

Adoption of Software Platforms: Reviewing Influencing Factors and Outlining Future Research

Completed Research Paper

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Abstract

Software platforms have received attention as the dominant model for cooperative software development. Growing the ecosystems around software platforms through increasing adoption by users and developers is of great importance for platform owners. However, there is a lack of research on how to increase adoption and growth of software platforms systematically. To address this issue, we conduct a literature review and make an in-depth analysis to uncover and organize factors that drive adoption of software platforms. Additionally, we derive effective directions of these factors on the respective sides. Finally, we outline three avenues for future research: aligning research on platform governance and platform launch and growth, taking an evolutionary, growth-oriented perspective on governance of software platforms and further detailing platform launch and growth strategies towards a design theory for platform launch. This paper contributes to the understanding of software platforms by reviewing factors driving adoption and triggering network effects.

Keywords: Software Platform Ecosystem, Launch strategy, Growth strategy, Platform adoption, Network effects

Introduction

Software platforms have established themselves as the dominant model for cooperative software development and software-based services (Reuver et al. 2018b; Tiwana et al. 2010). Typical domains for platform-centric software ecosystems are web browsers like Firefox or Google Chrome and mobile operating systems like iOS and Android. Following Tiwana et al. (2010, p. 675), we define software platforms as the “[...] extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and interfaces through which they interoperate [...]”. As highlighted by the examples, software platforms rely on developers in order to create valuable experiences for users with the platform mediating transactions between the groups, operating as two-sided platforms (Anderson et al. 2014; Cennamo and Santalo 2013). Creating and maintaining the ecosystem around a platform is a huge challenge for its operator. Since platforms are usually characterized as two-sided or multi-sided markets, they need to attract and cater at least two platform sides. The *user-side* (i.e. consumer-side) and *complementor-side* (i.e. developer-side or app-side) (Evans 2009). The interaction of both sides via the platform creates direct and indirect network effects (Eisenmann 2008; Katz and Shapiro 1994). An initial chicken-egg problem occurs within the ecosystem, since users will choose platforms that, among others, offer a variety of applications and developers will focus, among others, on platforms that offer a large audience of possible users (Caillaud and Jullien 2003; Schirmacher et al. 2017). Therefore, growing the platform ecosystem on both sides through increasing adoption and thus diffusion of its underlying digital technologies is crucial and depends on a multitude of different factors (Eisenmann 2008; Gawer 2014).

However, despite existing research on the topic, there is a lack of findings on how to increase adoption and growth of software platforms systematically (Tan et al. 2015). Prior research has attempted to mitigate these issues by introducing strategies for platform owners to launch and grow their platforms (Evans 2009; Evans and Schmalensee 2010; Wan et al. 2017). Still, these strategies lack empirical foundation as they are conceptual in nature (Reuver et al. 2018a; Tan et al. 2015). Descriptions of launch strategies are reduced to basic instructions, without references on how to specifically address the platform sides. This situation lead to calls for further investigation of factors and mechanisms that influence adoption and growth of multi-sided platforms by users and developers (Ondrus et al. 2015; Wessel et al. 2017). Therefore, the purpose of this paper is to make an in-depth analysis to uncover and organize factors that influence adoption of software platforms and thus growth of software ecosystems with regard to the two platform sides. Additionally, we show whether literature indicates any effective directions - direct or indirect, of these factors on the respective sides. The contribution aims to further enable platform owners to purposefully increase adoption of their platforms. To this end, we conduct a systematic literature review to identify relevant factors associated with adoption of software platforms. We further evaluate the factors regarding their direct and indirect influence on the two platforms sides based on insights of prior work. Hence, we are able to contribute to the discussion on platform launch and growth through providing factors driving adoption and their effective direction.

The remainder of this paper is structured as the following. We first present a literature review and the methodology of this study. Second, we introduce and group the factors driving adoption of software platforms identified from prior work. Third, we propose issues for future research that emerge from our findings. Last, we briefly discuss our results.

