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Flourish the Market of Open Source Enterprise Systems Through Cloud-Based Technology: An Perspective of Cross-Side Network Effects

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FLOURISH THE MARKET OF OPEN SOURCE ENTERPRISE SYSTEMS THROUGH CLOUD-BASED TECHNOLOGY: AN PERSPECTIVE OF CROSS-SIDE NETWORK EFFECTS

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ABSTRACT

Open source enterprise systems (OS-ES) have become an appealing option for small and medium-sized enterprises (SMEs) to bring powerful business computing tools into their organizations. However, the impact of OS-ES is still in their nascent stage because of the critical challenges they pose. We conclude that the challenges of OS-ES mainly come from three perspectives: limited economic scale, product-oriented business strategy, and insufficient product support. In this study, we propose that the emergence of cloud-based technology can catalyze the flourishing process of OS-ES market through leveraging both the OS-ES user-side and developer-side economic scale. Because of the two-sided nature of OS-ES market, we then draw on the *cross-side network effects (CNEs)* theory to explain the positive reinforcement loop between user-side adoption and developer-side engagement of OS-ES projects.

KEYWORDS

Open source enterprise systems (OS-ES), cloud-based enterprise systems, two-sided nature, cross-side network effects (CNEs)

INTRODUCTION

Complex information systems (IS) such as enterprise systems (ES) play an indispensable role in streamlining organizations' data flow (Davenport 1998) and supporting a range of functions in organizations with direct access to real-time information (King and Burgess 2006). However, the costly on-premises ES products outpace the capabilities of resource-constrained organizations (Fougatsaro 2009), such as small and medium-sized enterprises (SMEs). Consequently, open source enterprise systems (OS-ES) that are freely available for download and implementation (e.g., NetSuite; Kim and Boldyreff 2005) have become an important alternative to on-premises ES. Particularly, resource-constrained SMEs find OS-ES as an appealing option (Olson et al. 2018) in several regards: cost reduction (Kim and Boldyreff 2005), flexible for customization (Johansson and Sudzina 2009), and acceptable quality (Olson et al. 2018). However, the impact of OS-ES is still in their nascent stage (Olson et al. 2018). Only a small percentage of the ongoing open source applications are stable and mature on SourceForge (Fitzgerald 2006), especially for the complex OS-ES applications.

Obviously, the free OS-ES applications are not so appealing as expected, they also pose critical challenges. Inspired by the study of Fitzgerald (2006), these challenges arise from three key perspectives: limited economic scale, product-oriented business strategy, and insufficient product support. First, a limited economic scale indicates there are only a few developers and users who exist in the OS-ES market. Most potential users are not going to invest in OS-ES because of the high level of IT expertise requirement due to the complex nature of OS-ES applications. Second, the current OS-ES business strategies are product-oriented. This business strategy ignores the potential users' requirements for IT expertise. Thus, the current OS-ES business strategies are not sufficient for further market development in terms of attracting more users and developers. Third, the prevailing OS-ES product support mainly relies on the e-mail list and related forums (Fitzgerald 2006). Without continuous professional support, most potential users will not risk their capitals to implement OS-ES. The lower market demand will result in a limited number of OS-ES developers in the market.

The emergence of cloud-based technology can catalyze the process of flourishing the OS-ES market. On the one hand, cloud-based technology can increase the user-side economic scale of the OS-ES market through sufficient product support. More users invest in OS-ES because of the reduced entry barriers (e.g., lower requirement for IT expertise). On the other hand, cloud-based technology can leverage the developer-side economic scale through shifting business strategy from product-oriented to service-oriented. Due to the sustainable benefits (e.g., user's subscription fee) that

can be achieved from OS-ES industry, more developers will join in the market and devote more time and attention to certain OS-ES projects. Because the nature of OS-ES market is two-sided (e.g., users and developers), both user-side and developer-side market success can be amplified through the cross-side network effects (CNEs). In this study, the overarching objective is to explain how to flourish the OS-ES market through cloud-based technology based on the lens of CNEs. This objective is reflected in two research questions: (1) whether cloud-based technology facilitates both user-side and developer-side market success of OS-ES? (2) how do the CNEs of the OS-ES market further leverage both side market success of OS-ES?

