

Technological Platforms and Innovation: Review, Integration, and Extension

Full paper

Giorgi Shuradze
European University Viadrina
shuradze@europa-uni.de

Heinz-Theo Wagner
German Graduate School of
Management and Law (GGS)
heinz-theo.wagner@ggs.de

David Wagner
German Graduate School of
Management and Law (GGS)
david.wagner@ggs.de

Abstract

Information systems pervade everyday life and their transformative impact on organizations is increasing. Recent studies in IS field are particularly interested in the relationship between technological platforms and innovation. However, the broad variety of studies provides different perspectives on platforms and their impact on innovation. These differences result in divergent knowledge in the emerging field of platform research. In this paper we systematize existing literature by reviewing articles on technological platforms in the context of innovation. As a result of our review, we develop a thematic map and propose a research agenda for future studies.

Keywords

Platform, innovation, review

Introduction

Information systems pervade everyday life and their transformative impact on organizations is increasing (Yoo et al. 2012). Many scholars have already examined the impact of digital technologies on different firm outcomes such as strategy, structures, and processes (Sambamurthy et al. 2003; Sambamurthy and Zmud 2000), on creating business value and building sustainable advantage (Kohli and Grover 2008; Nevo and Wade 2010) as well as on innovation (Boudreau 2010; Gawer 2011; Gawer and Cusumano 2002; Kleis et al. 2011; Yoo et al. 2010; Yoo et al. 2012).

Recent studies are particularly interested in the relationship between platforms and innovation. In the literature two predominant forms of platforms are discussed (Gawer and Cusumano 2014): internal, or company-specific platforms, and external, also known as technological platforms (Gawer 2014). Internal platforms are defined as a set of assets organized in a common structure from which a company can efficiently develop and produce a stream of derivative products (Meyer and Lehnerd; Muffatto and Roveda 2002). In addition, “supply-chain platforms” are often discussed in the literature as a special case of internal platforms (Gawer and Cusumano 2014). The objective of supply-chain platforms is to enhance

efficiency and reduce costs. A major benefit for companies that have access to supply chain platforms is that they can get access to external resources and find more innovative and less expensive components and technologies, however this might result in the obvious disadvantage of having less control over companies' own technologies. Supply-chain platforms are common in assembly industry, like computers, automobile, and consumer electronics (Brusoni 2005; Sako 2003, 2009). Despite a range of platform types discussed in the literature, in our research the main subject is the technological platforms, which are defined as "products, services, or technologies that [...] provide the foundation upon which outside firms (organized as a "business ecosystem") can develop their own complementary products, technologies, or services" (Gawer and Cusumano 2014). A platform ecosystem can be understood as an environment built around platforms consisting of three main types of participants: platform owner, third-party developer (developing applications, services, or systems on platforms), and platform end-user (Ghazawneh and Henfridsson 2013; Tiwana et al. 2010). Examples of these platforms encompass operating systems for personal computers (Microsoft Windows, Linux), smart phones (Android, iOS), and video-game consoles (Xbox, Apple's iPod Touch, Sony PlayStation). There are certain similarities between internal and technological platforms in a sense that they both provide a foundation of usable components, but the difference is that this foundation in technological platforms is open to outside firms. This means that platform owners begin with the foundation of core components and the final result is not predetermined. This creates unprecedented scope for innovation on complementary products, services, and technologies (Gawer and Cusumano 2014).

For the purpose of this study we refer to innovation as a new product/service that is developed in the environment of a platform ecosystem. Innovating with platforms entails the design and launch of new products that will be based on the existing platforms that serves as a foundation for complementary products. These types of innovations can be portrayed in, among others, new hardware device introduction (Boudreau 2010); and innovating on software applications for, for example, handheld devices (Boudreau 2012) as well as for operating systems (Gawer and Cusumano 2014). Studies dealing with technological platforms' effects on innovation further provide insights on how companies innovate, e.g., by predicting customers' behaviour through analysing data that are produced while customers using services of external platforms (Garcia Martinez and Walton 2014). In addition, studies explore how platform governance affects innovation (Boudreau 2010; Tiwana et al. 2010).