Critical Mass, Network Effects and Diffusion

For platforms to succeed, prior contributions have highlighted the importance of reaching critical mass. Critical mass refers to a sufficient number of users and/or complementors on the platform to spark growth and overcome the chicken-egg problem (Caillaud and Jullien 2003; Cennamo and Santalo 2013; Evans 2009). Amit and Zott (2001) note, that not the sheer number of participants in an ecosystem, but the number of transactions or liquidity of the platform is decisive. Still, the number of participants on all platform sides is a proxy for these alternative measures.

Reaching critical mass in platform settings strongly depends on the value created by network effects (Evans and Schmalensee 2010; Katz and Shapiro 1986). The value a prospect participant obtains from a platform is based on two parts. First, the direct value derived from the platform itself and second, the value she may derive from the presence of and the interaction with peer-group and cross-group participants. Network effects describe the second part, the increased value a platform participant derives from the participation of others (Farrell and Saloner 1985; Katz and Shapiro 1986). Direct network effects arise when value for one user strongly depends on the presence, characteristics and/or actions of users of the same group such as in telephone networks or social networks (McIntyre and Srinivasan 2017). Since users' interest in software platforms primarily is not in direct interaction with peers, but in complements and vice versa, so-called indirect or cross-side network effects emerge (Song et al. 2018). Indirect network-effects are key to adoption and growth of digital ecosystems, since they strongly scale the value a prospect participant will derive from joining the platform. This accumulated value and its lock-in effect is the reason platform markets tend to have winner-takes all or at least winner-takes some dynamics, leading to wide diffusion and high level of adoption of certain platforms (Cennamo and Santalo 2013; Gallaughan and Wang 2002).

Prior Work Related to Adoption of Software Platforms by Complementors and Users

As pointed out, direct and indirect network effects impact adoption decisions of both users and developers in software platforms. Nevertheless, the details on the factors driving network effects and what manifests their strength are yet to be explored (McIntyre and Srinivasan 2017).

Prior contributions have analyzed various factors driving adoption, usually in isolation or with restriction to certain sets of aspects. For instance, pricing in multi-sided platforms has been examined by a multitude of authors. The general assumption within this research stream is that establishing the right pricing structure is the key to leverage network effects and thus spark ecosystem growth (Bakos and Katsamakos 2008; Rochet and Tirole 2006; Rysman 2009). Still, finding the right pricing structure is a difficult task for platform owners, since direction and intensity of network effects remain unknown. Another factor that has received considerable attention is platform openness and its influence on platform adoption (Soto Setzke et al. 2019). Benlian et al. (2015) develop a concept to evaluate platform openness, which they view as one of the primary drivers for platform growth. Other important factors that have been studied are governance, design and architecture of digital platforms (Kazan et al. 2018; Manner et al. 2013; Schreieck et al. 2016) and the relationship of platform owner and ecosystem participants such as application developers (Hein et al. 2018). One concept that is used to describe a subset of factors that can drive adoption of software platforms by developers are platform boundary resources. It subsumes software tools and regulations that are used to govern the relationship between platform owner and developer (Ghazawneh and Henfridsson 2013). While being studied in prior works, these factors have mostly been examined in isolation and without special focus on platform adoption. Further, the effective direction of these factors has often not been indicated.

Methodology of the Literature Review

The primary goal of this literature review is to identify publications that (a) focus on software platform ecosystems as the main topic of analysis, (b) derive explicit or implicit insights into factors influencing platform adoption via network effects and (c) do not solely take the user perspective. The design for the systematic literature review is adapted from the guidelines proposed by Webster and Watson (2002) and Vom Brocke et al. (2009). To ensure validity of our search we focused on literature from two research fields when choosing the relevant top journals (Vom Brocke et al. 2009). The restriction of our review to the fields of information systems (IS) and strategy and management literature is justified by the fuzziness of the term network effects, which is often referenced in these research areas. Since our overarching research focuses on growing software platform ecosystems from a platform owner perspective, we decided to focus on the AIS Senior Scholars' Basket of Journals and top strategy and management journals. As the database, we utilized SCOPUS, which yielded 239 hits using the keywords: (platform OR ecosystem OR *sided market) AND (software OR application OR complement*) AND (network AND (effect* OR externalit*)). To ensure inclusion of up-to-date research, we added the top IS conferences according to the Association for Information Systems, which

