MAKE-AND-SELL OR BUY OF WEB SERVICES
A REAL OPTION APPROACH

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Abstract

The emergence of the web service market in the last years offers more and more the opportunity for companies to buy web services from external service providers as an alternative to develop them internally. Such considerations are well-known in IS literature and discussed in the context of IT outsourcing and make-or-buy decision making regarding IT applications. However, characteristics of web services like loose coupling or highly standardized interfaces open the door for a further opportunity to companies: If a company decides to internally develop a web service (make decision), it has additionally the right (but not the obligation) to sell it on the electronic web service market. The present paper examines how such a sell option can be modeled to enhance traditional make-or-buy approaches to a make-and-sell or buy approach for web services. To evaluate the sell option, we draw on real option analysis which is frequently used in valuating IT assets like IT applications. Furthermore, we apply our approach in a real world example of a financial service provider to demonstrate its applicability and practical benefits. By doing so we illustrate that the option to sell a web service may have considerable impact on traditional make-or-buy decisions.

Keywords: Make or Buy Decisions, Web Services, Real Options

1 Introduction

Service-oriented architectures (SOA) are widely discussed as a design principle for application and enterprise architectures (e.g. Zhao et al. 2007, Demirkan et al. 2008). The more SOAs are implemented in practice (Heffner 2008, TechTarget and Forrester Research 2010), the more the question comes up, whether a company should develop a web service (see W3C 2004 for a definition) internally or buy it from an external provider. In contrast to monolithic IT applications, make-or-buy decisions concerning web services have to be made on a more fine-grained level, as web services normally comprise less functionality than monolithic IT applications (Erl 2005). In fact, the advantages of a web service base on its structure, communication and interfaces that follow well-defined, general standards (Umapathy and Purao 2007). Using those standards, the integration of (internally developed or externally bought) web services can be conducted faster and more efficient (Vollmer et al. 2004)[1]. Considering this development, nowadays an increasing number of software and non-software companies plan to enter the web service market, offering their (professional) web services - which were initially intended often only for internal use – as well to external parties (Legner 2009, Nüttgens and Dirik 2008).

Therefore, the make-or-buy decision regarding IT applications (e.g., also in the context of IT outsourcing) has to be enhanced to a make-and-sell or buy decision especially with respect to web services. Only a few works mention this additional sell option concerning software modules and web services (e.g. Gonçalves and Ballon 2011, Mueller et al. 2010). However, they discuss this option and its consequence on decision-making very briefly. Thus, we present in this paper how to model such a sell option and how traditional make-or-buy approaches can be enhanced to a make-and-sell or buy approach considering web services. To the best of our knowledge, this is the first approach to support make-and-sell or buy decisions of web services.

The remainder of this paper is structured as follows: In the next section, we review the literature concerning make-or-buy decision making for IT applications in general and for web services in particular. Furthermore, we investigate different (potential) business models on the web service market to get insights into the costs and revenues resulting from selling web services. Based on this analysis, we develop in the third section a normative approach to evaluate the option to sell web services using real option analysis. In section four, we apply our model in a real world example to demonstrate its applicability and practical benefits. Thereby, we illustrate the effect of the sell option on the traditional make-or-buy decision. In section 5, we summarize and review our findings critically and discuss several directions for future research.

2 Background

In an industrialized world with a global economy, outsourcing experienced a rapid growth during the 1990s (Bryce and Useem 1998) and has been accepted as a dimension of corporate strategy for quite some time. In this respect, outsourcing and make-or-buy decisions regarding IT applications have been discussed in research and practice for a long period of time (e.g. Knolmayer 1993, Lacity et al. 2009, Lyons 1995, Walker and Weber 1984). Thereby, research on IT outsourcing and make-or-buy decisions incorporates the development or transfer of different concepts and theories (e.g. Transaction Cost Theory, Principal Agent Theory, or Social Exchange Theory) to explain and understand various aspects of such decisions (e.g. Dibbern 2004, Lacity et al. 2009). Apart from behavioral science approaches, a series of normative approaches for both make-or-buy decision making and IT Outsourcing (e.g. Yoon and Naadimuthu 1994, Yang and Huang 2000, Wang et al. 2008) have published in the last two decades. However, in this large number of existing approaches primarily (monolithic) IT applications are taken into account. The number of normative approaches especially for software modules (e.g., commercial of the shelf (COTS), components, and web services), on which we focus on in this paper, is quite limited.

In this context, an early approach by Jung and Choi (1999) supports selecting adequate COTS components for modular software systems. They present two decision models that aim to maximize the quality of such a software system subject to a budgetary constraint. However, Jung and Choi do not consider the possibility to develop components in-house, but recognize the architectural flexibility that comes along with a modular software system. Cortellessa et al. (2008) investigate the decision, whether to buy COTS components or to develop them in-house. Hence, they incorporate costs as well as quality attributes in a non-linear costs-quality optimization model considering the architecture of the software system. Furthermore, Zhao et al.

[1] In fact, this statement is still pending on long-term evaluation results.

