Determining the Business Value of Volume Flexibility for Service Providers - A Real Options Approach

by

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Abstract

Service Providers often struggle with fluctuating demand of service requests which can lead to prolonged waiting times and hence to dissatisfaction of customers. Therefore, service providers strive for volume flexibility to cope with this challenge. In manufacturing context, a shift of excess demand to an external partner is already common practice while service providers reacted reluctantly to this possibilities in fear of high integration costs. The uprising of new technologies such as Service Oriented Architectures (SOA) lowered these cost and allowed the separation of up to now entangled software functionalities into services and the use of standardized interfaces. Nevertheless, investment decisions related to SOA oftentimes lack a well-founded valuation of the respective benefits. Therefore, we present an analytical model based on the Real Options Approach (ROA) that determines the business value of flexibility resulting from an IS-based integration of an external service vendor. Thereby we consider the trade-off between the investments into the technical requirements (e.g. SOA) that are necessary to gain volume flexibility on the one hand and the negative effects of unsatisfied customers on the customer equity on the other hand. We also provide first insights into the applicability of the model via a demonstration example.

Keywords: Business Value of IS, Flexibility, Real Options Approach, Valuation of IT benefits.

1 Introduction

The main objective of service providers is to conduct services for their customers in order to raise the customer equity and thus their own business value (Kumar and George 2007). There are many attempts to define the term "services" (e.g. Rai and Sambamurthy 2006, Fitzsimmons and Fitzsimmons 2010), but according to Johnston et al. (2012) their three essential characteristics are immateriality, inseparability of production and consumption, and the integration of the customer into the value creation process. As a consequence, services cannot be stored (Fitzsimmons and Fitzsimmons 2010), which makes the business of the service provider strongly sensitive with respect to time. In what way this time sensitiveness affects the service providers' business value and how a service provider can deal with it is addressed in this paper.

Services are oftentimes initiated by customers ("service requests") and afterwards processed by the service provider, which takes time and requires capacity, before the service is finally returned to the customer. Service providers thereby face the challenge of uncertain demand since they don't know when customers initiate how many service requests. At the same time, service providers oftentimes possess fixed internal capacities to process the service requests in the short term. Thus the combination of a limited capacity and uncertain demand can result in prolonged waiting times for customers. Customers are sensitive with respect to the total service time (e.g. Ray and Jewkes 2004), i.e. the time from a service request until the delivery of the service. If the total service time exceeds a certain time limit, customers may become dissatisfied and are more likely to switch their service provider. Since treating customers as assets is one key success factor for companies (e.g. Kumar et al. 2004), the impact of the total service time on the customer satisfaction – and thus on the long-term success of their business – is essential for service providers (Nguyen and Mutum 2012).

In general, service providers possess two ways to deal with the uncertain demand: First, a service provider can directly influence the demand of customers. This can be accomplished by means of revenue management, like e.g. dynamic pricing (Phillips 2005), bounding the number of service requests, or by marketing procedures. Second, a service provider can set up its supply side so that it is able to flexibly react on volatile demand. Since volatile demand can lead to either capacity shortages or idle times, a service provider might use methods of capacity management to cope with this challenge. Those methods include e.g. cross-training of employees, sharing of (companies' internal) capacities, using part-time employees, increasing customer participation, and work shift scheduling (Fitzsimmons and Fitzsimmons 2010).

To cope with the aforementioned challenges, this paper deals with providing flexibility on the supply side through the use of enabling information systems (IS). As we mentioned above, service providers' (internal) capacities are often fixed, so that we need to add temporary additional, external capacity to cover the demand fluctuations. As source for this additional capacity, we consider the temporary integration of an external service vendor[1], who offers volume-based contracting of capacity (Aksin et al. 2008). A respective integration of external vendors by means of IS used to be accompanied with huge technical efforts resulting in high cash outflows. However, the rising application and market penetration of Service Oriented Architectures (SOA) reduced the efforts enormously (Kohlmann and Alt 2010). As of today, standardized interfaces simplify the technical integration of external vendors. Consequently, a facilitated third party integration is considered to be one of the main advantages of SOA (Becker et al. 2011).

Scientific literature reveals that technical challenges related to SOA were rather discussed than its business value (Beimborn et al. 2008). Although there are a few articles that consider the business value of SOA by identifying and providing indicators for benefits of SOA, a formal model that supports the determination of the business value of SOA is still missing (Beimborn et al. 2008, Kryvniska et al. 2011). We address this research gap by valuating a specific kind of benefit which can be achieved by investments in SOA. To be more specific, we evaluate the business value of flexibility resulting from the integration of an external service vendor. Therefore, we answer the following research question:

"What is the business value of flexibility resulting from an IS-based integration of an external vendor?"

By answering this research question, we explicitly focus on the trade-off between the investments into the technical requirements (e.g. SOA) that are necessary to gain volume flexibility and the negative effects of unsatisfied customers on the customer equity. From a research perspective, our model extends knowledge on how to valuate IS-investments such as SOA by considering the daily business of companies as well as indirect effects such as negative effects on customer equity. Practitioners in departments such as strategic workforce are enabled to valuate the inclusion of external service vendors

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[1] For simplicity reasons, we speak in the following of an "external vendor".

while IT departments can justify IS-investments by using our model. Finally, strategic decisions in top management such as flexibility improvements can be valuated in a better way by applying our model.

