Valuing the Advantage of Early Termination: Adopting Real Options Theory for SaaS

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Abstract

Traditional financial methods such as “net present value” or “discounted cash flow” are strongly limited when evaluating IT with a high usage flexibility degree. Especially with SaaS, the option to adopt and quit these services short term cannot be valued adequately with traditional methods. Towards this end, theory provides the real option approach that allows for evaluating not only the costs and benefits, but also the flexibility of IS. However, in terms of IS research this theory is often applied in order to evaluate the option to “grow” or to “defer”. The advantage of early termination, such as with SaaS, has not yet been adequately studied. Therefore, this paper adopts the real option theory and transfers it to the purposes of early termination. Moreover, the impact of real options on overall service evaluation is impressively demonstrated by a case study. The paper aims to expand IS research on the use of real options in the context of SaaS decision-making.

1. Introduction

The importance of acquiring, implementing and using adequate information systems (IS) is rather significant for supporting business processes of organizations and can lead to competitive advantage [3, 8, 46]. Indicators such as costs, benefits, risks, or technical suitability constitute important factors for evaluating the economics of IS [22, 38, 55]. Hence, during the last decade, the IT industry has increasingly promoted various cloud service models such as software-as-a-service (SaaS) next to other outsourcing variations and traditional on-premise IS. SaaS is marketed as being cost efficient, highly scalable, and flexible [2, 34]. In contrast, security concerns remain the biggest obstacle for potential organizations [20, 32]. However, scientific research has recognized the SaaS trend early [58], and several critical papers dealing with related topics, such as risk assessment, provider selection, and the financial comparisons between traditional services and SaaS, have been published [e.g., 7, 35]. Although the corresponding results in terms of financial favorability basically involve both directions, the majority of the papers link SaaS with financial benefits [e.g., 9, 38, 44]. Independent from their specific outcomes, previous academic papers lack the consideration of one specific advantage of SaaS, namely the right, but not the obligation to cancel contracts with the SaaS provider short term without having upfront asset investments [2, 23, 39] as is usual with traditional IS, which leads us directly to the real option approach [42]. Almost every formal paper on financial SaaS evaluation and comparisons stresses the asset free provisioning model in the introduction section [e.g., 9, 31, 41], but assumes predefined usage periods for the underlying SaaS and its alternatives in the formal model. This research gap constitutes the starting point of the underlying paper.

In a first step, we involve the option to abandon via a mathematical model. Thereafter, we construct an illustrative case study to demonstrate the impacts of our approach on IS investment decisions. Herewith, we focus especially on the comparison between SaaS and traditional on-premise systems. We strongly believe that this approach will contribute to the existing body of knowledge of both theory and practice: On the one side, scientific research on cloud computing and SaaS will gain from important theory transfer on real options theory (ROT), which has been made only to very limited degree so far. Even though there are many papers on ROT in IS research, these mostly discuss investment decisions for traditional asset models, which can hardly be transferred to SaaS specifics. Moreover, the option to abandon is to the best of our knowledge missing in IS research so far, which again indicates the focus on traditional asset models. In practice, decision makers will gain from running favorability predictions on a more comprehensive and sustainable basis. Therefore, we state the following research question: Acknowledging SaaS, how can the option to abandon services be evaluated in a formal decision model?
The paper is structured as follows: After the introduction, the second section discusses the research approach. Next, we will outline the theoretical background and prior research. In section four, the prediction model is derived and subsequently tested by means of a simulation via an illustrative case study. The work ends with the conclusion section.

2. Research approach

Our research approach (cf. Figure 1) is presented in business process modeling (BPM) notation and grounds on a recommended procedure by Jenkins [25]. The first step constitutes the formulation of the research question and literature search. Second, we analyze the literature via a theoretical and empirical lens. Thereafter, we enrich the existing body of knowledge by designing the initial model and by evaluating the model via an exemplary case study [47]. The model design and application phases include an iterative development. Finally, the results have to be documented in research literature.

