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Governing Innovation in E-Health Platform Ecosystems – Key Concepts and Future Directions

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GOVERNING INNOVATION IN E-HEALTH PLATFORM ECOSYSTEMS – KEY CONCEPTS AND FUTURE DIRECTIONS

Research paper

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Abstract

This paper conceptualizes knowledge in the IS literature on governing innovation in platform ecosystems using boundary resources. Platform innovation arises when platform owners realize the need to expand the functionalities and invite external actors with specialized knowledge to do so. We conduct a literature review to identify the relevant concepts on governing innovation in platform ecosystems in IS and adapt them to the specific settings of the eHealth context. As most relevant concepts, we identify: 1) boundary resources as governance mechanisms: openness vs. control; 2) co-creating platform innovation across heterogeneous actors: accommodation vs. resistance; and 3) platform innovation within the underlying architecture: stability vs. flexibility. We then derive areas that should be prone to further research in eHealth, defined as: 1) patient data as a resource for eHealth platform innovation; 2) the role of institutions in eHealth platform innovation; and 3) innovating within platform-oriented eHealth information infrastructures. This paper contributes by expanding the understanding of the current state of knowledge in IS on governing innovation in platform ecosystems and provides basis for further research adapted to the eHealth context settings.

Keywords: platform innovation, boundary resources, third-party development, eHealth

1 Introduction

The healthcare sector is of central societal importance and has been a central empirical domain also for IS scholars (Fichman et al., 2011). Currently, the digital transformation in healthcare is driven by an increasingly central role for patients, parallel to the "consumerization" that accompany digital transformation in other sectors (Agarwal et al., 2010). Patient-centric healthcare systems seek to empower and engage patients to care for their own health, and this is enabled by the growth of easily available and affordable medical devices and software to work with smartphone applications, welfare technologies and wearable devices. This transformation involves not only patients themselves as more central actors, but also novel technology actors, both in the device, software and analytics industries. These actors are not necessarily part of the established health IT landscapes, and the need for harnessing the innovation potential from this segment has increased the interest of understanding the role of platforms as stimulators for third-party innovation.

The importance of platforms lies in their capabilities to enable modularization, where functionality is distributed between the core and complementing modules provided by third-party actors (Karhu et al., 2018). In this paper, we rely on Tiwana's (2013) definition of platforms as the "extensible codebase of a software-based system that provides core functionalities shared by apps that interoperate with it, and the interfaces through which they interoperate" (Tiwana, 2013). Platform architectures have been found to facilitate generative third-party development (Ghazawneh and Henfridsson, 2010; Eaton et al., 2015, de

Reuver and Sørensen, 2018), but the generative potential still needs to accompany a certain level of control over the platform externalities.

Third-party innovation emerges when platform owners realize the need to extend the platform functionalities in an area they are not specialized in (Bygstad, 2015) and invite external actors to build novel components which have not been foreseen in the initial design phase of the platform (de Reuver et al., 2020, 2018). Although boundary resources can orchestrate the development of modules in the platform periphery (Tiwana, 2013), extending the platform ecosystem can still result with ill-performing apps (de Reuver et al., 2020), large fragmentation of functionalities that are not compliant with the overall vision of the platform (Bygstad, 2015), or lead towards platform lock-in, where the core becomes increasingly dependent on third-party functionalities. To avoid such scenarios, platform owners need to find the proper balance between using boundary resources to "open up" the platform to external actors, while also exercising control over third-party innovations in the periphery.

We stick to defining boundary resources as "the software tools and regulations that serve as interfaces for the arm's-length relationship between the platform owner and the application developer" (Ghazawneh and Henfridsson, 2013). Such resources can consist of, but are not limited to: application programming interfaces (APIs), software development kits (SDKs), contract agreements, app distribution channels, and similar tools that increase the value for third-party developers.

Platform innovation gets increasingly intermingled in eHealth, where the partitioning of decision rights between platform owners and third-parties is not always clear, as diverse stakeholders appear on both sides of the platform – the core and the periphery. Due to the divergence of institutions involved at a national, regional and local level, multiple governmental bodies with overlapping jurisdictions, as well as private third-party vendors as part of the ecosystem, governance decisions spread across the entire healthcare information infrastructure, and not just within standalone platforms. Such differences impose the need to adjust decision-making on eHealth platform ecosystem innovation towards addressing the socio-technical complexity of the healthcare context settings.

This paper aggregates relevant conceptualizations on governing third-party innovation in eHealth platform ecosystems and adapts them to the healthcare context. While we find previous literature from all disciplines as fundamental and relevant, the purpose of the paper is to identify the current state of knowledge in IS and understand the distinct settings of eHealth platform ecosystems. Our research question is: what are the conceptual approaches in the IS literature on governing innovation in eHealth platform ecosystems? To answer this question, we conducted a systematic literature review to summarize the relevant concepts that are present in the IS literature and adjust them to the healthcare settings.