The remainder of the paper is organized as follows. We first describe shortly the role of SOA in the embedding of external vendors in subsection 2.1. Since there is a lot of research about flexibility and its definitions, we derive a definition that fits our problem in subsection 2.2. Section 2 concludes with a discussion of relevant literature on how to determine the business value of the integration of external vendors. Based on these findings, we develop an analytical model using the real options approach (ROA) to determine the business value of flexibility resulting from an IS-based integration of an external vendor in section 3. In section 4 we demonstrate the applicability of our model by providing a real world case of a large German insurance company. Finally, section 5 concludes the paper and discusses its limitations.

2 Theoretical Background

2.1 The Role of IS for the Integration of External vendors

While the integration of partners into the value chain is common practice in the manufacturing context, service providers lacked this kind of cooperation in the past decades. One major reason was the expectation of very high costs of integration. Recent developments of new technologies such as unified interfaces, Web Services, and SOA lowered these costs (Häckel and Dorsch 2012; 2013). Although there are other means (such as cloud computing or cross-company workflow management systems) that allow for cooperation among companies, we focus on SOA as our main example for an IS-based integration of a service vendor since it can be seen as a powerful underlying and enabling concept e.g. for cloud computing (Vouk 2008). SOA allows the isolation of up to now inseparable software functionalities into services. These services are well defined, self-contained modules that provide standard business functionality. Thereby, the services are independent from other services and their state or context. They are loosely coupled which means they communicate with each other requesting execution of their operations and can therefore be arranged in varying order or different contexts (Fremantle et al. 2002). Services furthermore have published interfaces, which are inviolable by other services. This implies that the services invocation is independent from the underlying infrastructure, the used protocol, and from being local or remote (Papazoglou et al. 2007). These characteristics enabled the uprising of new business models in the service industry which aim at outsourcing business processes to external vendors or embedding service vendors into the own value chain. SOA is therefore considered as an enabler for the allocation of business activities among business partners (Chesbrough and Spohrer 2006). This also requires an alignment of the technological and the business perspective (Steen et al. 2005) and the deduction of technological requirements from the business (Kohlmann and Alt 2010). Therefore, key challenges beyond the use of standardized interfaces include a common policy management, governance, and authentication, which need to be considered while still being able to maintain lightweight implementation and deployment of web services (Arrott et al. 2007). To meet these requirements, investment decisions have to be evaluated from both a technical and an economic perspective. However, if those investments are made, they enable service providers to flexibly react to core challenges such as fluctuating demand. The next subsection therefore presents a general overview of the characteristics of flexibility and discusses a specific type of flexibility, namely volume flexibility, in greater detail.

2.2 Relevant Types of Flexibility for Service Providers

Although a large amount of research focused on flexibility throughout the last decades, flexibility is still an uncompleted topic in research (Saleh et al. 2009, Neuhuber et al. 2013). Due to the complexity and context dependency flexibility is not easy to define, to categorize, and to measure. Sethi and Sethi (1990) identified about 50 different definitions for (manufacturing) flexibility, but the concept of flexibility is of course not limited to the manufacturing context. In the following, we go in line with Neuhuber et al.

(2013) and generally consider 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). Scientific literature basically agrees on a basic set of types of flexibility, i.e. new product, volume, product, and delivery flexibility.

As we mentioned in the introduction, we need a type of flexibility that is capable to cope with volatile demand on the capacity management side. This is necessary since customers are only willing to wait to receive their services for a certain period of time before they get dissatisfied, which forces service providers to be able to process more service requests in peak times. Due to that we consider volume flexibility in this paper, which is defined as "ability to change the level of aggregated output" (Oke et al. 2005, p. 975). Note that this definition is not limited to the manufacturing context but includes services as well. Since we are further focusing on getting this additional capacity from an external vendor, we are able to specify our understanding of flexibility. First, we complement the very broad definition of volume flexibility by adapting ideas of routing flexibility (Oke et al. 2005, Sethi and Sethi 1990), which is the ability to produce the same service on different capacities or by alternate routes through the service process (Oke et al. 2005). We also aim at addressing the challenge of fluctuating demand by using alternate routes of service fulfilment, which are based on the (temporary) integration of an external vendor. Therefore, the idea of vendor flexibility also becomes relevant. Vendor flexibility is defined as "the specific types of flexibility relating to individual vendors that support … [service production and service delivering] operations" (Gosling et al. 2009, p. 2). Consequently, the specific type of volume flexibility considered in this paper is defined as:

The ability to create process outputs using both pre-installed, internal capacity as well as temporarily volume-based contracting, i.e. additional capacity offered by an external vendor.

This type of volume flexibility can be created by a temporary integration of an external vendor through standardized interfaces, e.g. through SOA. However, this course of action also creates associated cash outflows. Therefore, the question arises, how the benefits of gaining this type of volume flexibility compare to the respective cash outflows. In order to derive a sound investment decision about whether or not to invest, a monetary valuation of the benefits of the investment, i.e. the value derived from the created volume flexibility, has to be assured in order to compare them to the corresponding cash outflows. Therefore we discuss approaches that monetarily valuate the benefits of volume flexibility in the next subsection.

