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IT Service Platforms: Their Value Creation Model and the Impact of their Level of Openness on their Adoption

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Abstract: Many IT service platforms (e.g., cloud computing platforms) are built as closed systems. They do not allow their customers to interoperate with other platforms or port their data to other platforms. As switching to different system is costly, customer of a closed IT system can be considered locked in. Consequently, potential customers, who are aware of this lock-in issue, do not adopt cloud services. Opening up an IT service platform, however, reduces users' concerns about lock-in and its associated switching cost. It is even predicted that an IT service platform gets more attractive, if it opens up. This paper validates this prediction by analyzing the level of openness (i.e., interoperability, portability, and usability) of cloud computing platforms on their adoption. For the validation, we develop a value creation model for IT service platforms, using existing methods on value networks. Based on this value creation model and a specification of requirements of open cloud computing platforms, the relationship between the openness of IT service platforms and the adoption of IT service platforms (i.e., attractiveness) is analyzed in detail. In particular, our results show that the level of openness plays a major role in the adoption of IT service platforms of emerging service providers.

Keywords: Open IT Service Platforms, Interoperability, Portability, Usability, Openness, Cloud Computing Adoption; Value Creation Model, Simulation, Computational Economics, System Dynamics, Value Networks.

JEL Classification Numbers: C15, C61, C63, D21, D24, D46, D81, L11, L15, L22, L86, M15.

1. Introduction

The Internet led to huge changes in the way that IT systems are designed, accessed, and operated. Cloud computing, as an example of those IT systems, delivers IT resources on demand. In preparation for these changes, many cloud resource providers invest in the development of new cloud platforms to attract customers to the cloud.

Cloud IT service platforms provide services in competition to or as alternative to on-premises (traditional) software. The crucial difference is that, while on-premises platforms are designed to support consumer-scale or enterprise-scale applications only, cloud platforms can potentially support multiple users at a worldwide scale. Based on the type of service delivered, IT service platforms can generally classified into three groups. These are platforms, which deliver software as a service, platform as a service, or infrastructure as a service.

Even if the benefits of cloud IT service platforms are significant for both users and providers, the adoption of cloud services is currently limited, in part due to the technological diversity of IT service platform offerings in terms of, for example, different virtualization technologies, different interfaces, and programming languages. The risk of being locked into an IT service platform that does not interoperate with other systems or infrastructures is a major concern for firms that discuss to adopt cloud computing technology. According to a 2011 IEEE report and a 2009 IDC survey [1] [2], the lack of integration between IT service platforms makes it difficult for organizations to consolidate their IT systems within the cloud.

To fully realize the vision of cloud computing, barriers (e.g., low data and application portability and interoperability between cloud platforms) should be overcome. It should be possible to create an IT service platform that allows moving data, applications, and/or virtual machine images in and out from one provider to another or back in-house, where a programmer can work with the language of choice. This would make this service ecosystem fully mature. It would enable customers to choose among different service providers according to their needs (i.e., their performance requirements, geographic spread, and cost). Customers would simply be able to choose a different service of a different provider, if a customer is dissatisfied with the provider’s IT services delivered, a new and better alternatives are offered by another provider, or the vendor goes out of business. Consequently, the current lock-in effects disappear and customers would get attracted.

The objective of this paper is to validate the positive impact of the level of interoperability, portability, and usability (i.e., the level of openness) on the adoption of cloud computing. In particular, this paper aims to address:

- Who are the major stakeholders in this ecosystem and what are their roles?
- How is value created in an open IT service platform ecosystem?
- What are the requirements of an open IT service platform?
- What is the impact of interoperability, portability, and usability on the adoption of cloud computing?

In order to tackle the first and second research question, we develop a value creation model for IT service platforms, which shows the stakeholders and the interaction among the stakeholders in the network. To identify stakeholders, revenue flows, and knowledge flows among stakeholders, we used the value network methodology. To answer the third research question, data was gathered from different open and closed IT service platforms about their requirements to deliver their services. Additional data comes from an intensive reviewing of literature. In order to address the last research question, we used the value creation model. Based on the results obtained from the value creation model and the system dynamics methodology, we can analyze the relationship between the level of openness (i.e., the level of interoperability, portability, and usability) of an IT service platform and the adoption of cloud computing. In particular, we develop a system dynamics simulation for analyzing cloud adoption, focusing on open and closed types of IT service platforms. The results of the simulations under various conditions (e.g., level of openness) allow drawing conclusions related to the level of cloud adoption.

The remainder of the paper is organized as follows: In the next section, we describe the state-of-the-art. It includes reviews on recently published research papers on IT service platforms, stakeholders, value network models, challenges of cloud computing, and open IT service platforms. Section 3 discusses value network modeling, provides a list of requirements for interoperability and portability, and introduces the cloud adoption model. Section 4 summarizes the cloud adoption simulation and reports on the analysis results. Section 5 concludes the paper with a discussion.