For the purpose of this paper, we put our focus on the technology-oriented perspective of platforms, where platforms are defined as "a set of stable components that support variety and evolvability in a system by constraining the linkages among the other components" (Schreieck et al., 2016). Such a perspective supports understanding the distinct settings of eHealth platforms by not treating them as multi-sided markets connecting buyers and sellers (de Reuver et al., 2018), but as "coordinating devices among innovators" (Gawer, 2014). Anyhow, we do not exclude publications discussing the relevant concepts from a market-oriented perspective, as we acknowledge that these perspectives interact and should not be considered in isolation.

This review will be useful to researchers in IS and eHealth as a basis for conceptualizing the governance of platform ecosystems using boundary resources as facilitators for innovation. Our findings also provide useful insights for practitioners in both, the public and private sector for making more informed decisions about governing platform ecosystems. The paper is organized as follows. In the next section, we describe our literature review design and paper selection process. Moving further, we highlight the relevant concepts in the IS field up to date and apply them to eHealth. In the discussion, we adjust the concepts to the eHealth

context and point towards areas that should be prone to further research. Finally, we highlight the contributions and limitations of our study.

2 Literature Review Design

To understand the relevant concepts on governing innovation in eHealth platform ecosystems, we conducted a systematic literature review (Webster and Watson, 2002) using a hermeneutic approach (Boell and Cecez-Kecmanovic, 2014), to aggregate present knowledge in the IS field. We searched the following databases: Web of Science (Web of Knowledge) and AIS Electronic Library (AISeL) to retrieve publications relevant to our research interest.

Initially, we searched for keywords and their variations, grouped within the following keyword sets: "boundary resources", "third-party innovation", "platform ecosystems" and combined them with "eHealth". Since the results retrieved a low volume of articles on eHealth platform innovation and also publications which we considered irrelevant to our research focus, we decided to extend the search by not limiting it to eHealth. That way, we got a broader perspective on the relevant concepts investigating platform innovation in the IS literature and contemplated it with publications focusing especially on the eHealth field.

We included publications that were peer reviewed, written in English and published in journals, conferences and books in the following date range 2000-2020. We excluded publications that were duplicates and irrelevant to the keywords and research area. On Web of Science, we additionally refined our search to include only the following document types: article, abstract of published item, book and book chapter. The search was limited to the following categories: computer science information systems, computer science interdisciplinary applications, multidisciplinary sciences, medical informatics, health care sciences services, management and business.

Our keyword search retrieved 649 publications. The main selection process involved two rounds. In the first round, we primarily selected publications based on their title, abstract, and keywords. At this stage, we only included publications that addressed all three keyword groups, or their variations, as defined above: "boundary resources", "third-party innovation", and "platform ecosystems". Such an approach helped us use boundary resources as the main unit of analysis for conceptualizing platform innovation (de Reuver et al., 2018). Therefore, we eliminated publications that discussed these keyword groups in isolation. At this point, we also eliminated articles discussing the concepts in complementary fields, such as: computer science, hardware computing, or software engineering.

We suspected that some publications may not have used "boundary resources", "third-party development", or "platform ecosystem" as exact keywords in the title, abstract, or keywords, but are still discussing these concepts in the main text. Thus, in the second round, we inspected the full texts and searched for all three keywords and their variations across the publication. This way we made sure not to eliminate relevant publications that use synonyms, and yet investigate the concepts of our interest. At this stage, we eliminated articles where the primary focus is on complementary issues, such as patient-generated healthcare data, integration of silo heavyweight systems, information infrastructures, artificial intelligence, machine learning.

Therefore, we ended up with 21 publications that were to be read in full and ranked based on their relevance. To enrich this review with a solid volume of relevant publications, we further augmented 9 articles found via backwards research and additional 14 publications known to us from previous work. After reading them in full, we eliminated 8 articles which we considered irrelevant to our research focus and ended up with 36 final publications that are of interest in this literature review. The literature review process is summarized in Table 1.

Database	Search Keywords	Hits	Selected	Final
Web of Science	*((“boundary resource” OR “boundary resources” OR “application programming interfaces” OR “API” OR “APIs” OR “SDK” OR “SDKs” OR “software development kits” OR ”third-party development” OR ”third party development” OR ”third-party applications” OR ”third party applications” OR “third-party developers” OR “third party developers” OR "lightweight technology" OR "lightweight technologies") AND (“platform” OR “digital platform” OR “digital platforms” OR “ehealth platform” OR “eHealth platform” OR “ehealth platforms” OR “eHealth platforms” OR “platform innovation” OR "platform eco-systems" OR "platform ecosystems" OR "platform eco-system" OR "platform ecosystem"))*	379	16	10
AISEL		270	5	3
Backwards citations	/	/	/	9
Papers known to us	/	/	/	14
			Summary	36

Table 1. Summary of the literature review process.

