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Value Creation in Software Service Platforms

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Abstract: In order to benefit from operating an IT service platform (e.g., SaaS platform), platform providers need to find a way to keep their existing users and application services active sources of value. However, the understanding of how to achieve that is limited due to the newness of this kind of business. This paper investigates whether all stakeholders of the platform ecosystem can generate sufficient value when participating in the platform. As stakeholders, we consider application service users, service developers, and service platform providers. We also analyze the interrelationship between these stakeholders. The analysis outcome is a value creation model that allows the calculation of the stakeholders' values. The model also helps inferring the relative impact of different factors on the evolution of values of the software service platform stakeholders. Our simulation results confirm that all stakeholders of a service platform mainly benefit from a growing installed base of application users. However, in a mature market, a large service variety mainly benefits the service platform provider, while the other stakeholders obtain a reduced increase in their benefits. In particular, the utility growth of application users becomes constrained as the benefit from new connections with other users decreases and the number of new services used decreases. Similarly, the revenue of service developer decreases, making service development less profitable. Therefore, we can state that not only a large fraction of the value creation goes to the platform provider but also that the software service ecosystem can collapse, if no mutually beneficial pricing of services is implemented.

Keywords: SaaS and PaaS platform, value creation, value distribution model, two-sided network effect, business modeling, software business, cloud computing, software ecosystem, software services.

JEL Classification Numbers: C15, C44, C61, D01, D02, D11, D46, L11, L15, L86, M15, M21.

1. Introduction

Software service platforms are becoming the founding infrastructure of today's digital economy. These platforms include Internet platform providers, which operate software-as-a-service (SaaS) services or platform-as-a-service (PaaS) services as part of the cloud computing infrastructure. They provide an enabling technology for the development and provision of application services. Although these stakeholders of the platform ecosystem obtain different values, the value creations are interrelated, creating a complex value distribution system.

Software service platforms achieve economies of scale and economies of scope quickly, making the speed of adoption, the size of the customer base, the diversity, and the number of application services offered important value drivers. For example, the mobile platforms, iOS and Android, each offered more than 700,000 applications services to more than 500 million users in 2012 [1], compared to 1,200,000 application services and 700 million iOS users in the beginning of 2014 [65].

While more and more application services are offered, very little studies have been performed to determine the values that these offerings actually generate for the stakeholders involved. Therefore, there is an inevitable challenge for service platform business managers to measure the value of services provided [2, 3]. Although an early definition of value exchange has been given in [4], it is not clear yet how the number of new application users and their capacity to use these services determine the long-term incentives for service platform providers and developers to participate in the platform.

Therefore, the understanding of the structure of value creation and value distribution in different situations is of major importance. It is the basis for innovations in the service platform. To that effect, the understanding of the structure of value creation and value distribution in different situations is the objective of this research. Based on this research objective, three research questions are defined: (1) How is value created in software service platforms? (2) How is the value distributed among the stakeholders? (3) How does the value distribution changes in different situations?

In order to answer the research questions, this study identifies three types of stakeholders and four service value parameters: quality of service (QoS), number of services (service variety), number of users (installed base), and cost. These value parameters are used for explaining the net value that an application service generates to the stakeholders of a software service platform. The three types of stakeholders are a service platform provider, service developers, and application service users. The four service value parameters are integrated into three additive utility functions, representing the values generated for the respective stakeholders. The utility functions enable the evaluation of the value creation and value distribution through a software service platform. For the analysis of the relative changes of values for platform stakeholders, system dynamics (i.e., a simulation technique) has been used. The system dynamics software used is Vensim of Ventana Systems [72].

Our simulation results imply that the value obtained by service developers is quite low in comparison to the one of the platform provider. Moreover, in a mature market (i.e., in a market, in which the number of new users slows down), service developers even experience a declining allocation of value. Furthermore, if the cost for application service users is high or the cost for service developers is high, service developers face the most difficulty in generating value. This indicates a risk that service developers will withdraw from the platform, causing a market failure.

Considering these results, our contribution is an understanding of the economic fragility of software service platforms. This understanding is essential, as our economies rely more and more on software service platforms. Any market failure would not only disrupt the software industry sector but also the industry sectors that rely on software solutions. In addition to this, our research is the first research on modelling the value creation of software service platforms and the distribution of value among stakeholders of a software service platform. The results will help specifying sustainable service platform businesses, in which service platform providers continuously innovate new ways of value exchange between application users and developers. This way, sufficient value is created for application users and developers, preventing them from withdrawing from the platform.

The outline of the remainder of this paper is as follows: Section 2 gives an overview about the state of the art of software service platforms. Section 3 presents the description of the proposed service value model and the utility functions of the stakeholders. This is followed by the description of the simulation settings in Section 4 and by the presentation of the simulation results in Section 5. Section 6 concludes the research with a discussion of the results, implications, and outlook.

2. State-of-the-Art

2.1. Software Service Platforms

A software service platform provides the underlying technology that enables the operation of software services and, therefore, the exchange of information and resources among the stakeholders of the platform [63, 64]. Besides computing services and storage services that are needed for software services executed on the platform, software service platforms also provide technological support. The software platform provider might offer these services by utilizing services of platform providers (e.g. PaaS providers and IaaS providers). The central concept of software service platforms is the hosting of software (e.g., social networking software, communication software, gaming software) created by developers and made available to end-users over the Internet. Some of the platforms currently available also provide their own service development kits (SDKs) to service developers.

According to Jansen and Cusumano [64], a software service platform is also an environment, in which an ecosystem of interacting stakeholders is created. It can also be considered a marketplace, in which the stakeholders trade [58, 61, 62]. Stakeholders that are considered in this study are: a platform provider, who provides platform-as-a-service and infrastructure-as-a-service to service developers; service developers, who develop and provide software-as-a-service to application users; and application users, who are consumers of software services. These stakeholders have interdependent roles and value expectations [4]. The interaction between the stakeholders creates value. Although not all stakeholders need to interact at the same time, all roles of these stakeholders are important to create a working software service ecosystem.

2.2. Value Creation in Software Service Platforms

Developments in service technologies, specifically the changes in the service delivery mode and the way of service use, reinforce a new way of thinking about the nature of the value that technologies generate for their stakeholders [5]. The main distinguishing feature of service platforms compared to traditional software markets is the provisioning of an environment for service developers to build functionality and offer it as a service to end-users. For example, software service platforms enable developers to target specific user groups by designing different software functionality bundles with specific pricing models on the software service platform.

In terms of the capabilities for value creation, the characteristics of software service platforms are also different from those of traditional software markets. In today's business environment, service providers can no longer just rely on simple comparisons of features, technical functions, and prices of their products with those of competitors, in order to determine their competitive advantage in the market. Value needs to be created through service integration, user generated content, and network externalities from the interaction of users. Studies pointed out that they have a significant positive impact on the total value generated for all market participants [6, 7, 8, 9].

Based on these facts, it can be stated that the unique characteristics of software service platforms result in new ways of value creations. Consequently, in order to properly identify the competitive advantages of platform providers through these value creations, the measures of value creations also need to consider these characteristics.

2.3. Theoretical Frameworks of Value Creation in Service Platforms

Theoretical value creation frameworks for e-businesses and, in particular, for service platforms have been proposed in recent literature [10, 11, 12, 13, 14, 15, 16, 56, 58]. A study of value creation in the context of e-business was conducted by Amit and Zott (2001) [10]. It identified dimensions of value creation and evaluated different business models related to service platforms. User-created value was discussed by Lee et al. (2010) [11], and research on value transformation in mobile service ecosystems was performed by Smedlund (2012) [12]. However, an evaluation of the effects of platform value distributions to its stakeholders, which is important for any business decision, cannot be performed with these frameworks. Hence, more sophisticated definitions of value factors and their measurable parameters are required.

Furthermore, there have been a number of studies that performed an analysis of the value creation process and value factors in platform-based markets [17, 18]. Among those, Kim et al. (2007) focused on the adoption of the mobile Internet, and Basole and Karla (2012) studied mobile service ecosystems [17, 18]. In addition to this, studies by Haile and Altmann (2012) and Gebregiorgis and Altmann (2012) focus on software service markets [3, 4, 57], explaining aspects of the impact of network effects and interoperability. Platforms for defining commodity services based on user preferences have also been analysed by Breskovic et al. and Risch et al. [59, 60].

Conclusively, we can state that the existing research works did not fully explain the value creation system of software service platforms in terms of all relevant parameters, the stakeholders involved, and the value exchange between the stakeholders. Our paper, however, addresses this research gap by introducing a new value creation framework for software service platforms, which can become a useful tool to service providers and policy makers. Besides the fact that the framework helps explaining the value of a service offering to application service users, service developers, and platform providers, it can also be used as a decision support tool for investments in service offerings and platforms, design of business models, service bundling, and market structure evolutions.

2.4. Two-Sided Network Effects

Two-sided platforms have been extensively studied in interdisciplinary literature of economics and information technology. One of the main issues brought up in this literature is the impact of network effect (i.e., demand-side economies of scale) on competition, market equilibrium, and compatibility decisions [19, 20, 21, 22, 23]. In determining the economic value of networked services, the role of network effects was described as an important value driver by these previous studies. Direct network effects create value generated from the number of existing users of a service, while indirect network effects enhance value built by the availability and interoperability of complimentary products [22, 23, 24]. The joined impact of those effects is explained through two-sided network effects [26, 27, 28]. The contexts of these studies dealing with two-sided network effects have been home videocassette recorders (VCRs), DVD players, personal digital assistants, and home video games [29, 30, 31, 32, 33, 34]. Some of these studies used equilibrium analysis to explain problems such as market failure, competition, and path dependency of markets [19, 20, 21, 24, 35, 37, 38, 39].

Two-sided network effects (i.e., demand-side and supply-side network effect) have also been considered a source of value in traditional software markets [25, 26, 27]. Users and providers experience value growth due to such effects. In the traditional software industry, Microsoft Windows is a very good example of the significance of two-sided network effects [42]. Microsoft built a business model that utilized network effects of platforms. The more Windows-compatible applications are available, the more reasons exist for users to choose Windows and, consequently, the more reasons for developers exist to build applications for Windows. This dynamics also exists in the current software service platform markets.