THEORETICAL BACKGROUND

Enterprise System Development

Recently, the most prevalent approaches of ES development are based on the following three business models: on-premise ES, cloud-based ES, and OS-ES. First, traditional on-premise ES is defined as large-scale software packages that are implemented on computers on the premises of the organization for integrating operational data and supporting business activities (Davenport 1998; Markus et al. 2000). The implementation of an on-premise ES is an extensive, lengthy, and costly process (Shanks 2000). Second, cloud-based ES refers to the approach to ES that makes use of cloud technology to host, maintain, and manage the software application from a central location (Guo and Ma 2018). Therefore, cloud-based ES support users through a network and charge them based on usage (Guo and Ma 2018). The cloud-based approach makes ES become affordable and easy to implement and manage, especially among SMEs. Finally, OS-ES is an enterprise system whose source code is made publicly available (ERP News 2016). Similar to the other open source software, OS-ES is developed on open source platforms by developers who join the project voluntarily and are freely available for download and installation (Kim and Boldyreff 2005). OS-ES have become appealing to organizations that are resource-constrained in terms of financial and human capital because of their free licensing structure (Olson et al. 2018; Serrano and Sarriegi 2006).

In this study, we focused on the OS-ES business model and try to investigate how to flourish this particular OS-ES market. Olson et al. (2018) stated that the most significant advantage of OS-ES is their obvious cost advantage whereas the fatal disadvantage is that user organizations cannot receive the same level support with OS-ES as with on-premise ES. Thus, it is critical to shift the business strategy of OS-ES from product-oriented to service-oriented (e.g., Software as a Service business model). Use cloud-based technology to increase the economic scale on both user-side and developer-side is another urgent task for the immature OS-ES market. On the one hand, cloud-based technology can reduce the users' entry barriers by providing more product support, resulting in increased OS-ES users. On the other hand, the cloud-based technology can guarantee a sustainable benefit (e.g., a monthly subscription fee) for developers, which can tremendously increase the engagement of OS-ES developers and attract new developers to join the OS-ES market. Inspired by Fitzgerald (2006), the advantages of embedding cloud-based technology into OS-ES are achieved from three perspectives: economic scale, business strategy, and product support (Table 1).

Key Perspectives	OS-ES	Cloud-based OS-ES
Economic Scale	• Few users • Few developers	• More users • More developers
Business Strategies	• Product-oriented	• Service-oriented
Product Support	• Fairly haphazard • Rely on e-mail lists and forums	• Professional ongoing support

Table 1. Characterizing OS-ES and Cloud-based OS-ES

Cross-side network effects (CNEs) theory

In the context of the OS-ES market, CNEs refers to the phenomenon that either the user-side or developer-side value largely depends on the value of another side in OS-ES market (Eisenmann et al. 2006; Parker et al. 2016; Song et al. 2018). CNEs exist in many industries, one popular example is in the ride-sharing industry such as Uber—two sides of the market are involved: riders attract drivers, and drivers attract riders. Similar dynamics also can be found in other businesses, such as Google's Android, craigslist, PayPal, and Airbnb. All these businesses have two-sided network

effects with positive feedback—overall value achieved as the platform matches demand from both sides (Parker et al. 2016).

Previous research of CNEs mainly focused either on platform competition (Rochet et al. 2003) or firms' business strategies (Eisenmann et al. 2006). The current study is more relevant to the latter research stream and has strategic implications for developing the OS-ES market from both user-side and developer-side. For instance, CNEs influence the OS-ES market's strategies by not only focusing on motivate developers (e.g., Roberts et al. 2006; Stewart and Gosain 2006) but also motivate more users to invest in OS-ES. In this study, the developers and users are two distinguished groups in this two-sided market. The OS-ES applications and the cloud-based services that bring these two groups together serve as the platforms (Eisenmann et al. 2006). In this two-sided market, once potential users find the OS-ES become appealing and come into the market, more developers will then join in on the other side of the OS-ES market for receiving more reputations and profits (Figure 1). Thus, the sustained market success of OS-ES will achieve because of the increased economic scale on both developers' and users' side through CNEs.