2.3   Determining the Business Value of Volume Flexibility

In the context of valuating volume flexibility one has to take care to distinguish between the economic valuation of an investment into its creation and the measurement of the degree of flexibility (Saleh et al. 2009). For a discussion of the latter one see e.g. Gupta and Goya (1989). In this paper we focus on the business value of the investment into the creation of volume flexibility under consideration of our particular focus on the customers' lifetime value. The value of integrating an external vendor to gain volume flexibility, i.e. to be able to handle uncertain demand, has been discussed in many different contexts and different approaches emerged within literature. Therefore, we will discuss some of the most influencing works for this manuscript in the following.

In our paper, we consider a random arriving process of service requests which is then processed by a number of agents who service the process. Papers in operations research literature, especially those in queuing theory also address this initial situation (for a comprehensive review of queuing theoretic approaches see for example Gans et al. (2002)). Following this idea, Whitt (2006) present a queuing model which is able to determine optimal internal staffing levels and overall performance of the queuing system and therefore lacks a consideration of external vendors for services. Moreover, although the model considers the possible abandonment of customers, it does not explicitly takes indirect negative affects initiated through unprocessed service requests of customers into account. Aksin et al. (2008) analyze a contract choice problem between volume- and capacity based contracts. They use a game theoretic approach instead of a queue theoretic approach, to be able to find optimal capacities and prices

between the two players, i.e. the service provider and the external vendor, with respect to both contracts. Addressing the shortcomings of Whitt (2006), they explicitly model the flexible embedment of a service vendor. Still, they neglect initial cash-outflows related to contracting issues and negative effects on customers. In contrast, Ren and Zhou (2008) deal with customer satisfaction in the context of service quality and outsourcing contracts. Nevertheless, they focus on contracting issues between the company and the services vendor and only consider a complete capacity shift or no capacity shift at all. Moreover, they abstract from initial cash outflows for realizing a contract.

Not explicitly grounded in the queuing theory but addressing a very similar problem, Häckel and Dorsch (2013) provide an optimization model allowing for the simultaneous consideration of different types of capacity supply. Thereby the flexible on-demand integration of external vendors is also considered. To apply their model, a discrete event simulation of a queuing system is necessary. A similar and thus also numerical approach to evaluate the embedding of an external vendor in times of demand peaks is found in Braunwarth and Ullrich (2010). Nevertheless, simulations of random processes deliver (pseudo-)random solutions, thus different repetitions of the simulations might lead to different solutions and thus to different insights and decisions. Moreover, companies need to put much effort in the conduction of simulations. The fact that simulations don't allow for easy sensitivity analyzes further limit their practical use. Therefore, an analytical approach – and thus a closed form solution – might be better to use in practice (Wang and De Neufville 2005).

Such an analytical approach is provided by Neuhuber et al. (2013). The authors develop a model that determines the business value of volume and functional flexibility and further provides an optimization model for the best mixture of both. However, although the authors focus on time sensitivity of customers, the model does not include negative effects on the customer equity (i.e. the sum of all customer lifetime values) as described above.

Benaroch et al. (2010) develop an analytical decision model that deals with the valuation of flexible IT-service contracts in the context of IT-outsourcing. Through these contracts an IT service provider is able to outsource all of its service requests to a vendor. Therefore, they address a problem that is quite similar to the one considered in this paper. To analytically evaluate the contracts the authors apply the real options approach (ROA). Several authors agree that – despite of many obstacles that come along with its application – ROA can be a useful approach to determine the value of flexibility (see e.g. Copeland and Antikarov 2003, Amram and Kulatilaka 1998, Trigeorgis 1996). Fichman et al. (2005) describe six types of real options applied in the IS field, that is the option to stage, to abandon, to defer, to have strategic growth, to change scale and to switch. For the purpose of this paper the option to change scale, that means e.g. to extend or contract allocated resources, fits very well to our context.

Bengtsson (2001) provides a good overview about the use of ROA to quantitatively valuate different types of (manufacturing) flexibility based on the classification of Sethi and Sethi (1990). He revealed that e.g. Tannous (1996) evaluates volume flexibility in the context of manufacturing using ROA. The articles written by Tannous (1996) and by Benaroch et al. (2010) therefore aim at a similar direction, i.e. an analytical valuation of volume flexibility based on ROA. However, Tannous' (1996) approach focuses on determining the optimal number of (internal) machines, so he does not consider the integration of an external vendor to provide volume flexibility as we do in this paper. Benaroch et al. (2010) in contrast explicitly focus on the integration of an external vendor, but there is still a major distinction from our paper: The authors consider flexibility as a binary decision either to outsource all or none service requests. Since this kind of flexibility is rather limited, we try to determine the number of service requests to be outsourced according to the corresponding customer satisfaction, which is determined through the customers' time sensitiveness and more importantly – as we stated above – is a major driver of business decisions for service providers.

Therefore, the aim of this paper is to develop a model based on ROA that helps to determine the business value of the creation of volume flexibility through an IS investment. This volume flexibility is established through the integration of an external vendor into the processing of service requests in order to avoid unsatisfied customers.