For the first and the second step, we applied a systematic literature review [56]. Towards this end, we searched the databases of the top 30 IS journals according to the AIS journal ranking list, the Digital Libraries of ACM and IEEE, as well as the major IS conferences ECIS and ICIS. For the search in the papers’ titles, abstracts, and keywords, we used the searching strings (“real option*”) AND (“Information system*” OR “information technolog*” OR “cloud computing” OR “SaaS”). Having reviewed the identified articles, we considered only those that not only argumentatively but also financially evaluate real options in IS. The reason for this is that only these papers discuss and consider the relevant assumptions of ROT. In this way, we identified 42 papers. Our major findings are discussed in the subsequent section.

3. Theoretical background and related empirical research

First, we briefly explain the cloud computing (CC) paradigm and SaaS as a specific CC model in particular. Thereafter, we discuss the ROT and outline its necessity for the evaluation of SaaS. Then, we integrate and classify our paper in related work.

3.1. Cloud computing

The National Institute of Standards and Technology generally defines CC as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” [39].

Figure 1: Research approach

The majority of the scientific literature outlines three service models [33, 39]: “Infrastructure-as-a-Service (IaaS)”, “Platform-as-a-Service (PaaS)”, and finally SaaS. The focus of our investigation is on SaaS, which ranges from simple supporting services such as travel management up to complex enterprise resource planning or supply chain systems. With SaaS, there is a switch to asset free IT provisioning models where highly scalable hardware, software, and data resources are available by means of a network [8, 34]. The SaaS end user is able to obtain complete software services from encapsulated functions directly from the provider via the web, at any location and at any time [3]. Furthermore, there are various CC deployments such as public, private, hybrid or community CC [23, 34, 39]. This paper addresses especially public CC where an external provider offers services through the Internet. This is because the other deployment types show a lower degree of outsourcing and hence, this weakens the “asset free” argumentation, which in turn lowers the suitability of ROT in the context of this paper.
Moreover, CC emerged from the general IT-outsourcing trend, and researchers in this topic will find several points of contact with the IT-outsourcing literature [e.g., 24]. But specific features of CC make it hard to compare traditional IT-outsourcing with actual CC issues. Here, we want to mention just a few relevant differences [cf. detailed discussion e.g., 2, 34] in order to delimit our paper from the overall IT-outsourcing research. First, with CC and the pay-as-you-go utility model there is a high “variability” of IT costs, which is not the case with traditional IT-outsourcing. In concrete terms, IT consumption and IT costs have a higher proportional relationship with CC. Moreover, the absence of upfront commitment by cloud users makes it easy to adopt, test, or quit new services short term. Such modifications are far more complicated with traditional IT-outsourcing services and their mid or long term contracts [2, 39].

3.2. Real options theory

Scientific literature often applies ROT for the valuation of IS investments [54, 57]. This is because these investments especially involve a great uncertainty arising from their complex, unpredictable, and changing circumstances [19]. Furthermore, ROT supports the evaluation of managerial flexibility that is accompanied by IS investments [6]. Moreover, early works on ROT in IS argue that classic prediction concepts, such as the simple net present value, undervalue investments that include higher flexibility degrees [e.g., 51, 53 pp. 152], which may lead to wrong decisions. ROT is derived from financial theory and transfers the basic flexibility logic – do not have to react but can – on all kinds of real life investment projects, often in terms of a financial valuation of these investments [42]. Basically all types of options enable the decision maker to conduct a certain action for an upfront agreed price in a certain period of time. Whereas the European option includes the possibility to react at one point in time, namely at maturity, the American option includes reaction possibilities prior to maturity as well.

In the context of IS investments, Trigeorgis [53 pp. 2] presented several types of managerial flexibilities and the related call and put options: (i) option to switch, when the input resources can be replaced; (ii) option to growth, when a successful adoption may lead to follow-up investments; (iii) option to defer, when investments may be postponed or carried out in stages; (iv) option to expand, when systems can be scaled up; (v) option to contract, when systems can be scaled down; and finally (vi) option to abandon, when running a non-adequate system can be stopped. In general, all these option types may be fruitful for investigating the differences between CC and on-premise systems. However, this paper focuses especially on the last aspect (vi) as we found that this was not adequately addressed by scientific research so far. Moreover, this option type is highly relevant for SaaS.