For software service platforms, interconnection of users and developers as well as service integration are more important factors than in traditional software markets [10, 40, 41]. If this can be achieved, service platforms can reach a large number of users and developers very fast. An example of this is the rise of the social network platform Facebook [5, 10, 11, 12]. Another study addressed the presence of direct and indirect utilities in the context of services and mobile app stores [18]. However, a comprehensive system model, which shows the stakeholders as well as the interdependence of their utilities, has not been developed so far.

All of the above-mentioned studies, with the exceptions of Gandal et al. (2000) and Park (2004) [29, 32], rely on frameworks, which cannot consider the dynamics of relationships between stakeholders. Although these studies provide good conceptual inputs, they have limitations in capturing the relationships of complex value creation systems. For example, Park (2004) [32], who modelled network effects in movie markets and assumed that consumer utility is a function of the number of consumers (installed base), did not consider movie variety in the model. Another example is Gandal et al. [29], which investigated the number of users in the context of CD players.

Furthermore, Zhu and Iansiti (2012) examined the relative importance of platform quality, indirect network effects, and consumer expectations on the success of entrants in a platform-based market [42]. They developed a theoretical model and compared the importance of these factors with respect to competition only. Their findings stated that the success of platforms depends on the strength of indirect network effects and the users' expectations regarding future services. Theories of network effects were also adopted as value factors in web service markets in studies by Amit and Zott (2001) and Lee et al. (2010) [10, 11], but they did not detail the exact value creation and distribution. Our analysis, however, provides a detailed value creation model that is based on the network effect of number of services, quality of service, and the network effect of users.

2.5. System Dynamics

The adoption of software service platforms represents a long-term commitment for users. As the benefits of a platform can only be realized over a long time of service use and through the establishment of personal connections on the platform, only a dynamic model can show the nature of the value creation for both the providers and the users. Such a dynamic model can capture the real life interactions and interdependences of stakeholders and can depict the impacts of their decisions. Motivated by these prerequisites for our research on software service platforms, system dynamics has been chosen as the method for analysing the interactions of stakeholders and for modelling the increase of value over time for each of the stakeholders.

System dynamics is an aspect of systems theory, which is concerned with the understanding of the behaviour of complex systems over time, taking into account time delays and feedback loops [43]. It is a methodology and modelling technique for framing and discussing complex issues and problems. System dynamics is currently being used for policy analysis and policy design. The basis of the method is the recognition that, in any system, relationships among its components are often just as important in determining the behaviour of a system as the individual components themselves. For further details on system dynamics, Sterman (2000) and Forrester (1961) can be consulted [43, 44]. Various research works using system dynamics can be found at http://www.systemdynamics.org/.

3. Proposed Value Creation Model for Software Service Platforms

The value creation model, we propose in this section, involves the identification of the stakeholders, the factors that determine the nature of values generated by the stakeholders, and a methodology for measuring the values. Therefore, the model is structured into three parts: stakeholder identification, specification of the factors and their effect on stakeholders, and formulas that quantify the values generated through the value exchange.

3.1. Identification of Stakeholders and their Value Exchange

As stakeholder theory suggests [45, 46], first we identify the group of stakeholders, who are affected by and can affect other stakeholders of a software service platform through their roles. Considering that a software service platform is comprised of the role of service development, the role of service consumption, and the role of establishment of a marketplace where services are offered to customers, three stakeholders can be identified. These stakeholders are the service developers (e.g., brokers, service integrators, and content creators), application users, and a software service platform provider. Although the ecosystem of a software service platform might involve more stakeholders such as advertisers, telecom providers (ISPs), shareholders of companies, consultants, policy makers, and integrators [47], the platform provider, the service developers, and application users are directly involved in the value exchange. Therefore, we consider them as the main actors of the value exchange system of the ecosystem.

A software service platform provider offers an environment, in which different types of third-party services (e.g., social network services, communication services, search engine services, entertainment services, computing services, and storage services) can be executed. The main part of the environment that is provided by the platform provider is the marketplace, enabling the value exchange between the two groups of platform customers, namely the service developers and the application users. A platform provider also plays the role of an intermediary between a service developer and an application user, enabling service discovery by prospective customers and potential integration with other services. As we do not consider the competition between software service platform providers, the interaction (e.g., brand name) with other software service platform providers does not need to be considered here.

In the context of this research, both, service developers and platform service providers, play the role of service providers to application users, since they own their respective services and are responsible for maintaining them. Nevertheless, as a distinguishing relationship between them exists, they will be treated as two different stakeholders.

Service developers are stakeholders, who are not only developers of application services but also the consumers of service development services and service deployment services offered by the software service platform providers. Service developers take on the role of producing and publishing services. They are software vendors or individual programmers, who use software development tools provided by the platform service providers to create application services that are deployable on the software service platform.

Application users are identified as stakeholders, who are the consumers of services developed and offered over the software service platforms. They are users of services offered by application service developers and platform service providers. Application service users aim at accomplishing a certain task through the use of an application service that matches their requirements.

The value exchange between these stakeholders can be direct (i.e., direct payments for services offered and used) or indirect (i.e., revenue through advertisement), resulting in net utility for users, profit (or loss) for the software platform provider, and profit (or loss) for service developers. The relationships among these stakeholders are depicted in Figure 1.

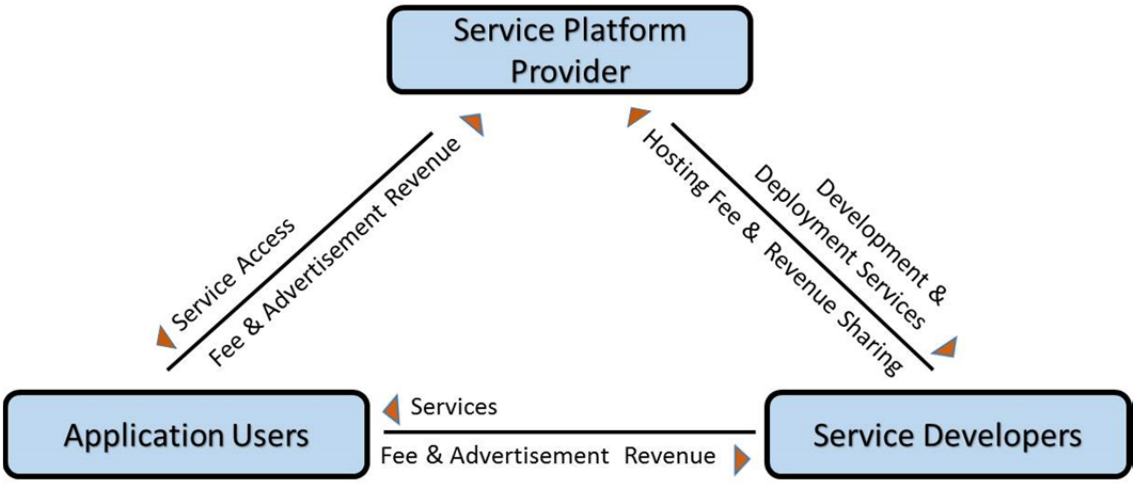


Figure 1. Value exchange of service platform stakeholders.

The value exchanged between a platform service provider and service developers comprises the provisioning of software development services and service provisioning services in exchange for cash fees or a share of the developers' revenue obtained from their users. Service developers provide their services to application users either for a fee (e.g., flat rate or usage-based fee) or free of charge but with advertisements. To both, platform providers and service developers, the application users are the major source of revenue.

3.2. Value Parameters and Their Effect on Stakeholders

Service value parameters determine the values obtained by stakeholders of the service platform. In particular, they indicate the sources of the values and are used for quantifying stakeholder's values. Understanding the impact of these parameters is important to platform providers and service developers for formulating their successful business models.

Existing theoretical frameworks have compared single value parameters and have identified their interdependence [10, 11]. Based on those theoretical frameworks and concepts, this study presents a consolidated set of measurable value parameters. This set considers quality of service (QoS), service variety (i.e., number of complementary services offered), installed base (i.e., number of users on the service platform), and cost. These value parameters and their interrelations as observed in real software service markets are shown in Figure 2.

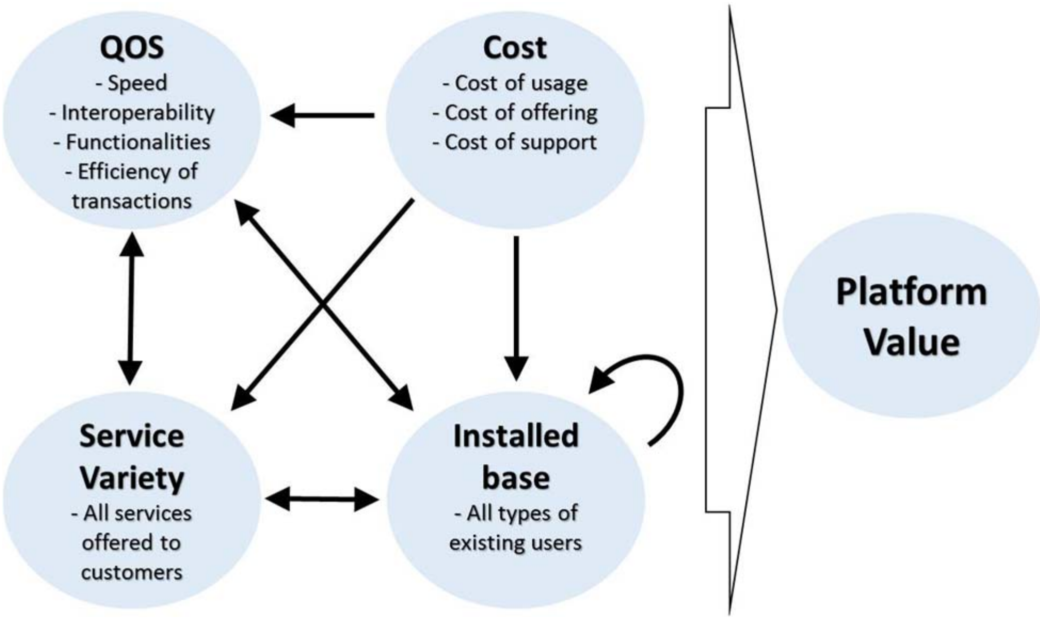


Figure 2. Service value parameters of software service platforms.