3 Determining the Business Value of Volume Flexibility for Service Providers

3.1 General Setting

On the intersection of uncertain demand and supply, we propose a model based on ROA to evaluate the option of a service provider to shift an arbitrary number of service requests to an external vendor. ROA is chosen because it is a common tool to valuate flexibility in the context of information systems (e.g. Ullrich 2013) and it offers the possibility to solve the problem in a closed form solution (through the Black Scholes Model). The model itself is based on the real world idea that a service provider has to deal with uncertain demand for services, but possesses a fixed internal capacity, which may lead to long processing times for service requests in times of high demand. Due to their time sensitiveness customers may become unsatisfied, which can be expressed as negative effects on their customer equity. Therefore, investing into standardized interfaces in order to integrate an external vendor to process service requests in peak times can be beneficial for the service provider, although it is associated with upfront investment costs. Thereby the external vendor is assumed to offer arbitrary high, volume-based contracted capacity, that is, a volume dependent capacity with a fixed price per service request. The model we develop in this chapter is able to account for this trade-off and determines the value of the option to shift service requests to the external vendor.

3.2 Connection between the Amount of Service Requests, the Total Service Time, and Customer Satisfaction

We consider a service provider that offers highly repetitive and standardized services. These services are initiated by randomly arriving service requests from customers. The service provider processes service requests continually with respect to the internal capacity determined by the available service stations (i.e. employees and machines). Due to the inseparability of production and consumption of services, the service provider cannot split one service to be processed in different service stations at the same time. If the number of service requests exceeds the capacity of the service stations, the processing of the exceeding service requests has to wait. Given that situation we assume:

(A1) The service requests are processed parallel in $s \in \mathbb{N}$ service stations according to the "first come first serve" principle.

(A2) The service provider's capacity (i.e. the number of service stations) has already been set in the past based on the expected arrival rate of service requests.

All service requests that are being or waiting to be processed by the service provider are said to be *in the service provider's system*. Arriving service requests are considered to be Poisson distributed, with a positive drift μ. At the same time, the service provider is able to linearly process service requests according to its internal capacity, which is based on the expected value of the arrival rate. Given this situation, the superposed process of service requests in the service providers' system is assumed to have zero drift, i.e. $\mu = 0$, but a non-vanishing standard deviation $\sigma > 0$.

(A3) The total amount of service requests in the service providers' system $n \colon \mathbb{R} \to \mathbb{N}$ evolves, according to a superposed Poisson process with zero drift.

The time a service request stays within the service provider's system is named total service time. It starts when a customer requests a service and ends when the service is fulfilled. The total service time consists of pure processing time to handle a service plus waiting time until the processing begins.

In conclusion the total service time of a service request on the one hand depends on the number of service stations $s \in \mathbb{N}$. On the other hand it depends on the amount of service requests $n(t) \in \mathbb{N}_0$ in the service providers' system at time $t \in \mathbb{R}$. Therefore, the total service time should be denoted as $T = T_s\big(n(t)\big)$. Since we consider a highly standardized type of service, we assume:

(A4) The pure processing time to handle one request in a service station, i.e. $T_1(1)$, is constant, equal and known with respect to all service requests.

The total service time $T_s: \mathbb{N}_0 \to \mathbb{R}_0^+$, respecting the waiting time plus the processing time of the service requests, in general is given by

$$T_s\big(n(t)\big) = \left\lceil \frac{n(t)}{s} \right\rceil \cdot b, \tag{1}$$

where $\left\lceil \frac{n(t)}{s} \right\rceil := \min\{k \in \mathbb{Z} | \frac{n(t)}{s} \leq k\}$ and $b := T_s(1) \in \mathbb{R}_0^+$ denotes the constant processing time for one service request.

The total service time is an important factor that determines the perceived service quality from the customers' perspective: An unforeseen rise (fall) in the total service time may lead to unsatisfied (satisfied) customers (Ho et al. 2006). Therefore we can state that customers become unsatisfied if the amount of service requests in the service provider's system exceed a critical number $n_{\text{crit}} \in \mathbb{N}$ and thus a critical total service time $T_s(n_{\text{crit}}) =: t_{\text{crit}}$. Certainly, customers behave and act highly individual, such that the critical service time may be different for each customer. Hence, we consider the critical service time for an average customer. To be able to handle this the service provider has to estimate this time, e.g. through experience from historical data. Therefore we assume:

(A5) The critical total service time $T_s(n_{\text{crit}}) = t_{\text{crit}}$ is known, fixed, and equal for all service requests and thus for all customers.

Thus a necessary condition for satisfied customers is

$$T_s\big(n(t)\big) \leq t_{\text{crit}}, \tag{2}$$

whereas the critical number of service requests is given by

$$n_{\text{crit}} = \left\lfloor s \cdot \frac{t_{\text{crit}}}{b} \right\rfloor, \tag{3}$$

where $\left\lfloor s \cdot \frac{t_{\text{crit}}}{b} \right\rfloor := \max\left\{k \in \mathbb{Z} \middle| k \leq s \cdot \frac{t_{\text{crit}}}{b}\right\}$.