we searched in the Association for Information Systems electronic library. In a two-staged selection process, we scanned and sorted the articles from the databases based on title and abstract. After a full-text review of the remaining articles, we selected 55 articles as relevant to our research endeavor. A forward and backward search resulted in another 14 selected articles.

Results of the Literature Review

In this part, we will summarize the insights we gained during the review. When analyzing the articles, we coded relevant factors that drive adoption of software platforms. For an even deeper understanding, platform owners need to know what factors affect which platforms sides through direct and/or indirect effects. Prior work on platform launch strategies, which deals with the coordination problem in two-sided platforms face in their pre-ignition stage, suggests that both platform sides have to be addressed via differing factors and mechanisms (Schirmacher et al. 2017). As confirmed by the findings of Song et al. (2018), certain factors affect the user and developer-side of a platform in different ways. Platform owners can incorporate this knowledge into platform launch and growth strategies and the underlying configuration of design and governance of their platforms. For this reason, we also coded the direction of the effects the identified factors are likely to trigger. During the coding process, we were able to identify three categories for the factors, which are based on the three sources of network externalities identified by Katz and Shapiro (1985). We will outline these categories before further presenting the factors driving adoption in the following.

Figure 1 shows the three categories the factors driving software platform adoption were assigned to. The categories are *universal*, *semi-universal* and *specific*, relating to whether a factor may be used to address both platform sides directly and indirectly, both platform sides partly or only one side directly.

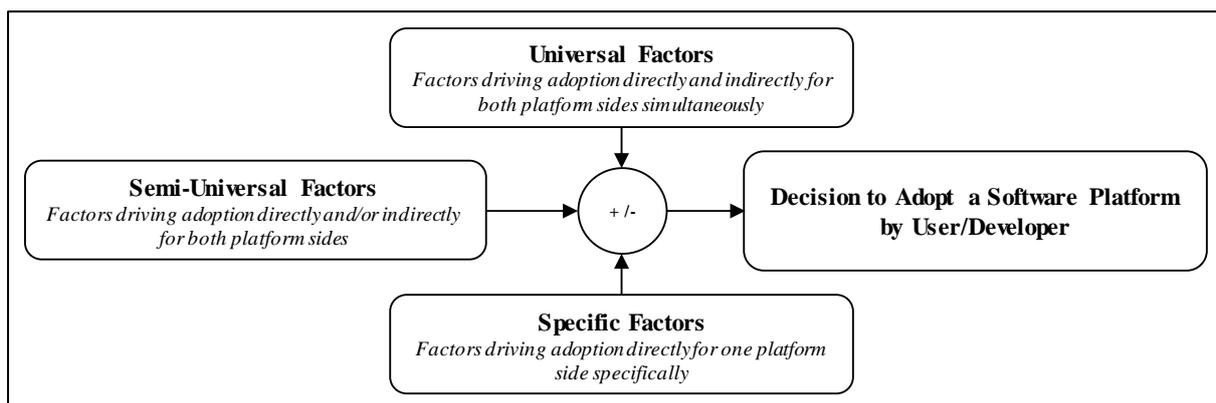


Figure 1 Categories of Factors Driving Adoption of Software Platforms

It is important to note, that the factors can have positive or negative impact on the adoption decision of users or developers of software platforms. Table 1 shows the factors we coded from prior works, their respective category and the effective direction these factors have. The categories and selected factors will be outlined in the next section.