In general, at a specific point in time real options have a specific value that cannot be negative. Herein, option pricing models are often used for assessing this value. Two major pricing models are dominating the scientific literature, namely the Black-Scholes-Model [10] and the Binomial-Model [15]. The Black-Scholes-Model is the most popular continuous-time model assuming that the underlying asset develops in accordance with a continuous geometric Brownian motion [e.g., 54]. Based on this, a solvable equation is constructed that enables the calculation of a European option. In a discrete-time perspective, the binomial-model is the most often applied particularly for multi-option analysis [1]. The multi-option analysis results in a binomial tree. The option values of the single points in time are discounted to the time of IS acquisition and weighted with risk-neutral probabilities in order to calculate the value of the option [15]. Since it is the purpose of this paper to evaluate the advantage of SaaS discontinuation possibilities, that may embed a number of options in various points in time after implementation (put options), we adopt the binomial-model. Furthermore, with the binomial-model the number of assumptions to be made is lower, which promotes transparency at simulation and sensitivity analysis [50].

From the above mentioned statements it is obvious that ROT constitutes a fruitful basis for valuing or comparing various types of SaaS with different periods of notice, or comparing SaaS with other IS such as on-premise systems that require upfront hardware and software investments which may lead to sunk costs in case of system unsuitability. In contrast, SaaS offers a higher degree of flexibility as there are “theoretically” no upfront-costs. The ever changing external business environment as well as internal events may lead to changes in the system adequateness. With SaaS usage, the potential to limit downside losses is bigger than with traditional systems. Hence, the price of a public SaaS includes a specific and hidden real option value that is not existent in traditional IS.

3.3. Related empirical work

As mentioned before, our literature search led to 42 high-quality papers that used ROT for valuing IS investments as well. In this sub-section, we outline the most important empirical findings. Thereafter, we explain how our work distinguishes from the existing papers.
Most of the papers (19) discuss growth options in IS investment decisions. Logically, earlier works discuss older IS. For instance, Dos Santos [17] investigated organization-wide ISDN implementation and the possible advantage of favorable ad-on services. Towards this end, Panayi and Trigeorgis [45] used a comparable approach for valuing the extension of a company’s telecommunications network. Stickel [50] and Campbell [13] discuss the growth option at a higher abstraction degree, while running extensive simulation analysis. Miller [40] focuses especially on the factors “infrastructure expenditures irreversibility”, “managerial flexibility”, and “uncertainty”. His sensitivity analysis impressively shows the value of a growth option by means of a multi stage procedure. At the end of the last decade, the works by Kim et al. [30] as well as Harmantzis and Tanguturi [21] focused on the IT investment-intensive business of telecommunication companies and the adequate procedure of decision making for profitable growth. All these papers have in common that they analyze investments in new IT projects and new business opportunities. Moreover, they criticize that investments are normally based upon “gut feel” [17]. When switching the view from “making new business” with IS to “adequate usage” of IS [54], there are a few papers that link enterprise resource planning (ERP) investments and growth options [e.g., 51, 52]. The paper by Chen [14] stands out for involving various kinds of risks such as team risks and competition risks, while presenting and applying a model for ERP investments.

There are significantly less publications addressing the other real option variants. Considering the option to defer (11 papers), especially the papers by Benaroch and Kauffmann provide valuable insights to IS research [e.g., 4, 5, 6, 28, 29]. Herein, the “timing of deployment” plays the major role (e.g., at a point-of-sale debit service by a shared electronic banking network). Regarding the switch option, Singh et al. [49] discuss the software rental agreements of application service providers. This work is important for our study as it includes the factor of spreading out payments along a contractual period; even the contract duration is predefined. Considering the option to abandon in IS research, we found only one paper [12]. Written from the providers’ perspective, the paper focuses especially on the cost structures of e-commerce products in order to evaluate new business options, while providing a framework that involves some of the other options types as well.