(1999) suggest a normative model for make-or-buy decisions of software components. They use linear integer programming to solve the proposed multi-factor constrained cost-minimization problem taking into account costs, time to market, system reliability, and operational profiles. Moreover, recent publications focus on web services in particular. Tansey and Stroulia (2007) develop a procedure for an economic valuation of a set of web services composed to a business process. They do not directly provide a normative model to support the make-or-buy decision. However, they implicitly account for it as they incorporate both choices in their valuation procedure and further state possibilities to determine the costs of each choice. Compared to this, Braunwarth and Heinrich (2008) develop a portfolio optimization model balancing costs and risks, that allows for valuating a set of internally or externally developed (web) services. However, they especially aim at assessing risks that come along with externally obtained services, and integrate these risks into their optimization model. Matros et al. (2009) investigate the make-or-buy decision related to cloud computing. They refer to cloud computing as provisioning of IT services over the internet which can be requested on demand causing only variable service fees. A costs-comparison approach and a Break-Even-Analysis are provided to determine for which IT services either the make or the buy choice is economically worthwhile.

To summarize: There are some normative approaches that support the make-or-buy decision concerning software modules and especially web services. However, those approaches do not model any sell option for web services. Web services are self-descriptive (standardized XML interface description that allows for automated communication), platform independent and loose coupled software modules which are based on standardized messaging systems (see W3C 2004). Hence, web services can be easier provided to other companies via internet than other types of software modules. As a result, besides the (internal) use of an (internally) developed web service within a company, these characteristics enable an option to sell web services on the web service market. Some scholars discuss or even suggest that the development of software modules and especially web services enables the possibility to further sell these modules (e.g. Gonçalves and Ballon 2011, Nüttgens and Dirik 2008, Mueller et al. 2010, Ravichandran and Rothenberger 2003). However, they do not aim to design a make-or-buy decision model considering the described sell option. Consequently, the actual make-or-buy decision approaches have to be enhanced to be able to support a make-and-sell or buy decision.

To be able to valuate a sell option we need to get insights into the costs and revenues resulting from selling web services on the web service market. Therefore, we take a closer look at existing literature concerning the web service market.

Nüttgens and Dirik (2008) investigate and categorize roles and business models on the web service market. A main criterion to distinguish between those business models is the existence of a *web service broker* or *web service intermediary* (WSI). A WSI does not develop web services by itself, but acts as middleman between a *web service producer* (WSP) and its customers. For example IT consulting companies or other companies like XMethods, RemoteMethods, Seekda!, eSigma, WebServiceList, Soa Trader, eCoComa or ProgrammableWeb act as WSIs and provide web services and related information to their customers. If a web service is sold, a WSI gets usually a commission for selling it on behalf of the WSP[2]. Besides employing a WSI, a WSP can also decide to sell its developed web services directly to the customer. Professional WSPs can be distinguished between two types: (1) Software companies like Fraudlabs, Xignite, StrikeIron or ServiceObjects, that are specialized on providing web services against payment. (2) Non-software companies which first and foremost develop web services for their internal use and additionally provide some of them on the web service market to earn additional revenues. We focus on (2) because mainly non-software companies are confronted with the previously described make-and-sell or buy decision problem.

Thus, we state two (opposing) business models (BM) differing by the amount of tasks a WSP transfers to a WSI:

- BM1: The WSP sells its web service by its own. Thus, no costs for commissioning the WSI arise. However, the WSP has to consider costs for hosting its own web services, for marketing, for billing customers, etc.
- BM2: The WSP instructs a WSI to sell the web service on its behalf. Thus, the WSP contracts out the tasks of hosting the web services, marketing, billing customers, etc. Therefore, the WSP has to pay a commission to the WSI.

[2] Our investigations of the web service market showed, that there are several WSIs (e.g. online repositories and search engines) which offer their services usually for free and generate revenues by advertising. In this case no commission for selling the web service is charged.

Since a discussion of costs is important to evaluate the sell option in our decision model, we go into more detail. Here, our analysis of academic literature and practice leads to the cost categories illustrated in Table 1. The occurrence of these costs *from a perspective of a WSP* depends on the selected business model:

Costs category	**Description**	**Occurrence in BM1**	**Occurrence in BM2**
Additional development costs	To make a web service marketable, which is initially designed only for internal use, the WSP has to consider additional development costs. These costs comprise for example efforts for making the web service more configurable or providing a standardized web service description file.	Yes	Yes
Hosting costs	To offer a web service on the web service market, the WSP needs to host a website containing information about the web service like functionality, configuration possibilities, integration manuals, pricing, and demos. In addition, investments in IT infrastructure like in security measures are required.	Yes	No
Marketing costs	For placing a web service on the web service market, advertising is necessary.	Yes	No
Billing costs	All efforts that are necessary for billing a customer, like sending an invoice or checking receipt of payment.	Yes	No
Commission costs	Commission costs appear when the WSP employs one or multiple WSIs that sell the web service and therefore receive a commission from the WSP.	No	Yes
Costs for embedded services	Costs for so-called embedded services occur if a provided web service uses additional chargeable resources (e.g., other chargeable external web services which are embedded when executing the provided web services).	Yes	Yes

Table 1. Costs categories for selling a web service and its occurrence in BM1 and/or BM2

Obviously, it is also possible that hybrid business models exist as mixed forms of BM1 and BM2. For example, when a WSP runs its own web site and hosts the web service by itself, but transfers marketing to a WSI, who then receives a commission for its support.