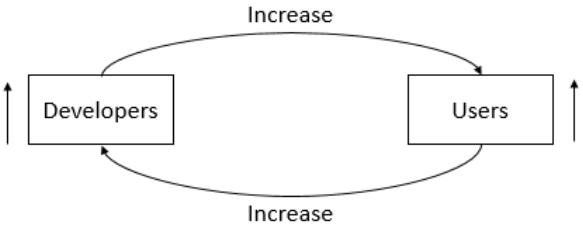

Figure 1. Cross-side Network Effects (CNEs)

In this study, the OS-ES developers refer to the software development experts who voluntarily join the OS-ES projects whereas the OS-ES users indicate the resource-constrained organizations (e.g., SMEs) that use the OS-ES applications. Consider the OS-ES market as a two-sided market (Figure 1), CNEs focus on the interaction between the two sides of the OS-ES market (Economides and Katsamakas 2006). When more users start to invest in OS-ES, the increased demand will attract more developers to join in the market and encourage the current developers to engage more. In a similar way, when the number of developers grows or developers engage more in developing OS-ES, the increased product and service quality will provide significant benefit for users, resulting in the number of users of OS-ES grows. As such, the OS-ES market success becomes more sustainable through its CNEs.

ROLE OF THEORY, RESEARCH MODEL, AND HYPOTHESES

Cloud-based Technology in OS-ES Market

The emergence of cloud-based technology has fundamentally changed the way of delivering, using, and managing OS-ES applications. By adopting cloud-based technology, OS-ES developers can maintain and upgrade the system on the cloud-based servers and their clients can access the software and service through the internet (Zhang and Seidmann 2009). Both users and developers can benefit from the cloud-based technology enabled OS-ES market, users can receive sufficient product support at a palatable price whereas developers can make stable profits via software as a service (SaaS) business model.

The cloud-based technology can facilitate user-side OS-ES market success from several regards: sufficient product support, sustainable product quality, and lower investment risk. First, the cloud-based technology shifts the business strategy of OS-ES from product-oriented to service-oriented. As such, users can experience the maximum product benefits enabled by the implemented OS-ES without any responsibility for product maintenance and update. Also, the cloud-based technology lowers the entry barrier (e.g., IT expertise requirement) for potential users through providing sufficient product support. Second, the overall product quality experienced by OS-ES users is determined by the adoption and patch strategies of OS-ES application (Arora et al. 2006). Users not only require their OS-ES applications can be installed rapidly but also want the reported bugs to be resolved efficiently through patches and upgrades. By adopting cloud-based technology, the bug-resolving process will become more efficient and effective. Finally, due to the complex nature of OS-ES applications, cloud-based technology can reduce OS-ES investment risks through decreased IT expertise requirements and improved professional support. Cloud-based technology, therefore, facilitates the user-side OS-ES market success in the form of increased number of users. We hypothesize that

Hypothesis 1a. Cloud-based technology has a positive direct effect on the user-side market success of OS-ES.

The cloud-based technology can also facilitate developer-side OS-ES market success. Similar to most OSS developers, the OS-ES developers are often self-employed freelancers and volunteers (Roberts et al. 2006). To motivate OS-ES developers to join in the OS-ES project and put more effort into those projects, the cloud-based technology facilitates the developers' engagement and attracts new developers through providing stable benefits to developers (e.g., a subscription fee). The cloud-based technology shifts the OS-ES business focus to product service and enables the developers to provide professional service with payment (e.g., SaaS). According to the prior literature on operant conditioning, rewarded behaviors are more likely to be sustainable and repeated in the future (Roberts et al. 2006), the monetary benefits can reinforce the existing OS-ES developers' engagements. Hence, developers who are being paid to contribute to the OS-ES project are more likely to participate intensely in OS-ES projects.