Moreover, there are some valuable works that analyze traditional IT-outsourcing in combination with ROT, which might be seen as a related field to SaaS (cf. 3.2 for major differences between IT-outsourcing and CC). And also the majority of these papers strive for growth options in particular. Nembhard et al. [43] investigate the optimal outsourcing conditions by means of a ein model (SEM)  simulation considering the unit production cost, unit outsourcing price, and unit delivery cost. Datta [16] links ROT and transaction cost theory for the purpose of providing decision support regarding the question under which conditions backourcing of activities (switch option) should be considered. The contribution of Jiang et al. [26] is of unique nature as the authors evaluate outsourcing contracts from the service providers’ perspective and also take account of the loss of waiting. In contrast, Meinl [36] as well as Meinl and Neumann [37] focus on the need for an advance reservation scheme in grid computing environments, when internal computational resources are limited (growth option). Additionally, there is one paper [48] linking CC and ROT by investigating the most important option types for cloud adoption. However, this paper uses the structural equation model (SEM) approach and indicates that the option to terminate services has a significant influence on CC adoption.

Our work distinguishes from the existing scientific literature for the following reasons. To our knowledge, there is up to date no paper that transfers ROT to SaaS (or CC) research via a formal model while providing a helpful decision making approach (i.e. outsourcing or backsourcing IS). Further, it gets obvious from the above stated references that termination options are underrepresented in IS research. And this kind of options is particularly critical in the context of SaaS. Within IS research, the traditional IT-outsourcing field is close to SaaS research. However, the pay-as-you-go model (cf. section 3.1) usually enables the user to enter into contracts with shorter terms in comparison with traditional IT-outsourcing, which leads to more flexibility and makes the option to abandon even more important in terms of SaaS usage. Furthermore, our paper provides a unique comparison model between a SaaS and traditional on-premise services via a case study simulation.

4. Binomial model application

With real option analysis one can answer the question which adoption strategy is the most appropriate considering the termination flexibility. As mentioned before, we use the binomial model by Cox et al. [15], which is acknowledged as a suitable method to value real options in discrete time using binomial lattice. The initial model assumes that the value of a risky underlying asset, in this case the SaaS, will move up or down \((u)\) by a specific factor at every step in the tree, where \(0 < d < 1\) and \(u > 1\). Following the
upward and downward movement, the value of an implemented SaaS may increase in value to \( uV \) or decrease in value to \( dV \). The probability that the value \( V \) will rise is assumed to be \( q \), and the probability that the value \( V \) will fall is \( 1-q \). At each node of the tree the option value is simply its exercise value. The value of a put option in the up state is \( Pu = \max(K - uV) \). The value of the down state is \( Pd = \max(K - dV) \). Beyond that the value of a call option is \( Cu = \max(uV - K) \) and \( Cd = \max(dV - K) \). Respectively. In these formulas, \( K \) is the strike price to exercise the option and \( rf \) is the risk free rate. The up and down factors are calculated with the equations:

\[
\begin{align*}
(1) & \quad P = (pPu + (1 - p) Pd) / (1 + rf) \\
(2) & \quad p = ((1 + rf) - d) / (u - d)
\end{align*}
\]

where \( \sigma \) is the volatility and \( dt \) is the length of each time step in the binomial tree (equal to the option’s maturity divided by the number of time steps). Once the binomial lattice of all possible asset prices up to maturity has been calculated, the option value is found at each node by working backward from the final nodes to present [11, 15]. In equation (1), the \( P \) is interchangeable with the value of the call option \( C \).

In a simple 3-year case, we would like to show the effect of using ROT for SaaS implementation decisions. Imagine initial service costs (SC) of $27.7k in \( t = 0 \) in order to enable the company to access the provider-hosted applications. The company has a constant potential service user amount of 10 and the SaaS takes in total costs of $10k per user. Provided that the service is suitable, the benefit would be 20% higher than the costs (\( u = 1.2 \)). Otherwise, the benefit is 50% of the costs (\( d = 0.5 \)). Hence, we define the periodic service costs of $100k to be equal to the benefit base \( BB \). Due to constantly changing user requirements and service updates, the suitability varies within the three years by the defined upward and downward values. The underlying risk free rate \( rf \) is 5%. Furthermore, we assume that there is an asset that has the same in term of arbitrage free markets (“pricing by duplication”).