As shown in Figure 2, QoS drives the number of application users and the number of service developers (service variety) that a service platform can attract [20, 48]. The quality of the services provided by service developers and the platform provider impact the decisions of application users and service developers to join the platform, respectively. The installed base, which represents users, impacts also the QoS, as the installed base determines the revenue that can be used towards improving QoS. The revenue from application users is also the motivation for service developers to join the platform [42]. Application users' benefit is also impacted by the number of application users, as the number of application users determines the potential information exchange. In the same way, the number of services impacts application users to join the platform, as the number of services determines the functionality available to application users. Cost has a major impact on the growth of the installed base and service variety. The cost (i.e., the amount of money) also determines the level of QoS that can be implemented in the platform and the services. It needs to be noted here that cost is considered exogenous in this model. The initial values of the cost factors are assumed to be given.

In the following subsections, the value parameters are not only described in detail but an explanation on how they impact each of the three stakeholder values is also given (Figure 3).

3.2.1. Quality of Service

The QoS value parameter represents the functional and non-functional capabilities of services. It indicates whether the functionality, interoperability, and performance of a service are up to the requirements of the users and meet the intended service level objectives. With respect to software, it should be noted that QoS also considers the quality of data that is returned by an application [49]. QoS is an important factor in driving the value of products. There are cases, in which late entrants managed to take the market leadership from incumbents by offering better QoS [20, 48]. Similarly, the value obtained by software service platform customers (i.e., application users and service developers) is also determined by the QoS offered (Figure 3). The QoS offered by a platform provider can be assumed to be either constant or dynamic. For example, as QoS of application services is determined by the availability of support and updates, platform providers have two options of actions. If platform providers invest in new functionality to meet user requirements, they improve the quality of the development environment for service developers and the service offering environment for application users (i.e., dynamic QoS). If platform providers do not make any investments, they keep the QoS at the same level (i.e., constant QoS).

In general, as QoS improves, the platform gets more valuable to its users. Figure 3 shows the positive impact of QoS on the value for application users and the value for service developers. Although a high QoS of a platform also positively impacts the operation of the platform (e.g., fast transactions and easy service discovery), we do not specify the details. Instead, we simply assume that the benefit of QoS to a platform provider is represented by an increase in revenue.

3.2.2. Installed Base

The installed base represents the number of active users of a service platform. The installed base affects the value of all stakeholders as a source of revenue and user utility (Figure 3). The effect of the installed base on the stakeholders' values is explained through network effects. The network effect benefits all stakeholders and attracts even more customers [10, 24, 35, 36]. Platforms with a large number of users can leverage their user network to gain a competitive advantage. First, considering the time and effort users spent on adapting to services and building their personal networks on a new platform (e.g., social networking platforms), users are less likely to switch platforms [10]. Users do not switch platforms, if the time and effort (switching costs) are higher than the benefit from switching to another service platform.

Second, the use of network effects has been identified as an IT platform business strategy [11, 29]. For platform providers, the idea behind network effects is that developers pay more to get access to a bigger network. Consequently, as the installed base grows, the platform providers' revenue will grow. Therefore, platforms with a critical mass have the advantage to stay in the lead among equally innovative platforms.

The network effects that come into play in a platform environment are the direct network effect and the indirect network effect. The direct network effect is the increase in the number of users reinforced by the installed base. The indirect network effect is the increase in service variety due to the increase in the number of users, which in turn makes more users join the platform.

3.2.3. Service Variety

Service variety, which is another value source in platforms, represents the availability of services that users of the platform can access over the platform. As the number of services offered by the platform increases, it generates a network effect by increasing the value of the platform to their potential application users and, consequently, expanding the platform's customer base. The larger the number of complementary services is, the more valuable the platform becomes to its customers [10, 42]. Therefore, in order to create additional value for service providers, cooperation between service providers of complementary services has been a successful strategy in the service industry [6]. Consequently, as the idea of considering service variety to be a value driver in the context of service platforms is well-supported [6, 10, 42], we consider service variety as a value parameter that impacts the value of two stakeholders (Figure 3). In detail, service variety positively impacts the revenue of the service platform provider and the utilities of application users.

However, it has to be noted here that we do not consider the value increase of the value for service developers due to an increase in the service variety. This value would come from the reuse of services that other service developers have provided earlier. As it simply represents a reduction in the development cost of new services, we can neglect this value creation from service variety without losing any validity of our results.

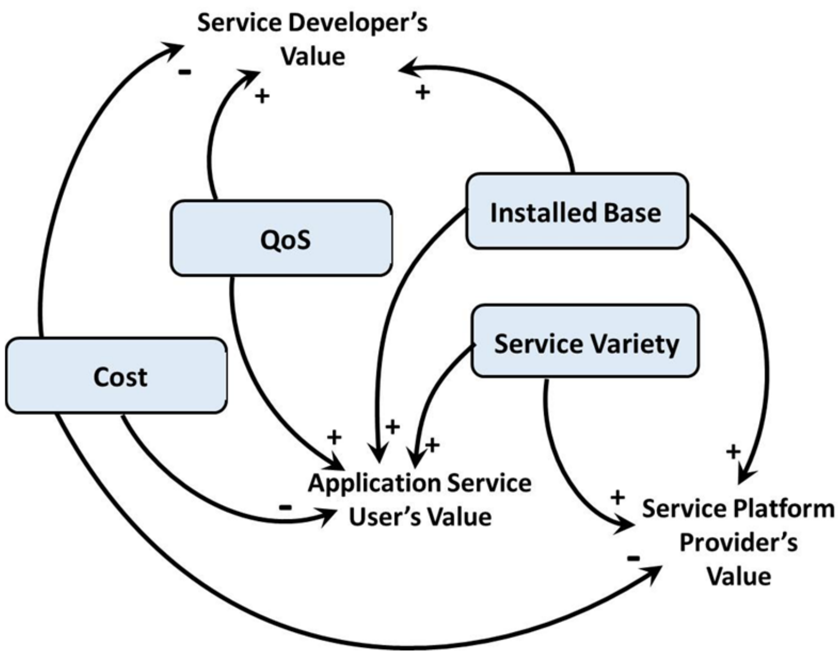


Figure 3. Effects of service value parameters on the values obtained by stakeholders.

3.2.4. Cost

Cost is used in this model to represent all types of costs incurred by all stakeholders. Cost incurred by stakeholders negatively affects their values (Figure 3).

The usage cost of application users in the context of platform services includes the usage fees paid by users to both providers. The platform provider and service developers face costs for offering services (e.g., service maintenance) and supporting their customers in the case of problems with services.

Reducing the cost of offering services (e.g., through improved efficiency) for service providers results in an increase in their net value [10]. However, in the overall platform ecosystem, an increase in the net value of one stakeholder might result in a decrease in the value of another. For example, if the price of a service is set high, the service developer's revenue increases, while the users' utility will be affected negatively.

3.3. Stakeholder Value Representations

Based on the variables identified and their relationships, we construct functions quantifying the values that the three stakeholders obtain from a software service platform. In particular, one software service platform, a variable number of application users, and a variable number of service developers are considered. The value functions, which represent the utility of the application user, the platform provider, and the service developer, use the value-determining parameters as input.

The application users and service developers continuously have to decide on the adoption of the software service platform based on the four value-determining parameters mentioned in the previous subsection. During each time period, new application users may join the platform and subscribe to services offered. Similarly, new developers may join the platform, buy service development tools, develop services, and sell their services to the installed base of the software service platform.

The system dynamics model is based on dimensionless values of quality of service and network effects from users and from services. The values are in the range from 0 to 1. This approach helps assessing the relative importance of the value-determining parameters in the model, following the approach described in [51].

3.3.1. Application User Value

Based on the service value model (section 3.2), we define the net utility $U_{j,a}$ of an application user. It is determined by the services cost and the functional and non-functional benefits that a user obtains from using services offered on the service platform. The net utility $U_{j,a}(t)$, which an application user a gets from adopting the service platform j at a given time t is defined as the sum of all positive benefits minus the services cost:

$$\mathrm{U_{j,a}(t)} = \mathrm{u1_{j,a}}\left(\mathrm{Q_j(t)}\right) + \mathrm{u2_{j,a}}\left(\mathrm{S_j(t)}, \mathrm{D_{j,a}(t)}\right) + \mathrm{u3_{j,a}}\left(\mathrm{N_j(t)}\right) - \mathrm{C_{j,a}}\left(\mathrm{D_{j,a}(t)}\right) \qquad (1)$$

where $u1_{j,a}(Q_j(t))$ represents a user's utility from the quality of service Q_j, which is the functional benefit of the service at time t. The variable $D_{j,a}(t)$ represents the average number of services a user uses at time period t, while $S_j(t)$ represents the total number of services offered on the platform. The utility $u2_{j,a}(S_j(t),D_{j,a}(t))$ represents the utility of the user a from using $D_{j,a}(t)$ services of the $S_j(t)$ services that are available on the service platform at time t. The utility represents the user's value from adopting a service platform with a certain number of different services available. The user's value is generated from the different functionality of services used as well as the availability and interoperability of complementary services (i.e., indirect network effect). The utility $u3_{j,a}(N_j(t))$ is the utility of the user a generated from the direct network effect from the number of existing users (i.e., installed base $N_j(t)$) on the service platform j at time t. It represents the benefit obtained from the level of platform adoption. The benefit comes from the fraction of utility from the two-sided network effect that increases the utility of users. The two-sided network effect comes from the interaction between the number of services (developed by service developers) and the number of users on the platform using the services. $C_{j,a}(D_{j,a}(t))$ specifies the total application usage cost that a user a faces for using the services each month on the platform j. The total cost depends on the number of services that a user uses at time t.

To detail the net utility function of application user, the shapes of the utility functions (i.e., $u1_{j,a}()$, $u2_{j,a}()$, and $u3_{j,a}()$) have to be determined. These utility functions represent the perceived values of the parameters $Q_j()$, $S_j()$, and $N_j()$. All utility functions are assumed to generate values in the range between *0* and *1*. The value *1* means that the maximum level of utility has been reached, while a value of *0* represents the lowest level.

It is assumed that the values of the utility functions increase as the values of the parameters increase but remain below the maximum utility represented by the value *1*. A maximum utility obtained from using a service platform can be assumed, as a user's utility is constrained by the user's capacity to experience services [50, 66]. Nonetheless, even if the momentarily highest quality of service has been achieved, even if all services are used, and even if all connections to all users have been established, utility could be improved even further through a growth of the platform.