We used an inductive coding process to code the retrieved publications based on the data provided from the search. Even though we chose this exploratory approach, we had previous knowledge on the topic to guide us from the start. Based on the retrieved publications, three main concepts emerged. Across the three concepts, we also identified tensions which encompass decisions about governing platform innovation.

The first concept focuses on boundary resources as governance mechanisms for platform innovation, investigating the tension between openness and control. The second concept explores the role of heterogeneous actors in co-creating innovation in platform ecosystems, through the tension of accommodation and resistance to change. The third concept provides an understanding on supporting platform innovation within the underlying architecture, shaped by the tension of stability and flexibility.

We also added two additional parameters to understand the context of the three concepts. The first parameter regarded whether the publications discussed the relevant concepts in the general IS field, or in the eHealth context. The second parameter determines the main unit of analysis in the publication, distinguishing between: 1) boundary resources; 2) platform ecosystems; or 3) platform architecture. Although all publications encompass all three units of analysis, this coding shows which one is predominant. The summary of publications included and the coding process are represented in Table 2 below.

Publication Title	Authors	Outlet	eHealth	Unit of analysis		
				BR	PE	PA
Journal Publications						
The Digital Platform: A Research Agenda	de Reuver et al. (2018)	JIT			X	
Distributed Tuning of Boundary Resources: The Case of Apple's iOS Service System	Eaton et al. (2015)	MIS Quarterly		X		
Complementors as connectors: managing open innovation around digital product platforms	Hilbolling et al. (2020)	R&D Manage-ment		X		
Digital platform ecosystems	Hein et al. (2019)	Electronic Markets			X	

Coherence or flexibility? The paradox of change for developers' digital innovation trajectory on open platforms	Brunswicker and Schecter (2019)	RP			X	
Configurations of platform organizations: Implications for complementor engagement	Saadatmand et al. (2019)	RP			X	
Cultivating Third Party Development in Platform- centric Software Ecosystems: Extended Boundary Resources Model	Msiska (2018)	AJIS	X	X		
Innovation, Openness, and Platform Control	Parker and Van Alstyne (2018)	Management Science			X	
Differential effects of formal and self-control in mobile platform ecosystems: Multi-method findings on third-party developers' continuance intentions and application quality	Goldbach et al. (2018)	Information & Manage-ment			X	
P for Platform. Architectures of large-scale participatory design	Roland et al. (2017)	SJIS	X			X
Design and governance of eHealth data sharing	Vesselkov et al. (2019)	CAIS	X		X	
Doing Infrastructural Work: The Role of Boundary Objects in Health Information Infrastructure Projects	McLoughlin et al. (2016)	SJIS	X		X	
Innovation Of, In, On Infrastructures: Articulating the Role of Architecture in Information Infrastructure Evolution	Grisot et al. (2014)	JAIS	X			X
Architectural alignment of process innovation and digital infrastructure in a high-tech hospital	Bygstad and Øvrelid (2020)	EJIS	X			X
Balancing platform control and external contribution in third-party development: the boundary resources model: Control and contribution in third-party development	Ghazawneh and Henfridsson (2013)	ISJ		X		
Appraising the impact and role of platform models and Government as a Platform (GaaP) in UK Government public service reform: towards a Platform Assessment Framework (PAF)	Brown et al. (2017)	GIQ			X	
Open Platform Strategies and Innovation: Granting Access vs. Devolving Control	Boudreau (2010)	MSJ		X		
Platform Desertion by App Developers	Tiwana (2015)	JMIS			X	
Research Commentary—Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics	Tiwana et al. (2010)	ISR			X	
On The Roles of APIs in the Coordination of Collaborative Software Development	de Souza and Redmiles (2009)	CSCW		X		
Co-Creating Platform Governance Models Using Boundary Resources: a Case Study from Dementia Care Services	Farshchian and Thomassen (2019)	CSCW	X			X