Table 1 Factors Driving Software Platform Adoption

Factors Driving Adoption		Direction of Effects				Sources (indicating the direction of the effects)
		Complementor		User		
		Direct	Indirect	Direct	Indirect	
Universal	Platform Pricing Structure	x	x	x	x	(Armstrong 2006; Casadesus-Masanell and Halaburda 2014; Clements and Ohashi 2004; Conte et al. 2010; Ghose and Han 2014; Koh and Fichman 2014; Mantena and Saha 2012; Parker and van Alstyne 2005; Tanriverdi and Chi-Hyon 2008; Yoo et al. 2002)
	Platform Strategy	x	x	x	x	(Eisenmann et al. 2011; Ghose and Han 2014; Huang et al. 2013; Li and Agarwal 2017; McIntyre and Subramaniam 2009; Tanriverdi and Chi-Hyon 2008)
	Governance & Control	x	x	x	x	(Boudreau 2010; Ghazawneh and Henfridsson 2015; Song et al. 2018; Tiwana et al. 2010)

	Platform Technological Performance	x	x	x	x	(Anderson et al. 2014; Bakos and Katsamakas 2008; Hann et al. 2016)
	Platform Updates	x	x	x	x	(Hann et al. 2016; Song et al. 2018)
Semi-Universal	In-House development by Platform	x	x	x		(Eisenmann et al. 2009; Huang et al. 2009; Li and Agarwal 2017; West 2003)
	App Updates	x	x	x		(Claussen et al. 2013; Tiwana 2015)
	Exclusivity of Apps	x	x	x		(Cennamo and Santalo 2013; Kang and Lee 2013; Parker et al. 2017; Srinivasan and Venkatraman 2008)
	Installed Base of Users	x	x	x		(Anderson et al. 2014; Boudreau 2010; Cennamo and Santalo 2013; Eisenmann et al. 2011)
	Quality of Apps	x		x	x	(Claussen et al. 2013; Ghose and Han 2014; Markovich and Moenius 2009; Song et al. 2018; Tanriverdi and Chi-Hyon 2008; Wareham et al. 2014; Zhu and Iansiti 2012)
	Platform Transparency	x		x		(Bhargava and Choudhary 2004; Gawer 2014)
	Power Relation	x		x		(Boudreau 2010)
	Killer Apps		x	x		(Anderson et al. 2014; Claussen et al. 2013; Srinivasan and Venkatraman 2008)
	Ecosystem Growth Potential		x	x		(Li et al. 2014; McIntyre and Srinivasan 2017)
	Word of Mouth		x	x		(Li and Agarwal 2017; McIntyre and Srinivasan 2017)
	Appropriability Regime	x	x		x	(Boudreau 2010; Ceccagnoli et al. 2012; West 2003)
	App Reviews by Platform	x	x		x	(Claussen et al. 2013; Li et al. 2014; Song et al. 2018; Wessel et al. 2017)
	Platform Architecture & Design	x	x		x	(Bakos and Katsamakas 2008; McIntyre and Srinivasan 2017; Song et al. 2018)
	Developer Properties	x			x	(Boudreau and Jeppesen 2015; Ghose and Han 2014; Hilker et al. 2010; Kankanhalli et al. 2015; Markovich and Moenius 2009; Song et al. 2018; Tanriverdi and Chi-Hyon 2008; Venkatraman and Lee 2004; Yoo 2005)
	Intraplatform Competition	x			x	(Boudreau 2012; Boudreau and Jeppesen 2015; Cennamo and Santalo 2013; Claussen et al. 2013; Huotari 2017; Li et al. 2014; Venkatraman and Lee 2004; Wareham et al. 2014; Wessel et al. 2017)
	Knowledge Sharing	x			x	(Ghose and Han 2014; Perrons 2009)
	Compatibility & Standards		x		x	(Ceccagnoli et al. 2012; Corts and Lederman 2009; Gallagher and Wang 2002; Huang et al. 2013)
Quantity of Apps		x		x	(Belleflamme and Toulemonde 2009; Boudreau 2012; Cennamo and Santalo 2013; McIntyre and Srinivasan 2017; Oh et al. 2015; Ondrus et al. 2015; Parker and van Alstyne 2005; Seamans and Zhu 2014; Tan et al. 2015; Tanriverdi and Chi-Hyon 2008; Yoo et al. 2002; Zhu and Iansiti 2012)	
Store App Description	x	x			(Ghose and Han 2014; Wessel et al. 2017)	
Specific	Factors directly driving adoption for complementors only: Platform Lifecycle Stage, SDK for Developers, Information Policy by Platform, Service Versioning by Platform, Ease of Multi-Homing for Developers, Accessibility for Developers, Platform-Specific Development Costs, Downstream Capabilities, Piracy of Apps, Trust, Interaction with Platform, Developer Community, Interplatform Competition, Total Market Size, Lead User Influence, Ease of Use, Trialability of Apps					
	Factors directly driving adoption for users only: Ease of Multi-Homing for Users, Variety of Apps					