The utility functions are assumed to increase to a maximum value close to *1*, showing an asymptotic shape [67, 68, 69, 70]. The asymptotic shapes of these functions are justified, as a parameter value improvement is perceived by a user depending on the actual level of the parameter value. The higher the actual level of parameter value is, the less the marginal utility is. Based on this discussion, we can adapt the application user net utility function $U_{j,a}(t)$ as follows:

$$U_{j,a}(t) = \left(1 - \frac{1}{\left(Q_j(t)\right)}\right) + \left(1 - \frac{1}{(S_j(t) * D_{j,a}(t))}\right) + \left(1 - \frac{1}{N_j(t)}\right) - c_{j,a} * D_{j,a}(t) \qquad (2)$$

As $u1_{j,a}()$ represents the basic value exchange through quality of service between the platform provider and its consumers, $u1_{j,a}()$ is used to show the level of application user utility derived from quality of service. An improvement of $Q_j()$ from the lowest value (i.e., *1*) to the highest value (i.e., ∞) is assumed to be the consequence of an investment by the platform provider. This assumption allows us not to put a limit on how much a platform can be improved for delivering QoS. An improvement of the platform simply follows the market demand. The behaviour assumed here is that, as the QoS of a platform increases, the utility received by the user also increases. In order to limit the utility to reach a value of *1*, as QoS increases to ∞, and to represent the user's perception of QoS, a utility function with asymptotic functional form has been chosen. A simple function, which fulfils it, is $(1 - 1/(Q_j(t)))$. It increases from *0* to close to *1*, if $Q_j()$ increases from *1* to ∞.

The second term $u2_{j,a}()$ represents the value received from the variety of services used. The term $S_j() * D_{j,a}()$ combines the user's benefit from indirect network effects obtained through the $S_j()$ services made available over the platform and the user's benefit from the number of services $D_{j,a}()$ downloaded (installed) by the user. $S_j()$ is assumed to have the same value for all users of the same platform, and, in this model, it also indicates the number of developers who adopted the platform. Therefore, $S_j()$ is a parameter that impacts the user's value and the platform provider's benefits for hosting and managing services. As there is also a limit to the utility $u2_{j,a}()$ a user can get from the number of services available and the number of services installed, we also use a utility function with an asymptotical shape [67, 68, 69, 70]. The utility function is *(1 – 1/*$S_j(t)*D_{j,a}(t)$*)*, where $S_j(t)$ and $D_{j,a}(t)$ can be assumed to be larger than *0* without limitation. An application user is only a customer of a software service platform, if the user uses at least one service.

The third term $u3_{j,a}()$ represents the utility obtained from the number of users present on the platform. The utility is the result of the direct network effect that comes from the installed base $N_j()$ on the service platform. This part of the user utility is assumed to be equal for all users of the service platform. Accordingly, the actual number of personal connections to other users is assumed to be equal for all users as well. To limit the value that a user obtains from the indirect network effect, we also assume an asymptotical functional form for the utility function [67, 68, 69, 70]. The utility function is $(1 - 1/N())$.

The fourth term is the cost $c_{j,a} * D_{j,a}()$ that the user faces. It is assumed to be driven by the number of services used on average $D_{j,a}()$. It mainly consists of the cost $c_{j,a}$ of selecting, purchasing, and using the installed services (i.e., the average service usage fee). In addition to this, it also includes the cost of time that the user spends using free services, generating advertisement revenue for the platform provider and the service developers. For this, we assume an average time, making it equal for all users of the service platform. Consequently, we can consider a linear cost function $c_{j,a} * D_{j,a}()$.

3.3.2. Service Developer Value

Based on the structure of the service value model (section 3.2), the net value $U_{j,s}(t)$ that a service developer *s* gets from adopting the service platform *j* at a given time *t* can be described as follows:

$$U_{j,s}(t) = \left(1 - \frac{1}{\left(Q_j(t)\right)}\right) + RS_{j,s} * c_{j,a} * \frac{N_j(t)}{S_j(t)} * D_j(t) - C_{j,s}(t) \tag{3}$$

where the first term of $U_{j,s}(t)$ represents a utility through quality of service $Q_j()$, identical to the one described for the utility of application users. Service developers also rely on the quality of the development and service offering tools of the platform provider. If the QoS of a platform increases, the utility received by the service developers also increases.

The second term of $U_{j,s}(t)$ represents a service developer's revenue. It comes from the average fee $c_{j,a}$, which a user pays for using a service, multiplied by the revenue share $RS_{j,s}$, the average number of users per service, and the average number of services a user uses. The average number of users per service is expressed as the fraction of all users of the platform $N_j()$ divided by the total number of services $S_j()$. It is to be noted, that we assume here, without losing validity of our results, the number of services to be equal to the number of service developers. This assumption does not change the results, as our model assumes that the costs of the development of a service are the same for all service developers. We only consider the cost incurred through the use of the platform. This cost increases linearly with the number of services, independently with the number of services already developed. The revenue share $RS_{j,s}$ that the service developer gets is the overall revenue divided according to the revenue sharing agreement with the platform provider.

The third term denotes the cost $C_{j,s}()$ that a service developer faces for offering a service. The cost comes from either a fixed subscription fee or a variable usage cost that has to be paid to the platform service provider. The fee covers the application hosting fees on the platform and varies based on the size of the application, the number of users supported, storage capacity required, and the amount of back-end processing needed.

3.3.3. Service Platform Provider Value

Following the service value model (section 3.2), the value (profit) $U_{j,p}(t)$ obtained by a software service platform provider p from offering a part of the service platform j at a given time t is defined as:

$$U_{j,p}(t) = F_p * \left(C_{j,s}(t) * S_j(t) + \left(1 - RS_{j,s}\right) * c_{j,a} * D_{j,a}(t) * N_j(t) - C_{j,p,a}(t) * D_{j,a}(t) * N_j(t) - C_{j,p,s}(t) * S_j(t)\right) \quad (4)$$

where the profit $U_{j,p}()$ of provider p is a fraction F_P of the overall profit generated on the platform. The fraction depends on the share of the platform that the platform provider contributes. The profit is the defined as the revenue generated from service developers and users minus the cost for offering the platform.

The first term of the profit $U_{j,p}()$ is the revenue from all service developers $C_{j,s}*S_j()$, which is the product of the fee that the service developer has to pay and the number of service developers.

The second term of the profit $U_{j,p}()$ is the revenue from all services, which is the product of the share of the revenue $(1-RS_{j,s})$ from services that goes to the platform provider, the cost of a user to use a service, and the total number of used services $D_{j,a}()*N_j()$ services.

The third and fourth term comprise the cost for services and users. They increase as the number of services $S_j()$ and users $N_j()$ increases. In detail, the third term is the product of the per-service cost $C_{j,p,a}()$ for supporting a user and the number of all used services $D_{j,a}()*N_j()$.

The fourth term is the product of the cost Cj,p,s( ) for supporting delivery of a service multiplied with the total number of services Sj( ). These costs come from maintaining data storage and from providing security to the services they host.

4. Simulation Model

4.1. Value Creation Dynamics

We employ system dynamics to better understand the behavior of stakeholders. System dynamics can help understanding the impact of service offerings by service developers, the impact of strategies of platform providers to create and add more value to their platform, and the impact of business policy adjustments in response to changed market conditions. For example, a platform provider could model how improved QoS (through new investments in infrastructure) changes its profit. A service developer could model whether the development of a new service increases its profit. A service developer could also apply a similar model as a platform service provider to understand the impact of QoS on its revenue. Consequently, it will help the stakeholders of the software service platform to build a sustainable ecosystem.

The system dynamics model of the value creation and distribution model (Figure 3) is illustrated in Figure 4. Within the system dynamics model, the number of services (service variety) increases by a certain number of new services in every time period. The installed base also increases by a certain number of new adopters in every time period. Note, as we do not consider an outflow of customers here, the installed base $N_j(t)$ and the number of services $S_j(t)$ are cumulative values increasing through new adoptions over time.

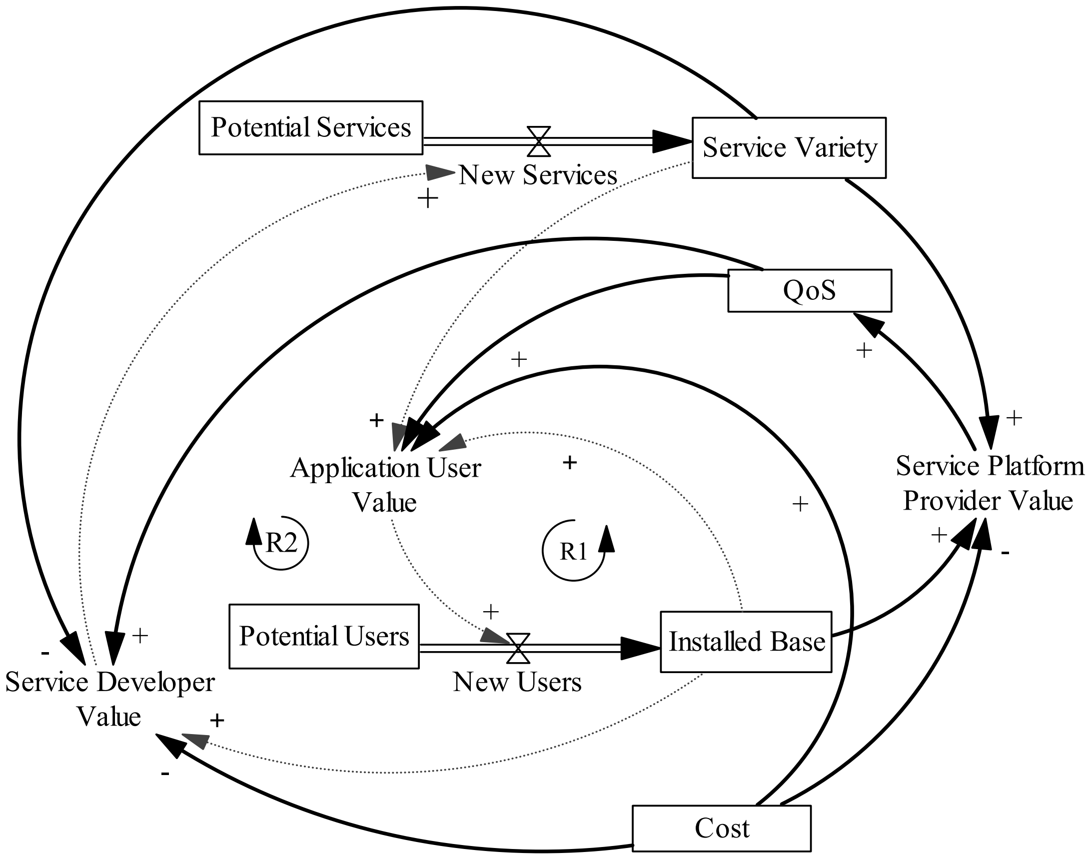


Figure 4. System dynamics model of the stakeholder value distribution, showing two feedback loops (R1 and R2).