Although platforms have been researched from a variety of perspectives, we currently lack a sound integration of platform research into the innovation agenda. The broad variety of studies results in a divergent body of knowledge, with vague relationships among existing parts of the literature that needs to be organized. Thus, the main motivation to conduct the study is to support scholarship in the emerging field of platform research by systemizing literature through conducting a literature review (vom Brocke et al. 2009), which is often regarded as a means to understand the structure of a subject, identify relationships between different parts of the existing body of knowledge, and identify avenues for future research in the field (Baker 2000). Moreover, we focus on a specific niche, i.e., technological platforms in the context of innovation. As a result of our review, we develop a thematic map that organizes extant literature by identifying variables and their interrelationships studied so far in literature and highlights promising areas of further research. Consequently, future research can define its place in the thematic map making clear the stream of literature they refer to and facilitates to define research's contribution. At the same time, future research can actively be positioned in areas which are currently understudied highlighting the relevance of future research.

The structure of the remaining part of the paper is as follows: the next section will describe the methodology used, then we provide the results of the literature review which include the discussion and a categorization of major insights. Ultimately, we will conclude the paper with recommendations for future research, and discussion on theoretical and practical contributions of the study.

Methodology

According to (Baker 2000), the purpose of a literature review is to systemize a current state of the literature on a topic under study in order to avoid reinvention of what is already known. (Webster and

Watson 2002) further argue that a literature review can do more than just reviewing the papers by providing directions to researchers for future theorizing.

We agree with these statements and for doing our literature review, we apply a framework for conducting IS literature reviews suggested by (vom Brocke et al. 2009). According to this framework, the literature review process is divided into the following 5 phases: (I) definition of review scope, (II) conceptualization of topic, (III) literature search, (IV) literature analysis and synthesis, and (V) research agenda.

(I) Defining the scope is a necessary first step for any literature review (vom Brocke et al. 2009). To define the scope of our literature review, we used the taxonomy of literature reviews initially presented by (Cooper 1988) and modified by (vom Brocke et al. 2009). In Figure 1, we present a summary of the scope of our review, using the taxonomy. The shaded areas depict the positioning of our literature review presented in this paper. The positioning will be explained in more detail below.

Characteristic	Categories			
Focus	Research Outcomes	Research Methods	Theories	Applications
Goal	Integration	Criticism		Central Issues
Organization	Historical	Conceptual		Methodological
Perspective	Neutral Representation		Espousal of Position	
Audience	Specialized Scholars	General Scholars	Practitioners/ Politicians	General Public
Coverage	Exhaustive	Exhaustive and Selective	Representative	Central/Pivotal

Figure 1. Taxonomy of Literature Reviews (vom Brocke et al. 2009), following (Cooper 1988)

The focus of our research is on the works that gather around the topic of technological platforms in the context of innovation. The goal is to integrate the literature on technology platforms and to develop a thematic map. To make the literature review thorough, we chose to take a concept-centric approach in order to organize the framework of our review (Webster and Watson 2002). This means that the review neither organizes the topics studied in chronological order, nor groups them according to the similar methods. Rather, it groups the articles around the same idea or concept. In this literature review, we do not advocate any position, giving it a neutral perspective. The literature review that we present is targeted at a specific group of IS scholars who are interested in technology platforms and their influence on innovation. That is why the audience choice for us is specialized scholars. And, finally, in this review we derive our conclusions based on a sample of articles in selected journals. That is why the coverage of our review is selective.

(II) As the next step, we conceptualize our topic. As mentioned earlier in our literature review we focus on the research on technological platforms, particularly the research on platforms into the context of innovation.

(III) The third phase of the framework deals with the literature search. In this study, we gathered literature published in the top scholarly journals in the field of technology and innovation. Because the articles in these journals are typically peer-reviewed before publication, they are commonly recommended as reliable sources (Rowley and Slack 2004). Even though some scholars also suggest proceedings of selected IS conferences when doing a literature review in the IS field (Webster and Watson 2002), we decided to exclude them because the quality of contribution in conference proceedings is usually lower than in peer-reviewed journals (Levy and Ellis 2006). Following the point made by (Webster and Watson 2002) and (Thongpapanl 2012) that major contributions are most likely to appear in the leading journals, we included the journals of the AIS Senior Scholars' Basket. According to the senior IS academics, the 8

journals from the Senior Scholars' Basket are considered as the top journals in IS field (Senior Scholar Consortium 2011). Given that not only IS researchers are interested in platforms, we furthermore scrutinized journals in the field of technology and innovation management, derived from a ranking by Thongpapanl (2012). We included the top 10 journals from this ranking in our study but excluded Harvard Business Review because it is not a peer-reviewed journal. The following table presents the review results of 17 peer-reviewed journals.