Apart from costs, we have to discuss revenues generated from selling the web service as well. Pricing of web services has already been investigated in literature. Thereby, different models for pricing web services have been discussed. For example, Mathew et al. (2004) propose different pricing models (subscription based, transaction based and risk based) depending on the type of the web service offered. They differ between commoditized web services (standardized functionality is needed by all customers), channelized web services (standardized functionality is offered only on an on-demand basis to selective users) and customized web services (individualized functionality for one specific customer). Esmaeilsabzali and Day (2006) investigate the pricing of web services related to a situation of a WSP with finite capacity of requests that can be served. They present an algorithm for selecting and pricing service requests, and charging them in a way that a WSP achieves optimal profit. Lin et al. (2005) focus on the development of a usage-based dynamic pricing approach to optimize resource allocation of web services. In their approach, they consider four types of elementary resources a web service uses: CPU time, mass storage access services, network bandwidth and use of specially licensed software programs. Yahav et al. (2006) present a bid-based web service pricing algorithm (Higher-Bid-First). There, a customer sends a request including a bid to a server, which arranges the request into a processing queue based on the bids received. They demonstrate the algorithm in a simple case to point out, that the bid-based algorithm increases the benefits of both WSP and customers. Günther et al. (2007) investigate the web service market and in particular the pricing of web services related to service composition by conducting an online survey. Based on their empirical findings they state that customers are not willing to pay more for a composition of web services than the sum of the single prices of the web services contained in the composition. In fact, when obtaining a composition of web services, customers rather expect a reduced price. Further, Günther et al. (2007) recognize that customers prefer flexibility in the allocation of pricing schemes (e.g. the possibility to switch pricing schemes during the run time of a contract). Eckert et al. (2009) provide a categorization of pricing models for web services. They differ between variable, fixed and hybrid pricing models. Thus, variable pricing models are usage-related (pay-per-use), fixed pricing models charge a fixed fee which grants a certain volume of requests and hybrid pricing models are combinations of both. This is similar to Nüttgens and Dirik (2008) who differ between transaction-based and transaction independent pricing models. Compared to these approaches, our investigations of the web service market showed that currently most WSPs or WSIs apply transaction-based pricing models like charge per call (e.g. Amazon WS, Google or Unified Software) or a charge per x calls per time period (e.g. Xignite, Ebay, StrikeIron or ServiceObjects). In addition, since usually little or no capacity limitations exist and customers prefer the possibility to request web service on-demand, bid-based or subscription-based pricing-approaches (in the sense of a flat fee) are hardly realized now. These results have to be considered in the later presented decision model.

Apart from costs and revenues from selling web services on the market, we have to discuss the methodical basis for modeling the sell option. Research done in the past two decades on IS has recognized the relevance of real options in managing IT investment decisions (cf. Wu et al. 2010). In the context of IT projects a real option is a right but not an obligation to take into account some further actions (e.g. abandoning, deferring, and expanding an IT project) during the runtime of a project. Early, Dos Santos (1991) highlights the importance of determining the potential value of new investments for IT applications and demonstrates that the Discounted Cash-Flow Analysis is not appropriate to valuate such investments. Since then, real options approaches are discussed more intensively and used to model situations, in which an option exists to invest in an IT asset (like an IT application). In this context, Benaroch and Kauffman (1999) provide a background for the validity of using the Black-Scholes Model (BSM - for a comprehensive description of the BSM see Black and Scholes 1973 or Hull 2009) for assessing IT investments. They use BSM and Blacks Approximation to calculate the optimal exercise time for an IT project. Taudes et al. (2000) discuss the practical advantages of an options analysis for software platform decisions and demonstrate this by employing BSM on a real world example. Bardhan et al. (2004) present a nested options model to evaluate and prioritize a portfolio of IT projects taking into account interdependencies among projects. Kauffman and Sougstad (2008) investigate contract portfolios of IT services for evaluating the trade-offs between contract profitability and service-level risk. Further, Benaroch et al. (2010) analyze the situation of an IT service provider that offers its customers the option to abandon the contract. Using real option analysis, they evaluate the service-related flexibility and determine the optimal exercise time. Summing up, several scholars apply real option models to assess the value of IT assets (like IT applications) and thus support IT investment decisions. Transferring the real option idea to our make-and-sell or buy decision problem regarding a web service, the sell option can be modeled as right but not an obligation for the WSP to sell a web service on the web service market after its development. For example, in case of a web service that represents a competitive advantage for the WSP, selling of this web service would not be a reasonable option. Also a strong individualization of a web service may be another reason against selling the web service (see Mueller et al. 2010 for further benefits of services and SOA). Summing up, several scholars apply real option models to assess the value of IT assets (like IT applications) and thus support IT investment decisions. Therefore, in the following we show, how a sell option can be modeled (applying a real option approach) in the context of a make-and-sell or buy-decision considering web services. Modeling the option to sell a web service after developing and using it internally has not been investigated in the field of IS yet.

3 Modeling the make-and-sell or buy decision of web services

3.1 Assumptions

A company has to decide in $t = 0$, whether it realizes some required IT functionalities either by developing a web service internally (make-decision with the option to sell it additionally later on) or by obtaining a web service from an external IT service provider (buy-decision).