Hypothesis 1b. Cloud-based technology has a positive direct effect on the developer-side market success of OS-ES.

Cloud-based Technology in OS-ES Market

Prior research indicates that the network effects depend on the size of the network (Parker et al. 2016). For example, the widely used QWERTY standard is enabled by the large size of the user network (David 1985). To realize the value of cross-side network effects in the OS-ES market, it is important to scale both side networks and to make sure that both sides of the OS-ES market grow proportionally (Parker et al. 2016). Hence, developer-side and user-side market successes are mutually influenced each other in the market and jointly influence the OS-ES market.

The increased number of users shapes the user-side market success in the OS-ES market. Because the OS-ES will embed into users' business practices and create dependencies within their business network, the early user will draw new users to the market to quickly adopt the OS-ES applications. The cloud-based technology enabled user-side success will provide additional profits for developers through subscription business models and make developers put more effort into the OS-ES project (e.g., more professional service and higher product quality). Meanwhile, the continuously increased number of users will draw more attention from new developers. More developers will join in because of the expanding demand and increased profits in this OS-ES market. Thus, we hypothesize that

Hypothesis 2a. Leveraged user-side OS-ES market success has a direct positive effect on developer-side OS-ES market success.

Developer-side market success is determined by the combination of the increased number of developers and the improved engagement of developers in the OS-ES market. After introducing cloud-based technology to OS-ES, developers need to not only deliver the free high-quality OS-ES applications but also provide professional ongoing support. As more developers join in the market and perform above-average contributions in OS-ES market (Roberts et al. 2006), the developer-side success is achieved. Due to the developer-side market success, OS-ES applications become much more reliable and stable. Users who invest in cloud-based technology enabled OS-ES will bear less business risk, such as software crash or too many system bugs, and experience more system flexibilities. Therefore, we hypothesize that

Hypothesis 2b. Leveraged developer-side OS-ES market success has a direct positive effect on user-side OS-ES market success.

In fact, OS-ES developers and users shape a two-sided market together. According to CNEs, the value of each side depends on the size of the other side of the market (Weyl 2010). As such, the user-side and developer-side market successes are mutually influenced each other. For example, Once the developer-side market reach to a certain point of economic scale where more high-quality OS-ES applications and service are delivered, these superior OS-ES applications will attract more users through the cloud-based technology enabled business model. Similarly, the user-side market success which creates a large market demand will attract more developers. Eventually, the OS-ES market is flourishing through this virtuous cycle (Figure 2).

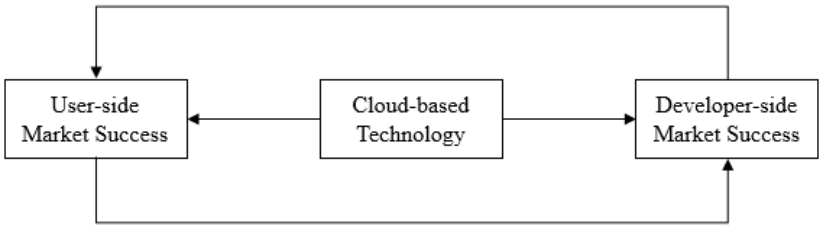

Figure 2. Research Model

RESEARCH METHOD

Sample and Measurements

The target samples of this study are 968 OS-ES applications listed on the SourceForge.net. SourceForge is one of the largest open source community. The historic and ongoing status of over 140,000 projects and over 1.5 million registered users' activities are recorded by the website. The ongoing data collection will include the OS-ES comminute activities such as the posts and responses in project forums, tutorial information provided by providers, when the project was registered, the application's development stage, download times of each release in each project. I will code and construct the time-series record for each OS-ES project including the starting time of the project, users' rating, the number of downloads, developers' activities, etc. The information about when the OS-ES project starts to offer cloud-based service is usually in the software updated newsletter section and will be manually coded.