Between Personal and Common: the Design of Hybrid Information Spaces	Vassilakopoulou et al. (2018)	CSCW	X			X
Technology Ecosystem Governance	Wareham et al. (2013)	OSJ			X	
Conference publications						
Collaborative Innovation in Healthcare: Boundary Resources for Peripheral Actors	Aanestad et al. (2019)	ICIS	X	X		
Building National eHealth Platforms: the Challenge of Inclusiveness	Vassilakopoulou et al. (2017)	ICIS	X		X	
Governing third-party development through platform boundary resources	Ghazawneh and Henfridsson (2010)	ICIS		X		
Governing eHealth Infrastructures: Dealing with Tensions	Bygstad and Hanseth (2016)	ICIS	X			X
Infrastructural tuning in public-private partnerships	Kempton et al. (2020)	ECIS	X		X	
The Coming of Lightweight IT	Bygstad (2015)	ECIS	X		X	
Design and governance of platform ecosystems – key concepts and issues for future research	Schreieck et al. (2016)	ECIS			X	
Extending eHealth Infrastructures with Lightweight IT	Øvrelid and Bygstad (2016)	SCIS	X		X	
Innovation Readiness in Healthcare Information Infrastructures: Key Resources to Enable Collaborative Digital Innovation	Aanestad and Vassilakopoulou (2019)	SHI	X			X
Book Publications						
Platform Governance	Tiwana (2014)	Book chapter, Elsevier			X	
The Architecture of Platforms: A Unified View	Baldwin and Woodard (2008)	Book chapter, MIT				X
Maintaining the Pharmacy Model: The Catalan Electronic Prescription Infrastructure	Modol (2017)	Book chapter, Springer	X		X	
The Swedish Patient Portal and Its Relation to the National Reference Architecture and the Overall eHealth Infrastructure	Sellberg and Eltes (2017)	Book chapter, Springer	X		X	

Table 2. Summary of publications, authors, outlets, context and unit of analysis (BR – boundary resources; PE – platform ecosystem; PA – platform architecture).

3 Findings

Our review identifies three conceptualizations on governing innovation in platform ecosystems and couples them with designated tensions, as follows: 1) boundary resources as governance mechanisms: openness vs. control; 2) co-creating innovation across heterogeneous actors: accommodation vs. resistance; and 3) platform innovation within the underlying architecture: stability vs. flexibility. We assigned these concepts to a particular scope across the platform ecosystem, respectively: 1) platform governance; 2) platform ecosystem; and 3) platform architecture. The findings are summarized in Table 3 and the concepts are described in more details as follows.

Scope	Lens	Concept	Tension	eHealth extension
Platform governance	Socio-technical	Boundary resources as governance mechanisms	Openness vs. Control	Patient data as a resource for eHealth platform innovation
Platform ecosystem	Socio-technical	Co-creating innovation across heterogeneous actors	Accommodation vs. Resistance	The role of institutions in eHealth platform ecosystem innovation
Platform architecture	Technical	Platform innovation within the underlying architecture	Stability vs. Flexibility	Innovating across platform-oriented eHealth information infrastructures

Table 3. Summary of the findings, identified concepts, tensions and eHealth extension.

1) Boundary resources as governance mechanisms: Openness vs. Control. Within the *platform governance* scope, there is an ongoing tension over the optimal level of openness and control using boundary resources as governance mechanisms for platform innovation. We find this tension to be of central importance in the IS literature. Some researchers investigated it by looking at private platforms of dominant players in the IT industry (Eaton et al., 2015; Ghazawneh and Henfridsson, 2013, 2010), but this tension was also investigated in eHealth where boundary resources allocate openness and control across eHealth platform ecosystems (Modol, 2017; Sellberg and Eltes, 2017).

2) Co-creating innovation across heterogeneous actors: Accommodation vs. Resistance. Within the *platform ecosystem* scope, we have identified the tension of heterogeneous actors resisting to changes and accommodating them. In IS, this tension was introduced by following the evolution of boundary resources in private platforms where the distinction between platform owners and third-party developers is clearly defined (Eaton et al., 2015). In eHealth, the tension was adapted to the larger information infrastructure (Aanestad et al., 2019; Kempton et al., 2020; Vassilakopoulou et al., 2017), where configurations of boundary resources were shifting across a more complex set of actors, such as: governmental bodies, institutions and private third-party vendors, with overlapping jurisdictions and roles.

3) Platform innovation within the underlying architecture: Stability vs. Flexibility. Within the *platform architecture* scope, we identified the tension of keeping stability in the interfaces, while enabling flexibility in the periphery. We found the concept of loosely-coupled architectures to be one possible solution towards balancing this tension in both the IS and eHealth field (Bygstad and Hanseth, 2016; Grisot et al., 2014). We explain our findings in more details further in the text.

3.1 Boundary resources as governance mechanisms: Openness vs. Control

Third-party innovation arises when platform owners realize the need to extend platform functionalities in an area they have to expertise in, and invite external parties with specialized knowledge to do so (Bygstad, 2015). Platform owners can support third-party innovation by providing standardized interfaces to facilitate the development of applications in the platform periphery. The key potential of boundary resources lies in transferring design capabilities to external actors, thus getting exposed to their specialized knowledge to build modules which complement the platform core (Ghazawneh and Henfridsson, 2010).

Although standardized interfaces “open up” the platform for external parties, thus stimulating them to contribute with novel functionalities, “too much” openness can result with platform owners losing control over the ecosystem and its evolution. On the other hand, opening-up the platform “too little” can suppress innovation by making it difficult for external actors to contribute with novel functionalities, if they do not have access to the core platform modules.