For that purpose, the costs for making and buying the web service have to be analyzed[3]. For buying the web service, we have to distinguish two cases: (1) If a web service that provides the required functionality is already offered by an external IT service provider, the company may obtain it directly. (2) If a web service that provides the required functionality is not offered yet, the company has to contract an external IT service provider like StrikeIron to develop it. As for case (1) the price for buying the web service is observable at the market and for case (2) the price is contractually fixed, the following assumption is reasonable:

[3] As the internal use of a web service - regardless of whether the company develops or obtains it - shall cause revenues with a comparable amount (due to equal functionality of web services), they have no (decision-relevant) effect on the considered make-or-buy decision (cf. also Cortellessa et al. 2008 or Zhao et al. 1999). In case, such revenues have to be considered because they depend on the make-or-buy choice, then they can be modeled like it is done for example by Dos Santos (1991) or Taudes (1998).

(A1) The costs for buying the web service are represented by certain and known discounted cash-outflows C_B.

In contrast, developing the web service internally leads to effort and consequently to costs. Such development costs cannot be determined under certainty, as software development is usually a risky endeavor (e.g. Sommerville 2010). To estimate the development costs considering risks, several cost estimation models like COCOMO (Boehm et al. 2000) or COSYSMO (Valerdi 2005) exist. As the focus of our paper is not on a best possible estimation of the uncertain development costs (for this see Cortellessa et al. 2008 or Tansey and Stroulia 2007, who apply COCOMO to estimate development costs of in-house components), we state the following assumption:

(A2) The costs for developing a web service for internal use[4] are represented by a known certainty equivalent C_M for uncertain cash-outflows.

Commonly, traditional make-or-buy approaches aim to compare C_B and C_M to come to a decision whether to make or buy IT applications. However, web services are characterized by a structure, communication and interface that follow well-defined and general standards. These characteristics make web services easier to reuse by other companies from a technological perspective. In this respect, after developing the web service a company can further decide in $t=T$, if it uses the web service only internally or it further invests in the web service to make it marketable and sell it additionally on the web service market. This opportunity can be modeled as a real option because the company has the right, but not the obligation to do the further investment in $t=T$.

As the company can only execute this sell option for an internally developed web service, the value of the option has to be considered when modeling the make-alternative. The company executes this option in $t = T$ when the additional revenues (discounted cash inflows) from selling the web service are greater than the additional costs (discounted cash outflows) for making the web service marketable and selling it to third parties. Thus, the option to sell the web service has the characteristics of a call option. The revenues from selling the web service result from the price for using the web service and the customer demand for the web service[5]. The price can be determined by the company and the resulting customer demand associated to the chosen price can usually be estimated, for instance, by considering information from similar web services on the market in $t=0$[6]. However, the revenues may change between the instants $t = 0$ and $t = T$. Thus, we assume the following:

(A3) The revenues S_t of selling the web service can be estimated in $t=0$ and follow a geometric Brownian motion over time.

A number of papers and empirical studies (e.g. Bethuyne 2002, Mahajan et al. 1993, Pfeiffer 1992) show that a geometric Brownian motion is a good descriptor for implementation opportunities, which typically involve applications that are based on novel software technologies (Taudes et al. 2000). From assumption (A3) further results that S_t is a log-normally distributed random variable at the instant $t = T$. As the revenues in $t = T$ are uncertain and cannot be negative, this property of the distribution of S_t is reasonable. The standard deviation $\sigma(S_t)$ represents the web service market risk resulting from fluctuations over time in the customer demand for the considered web service (see the real world example for an operationalization).

Besides, providing a web service on the web service market does not only lead to further revenues but also to further costs resulting from making the web service marketable and selling it on the web service market (cp. Table 2). Those cost categories are discussed in section 2 and can be distinguished in variable and fixed costs with respect to the customer demand of a web service.

[4] Costs for maintaining the web service after its development are included in the development costs C_M.

[5] In this context, the customer demand and the price for using the web service are of course not independently from each other. However, there is a huge amount of literature that elaborate demand curves in different markets in order determine the highest revenues from the perspective of a provider. Referring to this literature, we can suppose that a provider choose a price for using a web service that maximizes its expected revenues.

[6] Determining the price and estimating the associated customer demand for a web service will be alleviated in the future when more comparable web services and related access statistics are available on the market.

Business model	Variable costs	Fixed costs
BM1	– Billing costs of the WSP – Costs for embedded services	– Additional development costs of the WSP – Hosting costs of the WSP – Marketing costs of the WSP
BM2	– Variable commission costs to pay the WSI – Costs for embedded services	– Additional development costs of the WSP – Fixed commission costs to pay the WSI

Table 2. Cost categories for selling a web service

Variable costs that depend directly on the customer demand (either billing costs of the WSP, costs for embedded services or variable commission costs to pay the WSI[7]) are considered by a reduction of the price and are consequently represented in S_t (see assumption (A3)). In this case, revenues can be also denoted as contribution margin. Considering the fixed costs that are independent of the customer demand, we state a further assumption:

(A4) The *fixed* costs for making the web service marketable and selling it on the market are represented by certain and known discounted cash-outflows X.