2. II. IT Service Platforms

2.1. Stakeholders, Roles, and Value Chains

Only a few studies have been conducted on value chains, value networks, and value creation in cloud computing. Some research has been done in the context of Grid computing and ubiquitous computing. Altmann et al. developed taxonomy, describing stakeholders and their roles in Grid computing [3]. Another study conducted by Stanoevska-Slabeva et al. is based on industrial case studies. It describes different Grid computing stakeholders and developed a generic value chain and a value network for grid computing [4]. Lee and Leem studied the value chain for ubiquitous computing environments [5]. A value chain reference model for cloud computing was presented by Bany et al. [6]. They developed a value chain model based on Porter’s value chain theory and adapted it to the none-linearity value creation aspects of cloud computing. Böhm et al. also describe different cloud stakeholders, their roles in the market, and the interactions between them to develop a generic value network model, using e3 methodology [7].

2.2. Challenges for Adopting IT Service Platforms

Until now, many IT service platforms have been built as closed systems, (i.e., not allowing interaction between each other). Closed or proprietary IT service platforms require that all components (i.e., hypervisor, orchestration, automation systems, and metering tools) must come from a single provider to work together.

A survey conducted by the World Economic Forum in 2009 found that vendor lock-in is the second most common concern about public clouds in the European public sector [8]. It reached a value of 80%. Furthermore, in another study in 2011, the IDC enterprise panel identified that the issue of interoperability and data portability is as important as the security issue for the long-term adoption of IT service platforms [1].

To fully realize the vision of cloud computing, interoperable and easy-to-use platforms are needed. It would ensure that users can easily port and combine services regardless of the IT service platforms. It would also enable organizations to make a cost-effective transition of their IT systems to a service-oriented model, while keeping their development environment [1] [2].

1) Portability

In general, portability is the ability to run components or systems designed for one environment in another environment. In the case of IT service platforms, an environment comprises data, software, and hardware environments (both physical and virtual)[1]. Portability allows an application to have a common method of interaction to the underlying cloud services. Thus, the application and data will always work in the same way, regardless of the IT service provider or IT service platform, which can be public or private, internal or external, as well as open or closed [9] [10].

The lack of portability of data and applications between IT service platforms is currently hampering cloud adoption. Portability becomes increasingly important as more IT service platforms and providers are emerging. Furthermore, there should be an easy way out for customers, who are dissatisfied with the IT services offered by a provider and seeks a new and better alternative offered by another provider. Customers should be able to choose among different service providers according to their performance needs, geographic spread, and budgets.

2) Interoperability

Interoperability is defined as the ability of a component or system to work with more than one IT service provider simultaneously, regardless of the differences between the providers[2]. In other words, interoperability involves software and data being simultaneously active in more than one cloud infrastructure, while interacting to serve a common purpose.

IT service platform providers need to support interoperability, so that organizations can combine different capabilities of IT service providers into their specific solution [11]. It helps users to get solutions that are highly optimized towards their needs.

3) Usability

Usability is defined as the minimum number of personnel requirements (i.e., skills, experience, education, and certification) required of a customer to effectively utilize a service [33]. Usability indicates the ease of using a service. It has also been identified as one of the criteria that are important for the adoption of cloud computing.

2.3. Open IT Service Platforms

Existing literature has interpreted the concept of open and closed platforms in different ways. Schiff analyzes open and closed systems of two-sided networks, referring to the

[1] http://www.testingstandards.co.uk/interop_et_al.htm; see portability.
[2] http://www.testingstandards.co.uk/interop_et_al.htm; see interoperability.

compatibility between platforms [12]. Matutes and Regibeau found that open platforms allow consumers to mix and match components from competing firms [13]. Incompatibility or closed platforms obligate consumers to buy components from the same firm. Arora and Bokhari built a dynamic model for analyzing open versus closed systems [14]. Open firms can specialize in producing one component whereas closed firms cannot specialize and must produce all components.

In the case of IT service platforms, a closed system requires that all components (i.e., hypervisor, orchestration, automation systems, and metering tools) come from a single provider for it to work. In comparison, an open IT service platform allows for the creation of a system across a wide range of compatible suppliers. This allows enterprises to piece together the best of breed cloud system to meet their specific needs on a pay-as-you-go basis [15]. An open IT service platform allows data, applications, and/or virtual machine images to be moved easily in and out from one provider to another or back to the in-house data center, and on which programmers can work with the programming language of their choice (usability). Openness of an IT service platform improves portability and interoperability and, therefore, integrability [16].

Based on this description, we define openness of an IT service platform as a factor that describes the level of interoperability, portability, and usability, which facilitate data and application migration among different IT service platforms and allowing programmers using the development environment of their choice. It has to be noted though that the effect of openness depends on factors such as the type of service used, the type of cloud delivery model (i.e., private, public, or hybrid), and the service level agreement between providers and customers.