Universal factors drive adoption of software platforms via four different effects: First they have a direct effect on both platform sides, users and complementors. Second, they have indirect influence on both sides respectively. These characteristics make the factors in this group very important for platform owners, since they allow the owner to address both platform sides simultaneously and via different effects. For instance, *Platform Pricing Structure*, which has been intensely studied by researchers has direct influence on the adoption decisions of complementors and users through setting of prices by the platform owner (Parker and van Alstyne 2005). At the same time the price developers have to pay has indirect effects on the adoption decision of users, which might face a subsequent increase or decrease

of prices they pay for the complements provided by developers. Analogously, high or low prices for users will indirectly affect the adoption by complementors. This is due to users possibly refusing to adopt a certain platform for high initial prices, leading to decreased overall demand for complements (Yoo et al. 2002). Other factors driving adoption universally are *Platform Strategy, Governance & Control, Platform Technological Performance* and *Platform Updates*.

Semi-universal factors are characterized by being able to influence both platforms sides directly and/or indirectly through two or three different effects. That means, these factors influence the adoption decisions of both platforms sides at the same time, without being fully universal in their directions. The decision regarding *In-House Development by the Platform Owner* has direct and indirect effects on the adoption decision of complementors. Direct effects relate to the additional competition for complementors they face when adopting a certain software platform, while indirect effects come into play, when users are attracted to the platform through initial in-house development by the platform owner (West 2003). At the same time users only face direct effects through the availability of additional software provided by the platform owner (Eisenmann et al. 2009; Li and Agarwal 2017).

Specific factors only influence the adoption decision of one specific platform side. Interestingly, we only found evidence for direct effects in prior contributions regarding specific factors. Examples for developer-specific factors are *Platform Lifecycle Stage* or the *SDK for Developers*. These factors have direct influence on the adoption decision of complementors. For users we identified the *Variety of Apps* and *The Costs for Multi-Homing for Users* as the two only factors driving adoption directly.

Whether the effect of a certain factor on a platform side is positive or negative can vary based on its manifestation and other contingency factors. The influence of contingency factors has been excluded from our analysis and is an issue for future work. The same holds true for the strength of the effects caused by the various factors. However, based on the factors and their respective effective direction we provide platform owners with key insights on software platform ecosystem growth. Further, future research can build on our work and advance the topic in different directions.

Central Issues for Future Research

In this section we discuss the central issues for future research on software platform adoption and the way future research may utilize our findings to support platform owners in launching and growing their platforms. We will discuss three major issues.

Aligning Platform Governance and Platform Launch and Growth

We identified a large set of factors that drive adoption of software platforms by users and developers and their effective directions. Building on that, platform owners have first indications on how to launch and grow their platforms through purposefully triggering adoption of their platform. Still, there is a gap between research of platform governance – one of the main levers for platform owners to shape their ecosystem - and the factors driving adoption presented in this contribution (Manner et al. 2013; Song et al. 2018).