The situation described above is depictured in Figure 1.
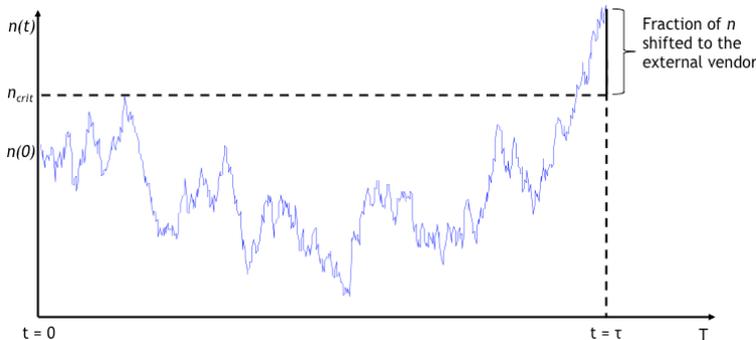

Figure 1.   Development of the number of service requests in the system over time.

After determining the critical number of service requests with respect to the total service time, we present the connection between the number of service requests and the corresponding cash flows for the service provider in the next subsection.

3.3   Cash Flows for Processing Service Requests

In case the service provider processes the service requests internally, cash outflows for each request are induced e.g. by consumed resources which is why they will be referred to as internal cash outflows.

Those cash outflows are also referred to as "insourcing costs" by Benaroch et al. (2010). For those we assume:

(A7) The internal cash outflows for processing a service request $k_{\text{int}} \in \mathbb{R}_0^+$ are constant, known, and equal for all service requests.

As we mentioned earlier, exceeding the critical service time causes unsatisfied customers. Unsatisfied customers become more likely to switch their service provider, which lowers their customer lifetime value and thus can be treated as cash outflows (see e.g. Braunwarth and Ullrich (2010) or Braunwarth et al. (2010)). A more concrete guidance on how to assess respective parameters can be found in section 4. Since a single customer induces one service request, we assume for the corresponding cash outflows:

(A8) The cash outflows resulting from customer dissatisfaction $k_{\text{dis}} \in \mathbb{R}^+$, are constant, known and equal for each of the $(n(t) - n_{\text{crit}})$-service request that appear in the case $n(t) > n_{\text{crit}}$.

If the service provider chooses to embed an external service provider to support the processing of service requests, further cash outflows have to be considered. In our model we assume that the external vendor offers to process $n_{\text{ext}}(\tau) \in \mathbb{N}_0$ service requests whereby the total number of service requests to be processed externally can be chosen freely at a future point in time $\tau \in \mathbb{R}^+$. For the external processing cash outflows we thereby assume:

(A9) The external cash outflows for processing a service request $k_{\text{ext}} \in \mathbb{R}_0^+$ are constant, known, and equal for all externally processed cash outflows.

Further, the integration of the external vendor induces two investments. Firstly, the initial investment into SOA that provides the standardized interfaces and thus enables the integration of the external vendor has to be made. Secondly, there are cash outflows related to the actual shift of service requests to the service vendor at the time τ. These cash outflows include factors independent of n_{ext} e.g. cash outflows related to changed responsibilities and handovers. These latter cash outflows materialize only if the service provider decides to route services requests to the service vendor at the time τ, whereas the former investment has to be made upfront.

(A10) The cash outflows for the initial investment $K_0 \in \mathbb{R}_0^+$ and the final investment $K_\tau \in \mathbb{R}_0^+$ are constant and known.

3.4   Valuation of the Option to Embed an External Vendor

In this subsection we want to financially determine the value of the service provider's volume flexibility, or in other words the value of the real option to outsource service requests to an external vendor. In order to determine the business value we have to consider the total cash outflows of the service provider with and without the external vendor at first, respectively denoted as B_0 and $B_{n_{ext}}$. Then we derive the threshold number of service requests at which the service provider is indifferent between the internal or external processing of service requests. Finally we will derive the value of the real option to outsource a certain number of service requests to an external vendor in a future point of time using the real option approach.

Processing all $n(t)$ service requests internally causes cash outflows, of

$$B_0(t) = n(t) \cdot k_{\text{int}} + max\big((n(t) - n_{\text{crit}}) \cdot k_{\text{dis}}, 0\big) \tag{4}$$

If the provider decides to process n_{ext} service requests externally, the total cash outflows for the service provider are given by

$$\begin{aligned} &B_{n_{ext}}(t) \\ &= \big(n(t) - n_{\text{ext}}(t)\big) \cdot k_{\text{int}} + n_{\text{ext}}(t) \cdot k_{\text{ext}} + max\left(\big(n(t) - n_{\text{crit}} - n_{\text{ext}}(t)\big) \cdot k_{\text{dis}}, 0\right) + K_\tau \end{aligned} \tag{5}$$

A necessary condition for outsourcing at time t to result in a positive cash flow is

$$B_0(t) - B_{n_{\text{ext}}}(t) > 0 \tag{6}$$

In order to determine the business value of this additional flexibility we further need to determine the number of service requests that will be outsourced. Whereas Benaroch et al. (2010) assume that all service requests are outsourced, we rather flexibly determine this number according to the amount of services in the system at time t. Therefore, we consider the case that all service requests that would have a total service time larger than t_{crit} will be outsourced, i.e.