3. Modeling Open it Service Platforms

3.1. Requirements for Building an Interoperable and Portable IT Service Platform

The basic requirement for achieving interoperability and portability is to allow technological diversity of IT service platforms. With respect to IaaS, there are two main issues: the format of the virtual machine (VM) images, which describes the configuration of the virtual resources, as well as the management APIs for uploading, downloading, inspecting, and configuring VM images. Currently, each provider has its own solution, preventing orchestration software from working with multiple service providers.

With respect to PaaS, portability and interoperability becomes much even more challenging. By nature, platform services can have drastically different data formats. For example Microsoft Azure provides database services and .NET application containers [17], which are not compatible with GoogleAppEngine and vice versa [18].

For SaaS, portability and interoperability are also challenging due to the inherent data diversity. For example, this becomes evident when exporting and importing data from Facebook to another social media web site.

Based on the data collected from different IT service platform vendors and from a comprehensive literature review, this paper identifies the following fundamental requirements for building an interoperable and portable IT service platform:

- *Virtualization management:* In a virtualization environment, computing environments can be created, expanded, shrunk, or moved according to the demand [16]. The virtual machine (VM) image is a fundamental unit of work and encapsulation, particularly for IaaS and PaaS service platforms. The format of these virtual machines is one of the major challenges for creating seamless portability among IT service platforms. As IT service platform customers have already mixed virtualization environments in their in-house data centers, IT service platform providers should support multiple hypervisor technologies (e.g., VMware, Hyper-V, KVM, and Xen). It would resolve potential lock-in issues [19].

- *Choice of operating system:* Application virtualization emerges to break the bond between applications and a particular operating system. Yet, most applications still depend on a specific version of an operating system [19]. As customers already have a heterogeneous mix of operating systems in their data centers, forcing a specific operating system on a customer would reduce the customer base. IT service platforms should offer a choice of operating systems or environments to their customers.

- *Programming framework:* IT service platforms should offer developers a choice of software development tools, programming languages, and runtime environments, as customers chose their programming models a long time ago for their in-house applications. IT staffs will likely avoid a complete change of their programming model, given their familiarity with a given programming model and their skill-sets. Thus, IT service platforms need to support the programming models that are in use today. Examples are the enterprise models such as .NET and Java as well as the Web models such as PHP and Ruby on Rails [16] [19].

- *Standardized programming interface:* Each IT service platform provider has its own application programming interface (API), which prevents orchestration software from working with multiple service providers. The incompatibilities of the management APIs for uploading, downloading, inspecting, and configuring are a significant issue for interoperability and portability. For example, the Amazon EC2 API is different from the GoGrid API [20] [21], even if both offer similar services regarding IaaS. In addition, each cloud provider has its own proprietary solution that tends to require users to use a specific technology. Examples of valuable, proprietary solutions are Amazon Elastic Load Balancing and Salesforce Real-time Query Optimizer [22] [23]. Standardized and open APIs, however, allow applications written for those interfaces to be moved to a new provider. Currently, customers can also leverage a few programming toolsets for readying their IT for cloud deployment [24] [25].

- *Storage / database:* Some IT database service providers built in restrictions to make their products more elastic. For example, they limit the possibility of querying against large datasets, which requires significant resources to process. Some other cloud databases do not allow joins across tables, and some do not support a true database schema [16]. These restrictions are major challenges to moving between cloud database vendors. In addition, platform services can have drastically different data formats. For example, Microsoft's Windows Azure provides database services (relational data modeling) and .NET application containers [17]. Applications and data within Azure are not compatible with GoogleAppEngine [18], which uses document-oriented BigTable, and vice versa [26]. To avoid lock-in issues, customers have to choose a framework offered by multiple providers, avoid provider-specific extensions (like the Python extensions in AppEngine), and to use emerged standards. However, in addition to this, vendors should support the easy movement of data in and out of their clouds.

- *Data and application federation:* Federation is the act of combining data or applications across multiple systems. Federation can be supported by service providers or service brokers, who provide integration support. If users need to combine data from multiple cloud-based sources, they need to coordinate the activities of applications running in different IT service platforms [16], which requires support from the service providers.

These six, basic requirements listed here affect not only the relationship between IT service platform providers, developers, and customers but also the value proposition of all stakeholders in an IT service ecosystem.

3.2. Stakeholders

After analyzing the literatures on stakeholders (i.e., market actors) in cloud computing [7] [6], grid computing [3] [4], ubiquitous computing environments [5], value creation models in traditional industries, and analyzing different services offered by open and closed IT service platforms, we could identify the following stakeholders related to IT service platforms:

- *Infrastructure (IaaS) providers* offer virtual hardware (e.g., storage, computing resources) and network capacity including firewall services. However, the customers have full responsibility for the VM instances received and control them. They are also responsible for security and disaster recovery with respect to data and infrastructure.
  - *Platform (PaaS) providers* offer an environment to develop, test, and run applications. This also includes services for team collaboration, web service integration, database integration, VM management, and versioning. These services depend on the operating system environment, the APIs available, and the programming languages used.
  - *Application (SaaS) providers* offer applications to their customers. Applications are hosted and operated by application providers in their own or outsourced data centers. These providers are also responsible for the smooth operation of applications including monitoring, resource management, and problem management. Customers access the applications via the Internet.
  - *Composite service providers (CSP)* aggregate services into complex, value-added solutions for their customers. CSP became possible due to the service-oriented nature of cloud computing, which enabled the emergence of a large number of small and modular services. According to the market analyst Gartner, three different types of CSPs exist: The first combines existing services created by different providers into a new service. The value-add reseller (i.e., the second type of CSP) adds value to a given service, to address a specific need of a customer. The third type categorizes,

compares, and ranks cloud services from different providers as well as provides a marketplace for cloud services.

- *Integrators* offer data, application, and system integration services for both customers and IT service platform providers. If a customer decides to use IT service platform services, integrators perform the following tasks: (1) convert preexisting, on-premise data into formats used in the cloud; (2) integrate a cloud computing solution into the existing IT landscape; and (3) develop interfaces between applications of different vendors and providers. In addition to this, integrators are responsible for system integration testing, ensuring a seamless cooperation between the applications, delivering training to users, and customer support.
- *Consultants* provide consulting services for customers and providers. For customers, they introduce cloud computing technology, provide an economic analysis to decide whether cloud computing is viable for the specific customer and whether security and data lock-in issues are acceptable. For providers, they exam technical problems, evaluate cloud providers' services, and analyze the demand of customers.
- *Regulators* provide legal a framework for all stakeholders in the ecosystem. This legal framework is the basis for the treatment of data (e.g., where can the data be located). When moving applications and data to the cloud, the provider may choose to locate the data in a low cost country. However, this could violate the laws that apply to the data. For example, the law might state that the sensitive health care data cannot leave the country. Therefore, the success of the cloud computing paradigm depends to a large extent on how the national and international regulatory bodies design the laws.
- *Standardization bodies* help coordinating the design of interfaces, in order to increase portability and interoperability. However, the lack of industry-wide accepted standards is currently hampering the cloud adoption. This limits the portability of data and applications between providers. If a customer is dissatisfied with the cloud services offered by a specific provider, or if the vendor goes out of business, there is currently no guarantee that the customer can move to a different provider without problems. System portability is also increasingly important as more cloud providers are emerging and looking for a niche market. If no portability exists, large provider will win the competition in the market [28]. We believe that a regulator-supported standardization body has to become a major stakeholder in the cloud ecosystem.
- *Consumers*, which receive services, can be businesses or individuals. Consumers do not create value within the cloud computing ecosystem. They are the starting point of the service request and the end point of the service delivery.

3.3. Value Creation Model

A value network is a "set of relatively autonomous units that can be managed independently but operate together in a framework of common principles and service level agreements (SLAs)" [29]. Based on this definition of a value network and the definition of the network entities (i.e., stakeholders), the value that each entity receives from being a network member are used to identify the value linkages between the stakeholders.

The result of the analysis is the design of the value network model for IT service platforms (Figure 1). While Figure 1 shows IaaS providers, PaaS providers, and SaaS providers as a single entity, the detailed illustration of the value creation between these stakeholders is shown in Figure 2.