Cloud-based Technology enables OS-ES developers to maintain and update the application anytime. The cloud-based vendors can also help users manage and analyze their data. In this study, "cloud-based technology" is measured by whether the project offers the cloud-based service to its users. Both User-side and developer-side market success will be measured in a similar way as Daniel et al. (2012) measure the market success of OSS projects. The user-side market success will be measured by the total number of downloads and users' ratings of OS-ES. The developer-side market success will be measured by both the number of developers and developers' engagement in the form of the total number of artifacts, such as requests and bug reports.

Analytical Techniques

The model will be tested using two analytical techniques. Firstly, we will use DID to investigate whether the transformation to cloud facilitates the market success of OS-ES project. The effects of cloud-based technology on both user-side and developer-side success are estimated through the following function:

$$OS\text{-}ES\ Market\ Success = \alpha Cloud * Transformation + \beta t + \gamma i + \varepsilon i,t$$

In this function, Cloud is a dummy variable that equals one if the OS-ES project offers cloud-based service when the data is collected; equals 0 if the OS-ES project does not offer cloud-based service when the data is collected. Transformation is a dummy variable that equals 1 for the time after the OS-ES project adding cloud-based service; equals 0 for the time before the OS-ES project has cloud-based service. βt reflects variance caused by external events and γi measures the key fixed effects of the OS-ES projects.

Later, the cross-side network effects between user-side and developer-side market success will be tested through the vector autoregression analysis (VAR). VAR has been used to detect the dynamic interaction among multiple time-series variables (e.g. Luo et al., 2013; Song et al. 2018). Applying this method can demonstrate the reinforcing and interdependent relationship between user-side and developer-side market success among OS-ES projects. The model will be tested through the following function.

$$\begin{bmatrix} US_t \\ DS_t \end{bmatrix} = \begin{bmatrix} C_{US} \\ C_{DS} \end{bmatrix} + \begin{bmatrix} \delta_{US} \\ \delta_{DS} \end{bmatrix} \times T + \sum_{j=1}^{j} \begin{bmatrix} \varphi_{11}^{j} & \varphi_{12}^{j} \\ \varphi_{21}^{j} & \varphi_{22}^{j} \end{bmatrix} \begin{bmatrix} US_{t-j} \\ DS_{t-j} \end{bmatrix} + \begin{bmatrix} \varepsilon_{US,t} \\ \varepsilon_{DS,t} \end{bmatrix}$$

In this function, C stands for the constant, similar to other linear models. Assume all the OS-ES projects may experience certain naturally grow/decline trends; thus, we also include T to capture this variance. Then, based on the CNEs theory, we propose that the current observation of user-side (US) and developer-side (DS) market success at time t depend on their own lagged values and each other's lagged values. The time lags are presented by J. This interaction is denoted in the summation of the equation. Last, a vector of white-noise disturbances is also included in

the function. The VAR analysis will follow the standard procedures in many of the previous literature. The Granger causality tests will be used to determine whether the constructed data is suitable for VAR analysis; the unit-root and cointegration test results will be used to finalize the model. The generalized impulse response functions will be used to assess the hypotheses.

EXPECTED CONTRIBUTIONS

Returning to the opening motivation of this study, we try to investigate the influence of cloud-based technology on OS-ES project development. This study makes the following theoretical contributions. First, we integrate the insights of both cloud-based technology and cross-side network effects theory to explain an emerging phenomenon—cloud-based OS-ES. Although the OS-ES market has gained some growth in recent years, limited research has systemically investigated this phenomenon. We fill the research gap by focusing on the development of cloud-based OS-ES. Also, we explain the positive reinforcement loop between user-side adoption and developer-side engagement of OS-ES projects. Cloud-based technology shifts the OS-ES projects from product-oriented to service-oriented. This strategy significantly lowers the users' adoption barrier, which leads to user-sider market success. Also, cloud-based technology provides potential benefits for developers through the subscription model, resulting in the developer-side market success. Next, using cross-side network effects theory, we explain the mechanisms through which user-side market success motivates the developer-side market success; and recursively, the prosperous OS-ES community (more developers) provides higher quality OS-ES application and service to attract more users. By applying CNEs in the context of OS-ES, we extend the generalizability of this theory and extend our understanding of CNEs.

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