Future research may close this gap by identifying concepts of platform governance from prior research that are able to activate or inhibit the respective factors driving adoption. Mapping the governance concepts onto the factors discussed here will help close the gap on governing platform launch and growth. One starting point is to focus on platform boundary resources, since they constitute an important subset of factors driving adoption (Ghazawneh and Henfridsson 2015).

Towards an Evolutionary Approach to Platform Governance

Launching and growing digital platforms is a highly dynamic process requiring platform owners to make various adjustments to strategy, business model and governance. Prior work on concepts for platform governance have neglected this issue. Wareham et al. (2014) call for an evolutionary perspective for governance, embracing differing maturity levels of ecosystems over time.

An issue for future work therefore is to find configurations of platform governance for differing stages of maturity. Driving adoption is central to the launch and growth stages of digital platforms, which is why the evolution of governance needs to take into account the different factors that drive adoption of platforms in different stages. Connecting insights of governance for the launch and growth of digital platforms with theory on the evolution of platforms yields further opportunities for further research.

Empirical Evidence for a Design Theory of Platform Launch

An issue with prior work on platform launch strategies has been the lack of empirical evidence, leaving platform owners alone with detailing these strategies and configuring factors like business models and governance without guidance (Evans and Schmalensee 2010; Reuver et al. 2018a). Reuver et al. (2018a) call for a design theory for platform launch.

Future research should address this issue with empirical work on platform launch and growth strategies using detailed insights from practice. Of special interests may be platforms that took long journeys along their line of evolution, applying different strategies or elements of strategies. First, this helps with understanding the impacts of these elements. Second, this knowledge can be used to specify strategies and further provide fully actionable strategies for platform owners. One starting point for developing such a design theory can be factors that drive adoption of digital platforms. The use of micro-strategies and microstructures when strategizing in a digital platform context as proposed by Staykova (2018) seems a promising approach. It allows to integrate knowledge of factors driving adoption, platform governance to trigger the factors driving adoption and platform strategy as the overarching guidelines for platform governance. The strategic use of appropriability mechanisms is an example for such a micro-strategy that strongly influences adoption by developers (Boudreau 2010; West 2003).

Conclusion

In this contribution, we identified factors driving adoption of software platforms leading to ecosystem growth. Further, we investigated the respective effects that these factors can trigger. Based on these results we propose three issues for future research. First, we call for future work to close the gap between ecosystem growth and platform governance. Integrating concepts from research on digital platform governance and the factors driving adoption from this research might be able to bridge the gap between platform governance and adoption of digital platforms. It therefore is also a first step towards the targeted use of governance in platform launch and growth strategies. Second, since launch and growth of platforms follows evolutionary steps, governance mechanisms need to be adjusted accordingly and be in tune with the strategy in place. Thus, we join recent calls for an evolutionary perspective on governance on digital platforms. Third, the lack of evidence and best practices regarding the details of launch and growth strategies highlights the need for further empirical investigation. Using micro-strategies and microstructures may be a first step in making launch and growth of digital platforms actionable and building a design theory for platform launch.

By reviewing existing literature in IS, strategy and management we contribute to literature in several ways. We first strengthen the understanding on network effects within software platforms through finding factors that drive adoption of software ecosystems and thus trigger network effects. Second, having knowledge about which factors are able to address the respective platform sides directly or indirectly, advances conceptualization and implementation of platform launch and growth strategies. This contribution therefore makes an important step towards the utilization of network effects in platform strategy. Third, linking our results with prior research yields three avenues to advance theoretical discussion on launch and growth of digital platform ecosystem.

Naturally, this contribution underlies several limitations. First, searching and reviewing literature has limitations regarding the outlets and keywords chosen to identify relevant articles. Further, we decided not to focus on the user perspective solely. Extending the list of outlets to domains of marketing and economics and using more and broader keywords will likely help corroborating the initial results. Second, the coding process of the factors driving adoption is subjective. Focusing on different factors in detail will be able to mitigate inaccuracies originating from consolidation of different sources.

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