The decisions are typically derived by starting backwards at the end of the binomial tree. Acknowledging the needed decision in \( t = 2 \) in the upward > upward stage, the calculation would be max [(0.786*$72.8k + 0.214*$28.0k) / 1.05, 0]. This equals the grey marked $48.8k, and hence, the service should not be terminated at this stage. In all other situations in which \( t = 2 \) it is not beneficial to continue the service. Using this approach in \( t = 1 \) and \( t = 0 \) as well, the company has an option-based net present value (NPV) of $22.9k in \( t = 0 \). However, the ROT concept prevents down side losses, which is stated with a zero in the grey fields.

For calculating this example with the NPV approach neglecting ROT, we would first need to define the “risk-adjusted” interest rate \( r \), which can be determined by (adopted from Stickel [50]):

\[
\begin{align*}
(5) & \quad DB = BB \sum_{t=0}^{3} \left( \right)^{t} \\
(6) & \quad NPV = DB + \sum_{t=1}^{T} SC(1+r)^{-t}
\end{align*}
\]

where the \( DB \) represents the discounted benefits for the whole binomial tree and \( BB \) is the benefit base. From this equation, we get \( r = 0.05 \). (In this example equal to the \( rf \) due to the linear relationship to \( p \)). Hence, we can use equation (6) for deriving the “NPV-only” value, involving the service costs \( SC \):

\[
\begin{align*}
(6) & \quad NPV = DB + \sum_{t=1}^{T} SC(1+r)^{-t}
\end{align*}
\]

In this case, the NPV is $0.0 and hence, this approach might lead to wrong recommendations. The value of the termination option can easily be determined by calculating the difference between option-based NPV and the NPV-only amount: $22.9k - $0 = $22.9k (see appendix for a more detailed calculation of the example).

### Figure 2: Example for early termination of SaaS

<table>
<thead>
<tr>
<th>t=0</th>
<th>t=1</th>
<th>t=2</th>
<th>t=3</th>
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<tbody>
<tr>
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<tr>
<td>-100.0</td>
<td>172.8</td>
<td>-100.0</td>
<td>144.0</td>
</tr>
<tr>
<td>-100.0</td>
<td>120.0</td>
<td>-100.0</td>
<td>60.0</td>
</tr>
<tr>
<td>-27.7</td>
<td>50.6</td>
<td>-100.0</td>
<td>60.0</td>
</tr>
<tr>
<td>-100.0</td>
<td>50.0</td>
<td>-100.0</td>
<td>25.0</td>
</tr>
</tbody>
</table>

In $k
Before we proceed with the simulation in section 5, we want to make two preliminary conclusions. First, in classic ROT, the early termination right is normally stated as a put option, enabling the decision maker to exit a project in case of undesired project developments. However, in these classic put option assumptions, the decision maker normally receives a predefined payment (e.g., from the counter position), when the underlying has a lower actual value than the strike price. The above stated simple example impressively shows that the right to terminate may not necessarily be connected to any predefined equalization payments, which is unrealistic in the provider-user relationship anyhow.

Hence, from the ROT perspective the right to early termination can be seen as subsequent call options, when the SaaS is beneficial for the company. Compared to traditional IT-outsourcing and on-premise services in particular, literature argues that cloud computing provides a higher degree of flexibility (joining and exiting services short term); and therefore, the additional value through termination chances should be considered in comprehensive decision making processes. From the financial perspective, this might be seen as something unique in the cloud paradigm, namely the ongoing chance to “call” a specific service.

Second, by stating that pure NPV calculations, which are often used for IS investment [49], are undervaluing more flexible information systems, this paper is in conformity with prior work [e.g., 6, 19]. Nowadays, this argumentation is even more valid when comparing more or less non-flexible on-premise systems with highly flexible information systems such as SaaS. For instance, the upfront investments of on-premise systems can be classified as “sunk costs” in case the system proves to be unsuitable. With SaaS, however, the costs are evenly spread along the usage duration, which enables the user to quit the service in case of unsuitability.