A platform is more "open" if it places fewer restrictions on third-parties for producing novel add-ons, plug-ins and platform functionalities (Parker and Van Alstyne, 2018). However, too much openness in the periphery can make the platform too fragmented to serve as a platform (Bygstad, 2015). Therefore, the need to incorporate new expertise provided by external actors, at the same time requires a delicate balance in control over third-party modules. While low levels of control can stimulate third-party innovation, this can result with diverse applications in the periphery that are not interoperable with the core, or are not compliant with the overall vision of the platform (Boudreau, 2010). On the contrary, high levels of centralized control can result with lack of flexibility in the periphery, thus making the ecosystem lose its ability to generate external innovation (Bygstad, 2015).

Our review shows that there are conflicting views among IS researchers over the optimal level of openness and control in platform ecosystems. Putting our focus on boundary resources as enablers for third-party innovation, we look at interfaces as the most stable parts of the platform. Thus, control over the interfaces amounts to control over the platform and its evolution (Baldwin and Woodard, 2008). While platform owners are usually seen as dominant actors in platform ecosystems, there is a continuous debate over how much control and autonomy third-party actors should have (Hein et al., 2019; Saadatmand et al., 2019).

It is generally accepted that control points should be dispersed across all actors, but it is still unclear how and at what degree control should be allocated. Some researchers argue that boundary resources as control points should be designated evenly across third-parties, to encourage greater third-party engagement with platforms (Saadatmand et al., 2019). Therefore, they point towards the need for autonomy of external actors to choose their desired level of control (Goldbach et al., 2018; Wareham et al., 2013), or negotiate control based on the perceived value (Hein et al., 2019; Tiwana et al., 2010).

Although studies shows that self-control of third-parties can result with higher application quality in the periphery (Goldbach et al., 2018), giving up too much control can make it harder to achieve cohesion between the complements and the focal platform, thus jeopardizing innovation (Boudreau, 2010). If external actors have too much control, they can use unofficial APIs to build novel functionalities and get the platform enveloped by another platform (Hilbolling et al., 2020). On the contrary, if faced with strict boundary resources, developers might look for alternative ways to open up the platform and "self-resource" new boundary resources themselves (Eaton et al., 2015).

Decisions about openness and control are even more complex when applied to the eHealth field, as they are allocated amongst multiple national, regional and local governmental bodies and different bureaucratic levels. For example, following the evolution of the Swedish Patient Portal, Sellberg and Eltes (2017) show that core components were owned by multiple national and local authorities, with overlapping jurisdictions. In order to coordinate such complex partitioning of decision rights, the project team used a National Architecture Framework for eHealth services as a coordination mechanism, providing SDKs, APIs and guidelines to support the development of third-party modules across the platform ecosystem (Sellberg and Eltes, 2017).

The governance of the Catalan e-prescription solution, on the other hand, is an example where the Department of Health as a governing body had full ownership over the initiative at first, but gradually shifted towards an interoperability framework to open up and include third-party services. Even though third-parties shared ownership over the complementary services, the governing body still kept control over the services using accreditation mechanisms and quality certificates to orchestrate the development of applications that are trustworthy and interoperable with the platform core (Modol, 2017).

This concept shows that there is an on-going discussion in the IS literature over how should control points be dispersed across platform ecosystems, using boundary resources as tools to facilitate openness and control. Next, we investigate the role of multiple heterogeneous actors in tuning boundary resources and shaping the evolution of platform ecosystems.

3.2 Co-creating innovation across heterogeneous actors: Accommodation vs. Resistance

Platform ecosystems encompass dynamic relationships emerging among multiple heterogeneous actors (Brown et al., 2017). To support such a diverse environment, platform owners need to respond to the different goals and objectives of third-party actors in the ecosystem. Although standardized interfaces play a central role in orchestrating third-party actors towards a common platform goal (Tiwana, 2014), it is not always clear how such changes will shape the evolution of the platform (de Reuver et al., 2020) and affect other actors in the ecosystem. Therefore, many IS researchers have put their focus on investigating how boundary resources evolve in diverse socio-technical environments, where platform owners and their ecosystems mutually shape each-other's goals.

Looking at boundary resources from the platform owners' perspective, IS researchers conceptualize them as tools for "resourcing" external platform functionalities and "securing" the platform core to control third-party innovation (Ghazawneh and Henfridsson, 2013). This typology was further adapted to eHealth, where third-party actors from within and outside hospitals, the public and private sector, as well as citizens are integrated into the innovation cycle (Aanestad et al., 2019). In such settings, the focus extends towards the third-party developers' perspective, who use boundary resources to "discover" the limitations and possibilities of the core, and "vest" the benefits through copyrights, ownership and data exploitation (Aanestad et al., 2019).