$$n_{ext}(t) = n(t) - n_{crit} \tag{7}$$

The internal cash outflows from above then become

$$\hat{B}_0(t) = n(t) \cdot k_{int} + (n(t) - n_{crit}) \cdot k_{dis} \tag{8}$$

whereas the external cash outflows are

$$\hat{B}_{n_{ext}}(t) = n_{crit} \cdot k_{int} + (n(t) - n_{crit}) \cdot k_{ext} + K_{\tau} \tag{9}$$

Now that we know the internal and external cash outflows we can determine the number of service requests $n_{\text{bound}} \in \mathbb{N}$ at which the service provider is indifferent between internal or external processing. This number follows from the condition

$$0 = \hat{B}_0 - \hat{B}_{n_{ext}} = (k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) \cdot n_{\text{bound}} - (k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) \cdot n_{\text{crit}} - K_{\tau} \tag{10}$$

and is given by

$$n_{\text{bound}} = \frac{(k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) \cdot n_{\text{crit}} + K_{\tau}}{(k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}})} \tag{11}$$

Applying the real option approach, we become able to deal with the randomness of $n(\tau)$ at a future time τ. First of all, we see that there is a direct connection between the evolvement of the number of service requests in the service providers' system and the development of the cash outflow. We call this underlying $S(t)$. Due to the random development over time, we only know the value of the underlying at $t = 0$:

$$S := S(0) = (k_{int} + k_{dis} - k_{ext}) \cdot n(0) \tag{12}$$

Outsourcing n_{ext} service requests also generates fixed cash outflows, which do not depend on the underlying. These fixed cash outflows are the execution value of the option and given by

$$X := (k_{int} + k_{dis} - k_{ext}) \cdot n_{crit} + K_{\tau} \tag{13}$$

Since we are looking for a closed form solution, we need an approximation for our superposed Poisson process with zero drift. Similar to the Black and Scholes model, which assumes that the underlying evolves according to a Geometric Brownian motion, it is possible to find a basic differential equation for the Poisson process whose solution gives the value for the considered option (see Cox and Ross 1975; 1976). But for an underlying Poisson processes it is often not possible to find an analytic solution for the partial differential equation, as it is possible for the Black and Scholes (1973) differential equation, i.e. the famous Black and Scholes formula.

If the intensity of the Poisson process, i.e. the arrival rate of the service requests, tends to ∞, the Poisson differential equation converges to the Black and Scholes differential equation (Cox and Ross 1975). But already with a finite arrival rate it is possible to approximate the solution of our option with the standard Black and Scholes model (Black and Scholes 1973). Therefore, assuming the discount rate r and the standard deviation σ, the value of the option to embed an external vendor can be expressed by the following equation:

$$C(S, \tau) = e^{-r\tau} \mathbb{E}(max(S - X, 0))$$

$$= e^{-r\tau} \mathbb{E}\big(max\,(n(t)(k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) - (k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) \cdot n_{\text{crit}} - K_{\tau}, 0)\big) \tag{14}$$

$$= (k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) \left(n(0)\mathcal{N}(u_1) - \left(n_{\text{crit}} + \frac{K_\tau}{(k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}})} \right) e^{-r\tau} \mathcal{N}(u_2) \right),$$

where $u_1 = \frac{ln\left(\frac{n(0)}{n_{bound}}\right) + \left(r + \frac{\sigma^2}{2}\right) \cdot \tau}{\sigma \sqrt{\tau}}$, $u_2 = u_1 - \sigma\sqrt{\tau}$ and the standard normal distribution $\mathcal{N}(u) = \int_{-\infty}^{u} e^{-\frac{1}{2}t^2} \, dt$.

Finally, we need a decision rule, whether the service provider should invest into the creation of volume flexibility through the integration of an external vendor or not. Therefore, the business value of volume flexibility has to be compared to the initial investments costs, K_0.

$$V(S,\tau) := C(S,\tau) - K_0 \tag{15}$$

So if $V(S,\tau) > 0$ the service provider should invest into the SOA components and therefore create the flexibility to temporarily integrate an external vendor. Otherwise, if $V(S,\tau) \leq 0$, the investment into the SOA components should not be made. For the case that $V(S,\tau) = 0$ the service provider is indifferent whether to integrate the service provider or not. But we have to note that this value is determined in a conservative way, since we only consider a single point of time where we allow for a shift of service requests to the external vendor. We thereby neglect any future shifts of service requests to the external vendor, which will be cheaper due to already implemented SOA.

4 Volume Flexibility at a Car-Insurance Company

4.1 Introduction

In order to evaluate the model described above, we apply it to a real world example in this section. We consider a major German car-insurance company that processes service requests in form of own damage claims. The real world case that underpins the relevance of the problem has already been used by Braunwarth and Ullrich (2010) for the selection of alternate execution paths within the insurance company. The insurance company has a fixed capacity, i.e. a fixed number of employees and machines that process the damage claims. It observes randomly appearing peak demand situations that are caused by randomly arriving damage claims. These demand peaks lead to high total service times and therefore to unsatisfied customers. Thus the risk of losing customers to competitors increases, which lowers their customer lifetime value and therefore the overall customer equity. Consequently, avoiding these complaints becomes an important issue for the insurance company. To cope with this problem, the company evaluates the option to integrate an external vendor. The external vendor would provide the necessary volume flexibility to deal with the uncertain demand through providing additional capacity. The insurance company therefore expects a decrease of the total service times in peak situations and thus aims to avoid the negative effects on the customers through the integration of the external vendor.