5. Illustrative case study simulation

In general, it is quite hard to predict critical variables such as benefits, the upward trend $u$, or the downward trend $d$ of specific IT services. And it is even more complex to compare various services adequately. One possibility to analyze the influence of the mentioned critical variables is to assume them to behave randomly according to an underlying probability distribution and to perform numerical simulations in order to obtain the corresponding histograms of the affected quantities. Towards this end, we transferred the above stated model (cf. section 4) to a software-supported simulation. For this purpose, the software Matlab by the provider MathWorks was used. Matlab is a multi-paradigm programming language for numerical simulations and it is used both in industrial enterprises and in scientific institutions. We designed the programming in such a way that basically all relationships of the model can be analyzed. In the underlying paper, we made especially use of the tool’s graphic options. In order to illustrate the relationships of the model, we created the following case study.

The upcoming data is derived from three semi-structured expert interviews at a SaaS-experienced international automotive supplier with headquarters in Germany. We aggregated and structured the data in order to increase the transparency and to illustrate the relations of the variables. For the SaaS solution, we take the costs and the benefits from Figure 2 as a basis. (The benefit base of $100k remains unchanged compared to the prior example).

Moreover, the case company estimates the probability for upwards trend for every of the three years to be $p = 0.8$ and movements to be $u = 1.2$ and $d = 0.5$. Herewith, we determine an interest rate $r$ of 0.06 (cf. equation (5)). Alternatively, the company receives an offer from an on-premise provider for a comparable solution. The investment in $r = 0$ would be $-268.3k$ (incl. hardware, software, and integration costs), while the annual service costs for operating expenses, proportional salaries, maintenance, and licenses equal $-10k$. For simplification reasons, we assume the on-premise solution to involve the same $u$, $d$, and benefit base structure as the SaaS (cf. Figure 2). These assumptions are not compellingly needed for carrying out the simulation, but they facilitate the understanding of the underlying relationships significantly. In this initial state, both solutions have the same NPV-only of $5.0k$, when not considering real options (see appendix for a more detailed calculation of the case study).

As the programming allows us to analyze the influence of virtually any variable (including $T$), we decided for this case exemplarily to vary the upward trend $u$ randomly according to a specific probability distribution. The case company assumes to have an upward mean of 1.2. For every randomly generated $u$ we computed in a first step the corresponding real option value and real option-adjusted NPV of the SaaS solution. In a second step, we computed the needed benefit base of the on-premise service in order to get the same NPV as the real option-adjusted NPV of the SaaS. These computations were carried out for 5,000 randomly generated upward trends $u$ and finally resulted in histograms of the computed quantities.

In research literature, the normal distribution is often used for generating random numbers [e.g., 50]. But this distribution type may include negative values
for $u, d$ or the benefits, which does not make sense in our case. Moreover, the normal distribution has a symmetric shaping, which prevents more optimistic or pessimistic formation. Therefore, the distribution for the upward trend $u$ was chosen to be a modified beta-distribution [18 pp. 34-42], which contains only positive values and may take basically any shape. The probability density function of the beta distribution, for $0 \leq x \leq 1$, and shape parameters $a, \beta > 0$, is defined by:

$$f(x; a, \beta) = x^{a-1} (1-x)^{\beta-1} / (B(a, \beta)).$$

For the numerical simulations we set the parameters to $\alpha=2, \beta=5$ to model the pessimistic case and to $\alpha=5, \beta=2$ for the optimistic case. For both cases we modified the probability density function by applying a linear transformation on the corresponding random variable $u$, comprising a compression of the possible value range from the interval $[0,1]$ to $[0,0.3]$ and an additional shift of the mean to 1.2. This case study implicitly assumes that the usage durations of the compared alternatives might differ. In general, this assumption has already been extensively discussed and is often used in ROT literature [e.g., 49].