Treating the evolution of boundary resources as a cyclical process, some IS researchers explained it through the prism of "tuning", where boundary resources evolve as a constant tension between third-parties resisting to change and accommodating it. Some used this tension to follow the evolution of boundary resources across private platform ecosystems (Eaton et al., 2015), while others adapted it to eHealth and extended it across the entire eHealth information infrastructure to investigate how public-private platforms emerge (Kempton et al., 2020). Looking at how boundary resources were "tuned" in Apple's iPhone platform, Eaton et al. (2015) showed that once the introduced set of boundary resources met resistance by third-party actors, the resources were either shaped by Apple additionally opening up the platform, or by third-party developers changing their goals and strategies to enter the platform ecosystem.

This tension was also used to follow shifts in decisions across large public-private platforms in eHealth infrastructures. Investigating the tuning of a welfare technology initiative in Norway, Kempton et al. (2020) found that decisions were constantly transitioning between the Directorate of Health's wish to overcome infrastructural silos, municipalities trying to make independent decisions about local investments and the need for autonomy of third-party actors. They propose a hub solution, whereby defining a minimal core and incremental changes to widen it, the circle between resistance and accommodation becomes tighter.

The process of tuning is shown to be highly dependent on the differences in power of third-party actors, to influence the trajectory of changes in the boundary resources' design (Eaton et al., 2015). This issue is also of significant importance in healthcare, where a multitude of actors, including governmental bodies, third-party vendors, as well as institutions come into play and influence the evolution of the platform ecosystem (McLoughlin et al., 2016). While in the case of Apple's iPhone platform (Eaton et al., 2015) Apple as a central actor controls the surrounding environment, in eHealth platform ecosystems the distinction between the role of platform owners and third-party developers is not always as clear, as a multitude of intertwined powerful actors appear on both sides and the platform owner is not necessarily the most dominant one.

Following the e-prescription initiative in Catalonia as an example, the pharmacy association managed to obtain a key role in governing the pharmacy IT system, which was initially part of the larger e-prescription solution, governed by the Directorate of Health (Modol, 2017). APIs were "tuned" only when the association determined that the new feature adds enough value to pharmacies, or when it was mandatory or required by law.

Implications from practice suggest that if the owner is less powerful than the peripheral actors, third-party actors with higher influence are more likely to dominate the platform, and make the platform less attractive to other actors in the periphery (Saadatmand et al., 2019). Therefore, some IS researchers point towards a more balanced, cooperative and less hierarchical power relationship between platform owners and third-party developers (Bygstad, 2015; Goldbach et al., 2018; Saadatmand et al., 2019). To create and maintain a coherent identity for the platform, complementors need to balance the pursuit of their own interests with the interests of other players in the ecosystem (Saadatmand et al., 2019).

This section shows that in eHealth, there is a multitude of actors appearing on both sides of the platform core and periphery. This social diversity increases the complexity of managing actor relationships and govern how eHealth platform ecosystems emerge. Next, we use a technical lens to understand how the arrangement of components within the architecture supports platform ecosystem innovation.

3.3 Platform innovation within the underlying architecture: Stability vs. Flexibility

Governing innovation in platform ecosystems is closely reliant on the underlying platform architecture (Kempton et al., 2020; Tiwana et al., 2010). The fundamental architecture behind platforms consists of stable "core components" with low variety, flexible "peripheral components" with high variety, and design rules or "standardized interfaces" that connect the complements with the core (Baldwin and Woodard, 2008). Interfaces act as the most stable parts of the platform, since they determine how the different components coordinate and work together (Baldwin and Woodard, 2008). Therefore, preventing changes in the interfaces is essential to keep the interoperability and compliance between the core and the periphery (Wareham et al., 2013), as architectures need to incorporate interfaces that are stable, but also versatile and evolve over time (Baldwin and Woodard, 2008).

Our review shows that balancing the tension between keeping stability in the core and enabling flexibility in the periphery is of central importance to support platform innovation. Contrary to understanding stability and flexibility as conflicting forces or "dialectics", some researchers look at them as "dualities" which are mutually reinforcing and interdependent (Bygstad and Hanseth, 2016). Peripheral components require a standardized platform core that can enable scaling, while the core needs flexible applications that can adapt to emerging local needs (Bygstad and Hanseth, 2016; de Reuver et al., 2018).

IS researchers commonly rely on the concept of loosely-coupled architectures, to balance the tension between stability and flexibility (Bygstad and Øvrelid, 2020; de Reuver et al., 2018; Saadatmand et al., 2019). When architectural components are loosely-coupled, changes in one application in the periphery do not necessarily result with changes within the core, or the other applications in the periphery, which can still remain stable or non-affected (MacCormack et al., 2010). In such a detached portfolio, boundary resources decouple the core from the distributed ecosystem of third-party apps (Brunswicker and Schecter, 2019), acting as coordinative tools between the dispersed components.