In addition to the value creation relationships shown in Figure 3, the impact of stakeholder values on value parameters is also shown in Figure 4. With respect to QoS, the higher the platform provider's utility is, the more incentives for the platform provider exist to improve the quality of its services so that the requirements and expectations of its customers are met. With respect to service variety, the number of new services is positively affected by the utility of existing service developers. The higher the utility, the more developers join. Furthermore, the higher the application user value is, the more application users will join.

Considering these relationships, two positive feedback loops (R1 and R2) can be identified (dashed lines in Figure 4). With respect to the installed base, the higher the number of users is, the more application user value is created, and the more users join the platform (feedback loop R1 in Figure 4). The second feedback loop (R2) involves service variety and installed base. As the service variety increases, the application user value increases, stimulating more application users to join (i.e., increasing the installed base). In turn, the increase in the number of users increases the revenue prospects of service developers, resulting in an increase in the service developer value, which is the basis for increasing the service variety.

4.2. Simulation Scenario Description and Simulation Settings

The value creation and value distribution model is used to analyse three scenarios: (Scenario 1) the reference scenario, which uses base values for all parameters; (Scenario 2) the scenario that differs to the reference scenario in an increased service sales rate; (Scenario 3) the scenario that shows a change in the user adoption rate starting from time period t = 50. All scenarios consider a software service platform with a limited number of potential users and potential service developers. The scenarios were selected based on their potentially significant impact on the value of the stakeholders. The results obtained from the simulation of those scenarios are also compared with each other, in order to derive implications for each stakeholder.

4.2.1. Scenario 1: Base Values

This scenario has been created to generate the reference values that are used for the comparison with the other two scenarios. The scenario settings used are given in Table 1. These settings are based on practices observed in the market, which have been described in literature on Apple iTunes [52], Apple Development Kits [53], Amazon Appstore for Android [54], and on Google Apps Marketplace [55]. In particular, these literature sources helped setting the average adoption rate of a software service platform (i.e., the increase of the installed base $N_j(t)$), the average growth rate of the number of services $S_j(t)$, the revenue share $RS_{j,s}$ used in the market, the average cost of service developers $C_{j,s}(t)$, the average cost of platform providers for supporting users $C_{j,p,a}(t)$ and for supporting services $C_{j,p,s}(t)$. The values for the average user cost $C_{j,a}(t)$ and for the average number of services used at a time $D_{j,a}(t)$ are adopted from a user survey conducted in software service platforms by Haile and Altmann (2013). The value of quality of service $Q_j(t)$ for both types of platform consumers (i.e., application users and service developers) is assumed to start from a satisfactory level and to increase slowly approaching the maximum level of 1.

Regarding the cost values, it is to be noted that we assume that, even if application users and service developers use free services, they generate value for providers (e.g., by looking at advertisement placed by providers). Therefore, we can simplify the model by assuming that all customers pay for the services they consume (average service usage fee of Table 1), either by paying a monthly service fee or by viewing advertisement placed within their services.

Besides, with respect to the adoption of users, it is assumed that, if the value of application users $U_{j,a}(t)$ is greater than 0 at time period t and market saturation has not been reached, a certain number of new users decides to join the installed base at time period $t+1$. The number of new users is determined in each time period and they are a portion of the potential users. In particular, we consider two types of user growth rates (adoption rates): First, a linear growth rate is assumed, keeping the number of new users joining every time period t constant. Second, a logistic growth rate is assumed. Using the logistic growth rate [71], the number of new users slowly grows in the beginning but increases exponentially until a maximum. From that maximum point onwards, the number of new users decreases exponentially due to market saturation. For the simulation, we use a special logistic function, the Gompertz function, which grows slowly in the beginning and at the end [71]. The theoretical assumption behind the logistic growth rate is the presence of network effects and market saturation. The growth dynamics of platforms also shows a slow growth rate followed by an increased rate as their network effect sets in due to popularity. As soon as the pool of potential users in a certain market segment decreases, the rate of growth decreases showing market saturation. Therefore, it is realistic to assume a logistic growth in software service platforms. The comparison of the two adoption rates of new users is important, as it helps understanding the impact of the number of new users on stakeholder values.

With respect to service developers, we apply the same principles of adoption as for the application users. However, the increase of new services follows only a linear growth rate.

4.2.2. Scenario 2: Increased Service Use

In this scenario, the average service use, which represents the number of services at a given time t, is increased. The motivation for this is that platforms can increase their sales (i.e., the number of services used by each user) through various marketing measures. For example, platform providers could improve the quality and attractiveness of the services offered, improve service discovery, and could lower usage cost.

For the simulation, we assume that the extra marketing measures of platforms result in an increase of the average service use from 1 service to 5 services (Table 1). Comparing the results with the results from Scenario 1, the impact of an increased service use on the values of all stakeholders can be analysed.

4.2.3. Scenario 3: Decreased Platform Adoption Rate

The platform adoption rate represents the number of new users, who start using the service platform in each time period. This rate of new adopters of service platforms can follow different principles (section 4.2.2) until the point of market saturation has been reached. In this scenario (Scenario 3) however, the case is assumed, in which the number of new adoptions started to decrease suddenly due to a negative market event. Such market events can be the rise of another competitive service platform or, simply, a decrease in the attractiveness of the platform to potential users due to some performance issues.

For the simulation, the negative market event is assumed to happen at time period $t = 100$. From this time period onwards, the growth rate (adoption rate) is half of the original growth rate of scenario 1.

Table 1. Simulation parameters used for the three scenarios.

Simulation Variables	Origin of Values Selected	Scenario 1: Base Values	Scenario 2: Increased Service Use	Scenario 3: Decreased Platform Adoption Rate
Cost of a service offering for service developers ($C_{j,s}(t)$) [$/service]	[54]	1	1	1
Share of revenue for service developers ($RS_{j,s}$) [%]	[53]	0.7	0.7	0.7
Average number of services used ($D_j(t)$) [services/user]	[57]	1	**5**	1
Average service usage fee ($c_{j,a}$) [$/month]	[57]	0.001	0.001	0.001
Cost of managing services for platform providers ($C_{j,s,p}(t)$) [$/service]	[54]	0.0001	0.0001	0.0001
Cost of supporting users for platform providers ($C_{j,a,p}(t)$) [$/user]	[54]	0.00001	0.00001	0.00001
Potential services [service]	assumption	500	500	500
New services [service/month]	assumption	1	1	1
Quality of service ($Q_j(t)$) []	assumption	[1…∞]	[1…∞]	[1…∞]
Potential users [user]	assumption	1,000,000	1,000,000	1,000,000
New users [user/month] - Linear growth rate - Logistic growth rate	 assumption [71]	 5000 ln(PotentialUsers/ N_j(t))*N_j(t)*0.03	 5000 ln(PotentialUsers/ N_j(t)*N_j(t)*0.03	 2500 (ln(PotentialUsers/ N_j(t))*N_j(t)*0.03)/2

4.3. Simulation Environment

The simulation environment needs to handle a single service platform provider, multiple service developers, and multiple application users. As Vensim Software, a system dynamics software developed by Ventana Systems, is capable of handling this [72], we used this software to implement the simulations of all three scenarios.

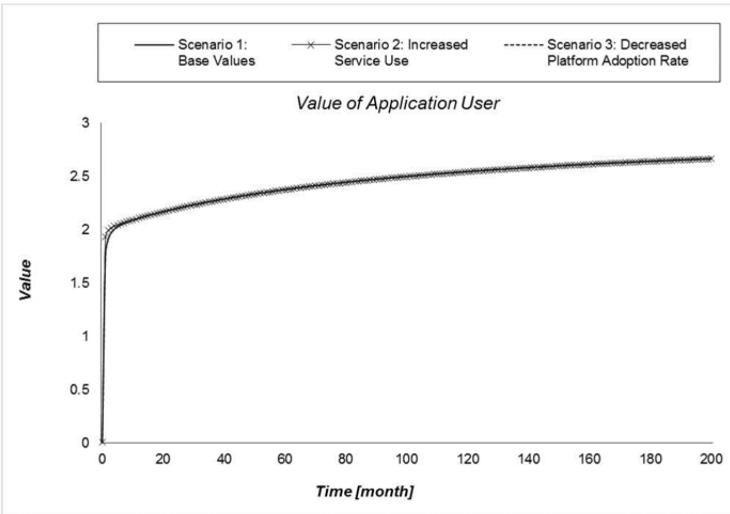
The simulation duration was set such that it allows observing the dynamics of the value creation and distribution model. After several test simulation runs, the number of time periods was set to 100 months (i.e., 100 time periods).