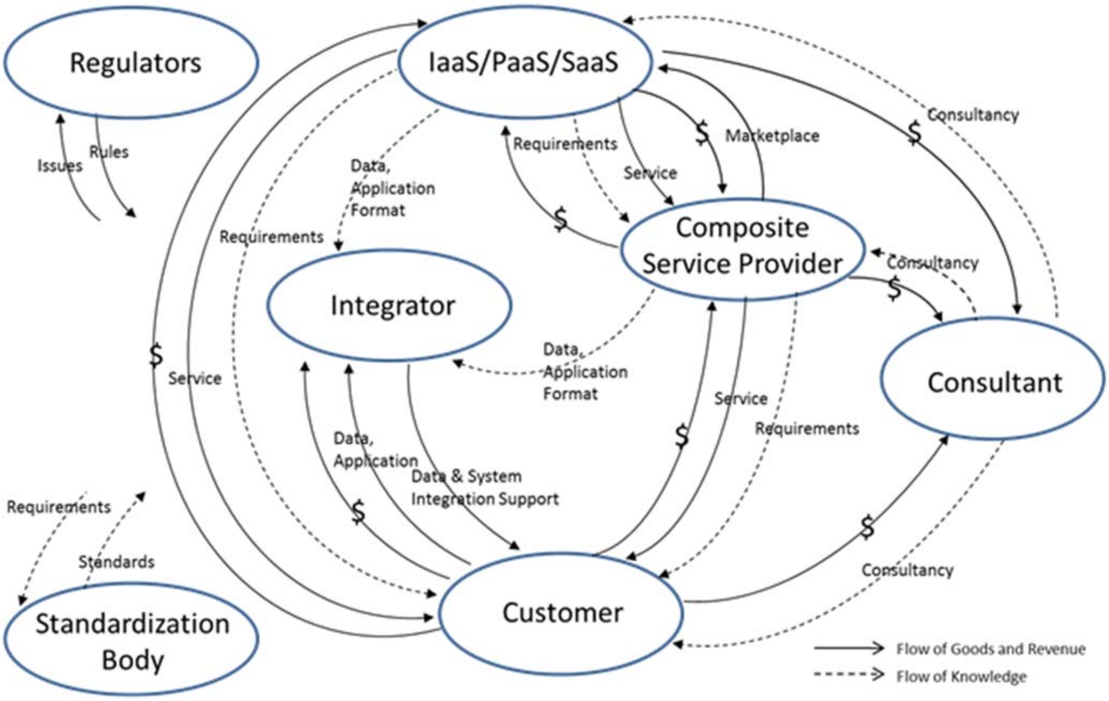

Figure 1. Example of a service network.

A customer C participates in the value creation (i.e., becomes a user of a specific service), if the customer value VC obtained is larger than zero. The customer value (i.e., net utility or attractiveness) depends on her utility (i.e., service value) gleaned from the value network and the total cost for using an IT service (e.g., payment made to other stakeholders for integration, for training, and service usage). This is expressed in the following equation based on linkages of the customer stakeholder in Figure 1:

$$V_C = ServiceValue - TotalCost \qquad (1)$$

The first variable represents the value obtained from using a service of a SaaS/PaaS/IaaS provider, a composite service provider or consultants. The second parameter denotes the cost of integration, which is composed of the cost of an integrator, the cost for fulfilling the requirements for using the service (e.g., the cost for upgrading the existing in-house IT infrastructure), and the usage cost of the SaaS/PaaS/IaaS service. The parameter values are represented in Figure 1 as in-coming and out-going arrows of the customer stakeholder.

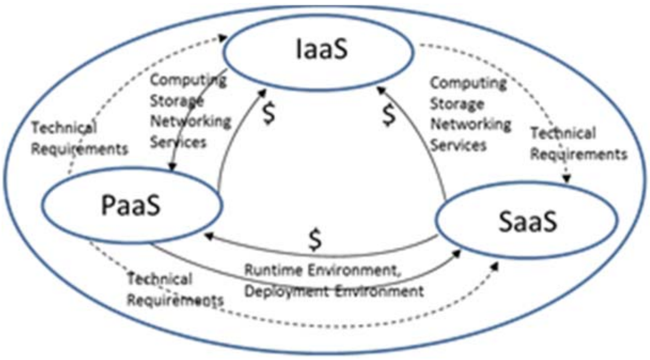

Figure 2. Value exchange between IaaS, PaaS, and SaaS providers.

From the value creation model (Figure 1), the value obtained by a provider P can also be identified. The value is equal to the revenue made from providing services to customer stakeholders and composite service providers (if they are resellers).

$$\begin{aligned} V_P = \ & NumOfCustomers \ * ChargeOfService \\ & AllocatedBudgetForImprovQoS \end{aligned} \tag{2}$$

As (2) shows, the provider value depends on the number of customers, the charge of the average use of a service consumed, and the cost for provisioning the platform, which is correlated to the budget that is allocated for improving QoS. It could be a fraction of the revenue of the previous billing cycle.

In order to increase its revenue, providers can follow many strategies. One strategy is to increase the number of customers (i.e., the number of customers that adopted the providers' platform). This can be achieved by increasing the attractiveness (e.g., easy integration, simple deployment, little requirements) of the platform. This would increase the value for its customers as well. The detailed description of the dependencies between attractiveness and revenue is given in the following section.

4. Simulation Model and Analysis

4.1. Modeling Technique

This paper uses the causal loop diagram from system dynamics, in order to get a better understanding of the interrelation between the adoptions of cloud computing (i.e., number of customers), customer value, and provider value. Causal loop diagrams are simple node arrow constructs that interlink key system variables by arrows. The tail variable (i.e., the variable indicated by the start point of the arrow) will lead to changes in the head variable (i.e., the variable indicated by the end point of the arrow). An arrow shows true causality, not a statistical correlation [30]. The diagram convention within system dynamics that has been adopted here is based on '+' signs and '–' signs that are placed on arrow heads. They indicate the "polarity" of the link. A '+' sign suggests that a change in the tail variable causes a change in the same direction in the head variable. Conversely, a '–' sign suggests the opposite effect [30].

4.2. IT Service Platform Adoption Model

To analyze the impact of openness (i.e., the level of portability, interoperability, and usability) on the attractiveness of an IT service platform, the relationship between attractiveness of a platform to a customer (i.e., customer value) and provider value (revenue) is modeled in more detail. The customer value and the provider value are illustrated in Figure 3, which shows the overall structure of the IT service platform adoption model. Each link of this figure is expressed as one equation.