The concept of loosely-coupled architectures to govern platform innovation is also adopted in eHealth (Bygstad and Hanseth, 2016; Grisot et al., 2014). One view from Grisot et al. (2014) is to build external components as a new architecture, that is loosely-coupled to the installed base and let it evolve in a bottom-up approach. That way, the innovation results in a flexible solution that is easily modified without disturbing the core and incorporates new functionalities "on top of what exists" (Grisot et al., 2014). Looking at the relationship between innovative lightweight technologies and stable heavyweight systems, Bygstad (2017) also supports that they should be coupled by interacting with each-other, instead of being integrated as a whole (Bygstad and Øvrelid, 2020). Thus, loosely-coupled components in platform ecosystems result with lower needs for coordination from the core and greater autonomy in the periphery (Bygstad, 2017).

As loose-coupling enables greater autonomy, it also has some positive effects on developers' motivation to innovate within the periphery (Brunswicker and Schecter, 2019; Goldbach et al., 2018). De Souza and Redmiles (2009) point out that while developers expect boundary resources to evolve, they still do not expect interfaces to be prone to frequent changes. And if frequent changes happen, they should not severely affect the interoperability and compliance of the app with the core (de Souza and Redmiles, 2009). Frequent changes in the interfaces can also enforce developers' decisions about "app desertion" to leave the platform ecosystem, since they require constant effort from third-parties to stay interoperable with the core (Tiwana, 2015).

Contrary to decisions about app desertion, findings show that developers are more likely to make frequent, iterative changes to applications which are coherent with their past knowledge and expertise (Brunswicker and Schecter, 2019; Vesselkov et al., 2019). However, developers' motivation for innovation is stronger if they can learn novel skills and make flexible changes to applications in the platform periphery (Brunswicker and Schecter, 2019).

Balancing the tension between platform's macro and micro architecture, requires an environment where the interfaces are kept stable, but also support agile changes in the complementary applications to keep interoperability with the platform core. Next, we adapt the three concepts to the eHealth context and extend them towards areas that should be prone to further investigation in eHealth platform ecosystems.

4 Discussion: Governing innovation in eHealth platform ecosystems

The proliferation of lightweight technologies, smartphone apps and wearable devices have placed the patient at the heart of healthcare service delivery, where patient data acts as a key driver for digital innovation in eHealth information infrastructures. Patient data associated with lightweight technologies has shifted the way healthcare is being delivered, how patients interact with caregivers and how information is exchanged and coordinated across the healthcare system (Bardhan et al., 2020). As a large set of haphazard and diverse patient data is gathered across dispersed apps and devices, developed and used outside hospital environments (Vassilakopoulou et al., 2017), there is a critical need to understand the role of patient data in leveraging the generative potential of eHealth platform ecosystems (Kempton et al., 2020; Vassilakopoulou et al., 2018; Vesselkov et al., 2019).

While this literature review uses IS knowledge as the basis to develop the findings, the purpose of the sections that follow is to adapt the concepts identified in the findings to the eHealth context and uncover areas that are understudied and require further attention. Relying on our previous knowledge of platform ecosystems in IS and eHealth, and not solely on the publications included in the literature review, we extended the three identified concepts on governing platform innovation, and the tensions associated with them, with key areas that should be prone to further research in eHealth. 1) First, we highlight the importance of patient data as a key resource for eHealth platform innovation. 2) Second, we address the role of institutions in eHealth platform innovation. 3) At last, we extend eHealth platform innovation towards wider platform-oriented eHealth information infrastructures. The transformation towards these three areas is elaborated in more details as follows.

4.1 Patient data as a resource for eHealth platform innovation

Lightweight technologies distribute a large set of standardized and unstandardized data across eHealth platform ecosystems (Constantiou and Kallinikos, 2015). This heterogeneous set of data challenges the traditional ways of storing patient data in clinical and hospital systems, providing access only to healthcare

professionals. Medical and non-medical data is now also gathered and stored using personal devices, smartphone apps and wearable technologies, generated and accessed by patients themselves.

The potential of integrating patient-generated healthcare data associated with lightweight technologies with traditional medical sources, uncovers missing opportunities to use patient data as a key resource to innovate across eHealth platform ecosystems (Aanestad and Vassilakopoulou, 2019; Bygstad and Øvrelid, 2020; de Reuver et al., 2018), as well as learn more about diseases, adhere to personalized treatments and predict treatment outcomes (Bardhan et al., 2020). The provision of core data modules can stimulate an agile, healthy ecosystem environment, as it is hard for third-party vendors to innovate, if they do not have access to core data modules (Kempton et al., 2018). While some applications can be developed using test data only, others may require access to real patient data in order to generate modules which add value to the overall platform ecosystem (Aanestad and Vassilakopoulou, 2019).

Therefore, researchers need to understand how platform owners can govern access and control over sensitive patient data (Kallinikos and Constantiou, 2015) in order to facilitate innovation for third-party actors in the ecosystem. Further research need to explore the types of boundary resources that can regulate access and control over patient data as a key resource for innovation (Aanestad et al., 2019), as well as understand how to sustain a healthy third-party environment, in which peripheral applications generate value to the platform ecosystem as a whole.