This assumption is reasonable for BM1 as well as BM2 as the fixed costs can be mostly determined under certainty ex ante. If the company aims at realizing BM1 and for instance, a new server is required to host the new web services, the costs for buying and maintaining the server are known and observable because it is provided by infrastructure service providers like IBM or Dell. With respect to marketing costs assumption (A4) usually holds as well: As potential customers of the web service generally search for adequate web services in the Internet, it seems to be reasonable to promote the web service on highly frequented web sites or search engines. As search engine providers like Google.com or web service lists like RemoteMethods.com usually have known fixed promotion fees, the marketing costs can also be assumed as known[8]. If the company aims at realizing BM2, assumption (A4) also holds for fixed commission costs as the fixed fees of a WSI for hosting and offering a web service can be observed or negotiated ex ante as well. The only cost category where assumption (A4) seems to be too restrictive are the additional development costs because as already mentioned software development is usually a risky endeavor. However, as the additional development effort first and foremost comprises standardized investments like making the web service more configurable and providing a standardized web service description file (WSDL file), these costs seem to be associated with much lower uncertainty than developing new functionality from scratch. Though, if the risk of the additional development costs is considered as high, the assumption (A4) can be relaxed to consider uncertain costs. In this respect, the Margrabe Model (Margrabe 1978) can be applied (e.g. Dos Santos (1991) applied the Margrabe Model to the valuation of IT investments). However, for reasons of simplicity and since applying the Margrabe Model leads to comparable results, we hold this assumption.

Based on the assumptions (A1) to (A4) we show in the next section how to model the option to sell a web service on the market and its impact on the decision whether to make-and-sell or buy a web service.

3.2 Evaluating the sell option

To consider the option to sell a web service in evaluating the make decision we have to reduce the costs C_M of the make choice by the option value O, which represents the potential additional benefits and costs of selling a web service. This leads to the adjusted costs AC_M of the make choice represented by (E1)[9]:

$$\text{(E1)}\ AC_M = C_M - O$$

To calculate AC_M we need to model the sell option. To valuate real options, financial option pricing models like the BSM (e.g. Benaroch and Kauffman 1999, Taudes et al. 2000) or the Binomial model (e.g. Benaroch 2002) are suggested in the literature. However, those models are based on a risk neutral valuation of the op-

[7] In the case that a WSI is used which offer its services for free and generate revenues by advertising, no commission costs come up.
[8] Similar to the discussion of demand curves in different markets (see footnote 5), there exists also a dependency between marketing effort and expected revenues (cp. e.g. the Dorfman-Steiner Theorem and its extensions for a non-deterministic optimization). Referring to this literature, we can also suppose that a provider choose not only a price for using a web service but also its marketing effort to maximize the expected revenues for a provided web service. Therefore, such considerations are not part of our model.
[9] We base our decision on the adjusted costs. In terms of profits, the formula (E1) can be rewritten as O - C_M.

tion, whereby all risks are duplicated and thus hedged through a replicating portfolio consisting of the underlying asset and the option (Hull 2009). In order to be able to build this replicating portfolio and to hedge continuously the risks during the runtime T of the option, a traded underlying asset is required. As real investments (like IT investments) are usually not traded, the creation of a replicating portfolio is hardly possible. Thus, critics came up in the past and raised questions about the applicability of real option approaches to valuate IT investments (e.g. Kauffman et al. 1993, Kogut and Kulatilaka 1994). Sick (2005) picks up these critics and argues that the replicating portfolio does not necessarily have to consist of the option and its underlying asset per se. In fact, any traded asset ("twin security", see Taudes et al. 2000) that correlates perfectly to the underlying asset can be used for building the replicating portfolio. In our case, as usually other web services are provided on the market, which provide similar functionalities as the underlying web service, they can be used as "twin securities" to build the required replicating portfolio. Thus, the applicability of financial option pricing models to our investigation seems to be appropriate in particular, because web services are "traded" on the web service market (compared to many existing real option-based approaches in IS which consider untraded IT applications as underlying assets or "twin securities"). We choose BSM over BM[10] due to its computational simplicity and the possibility to apply sensitivity analysis[11]. The BSM to valuate a call option is formalized by (E2):

$$\text{(E2)}\ O = S_0 N(d_1) - e^{-r_f T} X N(d_2) \ \text{ with } \ d_1 = \frac{\ln\left(\frac{S_0}{X}\right) + \left(r_f + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \ \text{ and } \ d_2 = d_1 - \sigma\sqrt{T}$$ [12]

The discount rate r_f represents the rate of return an investor can expect from an risk-free investment over a given period of time. The terms $N(d_1)$ and $N(d_2)$ equal the value of the standard normal distribution at d_1 and d_2, respectively. Other parameters of BSM and their representation in our approach have already been discussed in section 3.1. By using equation (E2) we are now able to calculate the value of the sell option and thus to determine AC_M, which represents the counterpart of the costs C_B for buying the web service. So, if AC_M is less than C_B the make alternative is economically worthwhile for the company, otherwise the company should buy the web service from an external service provider.

In the following, we apply our approach to a real world example to illustrate the impact of the sell option on the decision.