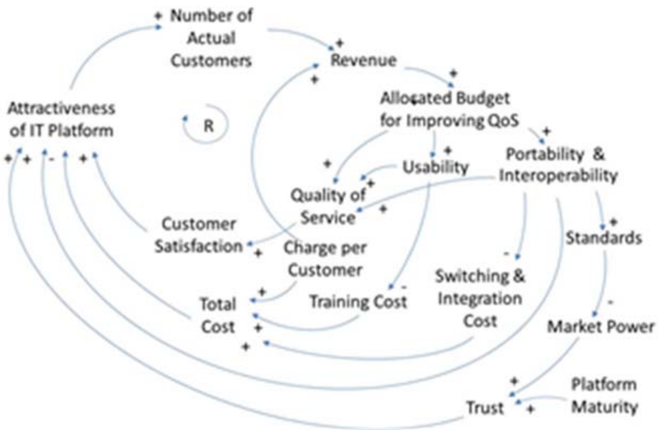

Figure 3. IT service platform adoption model.

For the analysis, we start analyzing the *ServiceValue* obtained from a service of an IT service platform in detail.

$$ServiceValue = \mu_1 * InteroperabilityPortability + \mu_2 * CS + \mu_3 * Trust + \mu_0 \quad (3)$$

In (2), the three variables that impact the attractiveness positively are customer satisfaction CS, interoperability & portability, and trust [1] [2]. The factors μ_0, μ_1, μ_2, and μ_3 determine the fractional relationship between those factors. The sum of the factors is one. It is assumed that the utility function is additive.

To increase customer satisfaction, the quality of service (i.e., number of services, the service performance, and the functionality of services) needs to be improved.

$$CS = \alpha * QoS \quad (4)$$

This, however, depends on the amount of investment a provider wants to allocate for improving the service quality [31]. The investment is independent of the market structure. In a monopolistic market and an oligopoly market, the strategy relies on non-price competition, differentiating their products to attract more customers to their service. It is used to increase the total demand of the market. In a competitive market, high revenue will motivate a provider to invest in the quality of service. Based on these economic principles, providers are assumed to improve the quality of service through investment and, therefore, attract more customers [32].

As potential activities for increasing the quality of service, we follow the service management index (SMI)[3] [33]. It identifies seven attributes including interoperability, portability, and usability to improve QoS. Note, as interoperability and portability has the same effect in our context, we combine those two attributes.

$$QoS = \beta_1 * AllocatedBudgetForImprovQoS + \beta_2 * InteroperabilityPortability + \beta_3 * Usability + \beta_0 \quad (5)$$

As interoperability, portability, and usability indirectly impact QoS, we allow allocating revenue to them as well, which is expressed as:

$$InteroperabilityPortability = \gamma * AllocatedBudgetForImprovQoS \quad (6)$$

$$Usability = \delta * AllocatedBudgetForImprovQoS \quad (7)$$

The sum of β_1, γ, and δ is equal to one. Supporting usability (e.g., many programming languages) decreases the potential cost of a user to learn new languages (i.e., increase his skill) to use the service. Therefore, providing a choice of programming languages to a user reduces the training costs for learning a programming language to users using the IT platform service. In general, training costs occur when a customer needs additional knowledge to use a service in the cloud.

Interoperability and portability also negatively affect the switching and integration cost. Thus, if interoperability and portability increases, switching and integration cost decrease. Switching cost measures the cost when a customer tries to change the service platform provider or back to in-house services.

The sum of the training cost, switching cost, and usage cost defines the total cost for a user to use an IT service platform. As we are only interested in the relative cost, we divide the sum of the three cost factors by the maximum possible cost, named MaxCost. The maximum possible cost is calculated by estimating the maximal values of each cost factor.

$$TotalCost = (ChargePerCustomer + TrainingCost + SwitchingIntegrationCost) / MaxCost \quad (8)$$

As interoperability and portability of IT service platforms supports the use of standards, the higher the level of interoperability and portability, the stronger the standard gets.

$$Standards = \theta * InteroperabilityPortability \quad (9)$$

Standards negatively affect a provider, who has market power in the ecosystem. If a market leader uses standards, the provider loses power in the ecosystem in the long run. This is a major cause why market leaders do not participate in standardization initiatives, block decisions, or drive standardization decisions in a certain direction. Following a standard reduces the chance for market leaders to emerge as a de facto standard in the market. This is simply expressed by reversing the value of the variable Standards.

$$MarketPower = 1 - Standards \quad (10)$$

[3] The service measurement index (SMI) of cloud computing identifies seven attributes of organizations, to measure cloud-based business services according to their specific business and technology needs.

In an immature ecosystem, market power positively affects the trust of users. Customers do not fear that large provider go bankrupt easily. Therefore, they do not fear the risk of having to reverse their migration of applications and data back to their in-house data center or to another provider. Trust, in turn, has a positive impact on the attractiveness of IT service platforms.