5. Simulation Results

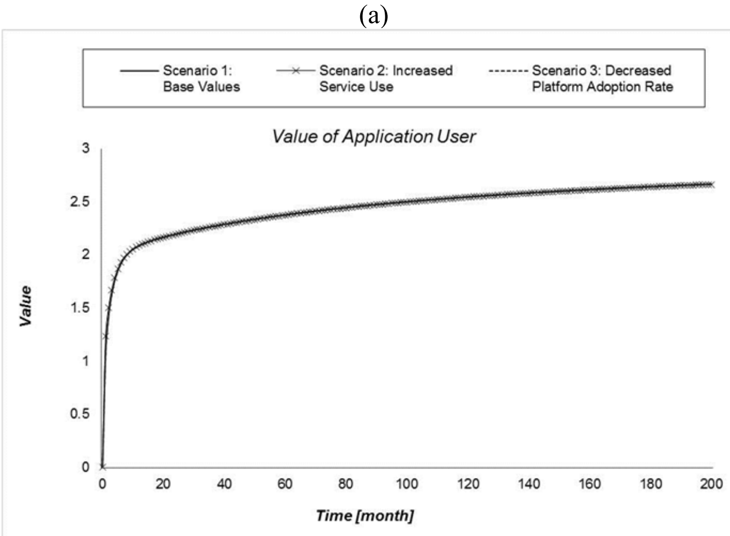
5.1. Comparison of Scenarios

In this section, we present results for the three scenarios of section 4.2, showing the dynamics of the value creation for all stakeholders. The comparison of the simulation results for these three scenarios will give some insight about the impact of the different scenario variables on the value for the application user $U_{j,a}(t)$, the value for the service developer $U_{j,s}(t)$, and the value for the platform provider $U_{j,p}(t)$. If all simulation variables, except for the number of new users (for Scenario 3) and the average number of services used per user (for Scenario 2), are kept constant, the differences in the values for application users, service developers, and platform providers are caused by the decrease of new users (Scenario 3) and the reduced average number of services used per user $D_{j,a}(t)$ (Scenario 2).

Looking at the simulation results of the application user value for the base values scenario (Figure 5), it can be seen that application users subscribe to a service from a service developer already at the beginning of period $t = 0$, as it outweighs their user cost $c_{j,a}$. The value that a user obtains at the time of joining the platform comes from the level of quality of service $Q_j(t)$ (equation 2). Afterwards, the utility $U_{j,a}(t)$ increases quickly within the initial time periods up to a value of 1.8. From this time period onwards, the application user value only increases slightly for all scenarios. It is to be noted that the application user value is independent to the two types of user growth rates (i.e., linear growth rate (Figure 5a) and logistic growth rate (Figure 5b).



(a)



(b)

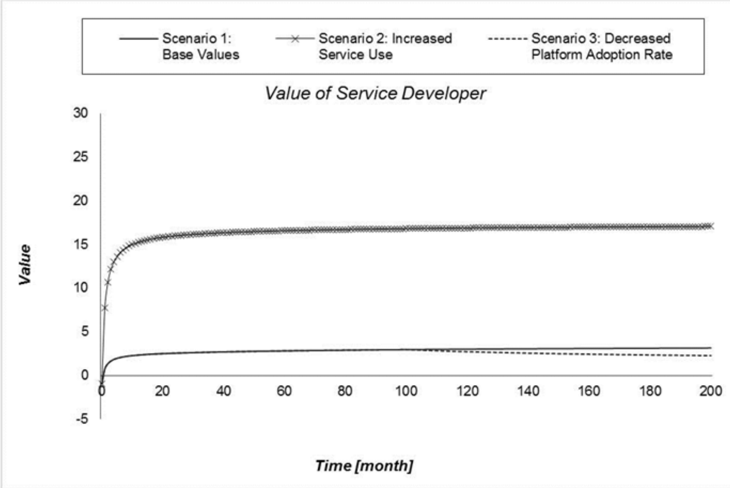
Figure 5. Value created for application users for the three scenarios, using a linear growth rate (a) and a logistic growth rate (b).

As Figure 5 also shows, there is only a very slight difference between the values resulting from the three scenarios. Only during the initial time period of Scenario 2 (i.e., increased average number of services used), the value for application users is a little bit higher than the value obtained from the other two scenarios. There is no difference between the base values scenario (Scenario 1) and the decreased platform adoption rate scenario (Scenario 2). The change in the number of new users at time 100 does not impact the overall value for application users, as the value for application user is already at a high level.

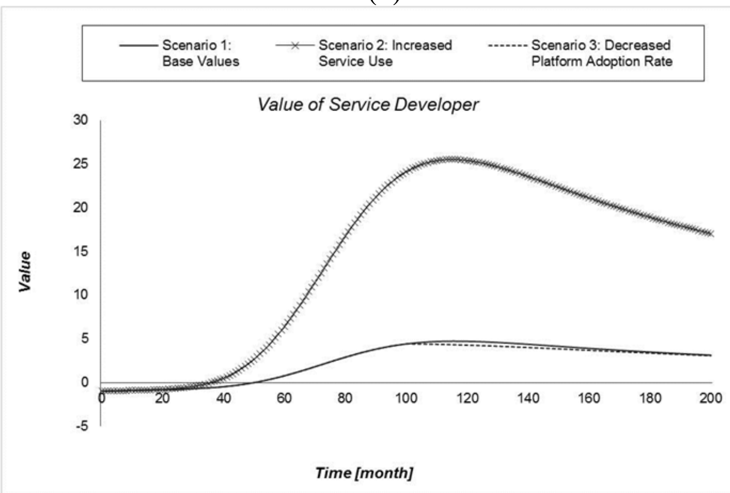
Service developers also need to subscribe to a service platform before they can utilize the platform providers offerings for building new services. However, the service developer values (equation 4) for the three scenarios show a different shape in the beginning (Figure 6) compared to the values for the application users. This is due to the fact that the service developer's initial cost is higher than the cost faced by application users. The service developer cannot recover their costs of a service offering $C_{j,s}(t)$, until they generate revenue from the acquisition of a sufficiently large number of application users. Therefore, it takes a few time periods, until they receive a value $U_{j,s}(t)$ that is larger than 0. The significant impact of a linear growth rate (Figure 6a) and a logistic growth rate (Figure 6b) can clearly be seen. With a linear growth rate, the service developer becomes profitable quickly (i.e., within the first two time periods). With a logistic growth rate, due to the low number of new users in the beginning, the service developers have to wait 35 time periods (Scenario 2) and 50 time periods (Scenario 1 and Scenario 3), respectively.

Figure 6 also shows another difference between the scenarios with linear growth rate and the scenarios with logistic growth rate. While the value for a service developer slowly but steady increases after a steep increase in the initial time periods for the scenarios with a linear growth rate, the value for a service developer reaches a maximum value around a time period of 115. From this time period onwards, the total value that all service developers get grows slower than the number of service developers joining the software service platform. Consequently, the average value for a single service developer reduces.

Figure 6 also illustrates that the time periods of value creation for service developers is significantly different for scenarios with linear growth rate and scenarios with logistic growth rate. While the scenarios with linear growth rate (Figure 6a) generate the value for service developers from the initial time periods, the value for service developers in scenarios with logistic growth rate is very low initially, increases quickly to a maximum, and decreases to the same level at time period $t=200$ as the value for service developers in scenarios with linear growth rate. This shape of the value curve for service developer reflects the adoption rate of new technology through consumers (i.e., the application users). The scenarios with linear growth rate represent a constant adoption rate through consumers, while the scenarios with a logistic growth rate represent a dynamic adoption rate through consumers.



(a)

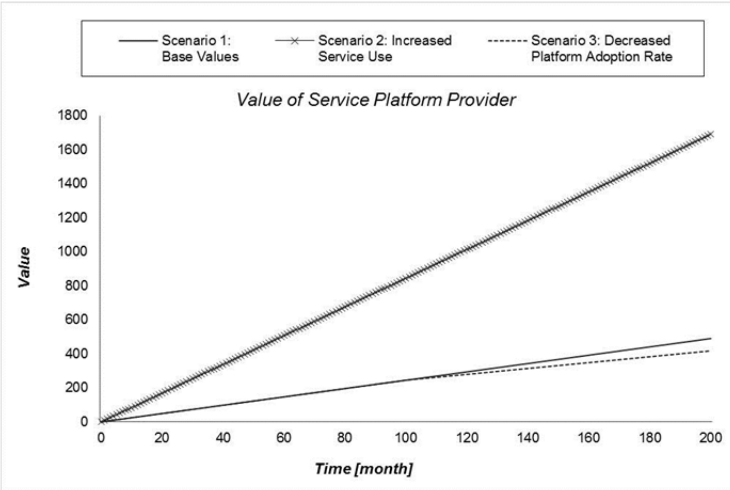


(b)

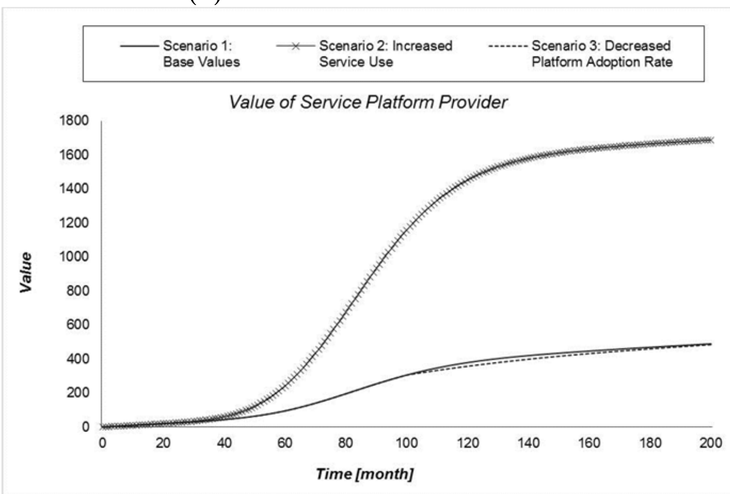
Figure 6. Value created for service developers for the three scenarios, using a linear growth rate (a) and a logistic growth rate (b).

With respect to Scenario 2, in which the average number of services used per time period $D_j(t)$ is 5, the value for the service developers shows a significant increase compared to the base values scenario, in which the average number of services used is only 1 (Figure 6). The increase in value simply reflects a 5 times higher consumption of services by application users. With respect to Scenario 3, in which the number of new adopters drops at time period $t=100$ to half of the original growth rate, Figure 6 shows clearly that the reduced number of new adopters affects the value for service developers more significantly than the value for application users. The reason is that service developers can mainly make money from new users. Existing users can only consume a limited number of services, capping the overall market capacity.

Figure 7 shows that, contrary to service developers and application users, who exhibit a common behaviour as customers of a platform provider, platform provider's value is only determined by selling its platform service. Consequently, the value for the platform provider $U_{j,p}(t)$ at time period $t = 0$ is 0. The value only increases, if the platform provider starts getting customers, generating revenue from service developers through development tools fees and hosting fees $C_{j,s}(t)$, as well as from application users through average service usage fees $c_{j,a}$. The only costs that have to be covered by platform providers are the cost for supporting application users $C_{j,a,p}(t)$ and the cost of managing services $C_{j,s,p}(t)$.