4 Real World Example

In the following, we illustrate the application of our approach in a real world example of a German multichannel retail bank (MCRB) (for reasons of confidentiality, all specific figures and data had to be changed and made anonymous). The MCRB wants to increase the level of automation of its consumer loan processes and to enable a risk-adjusted pricing of consumer loans. Additionally, new consumer loan products (e.g. instant loans with small volumes) shall be launched. Therefore, the existing consumer loan processes have to be redesigned, which also requires a revision of the existing IT landscape. This IT landscape (cf. Figure 1) supports several distribution channels (especially the channels branch and internet) by a middleware, which provides hundreds of web services composed for business services (e.g. a business service for creating a business partner in the SAP Business Partner (BP) system). The different distribution channels use individual web frontends to access and use those business services. Apart from integrating internal backend systems of MCRB, the middleware also connects the frontends with external systems (e.g. from rating agencies like Schufa).

This architectural design has to be retained when redesigning the consumer loan processes, as a large potential exists for reusing services within other business processes (e.g. debit card processes). In addition, the middleware already provides essential business services like those used for creating or searching business partners in SAP or for internal and external ratings of customers. However, for realizing the redesigned consumer loan processes, some modifications and extensions are necessary: Apart from a slight revision of existing business services, the following business services (each decomposed in several web services) have to be newly developed to support the redesigned consumer loan processes:

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[10] The BSM and the BM are based on the same stochastic process described by a geometric Brownian motion (cf. assumption (A3)). From this results that the BM converges to the BSM when the considered binomial calculation steps n of the BM increase. Thus, the BM is equivalent to the BSM for $n \to \infty$ (cf. Trigeorgis 1996, Copeland and Antikarov 2003).

[11] For a detailed description of the BSM see Black and Scholes (1973) and Hull (2009).

- Loan models: The customer can choose between different loan products, loan volumes, and runtimes of a loan. The business service returns a record that describes the calculated alternative loan models.
- Budgetary calculations: To get an internal rating of a potential customer, this business service calculates the available budget of an individual customer based on his/her entered monthly incomes and expenditures. Essentially, the service provides a plausibility check of the input data.
- Contracting: Based on the rating results for an individual customer and the chosen loan model, this service calculates the conditions of a loan to be offered in a proposal. In case of acceptance, this service creates the loan documents for contracting and stores the accepted loan contract in the SAP Consumer and Mortgage Loans (CML) system.

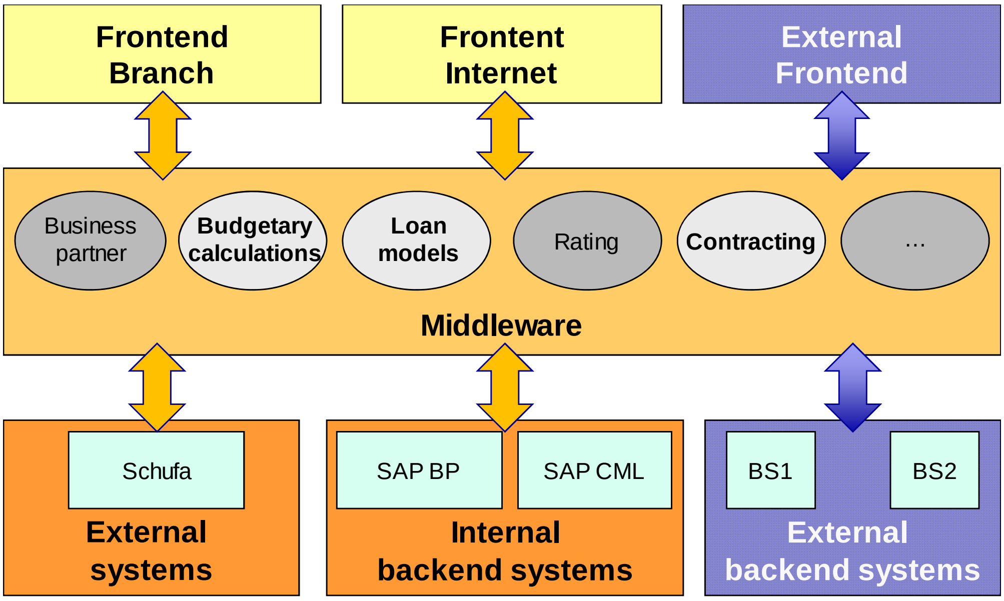

Figure 1. IT landscape of the MCRB (simplified illustration)

Each of those business services are decomposed to several web services. To estimate the effort for developing them, the MCRB has a classification scheme for the complexity of web services where to each complexity class a specific development effort measured according to the number of person days (PDs) is assigned. Here, the development effort includes efforts for project management, analysis and design, implementation, test, integration and overhead. To develop all web services which are composed by the three business services and the required revision of already existing business services, the MCRB calculates with 1,500 PDs. By a charge rate of 1,000 EUR per PD the MCRB calculates with costs C_M of 1.5 M EUR for developing the required business services in-house (make-decision).

Alternatively, the MCRB has the possibility to buy a configurable standard solution called *SmartCredit*[13] provided by the rating agency Schufa. *SmartCredit* is a solution to support customer loan processes of different FSPs. This solution includes all functionalities required by the MCRB. Resulting from negotiations with Schufa the MCRB has to pay a fixed price of 1.15 M EUR (variable C_B) for using *SmartCredit* for a period of four years.