Journals	Hits	Analysed
IS Journals from the Senior Scholars' Basket of Journals (alphabetical order)		
European Journal of Information Systems	3	0
Information Systems Journal	6	2
Information Systems Research	10	3
Journal of the Association for Information Systems	0	0
Journal of Information Technology	7	1
Journal of Management Information Systems	7	0
Journal of Strategic Information Systems	2	0
MIS Quarterly	12	4
Top 10 TIM Journals from the List by (Thongpapanl 2012) (ranking order)		
Research Policy	14	4
Strategic Management Journal	6	0
Journal of Product Innovation Management	27	5
Management Science	14	3
Academy of Management Journal	2	1
Harvard Business Review (excluded)	-	-
Academy of Management Review	0	0
Research Technology Management	11	2
Organization Science	9	4
Technovation	16	3
Overall	146	32

Table 1. Selected Sources and Results

After we chose the journals, we followed the suggestion by (vom Brocke et al. 2009) and searched for the database that would grant us access to these sources. In our study, we used Web of Science (WoS) database provided by Thomson Reuters, because it granted us the access to all the listed journals (Chapman and Brothers 2006). The time period covered during the search was from 1945 to January 2015.

The fields of WoS that were used in the search were *Topic* in combination (using the Boolean operator "AND") with *Publication Name*. In the *Topic* field, the preselected keyword was indicated. With the *Topic* field search, the Title, Abstract and Author Keywords of the articles in the database were covered. In the *Publication Name*, the name of the selected journal was indicated. We used the following keyword for all the journals: *platform* AND (innov* OR advant*)*. This keyword combination, according to the WoS, is equivalent to two separate search results: 1) search with the keyword *platform**; and 2) putting additional keywords for searching into the search results *innov* OR advant**.

Based on the abovementioned keyword, we found 146 articles. First, we read titles and abstracts of all the articles, and those containing information about technological platforms in the context of innovation were selected for further analysis. Overall, we selected 32 articles for an in-depth analysis (for a full list, please refer to the Appendix).

The final two phases of the framework, (IV) literature analysis and synthesis; and (V) research agenda deal with the results of the literature search and will therefore be presented in the following section.

Results

(IV) In this section we present the results of our review. First, we discuss what extant literature says about the *determining factors of platform adoption*. Then, we continue with reviewing articles covering *platform characteristics*. Next, we will present the results of the articles that debate about the *governing mechanisms of platforms*. Finally, we discuss articles dealing with the *business impact of utilizing platforms*. Underlying logic of categorizing the results in the four groups was that all the articles that we reviewed contained observable patterns of discussing either of these topics, sometimes even several of them, and no additional group seemed plausible (Braun and Clarke 2006). In addition, we believe this type of categorization depicts a structure of the extant body of knowledge of the field, and provides a comprehensive view of the path from platform adoption to its business effects, including factors influencing successful outcome. Identified aspects in each groups had different centrality in the respective studies. In some cases these aspects were central for the study, while oftentimes there were briefly reviewed. In order to better illustrate the contexts how authors address these aspects in their studies, examples from certain articles are provided per each aspect.

In order to save space on references in the tables of this section, we numbered all 32 reviewed articles and indicated only these numbers in source column of each table. To see a full corresponding reference of each number, please refer to the Appendix.

Determinants of Adoption

This section deals with literature examining the factors determining platform adoption (Table 2). As the results show, there is a dearth of literature focusing on reasons leading to platform adoption. Claussen et al. (2013) use the case of Facebook to describe how the company, in order to stimulate its platform adoption, provided developers with various tools that decrease development costs, offered different strategic subsidies, like open and well-documented app programming interfaces, free test facilities, and support forums and conferences. In addition, they demonstrate how the large variety of product offers motivated users to join the platform. Gawer and Cusumano (2014) argue that in order to be adopted, platforms need to have an essential functionality in the larger technological system of the adopter. In addition, platforms have to address important business problems of both users and the targeted industry (Gawer and Cusumano 2014).