4.2 The role of institutions in eHealth platform innovation

The complexity of heterogeneous actors in eHealth platforms does not encompass only national and regional government bodies, local municipalities and software vendors, but is also influenced by institutional logics, laws and regulations, politics and concentration of power that shape the evolution of the platform ecosystem (Eaton et al., 2015; Hein et al., 2019). Regulators and interest organizations can exercise power to protect their own interests, influence actors toward a certain behavior, as well as shape public opinion on trust in sharing patient data, and affect decisions about patient data privacy and security (Eaton et al., 2015).

The changed landscape of lightweight technologies used outside hospital environments, incorporates various actors participating in a shared platform ecosystem, which cannot be separated from the political context in which it is embedded (Eaton et al., 2015). Therefore, the dialectics between accommodation and resistance in eHealth platform ecosystems, spread across conglomerates of the public and private sector, prone to institutional pressures, all of which can shape the evolution of boundary resources and therefore, influence decision-making in eHealth platform ecosystems.

Further research needs to investigate the cyclical process of how institutional power shapes boundary resources and decisions about patient data sharing, privacy and security, as well as how institutions are influenced to accommodate changes in response. Researchers need to understand how different actors come and shape decision-making about patient data across public and private eHealth settings (Bygstad and Øvrelid, 2020; Øvrelid and Bygstad, 2016), as well as explore third-party vendors' motivation to contribute, stay within, or leave the eHealth platform ecosystem.

4.3 Innovating across platform-oriented eHealth information infrastructures

The large arena of lightweight technologies used by patients have resulted with multiple platforms and isolated data repositories across eHealth information infrastructures, which do not exchange data with each-other. Patient data is captured and stored in many independent databases, using different patient identifiers, which impose the challenge of deciphering the interrelationships of the data cube to provide critical insights

for organizations (Baesens et al., 2016). It is not yet clear how to integrate data gathered from such a diverse set of sources, and in different types, such as: text, images, video, audio, as they raise questions about semiotic compatibility and interoperability across disparate systems (Constantiou and Kallinikos, 2015).

Platform silos in eHealth spread across the entire information infrastructure, relying on distinct architectures arranging their components, as well as diverse boundary resources guiding their interaction with other platforms (Hanseth and Bygstad, 2018). Therefore, there is a need to understand how different eHealth platforms can be integrated across information infrastructures, where multiple core and peripheral components, as well as standardized interfaces are mashed together, to improve healthcare service delivery (de Reuver et al., 2018). In such a diverse eHealth landscape, the tension between keeping the boundary resources stable, versus enabling flexibility in the periphery needs to be addressed across the entire eHealth infrastructure, and not just within standalone platforms (Bygstad and Øvrelid, 2020).

Our review shows that decisions about data sharing in fitness mHealth platforms have greater implications on platform generativity, than the actual design and architecture of the platform (Vesselkov et al., 2019). In order to break down the platform silos and exchange patient data, researchers need to understand how to balance stability and flexibility of various boundary resources dispersed across multiple national, regional and local levels, while at the same time supporting the need for common standardized interfaces that can standardize data exchange across eHealth platform ecosystems.

5 Conclusion

In this paper, we aggregate IS knowledge on governing innovation in platform ecosystems, by answering our research question: what are the conceptual approaches in the IS literature on governing innovation in eHealth platform ecosystems? We answer this question by developing three concepts on governing innovation in platform ecosystems within the IS literature and adapt them to the complexity arising from the specifics of the eHealth context settings.

By conceptualizing the existing literature and adjusting it to the eHealth context, we contribute to the current state of knowledge in several ways. First, this review aggregates IS knowledge on governing innovation in platform ecosystems and investigates it through assigned tensions spreading across platform ecosystems. Second, we adapt the identified concepts to the complexity of the cross-disciplinary eHealth settings, which was not done in the IS literature before. At last, we provide areas that should be prone to further research, as derived from the complexity arising in eHealth platform ecosystems.

We conclude that while IS literature is relevant for conceptualizing the governance of innovation in eHealth platform ecosystems, we need to adjust these concepts to the emerging healthcare landscape, where external innovations are developed outside hospitals and diverse actors across multiple national, regional and local governmental levels, with overlapping jurisdictions are included in eHealth platform ecosystems.

We also acknowledge the limitations of our paper in two ways. 1) Inconsistent terminology: boundary resources, third-party innovation and platform ecosystems are referred to using different terms across IS literature. Therefore, this review may not retract all relevant publications in the IS field. 2) Cross-disciplinarity: colliding IS and eHealth might neglect some of the findings in the current state of knowledge, as what works in the private sector, may not be applicable to the public-private partnerships arising in eHealth information infrastructures.

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