In a similar way, the maturity of the platform also impacts trust. A platform can be considered mature, if the platform is available to potential customers over a long time period and the provider's technological expertise is high. Consequently, we model the effect on trust by calculating the product of market power and platform maturity.

$$Trust = MarketPower * PlatformMaturity \quad (11)$$

With the help of the eleven equations, the links of the IT service platform adoption model can be fully described.

4.3. Simulation Model

Our simulation model is based on the IT service platform adoption model (Figure 3). It has been extended by introducing flows between parameters of the adoption model, a source of new customers (*NumberOfPotentialCustomers*), and a parameter for calculating new customers (*AttractedCustomers*) based on the attractiveness of the IT service platform. Using this simulation model, the total number of actual customers that are attracted to the IT service platform over time can be calculated. Figure 4 illustrates this simulation model.

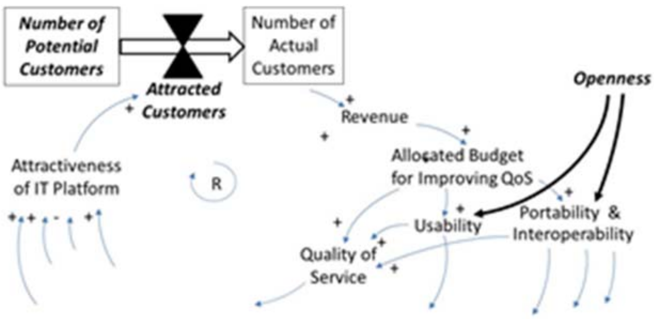

Figure 4. Simulation model of the IT service platform adoption model.

The number of potential customers C_P and the number of actual customers C_A is calculated as follows:

$$C_P(t) = C_P(t\text{-}1) - AttractedCustomers(t) \quad (12)$$

$$C_A(t) = C_A(t\text{-}1) + AttractedCustomers(t) \quad (13)$$

Where t denotes linear time intervals and *AttractedCustomers(t)* is defined as the attractiveness VC at time t-1 multiplied with $C_P(t\text{-}1)$. Furthermore, the sum of C_P and C_A is assumed to be constant.

Furthermore, a parameter called Openness has been introduced, which can range between 0 (closed) and 1 (open). This parameter is used to simulate the provider's strategy about the level of interoperability, portability, and usability of its IT service platform. This means the value of Openness is directly multiplied with (6) and (7), the values of *InteroperabilityPortability* and *Usability*.

5. Analysis of Simulation Results

The simulation results address the effects of the level of openness on the attractiveness of IT service platforms.

5.1. Effect of an Open Strategy on the Attractiveness of IT Service Platform Providers

Based on our definition of openness, the open strategy represents the decision of a provider to improve the quality of service by increasing the interoperability, portability, and usability of his specific IT service platform. If a provider decides to use the open strategy, the value of the parameter Openness is greater than zero. The closed strategy is used, if the value of the parameter Openness equals zero. It means that the provider does not improve the interoperability, portability, and usability of its IT service platform.

Figure 5 shows the number of actual customers of using the IT service platform over a course of 11 time periods (e.g., months) for four different levels of openness (i.e., *0.0, 0.1, 0.5*, and *1.0*). All other parameters remain constant during the simulation runs and platform maturity is set to *0.5*. Note, according to our adoption model of section 4, the number of actual customers depends on the attractiveness of the IT service platform.

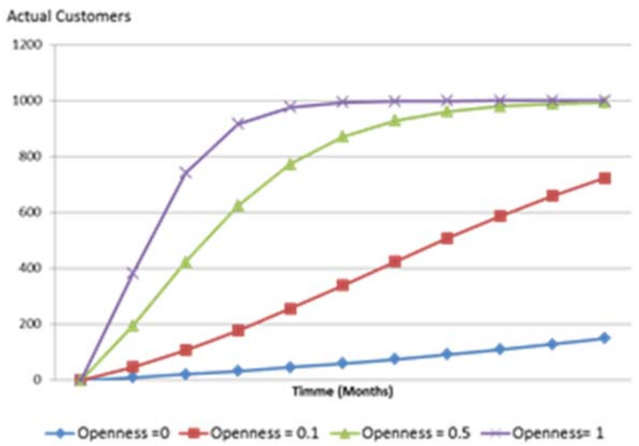

Figure 5. Impact of the level of openness on the number of actual customers of a IT service platform.

The results indicate that portability, interoperability, and usability among IT service platforms play a major role in increasing the IT service platform adoption. Figure 5 shows that the number of actual customers of portable and interoperable IT service platforms increases the more the strategy tends towards openness. In particular, it can be observed that interoperability and portability allow providers to attract faster customers, if they follow an open strategy.

5.2. Open Versus Closed Strategy for Newly Emerged Providers

Customers are concerned that a provider may go bankrupt, as migrating data and applications back to in-house data centers or to another provider is very expensive. Therefore, customers consider the maturity of the platform (i.e., the age of the platform, technological expertise) and the market power (i.e., the number of actual customers) as an indication for the future existence of the platform.