The companies' usual claim handling process is assumed to consist of the following activities. First, the damage is scanned and classified, after which the necessary data for the claim is extracted so that the invoice can be checked in the next step. After the check, payment needs to be fulfilled before the claim can be closed. Most of the activities are handled completely automatically or with little binding of employees, except "*check invoice*" which is processed manual. The employees assigned to this process activity handle the claims in sequence, thus it is prone to waiting queues. Due to the human involvement, "*check invoice*" represents a bottleneck of the process and requires a lot of flexibility in particular.

4.2 Determining the Business Value of Volume Flexibility

In the considered scenario, the company's internal capacity for "*check invoice*" has already been adjusted with respect to the historical average claim arrival rate in non-peak demand situations, i.e. for the regular business. Expressed in full time employees there are $s = 30$ employees planned for this

process step. Further, the pure processing (without waiting time in a queue) of one instance of "*check invoice*" takes usually $T_s(1) = b = 0,5h$ and causes an internal cash outflow of $k_{int} = 50$ €. Since the other process activities are highly automated, waiting queues are less likely to occur at other steps of the processes, so that every arriving service request can be processed immediately prior to the "*check invoice*" step. Nevertheless, the processing time of those activities may take a considerable amount of (fixed) time until completion, e.g. the time until the fulfilment of a transaction from account to account or the time until a letter with legal documents is received. Within the car insurance company, the processing time of the other process activities amount to 5 working days.

An analysis of the company's data on complaints shows that customers tend to complain if their request is not fulfilled within ten working days, such that the critical total service time with respect to the whole process should not exceed these ten days. Combining this information with the accumulated cycle time of 5 working days for the other process activities, the critical service time of "*check invoice*" is 5 working days, i.e. $t_{crit} = 40\ h$, whereas the companies' employees work $8\ h$ a day. We omit weekends, free days, and effects resulting from arriving claims at these days and assume 240 working days per year. Since the critical process activity is "*check invoice*" due to its bottleneck position in the whole service process, this process step determines the maximal number of possible claims in the system, which the company is able to handle without complaining customers. Thus by equation (3), the insurance company can handle a maximum of $n_{crit} = 2,400$ claims in the system without complaining customers.

If customers become dissatisfied they might want to switch their car insurance. Especially in times of emerging online direct car insurances, which often advertise their quick response time and pronounce that as their competitive advantage, customer loyalty is hard to obtain. With every customer lost his or her customer lifetime value diminishes, which lowers the overall customer equity. Therefore, the cash outflows resulting from the loss of unsatisfied customers can be analyzed by means the historical average of customers who left the company after they complained. This average value is then homogeneously distributed over all complaints in form of a risk value. Through this procedure the company determined an average loss of $k_{dis} = 250$€ for each customer whose total service time is too long.

The company has chosen an external vendor who offers to handle the "*check invoice*" for $k_{ext} = 75$€ per claim and additionally causes fixed transaction costs of $K_\tau = 5,000$€ independently of the number of shifted requests, if the claims are transferred to the vendor at some point in the future. Further the company has to invest $K_0 = 30,000$€ to implement the necessary SOA components into the IS infrastructure. Since the insurance company has already moved toward a SOA integration, the initial amount of the investment is moderate. If the company decides to invest into the SOA components, managers agreed that the shift of damage claims could be realized one year later ($\tau = 1$).

Taking into account that the company currently has $n(0) = 2,000$ claims in the system, the risk of exceeding the critical amount of $n_{crit} = 2,400$ claims becomes highly relevant. Therefore the integration of the considered external vendor seems to be attractive. By analyzing the number of arriving claims on a daily basis collected over the last year, the volatility of the arriving claims can be derived by the standard deviation and in this case amounts to $\sigma = 0.4$. The discount rate used for the valuation is $r = 0.1$ and was derived by determining the average cost of capital.

After we collected all necessary data, we are able to calculate the value of the option contract with the external vendor. By utilizing equation (15) we derive the following result:

$$V(S, \tau) = C(S, \tau) - K_0$$
$$= V(450,000€, 1) = C(450,000€, 1) - 30,000€ \tag{16}$$
$$= 55,106€ - 30,000€ = 25,106€.$$

Hence, the car insurance company should invest into the SOA components.

4.3   Interpretation and Discussion

As the result of the application of our model we conclude that – given the information described above – the service provider should conduct the technical integration of the external vendor due to the positive business value of the resulting volume flexibility. However, if one has to make this decision, it is necessary to be aware of the robustness of this result.