Aspect	Example	Source
Variety of product offers	“Having a large variety of apps has consequences for consumers’ product search and adoption” (3, p. 188)	3, 30
User innovations	“User innovations are more likely to cater accurately to market demand, which could lead to higher adoption rates” (11, p. 1596)	8, 11
Pricing	“Zero platform price leads to higher platform and application adoption” (22, p. 1065)	3, 15, 22, 27
Solving business problems	“The platforms must solve a business problem for many firms and users in the industry” (15, p. 421)	3, 15

Table 2. Determinants of Platform Adoption

Characteristics

Table 3 depicts the papers that discuss how platforms are conceptualized in empirical research. The majority of articles in our search results emphasize the importance of a degree of modularity in platforms for combinational innovation (Chai et al. 2012; Frattini et al. 2014; Yoo et al. 2012). According to Frattini et al. (2014), the idea of modularity is based on minimizing the interdependence between the modules in the system and maximizing the interdependence within them, in order to obtain a new configuration without loss of the system’s functionality and performance. In order to encourage innovation by module

developers, platform owners need to balance control and openness in platform ecosystem (Tiwana et al. 2010). In addition, one of the characteristics of platforms applied to empirical research is the number of third party developers in the platform ecosystem. According to the research by Boudreau (2012), this characteristic of the platform allows measuring how the number of third party developers can influence the innovation degree. Another important characteristic of platforms is generativity which refers to the ability of a self-contained system to innovate without any input from the originator of the system (Wareham et al. 2014). Yoo et al. (2012) and Ghazawneh and Henfridsson (2013) describe how generativity can lead to innovation on smartphone platforms. After initial design and production of smartphone platforms, because of its reprogrammable nature, third-party developers can enable innovation by adding new capabilities and functions to the platform, without any additional effort from the platform owners.

Aspect	Example	Source
Modularity	“The central tenet of the modularity literature is precisely that modular product architectures facilitate innovation” (12, p. 1242)	4, 10, 12, 17, 18, 27
Accessibility	“I find a tight link between the number of producers on platform and the number of software varieties that were generated” (28. p. 1409)	1, 2, 28, 30
Convergence	“Convergence can offer opportunities for a platform to expand into the domain of adjacent but unrelated platforms and simultaneously allow unrelated platforms to offer the focal platform’s functionality as part of a multiproduct bundle” (4, p. 681)	4, 5, 11, 27
Generativity	“Generativity refers to the ability of a self-contained system to create, generate, or produce a new output, structure, or behaviour without any input from the originator of the system” (26, p. 1195)	26, 27

Table 3. Characteristics of Platforms

Governance Mechanisms

The following table (Table 4) deals with the decisions about the governance of platforms for an effective implementation (Boudreau 2012; Tiwana et al. 2010; Venkatraman and Lee 2004; Wareham et al. 2014).

Aspect	Example	Source
Degree of platform openness	“I find that granting greater levels of access to independent hardware developer firms produces up to a fivefold acceleration in the rate of new handheld device development” (20, p. 1849)	1, 11, 15, 20, 22
Degree of power	“Power can dramatically accelerate the multi-firm innovation process for the benefit of an entire technological ecosystem” (14, p. 1309)	14, 26
Aligning business models and incentives	“Ecosystem governance should include reinforcing the business models of members, which is essential to sustain their incentives to invest and produce complementary innovations” (15, p. 429)	15
Degree of network diversity	“A diverse and non-convergent network may develop new innovation strategies, business models, technological platforms and radically different technological artefacts” (13, p. 934)	13
Level of external participation	“Higher levels of external participation create additional value for platform owners” (1, p. 441)	1, 2, 8, 23

Table 4. Governance Mechanisms of Platforms

Because external developers play a significant role in platform innovation (Ghazawneh and Henfridsson 2013), openness of the platforms to them can moderate the relationship between platforms and innovation success (van der Boor et al. 2014). According to Bergvall-Kåreborn and Howcroft (2014), higher levels of external participation create additional value for platform owners, therefore the more

open the platforms are, the more likely it is to lead to innovation, due to increased external contributions. In his study, Boudreau (2010) further explores how the opening of platforms to third party developers might affect the innovation degree and finds an inverted U-shaped relationship between platform openness and innovation. Platform owners have the possibility to develop heterogeneous innovation capabilities and knowledge sources by allowing third-party developers from various areas to develop applications for their platforms (Ghazawneh and Henfridsson 2013). Since external participants of the platforms bring innovation to established firms (Ceccagnoli et al. 2012), too strong control over platforms (e.g., high entry requirements) might prevent innovative entrants who are not yet established in the market (Claussen et al. 2013). In addition, with the study of mobile application developers, Bergvall-Kåreborn and Howcroft (2014) argue that a high level of external participation can create additional value for the platform owners.