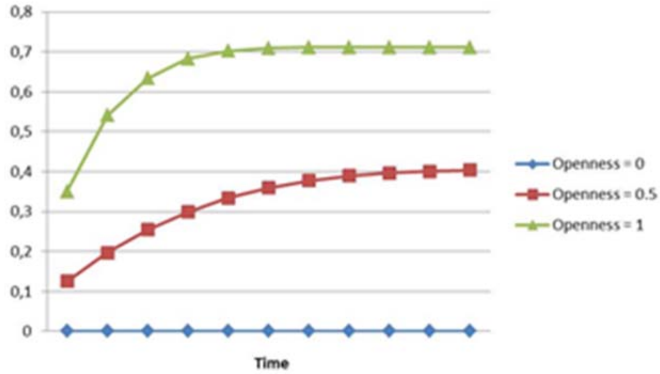

Figure 6. Impact of the level of openness on the attractiveness of IT service platforms provided by newly emerged firms.

For the simulation results shown in Figure 6, the platform maturity has been set to the constant value 0, representing newly established firms. In particular, Figure 6 displays the attractiveness of the IT service platform for these newly emerged platforms, depending on the open strategy (i.e., 0.0, 0.5, and 1.0) over the duration of 11 time periods (e.g., months).

The analysis of the simulation results shown in Figure 6 indicate that openness is mandatory for new providers to survive in the ecosystem. In the first simulation, when a new provider chooses to build a closed platform (i.e., openness = 0), the attractiveness of the platform remains 0. This means the provider's platform proposition is not able to attract any customer in the market. The second and third simulation run exhibits that an interoperable, portable, and easy-to-use (i.e., openness = 0.5 and 1.0) platform is essential to newly emerged providers to be attractive to customers.

5.3. Open Versus Closed Strategy for Market Leading Providers

The setting of this simulation run is identical to the one in the previous section, except for the parameter platform maturity, which is 1 for this simulation run, representing a fully matured platform.

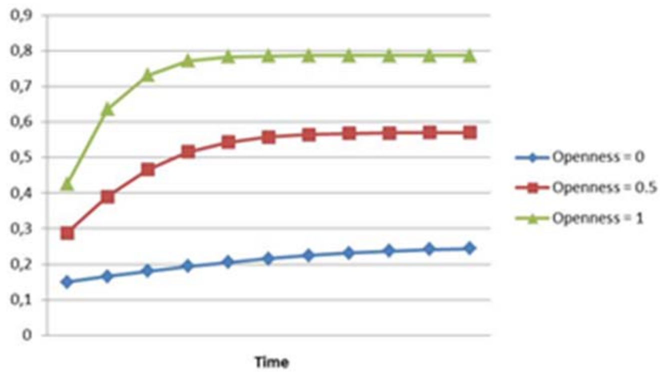

Figure 7. Impact of the level of openness on the attractiveness of IT service platforms provided by market leading firms.

The analysis of the simulation results for market leading firms (Figure 7) shows that even the closed platform proposition of a provider is attractive to customers. The main reason behind this result is that a customer's trust is obtained from market power. Additionally, if a market leading platform provider improves the openness of the platform, the resulting attractiveness of a platform is even higher than the attractiveness of a platform provided by a newly emerged provider.

However, comparing the attractiveness of a completely open strategy of a newly emerged IT service platform provider (Figure 6) with the attractiveness of a closed strategy (or partially open strategy, openness = 0.5) of a market leading firm (Figure 7), an interesting aspect becomes visible. It shows that providers, who currently have market power, can be challenged by small IT service providers offering interoperable IT service platforms. Consequently, it can be predicted that, over time, market leading platform providers will need to adjust their strategy (i.e., run an open strategy) to compete and keep their position in the ecosystem.

6. Conclusion and Recommendations

Portability, interoperability, and usability of an IT service platform play a major role in improving IT service platform adoption for both newly emerging and market leading service providers. For new providers, a high level of openness is mandatory. Providers, who currently have market power and run a closed platform, are challenged by a high level of openness of new IT service platforms. They will need to adjust their strategy (i.e., to run an open strategy) to survive in the long run.

In conclusion, interoperable IT service platforms allow the seamless creation of systems from a wide range of compatible suppliers. Consequently, blocking data or application portability and interoperability is not attractive to users. To attract more customers, providers need to convince customers through innovation and the provision of service quality in the IT service platform ecosystem. As soon as an interoperable service platform reaches a certain size, a close strategy is no longer a suitable strategy for providers. These results can be directly applied to cloud computing. Interoperability of cloud service platforms needs to be achieved, in order to build a reliable and consumer-accepted IT infrastructure.

A limitation of our research is that the obtained simulation results can only provide an understanding of tendencies within the market but no absolute results. The data used for our simulation are average values found in literature or are normalized.

Our future research will validate the simulation results using case study data. The IT service platform adoption model will also be extended to include privacy, security, and other factors that affect the attractiveness for a customer.

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