can be realized.

In reality, it is sometimes difficult to determine reliable values for some parameters. The processing time as well as the current set-up and waiting time can be determined in a straightforward manner, e.g., by analyzing the event logs of workflow management systems. The same holds true for the share of runners, repeaters, and strangers. The profit contribution can be extracted from enterprise resource planning systems or calculated using modeling tools with a process valuation component. The highest amount of consumer requests that can be realized can be estimated by the marketing department. The cash outflows that result from implementing all volume and functional FPs can be approximated by means of approaches from the effort estimation domain. Determining the maximum savings regarding set-up and waiting time, in contrast, relies much more on the experience of subject matter experts and BPM professionals. The parameters the most difficult to estimate are those that determine the shape of the time savings functions. For some of these parameters, operationalizations were proposed in the literature, e.g., the variability of strangers can be estimated using the Lorenz curve concept. We provided some further hints in the prior section. Summing up, we chose the following parameter values for our example:

- Cash inflows (see section 3.2): $t' = 70$ min, $t'' = 130$ min, $p = \$300$, $x_{\max} = 150$, $T_{\text{proc}} = 10$ min, $T_{\text{set-up,act}} = 40$ min, $T_{\text{wait,act}} = 120$ min, $TS_{\text{set-up,max}} = 30$ min, $TS_{\text{wait,max}} = 80$ min, $\delta = 0.4$, $\alpha = 0.5$, $\beta = 0.5$.
- Cash outflows (see section 3.3): $c_{\text{vol,max}} = \$30{,}000$, $c_{\text{fun,max}} = \$20{,}000$, $\varepsilon_1 = 1.4$, $\varepsilon_2 = 1.4$

To determine the optimum shares of volume and functional flexibility, we first analyze which parts of the objective function are included. We therefore determine the total service time when no volume and functional FPs are realized and the total service time when all volume and functional FPs are realized. The result is a maximum total service time of 154 minutes and a minimum total service time of 56 minutes. As the minimum total service time is smaller than t' and the maximum total service time is higher than t'', we have to consider all three parts of the objective function.

According to formula (10), the overall optimum results from comparing the part-specific optima. As already mentioned above, the optimum of part 3 results from not investing into flexibilization at all. Hence, the part-specific optima are $f^*_{\text{vol},3} = 0$ and $f^*_{\text{fun},3} = 0$, which yields an optimum cash flow of $CF^*_3 = 0$. In part 2, the optimum can be determined by means of formula (8) and (9). This leads to $f^*_{\text{vol},2} = 0.69$ and $f^*_{\text{fun},2} = 0.21$ with an optimal cash flow of $CF^*_2 = 17{,}931$. In part 1, reducing the total service time does not increase the cash inflows anymore while cash outflows are still increasing. Therefore, the optimum of part 1 results when the total service time equals the critical value (t') where all interested consumers are happy with the total service time. This leads to $f^*_{\text{vol},1} = 0.87$ and $f^*_{\text{fun},1} = 0.26$ with an optimal cash flow of $CF^*_1 = \$17{,}092$. Since the optimal cash flow of part 2 exceeds the optimal cash flow of part 1 and part 3, the overall optimum equals the part-specific optimum of part 2. However, the exact values are not covered by the discrete values shown in Tab. 2. We therefore investigate each peripheral solution. The peripheral solutions regarding volume flexibility include the FPs 1-3 or the FPs 1-4. The peripheral solutions regarding functional flexibility include FP 1 or the FPs 1-2. Considering the results, we recommend implementing functional FP 1 together with volume FPs 1, 2 and 3. This leads to cash inflows of \$36,469 and cash outflows of \$19,004. Hence, the overall optimal cashflow is $\$17{,}465$.

Despite its brevity and limitations, the example demonstrated the basic steps that have to be conducted when applying the optimization model in the real world. We hope that it also advanced the understanding of the general relationships governing service process flexibilization.

5 Conclusion and Outlook

In this paper, we addressed the question of how much service providers should invest in the flexibilization of their service processes. We therefore presented an economic optimization model and corresponding analytic solutions that capture the general relationships of service process flexibilization with respect to volume and functional flexibility. The optimization model also enables to estimate which sub-set of pre-selected and pre-ordered flexibilization projects a service provider should implement. Paying particular attention to cash inflows and the constitutive criteria of services, we considered that flexibility as the key driver of the total time that consumers have to wait for service delivery, which in turn has an impact on whether consumers are willing to pay for the service.

We identified that, in general, it is not reasonable to invest as much in service flexibilization as possible. Rather, it can under certain conditions even be advisable not to invest in flexibilization at all. The optimal levels of flexibilization – and thus the set of flexibilization projects to be implemented – depend on parameters that relate to the service provider's business environment and internal condition. These parameters include among other things the market potential of the service process, the time-sensitivity of the service provider's customer portfolio, the distribution of ordinary requests (i.e., runners and repeaters) and extraordinary requests (i.e., strangers) as well as the overall amount of extraordinary requests. It moreover needs to be considered how probable excess demand is and how well the company deals with the complexity of large flexibilization projects. These relationships do not depend on concrete parameter values.

As we investigated the problem of service process flexibilization from a high level of abstraction, the optimization model itself as well as its applicability are beset with limitations that should be subject to further research.

1. Currently, the appropriate levels of volume and functional flexibility are determined on the assumption of certainty. Since cash flows usually are stochastic in reality, the optimization model should be expanded by risk components to cope with uncertainties and dependency structures.
2. So far, the optimization model only considers a single period of investigation. While this enables capturing the relevant relationships of service process flexibilization, long-term effects are not integrated. In line with the previous limitation, the optimization model should be extended to a multi-period analysis, e.g., by relying on stochastic cash flow present values. This would also allow for analyzing the effects of investment outflows and recurring cash outflows separately.
3. We currently focus on a single service process as unit of analysis. Dependencies among multiple service processes are neglected. However, in order to maximize the cash flow of the SP, all service processes and their dependencies would need to be considered.
4. Finally, volume flexibility and functional flexibility are treated as independent as the corresponding flexibilization projects split into disjoint lists. It might be an interesting and promising avenue for future research to explore potential interaction effects between both kinds of flexibility in more detail.

Nevertheless, it needs to be deliberated for each extension whether the additional insights outweigh the additional complexity as well as the potential loss of analytic solvability and clarity. Despite its weaknesses, the optimization model advances the current knowledge regarding the economics of service process flexibilization by means of the uncovered general relationships and dependencies on internal and external parameters. We hope that this piece of research provides fellow researchers with a sensible foundation for continuing research in the domain of service process flexibilization.

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