Business Impact

In this part we present the literature about the business value of platforms and what effects a utilization of platforms can have (Table 5). The extant literature focuses on the innovation that is generated in the environment built around technological platforms, referred to as “platform ecosystems” (Gawer and Cusumano 2014). According to the authors, platforms tend to facilitate the degree of innovation in complementary products in the platform ecosystems. Results of the study by Ceccagnoli et al. (2012) suggest that by joining the major platform ecosystem, third-party developer’s sales and the likelihood of an initial public offering increase. Selander et al. (2013) provide further evidence that non-focal firms of ecosystems innovate simply by participating in the platform ecosystem. However, they cannot rely on a single ecosystem and need to operate across different ecosystems. In addition, Boudreau (2010) empirically justifies how strategically managing controlling mechanisms of the platform can increase the innovation rate by 20%.

Aspect	Example	Source
Complementary innovation	“Platforms tend to facilitate and increase the degree of innovation on complementary products and services” (15, p. 421)	8, 11, 14, 15, 20, 28
Network effects	“The more users who adopt the platform, the more valuable the platform becomes to the owner and to the users because of growing access to the network of users and often to a growing set of complementary innovations” (15, p. 417)	15, 16, 19, 30
Economic gains	“Platforms allow their owners to achieve economic gains by reusing or redeploying assets across families of products developed by either the firm or its close suppliers” (15, p. 428)	11, 15, 16, 18, 19
New product development	“The first popular usage of the term platform seems to have been in the context of new product development” (15, p. 418)	15, 16, 18, 19, 20
Product development speed	“Platforms [...] speed up product development processes” (19, p. 555)	19, 20

Table 5. Business Impacts of Platforms

Thematic Map

Based on the insights gained from the literature review, we developed a thematic map illustrating the interrelationships between the results of the study (Figure 2).

According to the literature, the adoption of technological platforms is usually preceded with certain external/internal determining factors, or expectation from the adopter’s side. In some cases, the adopter

seeks benefits provided by the platform owner (Claussen et al. 2013). In others, the adopter wants to solve certain business challenges (Gawer and Cusumano 2014).

The expectations preceding the platform adoption are to a certain degree portrayed in various firm outcomes. The outcomes can be complementary innovation for the users of the platform ecosystem (Boudreau 2010; Boudreau 2012; Ceccagnoli et al. 2012), new product development (Chai et al. 2012; Mäkinen et al. 2014), or increased new product development speed (Sköld and Karlsson 2007).

Successful governance of platforms is usually moderated by the governing mechanisms that the organizations pursue. The extant literature debates about the degree of openness of platforms. Some scholars argue that the open platforms lead to increased innovation (Bergvall-Kåreborn and Howcroft 2014; Economides and Katsamakas 2006), on the other hand there are empirical evidences of inverted U-shaped relationship between the platform openness and innovation degree (Boudreau 2010).

Finally, the thematic map illustrates the characteristics of the platforms that are used in existing literature for platform conceptualization (Boudreau 2012; Gawer 2014; Tiwana et al. 2010; Wareham et al. 2014).