Figures 3 and 4 illustrate histograms of the discounted benefits, the real option-adjusted NPVs of the SaaS solution as well as the equivalently needed benefit bases of the on-premise service for the pessimistic and optimistic case, respectively. It can be seen that the benefit base of $100k$ of the on-premise solution has to increase up to 10% in order to have the same option-adjusted NPV as the SaaS solution. Moreover, the function of the option values shows that there is a non-linear relationship between the upward trend and the needed benefit of the on-premise solution. In the pessimistic case, the probability of smaller SaaS benefits is higher, which in average leads to a higher value of the option. In order to compensate this higher option value, the needed benefits of the on-premise solution have a skewness to the left. In the optimistic case, the average option value is lower and consequently the needed benefits of the on-premise service are skewed to the right.

This case study simulation leads to a counterintuitive and noticeable outcome, namely the higher the average benefit of the SaaS, the lower the NPV advantage of the SaaS compared to the on-premise service. This is due to downside losses get more unlikely, leading to a lower value of the termination option. These results impressively show the usefulness of simulation analysis for decision-making processes in IT procurement comparisons.

### 6. Conclusion
#### 6.1. Implications for theory and practice

To the best of our knowledge, as the earliest paper demonstrating the valuation of termination in highly flexible systems such as SaaS, the underlying study extends the burgeoning theoretical literature on real options. It is also consistent with what Kahneman [27] characterizes as systematic errors that arise due to managers' bounded rationality. We explicitly want to mention four major implications. First, we show that the traditional capital budgeting technique cannot
appropriately price the flexibility of pay-as-you-go services such as SaaS, while the option pricing analysis is able to quantify such flexibility. This assessment of flexibility offers the decision maker the ability to evaluate SaaS contracts that offer sequential termination opportunities. Second, the explained stochastic programming model captures the flexibility of decision-making in IS procurement processes and provides support in finding the most appropriate strategy. Thus, it supplies decision makers involved in IS investments with a scientific and useful decision-making simulation analysis that allows them to seize investment opportunities more effectively. Third, we created a unique comparison procedure in order to set various IT services in direct relation to each other, which enables the decision-maker to select the right IS and thus ensures higher returns. Fourth, a case study has been conducted with a predefined number of users for the SaaS, and the time span was predefined. This might contradict the pay-as-you-go model at first glance. Here we want to encourage the practitioners to test the upload file, where cases with varying user amounts (function of benefits/costs) as well as subscription periods (function of benefits/costs and interest rates [e.g., monthly rate = \( r/12 \)]) can be simulated easily.

6.2. Limitations

With ROT there are certain general assumptions needed that simultaneously reflect limitations of the method [e.g., 15]. Nevertheless, this is an accepted method in the dynamic investment calculations [5, 19]. Focusing on our specific assumptions, the model involves the termination option only as we were about to explain particularly this advantage. However, the model involves the possibility of comparing different usage durations. Here we go in line with the argumentation of existing literature [e.g., 49] by stating that (i) a replacement SaaS is not compellingly needed in all cases (e.g., business unit stop) and that (ii) even if a replacement would be needed, the replacement service might have virtually any favorability. However, a combination with other option types (e.g., switch options) might lead to additional valuable findings. Further, the linear development of the benefits and constant yearly costs might be more complex in other cases, when firms face strongly changing requirements. Moreover, we adopt risk neutrality when comparing the services while neglecting factors such as security risks. Future research might include this aspect within interest rates or yearly costs.

6.3. Outlook

The paper at hand bridges ROT and research on SaaS. Starting with theoretical and empirical work, we clearly explain the valuable contribution, namely the advantage of early termination of flexible IT services. We adopt the binomial model and run an extensive case study simulation in order to present the impacts and relationships in more detail. Future research might expand our work in two ways. On the one side, it could broaden the scope of our approach (cf. limitations) in order to derive more realistic models. On the other side, more empirical assessments of the model are needed for an in-depth validation. To conclude, we
would like to encourage practice to utilize the presented model for the following reason: with the paradigm shift towards asset free IT, various IT concepts have to be compared and it is mandatory for decision makers to acquire deep technical as well as financial knowledge in order to select the adequate service in the long run.

7. References


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Appendix

Further calculations to this paper are available online and may be downloaded from the following link: http://tinyurl.com/nmgr5yx