(a)



(b)

Figure 7. Value created for service platform providers for the three scenarios, using a linear growth rate (a) and a logistic growth rate (b).

Figure 7 shows that the value for service platform providers $U_{j,p}(t)$ grows faster and reaches higher levels than the value for service developers $U_{j,s}(t)$ and application users $U_{j,a}(t)$. The platform provider's value increases with the size of the other two types of stakeholder groups. The platform provider obtains benefits from both sides of the market.

The difference in the value curves for scenarios with linear growth rate and scenarios with logistic growth rate can also be noticed. While, for scenarios with linear growth rate, the value for platform providers increases linearly, the value for platform providers shows a s-shaped curve. It clearly reflects the different number of new users joining the platform at each time period. It highlights the platform provider's strong dependency on application users.

In the case of scenario 3, the decreasing number of new application users can only slow down the value growth but cannot decrease it. Unlike for service developers, an immediate decrease of value does not occur for the platform provider. In case of Scenario 2, the increase in service sales shows a significant improvement for the platform provider, similar to the effect on the value for service developers.

5.2. Sensitivity Analyses

Sensitivity analysis is conducted to understand the changes of the stakeholder values with respect to changes in the cost of a service offering for service developers and the average service usage fee for application users. The values of these two simulation variables are set to five different values, representing pricing decisions of a platform provider and service developers. Five values are sufficient, in order to show the changes in the value for the three types of stakeholders. Except for the cost of a service offering and the average service usage fee, all other simulation variables remain the same. The variable setting of scenario 1 with logistic growth rate is taken for the following simulations.

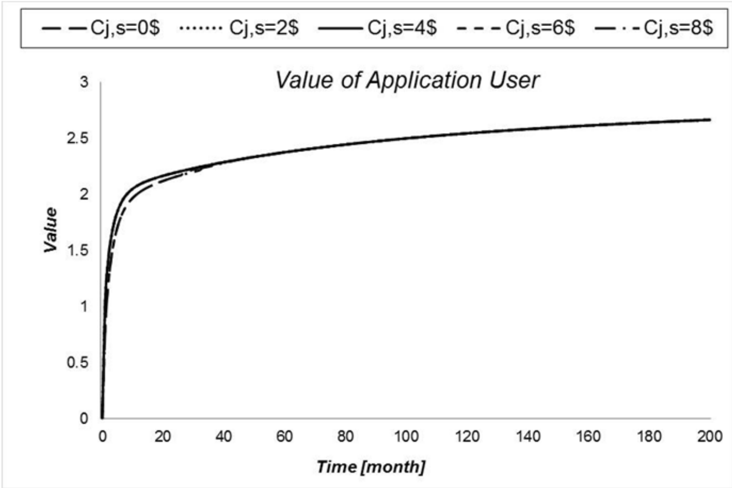
5.2.1. Sensitivity Analysis Regarding the Cost of a Service Offering

The monthly cost $C_{j,s}(t)$ for service developers for offering their services on the platform depends on the fee set by the platform provider. For the sensitivity analysis, the value of $C_{j,s}(t)$ is chosen in the range from 0 \$/month to 8 \$/month. The impact of five different service offering cost values (i.e., *0 \$/month*, *2 \$/month*, *4 \$/month*, *6 \$/month*, and *8 \$/month*) on the values for the three types of stakeholders (i.e., application user, service developer, platform provider) is presented in Figure 8a, 8b, and 8c.

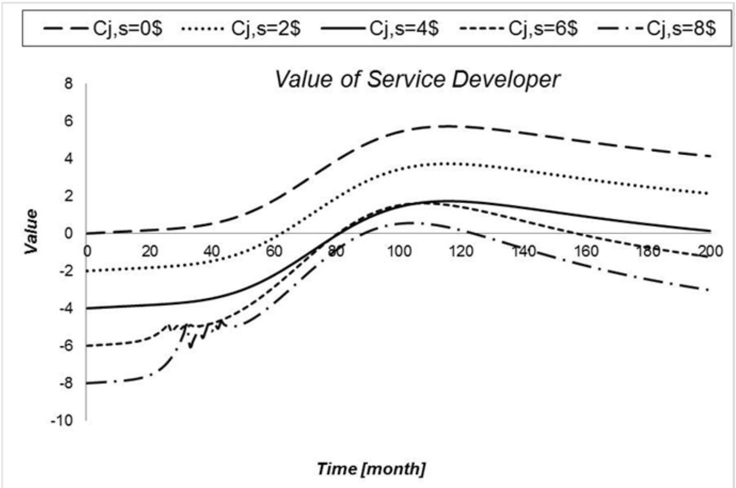
Figure 8a, 8b, and 8c show that, if the value of $C_{j,s}(t)$ is in the range of 0 \$/month to 4 \$/month, the value creation model functions normally (i.e., the curves look similar to the one shown in Figure 5b, 6b, and 7b). However, the more the cost $C_{j,s}(t)$ increases, the longer it takes for service developers to become profitable (Figure 8b). From a cost value of $C_{j,s}(t)=6$ *\$/month* onwards, the service developers even struggle to become profitable at all. For example, in the case of $C_{j,s}(t)=6$ *\$/month*, service developers are only profitable during the time period $t=81$ and $t=156$. Only during this time period, the number of new users per time period is sufficiently high to cover the cost of service developers.

Figure 8a also shows that the value for application users is not impacted by different values of $C_{j,s}(t)$. As seen in Figure 5b, the value for application users increases slowly after a steep increase in the beginning.

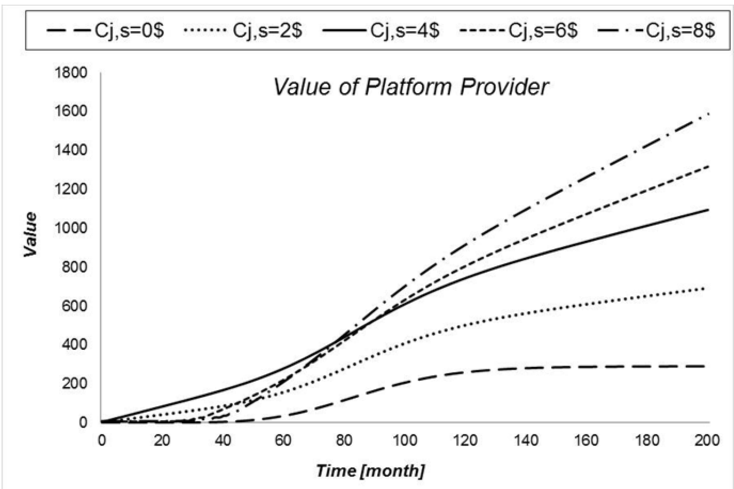
Figure 8c shows however, that the value (profit) for the platform provider also depends on $C_{j,s}(t)$. The higher the platform provider sets $C_{j,s}(t)$, the higher its profit. It has to be noted though that the profit is lower in the beginning of the simulations, if $C_{j,s}(t)$ is set high (e.g., values larger than *6 \$/month*). The reason is that, if existing service developers struggle to become profitable in the beginning, the platform becomes less attractive for new service developers to join. It leads to a decrease in revenue for the platform providers. That means, without a critical mass of application users, the software service platform is not attractive at all.



(a)



(b)



(c)

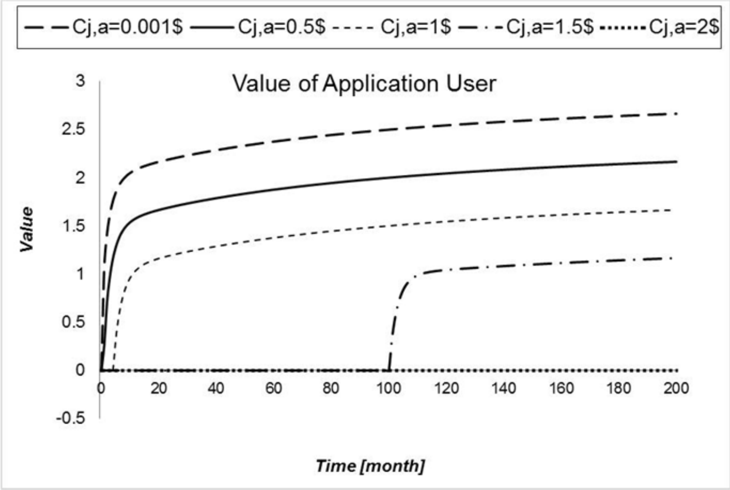
Figure 8. Sensitivity analysis of stakeholder values (i.e., (a) application user value, (b) service developer value, (c) platform provider value) regarding the cost of a service offering for service developers.

5.2.2. Sensitivity Analysis Regarding the Average Service Usage Fee

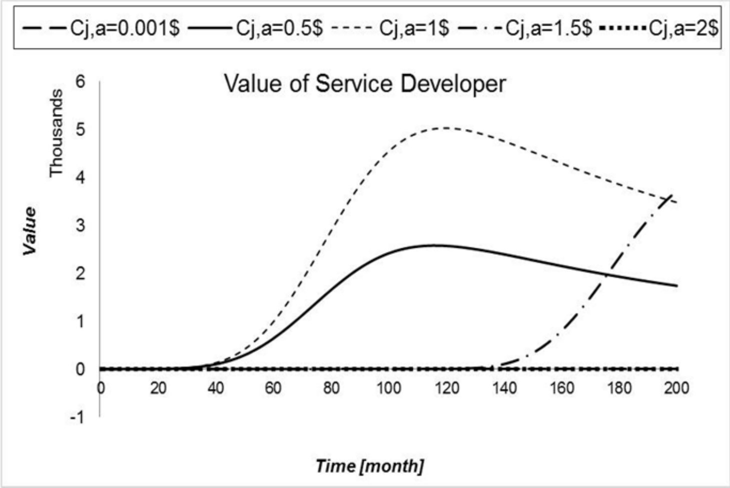
The average service usage fee is the monthly cost of an application user for using a single application. It includes the purchasing price of the application and the cost for viewing advertisement within the application. The purchasing prices for application services are set by the service developer of the application or the platform provider depending on the business model of the service platform. For the sensitivity analysis, the average service usage fee $c_{j,a}(t)$ is set to increase from *0 $/month* to *2 $/month*. For keeping the figures readable, the actual values chosen are *0.001 $/month*, *0.5 $/month*, *1 $/month*, *1.5 $/month*, and *2 $/month*. The impact of these five different average service usage fees on the values of the three stakeholders is presented in Figure 9a, 9b, and 9c.