Therefore, we first need to discuss ROA as valuation method in greater detail. As Ullrich (2013) revealed, there are four key assumptions that have to be fulfilled in order to be able to apply option pricing models to the valuation of IS investments. The most critical assumption is that the underlying of the option needs to be traded to allow for a risk neutral valuation. Ullrich (2013) suggests to use a preference-related valuation approach in order to avoid this assumption. Our underlying of the option, i.e. the difference between internal and external costs multiplied by the number of service requests, may be tradable, if one assumes that there are enough specialized and publicly listed service vendors that can process any number of service requests at different prices. Furthermore, we follow the argumentation of Taudes et al. (2000), who state that the value of the real option does not need to be accurate; it can rather be interpreted as a lower bound. In our case, the value obtained above can also be interpreted as a conservative valuation, since we neglect the possibility of repeating shifts of service requests to the external vendor. If the service provider chooses to shift its service requests to the external vendor a second time, no initial investments would be necessary anymore, which makes that step even more profitable.

Through the application of SOA – especially the Black Scholes Model – the robustness of our result can be easily analyzed through partial differentiation of the different input parameters (also known as Greeks). This is especially helpful to check the effects of input parameters that are difficult to estimate in advance on the result. In our case it is interesting to analyze how the volatility, which could be derived from historical data in the real-world example, affects the result. Figure 2 therefore shows the business value of the investment depending on the value of the volatility used for the calculations. As it can be seen in Figure 2, the investment would be denied if the volatility falls below 26%. However, since historical data showed a volatility of 40% and no signs of lower volatility were observable, the result seems to be robust with respect to the volatility.
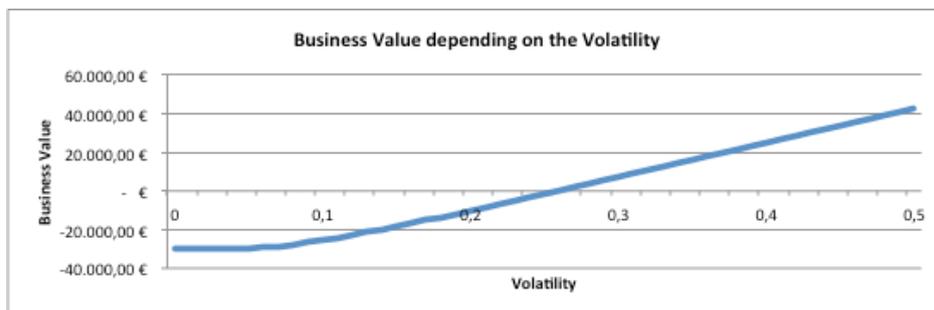
Figure 2.   Business Value of the investment depending on the volatility.

5   Conclusion

In this paper, we presented an analytical model that determines the business value of flexibility resulting from an IS-based integration of an external vendor. Thereby we considered the trade-off between the investments into the technical requirements (e.g. SOA) that are necessary to gain volume flexibility and the negative effects of unsatisfied customers on the customer equity. Our model is based on the real options approach, which is an appropriate framework for our model, since it is able to valuate the core element of flexibility: the ability to respond to uncertain events in future. We demonstrated the applicability of our model by valuating an investment decision of a German car-insurance company.

With our model, we contribute to IS literature by providing the (to the best of our knowledge) first analytical model which provides a closed form solution for the value of a future IS-based integration of an external service vendor considering important economic parameters such as contracting costs and indirect effects on the customer equity. Furthermore, we extend the new research stream initiated by Benaroch et al. (2010) that applies ROA to the valuation of additional capacity. To this end, our models reveals that the consideration of the indirect economic effects can be a game changer when deciding whether to perform service requests in a company or to shift them to an external vendor.

However, the model is beset with the following limitations, which should be (and already are) subject to further research:

- Currently, we focus on shifting the demand peak to an external vendor only once at a specific future point of time. This is a pessimistic valuation of the respective IS investment, since for further shifts of demand peaks no additional investments into the technical infrastructure are necessary. Therefore, future research should consider multiple periods and therefore multiple possibilities to shift demand peaks to an external vendor.

- Although we consider negative effects on customer equity by analyzing total service times and time preferences of customers, our model is only a first step towards a thorough understanding of the interplay between customer preferences and flexibility achieved through IS investments such as e.g. SOA components. Due to that we treat each customer's reaction the same, even independent of the actual total service time. Future research should analyze those effects on a more detailed level, such as (e.g. exponentially) increasing negative effects depending on the total service time.

- Our paper explicitly addresses the cash effects of capacity shifting to external partners. We consider this focus as an important part, but we are aware that there might come other, more qualitative aspects into play. These include for example a possible loss of quality for the shifted service requests, risk and monitoring issues or strategic considerations not to shift capacity if the related output concerns key activities of a company and therefore should remain internal. A combination of respective research (especially from outsourcing literature) and quantitative models such as ours would allow for a more holistic decision support.

Nevertheless, the additional insights resulting from the extensions mentioned above need to outweigh the increased complexity of the model and the possible loss of deriving a closed form solution. Therefore, the extensions should be considered carefully. Despite its shortcomings, our model enables a company to determine the business value of IS leading to the creation of volume flexibility. We hope that our paper provides fellow researchers with a sensible foundation for continuing research in the domain of business value of IS and flexibility valuation.

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