Following traditional make-or-buy approaches, the MCRB would compare the internal development costs (C_M = 1.5 M EUR) and the costs to buy the externally provided solution *SmartCredit* (C_B = 1.15 M EUR) to come to a decision. Consequently, the MCRB would prefer to obtain *SmartCredit* ($C_B < C_M$). However, when evaluating the make alternative, the MCRB wants to additionally consider the option to sell the business services to other FSPs. Precisely, the MCRB wants to provide an access to their business services via proprietary frontends of external FSPs (illustrated by the external distribution frontends in Figure 1). This option can be exercised at the earliest after finishing the internal development of the web services which the MCRB estimates to 0.5 years (variable T). However, the MCRB cannot sell the services without further investments to make them marketable. Some additional costs are exemplified in the following:

[13] For detailed information, see www.informationlinks.de/smartcredit_uebersicht.html and www.schufa.de/de/produkteservices/entscheidungsmanagementsystemlsungenberatung/smartcredit/smartcredit.jsp.

Additional development costs:

- *Extensions of channel tags*: Web service requests contain meta-data to identify the channel from which the web service is requested (channel tag). Depending on the channel tag, the available loan models and conditions may differ. Therefore, the existing channel tags have to be extended for external requests.
- *Extensions of enumerations*: Potential customers have to choose (by means of a drop-down list) several characteristics of themselves and the requested loan model. For instance, each customer has to select the intended purpose (e.g. "home renovation" or "new car") of the requested loan by a choice from an enumeration of purposes. As external FSPs may offer more or different intended purposes compared to the MCRB, the web services have to be extended accordingly.
- *Modifications of web service interfaces*: To support communication to backend systems of external FSPs, the interfaces of the web services have to be made more flexible.

Hosting costs:

- *Security measures*: To ensure that no additional security risks arise by providing the web services externally, additional security measures like additional firewalls or secure channels are necessary.

According to internal cost estimations conducted by the MCRB, the additional costs for making the web services marketable reach the total of about 0.7 M EUR (variable X). Obviously, the MCRB will only further invest in the business services at the *instant* $T = 0.5$, and thus provide them to other FSPs, if the revenues from selling the business services exceed the costs for making them marketable. For better estimations about the revenues in $t = 0$, the MCRB asked other FSPs, with whom they have been cooperated already, in order to see if they are interested in using the web services for a fee of 2.20 EUR per signed loan contract. Two of the asked FSPs showed interest in using the services to the mentioned conditions. For estimating the customer demand in $t = 0$, we first analyzed historical data concerning the number of quarterly signed consumer loan contracts in Germany in 2008, 2009 and 2010 (cf. Figure 2).

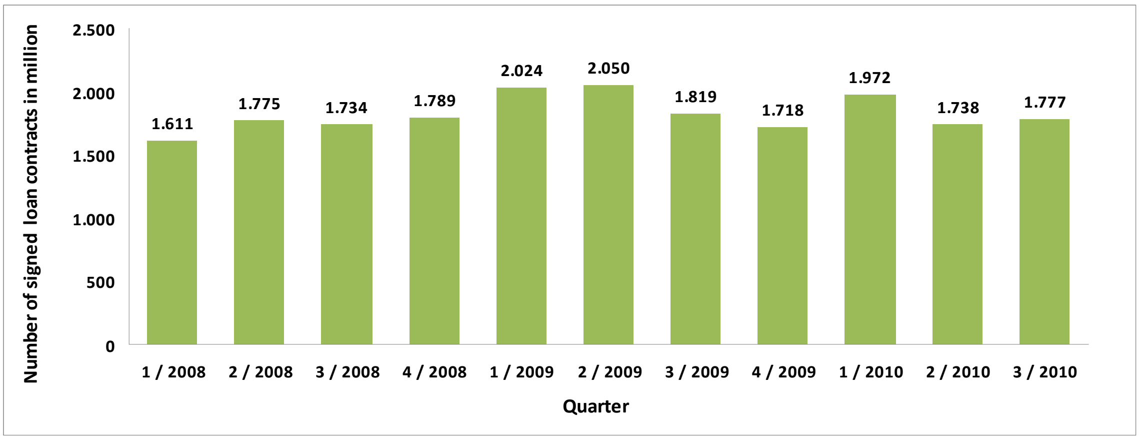

Figure 2. Quarterly signed consumer loan contracts (SCHUFA 2010a, SCHUFA 2010b)

Based on these historical data we are able to calculate the arithmetic mean of the signed contracts per year in Germany to an amount of approx. 7.2 M contracts. As in recent years, the two interested FSPs had a consumer loan market share of about 2% in total, we assume a comparable market share for the future. Based on this assumption, we calculate the future revenues from selling the web services by multiplying the expected number of annual signed contracts of both interested FSPs (over four years[14]) with the fee of 2.20 EUR per signed contract. This results in a (conservative) estimation of about 1.28 M EUR (variable S_0) for the expected revenues from selling the web services. To calculate the volatility of the revenues we also use the historical data of *Figure 2*. Based on the approach of Hull (2009) to empirically estimate this volatility we calculate an annual standard deviation of 17.7 % (variable σ). The risk free rate r_f currently accounts for 3% (ECB 2011). Based on these input data, we are now able to calculate the value of the sell option to approx. 0.59 M EUR (variable O) using equation (E2). The parameters for calculating the value of the sell option are summarized in Table 3.