Comparing the changes of the values on the three stakeholders in Figure 9, we can make two interesting observations. First, the intuitive observation is that the higher the average service usage fee is, the less value is generated for the application users (Figure 9a) and the more value is generated for the service developers and the platform providers (Figure 9b and Figure 9c). The value for the application users is the highest for $c_{j,a}(t)=0.001$ *$/month* and the lowest for $c_{j,a}(t)=2$ *$/month*. Inversely, the service developers and the platform provider achieve the lowest profit at $c_{j,a}(t)=0.001$ *$/month.* Their profit is much higher for values of $c_{j,a}(t)$ that are larger than *0.001 $/month*, under the condition that the application users obtain a value larger than *0 $/month*.

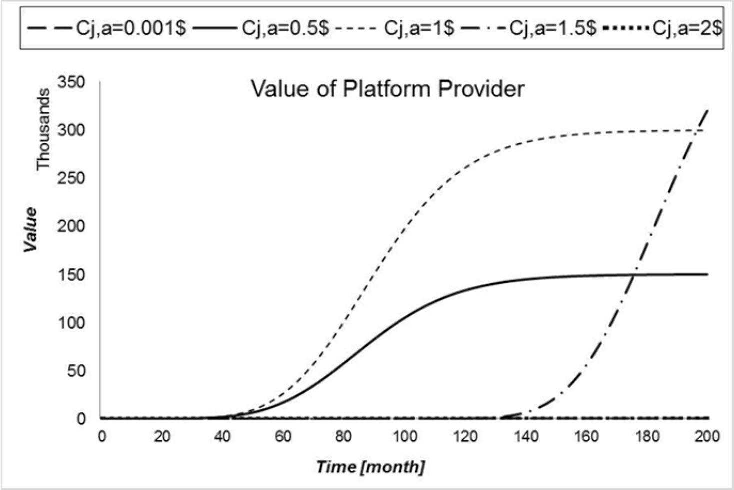
Second, if $c_{j,a}(t)$ is below *1 $/month*, the values for all stakeholders increase over time from the beginning as also shown in Figure 5b, 6b, and 7b. At $c_{j,a}(t)=1$ *$/month* however, the value for application users $U_{j,a}(t)$ stays at zero until time period 5. If $c_{j,a}(t)$ increases further, the time duration expands before the value for application users $U_{j,a}(t)$ becomes larger than 0. For example, for $c_{j,a}(t)=1.5$ *$/month*, the time duration is larger than 101 time periods. Once the application user value is larger than 0, the curves show the same shape. The value of service developers and the value of the platform provider show a similar shape as in Figure 6b and 7b. Only once the application users obtain some value, the service developers and the platform provider can generate some value themselves. It strongly shows that the application users are the source for the value creation in this software service ecosystem. The value creation for the application users comes from the number of other users on the system only. Consequently, we can state that this software service ecosystem needs to have a balanced value exchange between the different types of stakeholders. Only then, bootstrapping and sustainability of the value exchange is possible. Finally, it has to be noted that, if $c_{j,a}(t)$ is set to a value larger than 2 $/month, the critical mass of application users has not been reached at time period $t=200$. As a consequence, the value of service developers and the value of the platform provider stay at 0 as well. With this value setting, the software service platform cannot be bootstrapped. It could not attract a sufficiently large number of application users at that time.



(a)



(b)



(c)

Figure 9. Sensitivity analyses of stakeholder values (i.e., application user value (a), service developer value (b), platform provider value (c)) regarding the average service usage fee.

5.3. Discussion and Implications

One of the simulation results is that all stakeholder values are interdependent and a change in the value for application users affects the values for the other stakeholders. Looking at the results from the three scenarios (section 5.1) and the sensitivity analyses (section 5.2) in detail, it also becomes clear that the number of application users (i.e., installed base, $N_j(t)$) is a common positive determinant of the value for all stakeholders. A positive value for application users is required to bootstrap and sustain this software service ecosystem. The positive value for application users is the basis for service developers and the platform provider to generate any revenue. Only if a sufficiently large number of application users joined the platform, service developers can recover their cost and remain in the service platform market.

Furthermore, it is interesting to observe that, under both user growth rate assumptions, the values for service developers are quite low (e.g., *0.3$* at time $t=200$ for Scenario 1 of Figure 6a) compared with the values that the platform provider obtains (e.g., *150$* at time $t=200$ for Scenario 1 of Figure 7a). This constitutes a risk for the success of a platform, as service developers do not have an incentive to stay with the service platform and, therefore, might withdraw from the service platform due to insufficient revenue (i.e., revenue not larger than the opportunity cost).

In addition to this, despite the assumption of a growing number of new services, an upper limit on the average number of services that a single user can use (Scenario 2) and a decrease in the number of new adopters at a specific time through a market shock (Scenario 3) also indicate a sustainability problem for the software service ecosystem. While the value for platform providers increases steadily in all scenarios (as long as the value for application users is larger than zero), the marginal value for service developers decreases as the number of new users joining the platform starts to decline. It raises the question whether sufficient value is created for service developers to stay with the software service platform.

The sensitivity analyses, which have been performed with respect to the average service usage fee and the cost of service offerings, indicate the negative impact of higher cost of a service offering and service use fee on the bootstrapping and sustainability of a software service platform.

If the cost of service offering (i.e., hosting fee to be paid by a service developer) is increased, the negative impact on the value not only for service developers but also the platform provider can be noticed. As the service developers fail to recover their cost and fail to make profit from their share of the revenue (e.g., $C_{j,s}(t) \geq \$6$ in Figure 8b), the attractiveness of the platform to other service developers is reduced, resulting in less adoptions of the platform. Consequently, as the platform providers revenue depends on the number of services (i.e., $S_j(t)$) on the platform and the fraction of revenue $(1-RS)$ that they share with service developers, the value of the platform provider is also negatively impacted (Figure 8c).

The impact of an increased average service usage fee is also negative. A value of $c_{j,a}(t) = 1.5\$$ resulted in a delayed value creation (after 101 time periods). For $c_{j,a}(t) = 2\$$, the platform fails in producing any value for any stakeholder within the first 200 time periods at all. In these cases, the average service usage fee is too high for application users to gain a positive value from the beginning (Figure 9a). It also prevents service developers and the platform provider from gaining any value (Figure 9b and 9c). Only after a critical mass of application users $N_j(t)$ joined the platform, the value for application users becomes larger than zero and the value creation and distribution system begins to work.

The implication of these simulation results for the software service platform market is that service developers and the service platform provider need to focus on finding a pricing scheme that allows bootstrapping and sustaining the value creation and value distribution between the stakeholders. In particular, appropriate values for the service usage fee, the hosting fee, and a revenue sharing scheme have to be found. Only then, a value creation model exists that allows service developers to develop innovative services and to sustain their services over a long time period. Otherwise, with a decline in the average return on a single service (assuming a constant number of application users), the risk of market failure through the withdrawal of service developers from the market and the risk of stalling innovation increase.

6. Conclusions

In this study, we addressed the problem of value creation and value distribution in software service platforms, which exist in today's cloud computing market. In particular, we developed a value creation model, based on additive utility functions and three types of stakeholders. The types of stakeholders identified are platform provider, service developers, and application users.

As part of the additive utility functions, the major parameters for determining the value obtained by the three types of stakeholders are quality of service (QoS), service variety, installed base, and cost. The installed base represents the application users that generate monetary benefits through the payment of service usage fees for purchasing services and viewing advertisements. Besides consuming services, their own benefit is enhanced through direct and indirect network effects. QoS represents the amount of functional and non-functional capabilities, which application users will be able to use through services on the software service platform. QoS from the perspective of service developers represents the benefits of service developers coming from development tools, hosting and management services offered to service developers by the platform provider. Service variety denotes the number of different services that are offered by service developers on the software service platform. Cost, which is faced by all stakeholders, differs depending on the type of stakeholder. The different cost types considered are the cost of service usage for application users, the cost of service offering (e.g., cost of hosting and cost of using development tools) for service developers, and the cost of managing services (e.g., providing QoS) for the platform provider. As these four value parameters can impact the value for the three stakeholders simultaneously, a complex interdependency between the three types of stakeholders exists in the value creation model.

According to the value creation model, the main value generator in this software service ecosystem is the number of application users (installed base). In detail, an increase in the number of application users triggers three different effects: 1) an increase in the value for the application users due to the availability of more potential connections to other users; 2) an increase in the benefits for the service developers due to income from service sales; and 3) an increase in the benefits for the service platform provider due to the share of income they receive from service sales and due to hosting fees. The second most important value generator is the number of service developers that joined the platform. The number of service developers is mainly a consequence of the amount of service usage and, as mentioned, the number of application users. An increase in the number of service developers has also an effect on the benefits for application users due to an increase in the diversity of services. As a consequence, more services are sold and more application users join, bringing more profits to the platform provider and the service developers. Although our simulation results also indicate that the number of application users benefits all stakeholders, the service platform provider benefits mainly from the two-sided network effect between application users and service developers.

The current value creation model generates most of the benefits for the platform provider, while service developers are the least benefiting stakeholders. This result of our simulations shows a potential risk of unsustainability of the value creation and value distribution process in software service platforms. The risk is eminent for established platforms, if market saturation has been reached and prices of services are high. Under a market saturation condition, the number of new users joining the platform decreases and existing users reached their limited capacity of service consumption. Consequently, the demand is negatively affected, leaving service developers unable to recover their total costs (Figure 8b, Figure 9b). Consequently, we can state that, due to wrong pricing of application services and platform services, the software service ecosystem can collapse.

These findings aim at helping software service platform providers in the cloud computing market for making policy decisions on pricing and revenue sharing. As a strategy for platform providers, it is not only important to focus on building the network of application users but also to maintain attractive returns for service developers. An attractive revenue sharing scheme is important for sustaining the value generation for all stakeholders and the growth of the service platform in the cloud computing market.

Our future studies will explore additions to our value creation model by incorporating more factors such as pricing policies and market structures. We will also investigate how the competition between software service platforms affects the value for platform providers and the value for service developers.

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