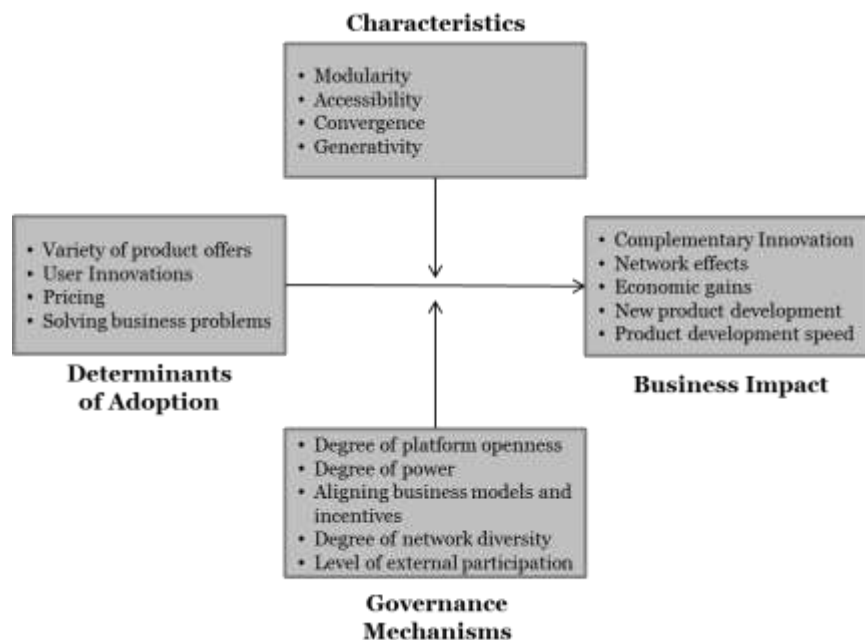


Figure 2. Thematic Map

Discussion and Conclusion

In this section we present the last step of the framework for literature review and propose a (V) research agenda for further studies. Additionally, we discuss contribution and limitation of the study.

This literature review synthesizes the existing research on technological platforms in the context of innovation by analysing 32 articles from 17 leading journals in the IS and innovation management fields. In order to offer an overview of the existing body of knowledge, we sort the results in four different categories: determinants of platform adoption, platform characteristics, platform governance mechanisms, and platform business impact.

We further suggest four research thrusts that we would like to propose for future studies.

1 – Antecedents influencing platform adoption

As we saw in the results of the review (Table 2) the studies on factors that stimulate the platform adoption are very scarce and the topic is under researched. There are only few studies explicitly examining the

determinants of platform adoption. Future studies, therefore, should address this gap by conducting empirical research exploring what motivates organizations to adopt platforms.

2 – Platform conceptualization in empirical research

For any empirical research on platforms it is pivotal to have a good understanding of its characteristics. In order to further extend the research on technological platforms, future researchers should focus more on exploring different characteristics of platforms. Most of the current studies in the literature use only few platforms' characteristics and unless this situation is changed, it could be a challenging task to advance a research in this field.

3 – Factors influencing the successful implementation of platform in innovation processes

As we saw in the results of the literature review (Table 4), there is no direct relationship between the platform adoption and firm innovation. Usually these relationships are moderated by number of mechanisms, like degree of platform openness, degree of network diversity, level of external participation, etc. Future studies should further empirically explore what could be other factors influencing these relationships and to what extent these factors could influence innovation success of the companies.

4– Potential outcomes of joining the platform ecosystems

To better evaluate the business value of platforms it is essential to learn more about the effects that platform adoption can have. In addition, because of growing speed of platform ecosystem evolution (Gawer 2014), it is of utmost importance also to investigate the impacts of joining the ecosystems, for the platform owner as well as for third party developer and platform user. Furthermore, the extant literature mainly focuses on investigation of positive impacts of platform adoption and joining the platform ecosystem, while it is silent about the disadvantage caused. Future studies might also investigate the negative effects of platform adoption and joining the platform ecosystem.

The result of our review contributes to theory in different ways. Firstly, by conducting a literature review we make the first and essential step towards theory building on technological platforms and its influence on innovation. Secondly, we categorize the extant literature in four groups and establish causal relations among them, i.e. exploring what causes platform adoption, and how the path from platform adoption to gaining successful business impact from platforms could be moderated by platforms characteristics and governance mechanisms. Thirdly, by building thematic map, we depict the areas of the field that are relatively well explored, and areas where future studies need to look deeper. And finally, by identifying moderating effects on successful platform adoption, we better explain the chain of variables influencing path from platform adoption to its successful business impact.

This paper also contributes to management practice. The results of the study indicate that a degree of openness has a moderating effect on innovative output in platform ecosystem. Managers willing to increase the degree of innovativeness in the platform ecosystem might consider introducing policies about openness of the platform, e.g., lowering entry barriers. In addition, by acknowledging the importance of network diversity in the platform ecosystem for increased innovativeness, managers can develop strategies that would stimulate the entrance of new actors into platform ecosystem, e.g., by providing incentives to new members joining the ecosystem, or giving them access to resources of the ecosystem.

We hope the proposed paper will trigger more studies in the platform research; yet we would like to point out the limitation that this study contains. In the literature review we only refer to the top peer-reviewed journals, as the quality of contribution in these journals is expected to be higher than in conference proceedings. However, we believe it could also be seen as a limitation because conference proceedings' contributions are usually prompter, as the review process for proceedings is shorter. Given that the research on platforms is relatively new, future researchers may also consider reviewing conference proceedings in their studies.

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APPENDIX

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