[14] With respect to changing business requirements and technological innovations, we assume a planning horizon of four years for the composite web service.

Variable	Definition	Parameterization in the real world case	Amount
Input			
S_0	Excepted Revenues (EUR)	Calculated using subsequent input parameters	1,280,448
	Average number of signed contracts per year in Germany	Calculated using statistical data from Schufa (2010a) and Schufa (2010b)	7,275,273
	Planning horizon of the composite web service (in years)	Estimated based on involved technology and business area	4
	Cumulative market share of customers (other FSPs)	Estimated based on historical data	2 %
	Fixed fee (for using the web service) per signed loan contract (EUR)	Determined by MCRB in order to maximize its expected revenues	2.20
X	Fixed costs (EUR)	Estimated based on internal cost estimations	700,000
σ	Volatility in customer demand	Calculated using statistical data from Schufa (2010a) and Schufa (2010b)	17.71 %
r_f	Risk-free discount rate	Estimated based on statistical data from ECB (2011)	3 %
T	Time to maturity of the option	Given as input data by MCRB	0.5
Output			
O	Value of sell option (EUR)	Calculated using BSM	590,870

Table 3. Input and output parameters for calculating the value of the sell option O

Furthermore, using equation (E1) and the calculated costs C_M of 1.5 M EUR for developing the required business services in-house we are now able to determine the adjusted costs for developing the web service of approx. 0.91 M EUR (variable AC_M). Taking the sell option into account, the company would now prefer to develop the business services internally as AC_M of about 0.91 M EUR is smaller than C_B= 1.15 M EUR. Hence, we illustrated that the presented make-and-sell or buy approach can lead to different results than traditional make-or-buy approaches. By integrating the option to sell a web service, the presented approach provides a more adequate modeling of the underlying economic situation (in case of a web service, which is suitable to be offered on the market) and therefore provides companies with an enhanced decision support.

5 Conclusion, limitations and future research

Throughout this paper a normative approach for supporting make-and-sell or buy decisions of web services has been presented. Because of the characteristics of web services like loose coupling or high standardized interfaces, they can be easier offered to other companies than traditional IT applications like software components, etc. Thus, if a company decides to internally develop a web service, it has additionally the option to sell the web service (but not the obligation) on the electronic market. Considering this, we introduced an approach to enhance traditional make-or-buy decision approaches by this option. To model the sell option we used real option theory and here the BSM. Therefore, it is important to note that applying BSM to evaluate the sell option seems to be reasonable, because web services are traded assets on the web service market. By the real world example we further illustrated that the option to sell a web service may have a considerable value, which has to be integrated into traditional make-or-buy decision making. To the best of our knowledge, this is the first approach to support such make-and-sell or buy decisions of web services.

Although we illustrated the strength of our approach in a real world example, we have to discuss some limitations that are starting points for further research:

- *Parameterization*: Although we extensively presented how the input parameters of our approach may be estimated, these values are often based on historical data, experiences, and subjective estimations. Consequently, in practice, errors will occur regardless of the accuracy in the estimation procedure. Therefore, decision makers should use a sensitivity analysis to identify input parameters that are crucial for the make-and-sell or buy decision. We did such a sensitivity analysis according to our real world example, which means we increased and decreased each estimated value up to 18% for the input parameters S_0, X, T, r_f and σ ceteris paribus. In our example, such a deviation would not have changed the resulting decision for developing the web services internally. However, it is the task of research, to further refine the available estimation techniques.

- *Modeling*: The presented approach is based on the assumption that the costs to make a web service marketable are certain and known in advance. This was necessary to use the BSM in a well-founded way and thus demonstrating the effects of the sell option on decision making. Applying the Margrabe Model (Margrabe 1978) to evaluate the sell option makes it possible to relax this assumption, which means we can consider uncertain costs. Hence, investigating the applicability of the Margrabe Model is a future research step. In addition, we assumed that the revenues from the internal use of the web service are equal regardless whether the web service has been developed in-house or bought from an external service provider. In case revenues are not supposed to be equal (e.g. due to different service functionalities of both alternatives), they have to be considered in decision-making. Thus, it is also an issue for further research. In this respect, for example Dos Santos (1991) and Taudes (1998) illustrate how such revenues can be modeled (using traditional NPV methods) and Taudes et al. (2000) present a possible procedure to calculate revenues.

Having discussed important limitations of our model, we want to conclude with a more general perspective on the generalizability and the breadth of the application of our approach. We have illustrated that our approach is appropriate for the valuation of web services supporting consumer loan processes because these web services can be reused by other FSPs. Because the latter characteristic is crucial for applying our approach, it seems to be applicable to further companies of different branches which aim also for valuating (externally) reusable web services. Furthermore, we expect that the approach is transferable to other IT services like infrastructure or platform services. Also digital products which are traded on markets seem to be appropriate to be evaluated by our approach. Such a possible further application may be for example the evaluation of make-and-sell or buy decisions of mashup-oriented and presentation-oriented services which are embedded in websites or portals, and introduce newer Web 2.0 styles services based on APP, Atom, RSS or REST (Legner 2009).

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