Managing Open Innovation through Digital Boundary Control: The Case of Multi-Sided Platforms in the Collaborative Economy

Romain GANDIA
Université Savoie Mont Blanc
Laboratoire IREGE (France)
romain.gandia@univ-smb.fr

Guy PARMENTIER
Université Grenoble Alpes
Laboratoire CERAG (France)
guy.parmentier@univ-grenoble-alpes.fr

ABSTRACT
The sharing economy is a growing sector that is profiting from digitalization by developing multi-sided platforms allowing users to create and manage valuable transactions around products and services. However, for companies, this type of platform requires the implementation of opening processes to provide internal resources in order to help users interact between them and to innovate. This poses a problem of the openness control of boundaries of the company and the platform, which the present research proposes to study. Through the comparative study of several multi-sided platforms, we show that the control mechanisms depend on the type of boundary and the nature of the opening. We also analyze the role of the platform, technological tools and governance in the dynamic management of these boundaries, and the management of open innovation.

KEYWORDS: Boundary, Openness, Innovation, Multi-Sided Platform, Sharing Economy, Digital

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The digital age has opened the way for a new economy and new strategies based on multi-sided platforms and communities in which the end consumer

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can assemble the offering, create value for the company, and sometimes produce the service delivered. These strategies are best illustrated in the collaborative economy, where the objective is to develop collaborative, social and open platforms to foster innovation and network externalities between users (Acquier *et al.*, 2017). In these innovative platforms, the multi-sided dimension plays a crucial role in organizing interactions between different complementary user groups within a common digital space in order to create value and to innovate (Gawer, 2011). Within this digital space, the company must open up to share some of its resources in order to organize interactions and guide users towards value creation. This is typical of platforms such as Blablacar, Troc.com, and AirBnB, where users are key elements in the development and production of the business. Therefore, the notion of openness to different communities is important but raises the question of boundaries.

Indeed, the principle of the openness of the innovation necessarily implies opening the company's boundaries in order to 1) make internal resources available to the outside and 2) capture profitable external resources within the company (Chesbrough *et al.*, 2006). By opening up, the company may deal with an ecosystem of diversified actors (communities, partners, suppliers, customers, users, etc.), which implies the issue of boundary management and control. Until now, the literature on open innovation has focused mainly on the question of the company's organizational boundaries (Burger-Helmchen *et al.*, 2011), particularly through the analysis of openness processes (*e.g.* inside-out, outside-in, and coupled processes, Gassmann, Enkel, 2004). However, this approach remains confined to the physical and tangible environment of the company and does not necessarily include the digital dimension. In contrast, open innovation can be increased tenfold and organized within digital environments such as digital platforms, applications, networks and ecosystems (Attour, Barbaroux, 2016; Boudreau, 2010; Gawer, 2014; Thomas *et al.*, 2015; Parker, Van Alstyne, 2018). The question of digital boundaries remains little studied, which is paradoxical given the crucial importance of this issue for companies in the age of industry 4.0. Although some research shows the role of digital platforms in the collaborative economy in coordinating different actors within an open innovation approach (Gawer, Cusumano, 2002; Loilier, Malherbe, 2010), there is no question of boundaries or their control. The specific case of multi-sided platforms is therefore ignored, even though openness is one of their strong characteristics because their strategic and commercial mechanisms are based on the building of a real community ecosystem (Koenig, 2012) to produce a business and to innovate (Gawer, Cusumano, 2014). In this new digital organization of the company, traditional boundary management mechanisms can fail.

The objective of this research is to examine how the opening of digital boundaries on a multi-sided platform can be controlled. This involves three steps: 1) characterize the types of boundaries at work on a multi-sided platform, 2) identify control mechanisms and classify them according to the type of boundary, the type of community and the nature of the opening and 3) show the key role of the multi-sided platform in the control framework and its effects on the management of open innovation. After presenting the theoretical framework of the research, we detail the method used and then present and discuss the results obtained before concluding with the main contributions, limitations and future avenues of research.

Theoretical Framework

This research involves multi-sided platforms, the concept of boundaries, and open innovation. We first show how multi-sided platforms can be viewed as an open digital innovation space that disrupts the traditional organizational approach to innovation. Second, we address the concept of boundaries and their dimensions. Finally, we detail the issues inherent in the management and control of the opening of digital boundaries on a multi-sided platform.

Multi-sided platforms as open innovation spaces

In contrast to the traditionally closed model of innovation, based solely on internal resources and skills, open innovation consists of opening the company's boundaries to all types of external stakeholders to stimulate innovation processes and thus create, capture and enhance new resources, ideas and knowledge (Chesbrough, 2003). Since the advent of this paradigm, research on open innovation has been booming and has been greatly enriched by the development of the digital economy, communities and platforms (West, Bogers, 2017). Indeed, by providing a digital space for orchestrating value creation and capturing interactions with stakeholders within a network, the platform is a driver of open innovation (West, 2014). However, the majority of studies focus on the role of the platform as a tool and technological resource supporting open innovation and not as an open space for the production of innovative business, as is the case with multi-sided platforms in the collaborative economy. Unlike traditional digital platforms used as technological support tools, the multi-sided platform provides a truly self-organized collaborative social space. It is therefore particularly interesting to study.

A multi-sided platform is a technological environment (website, applications, databases) that organizes interactions and transactions between several distinct but interdependent groups of customers or users (the sides of the platform) (Hagiu, Wright, 2015). The presence and activities of these groups on the platform increase the value of the service and attract more customers or users through network effects (Hagiu, 2014). This type of platform also offers a market space, as well as technological tools and services to meet the needs of various user groups and engage them in a process of value creation and innovation (Gawer, Cusumano, 2014; Parker, Van Alstyne, 2018). For example, using a digital platform (web, mobile applications and database), BlaBlaCar offers a carpooling service that connects drivers and passengers remotely before the trip. Such carpooling services already existed informally (niche market), but they exploded with the advent of the Internet and smartphones. The opening of a technological platform to independent external companies is an innovation accelerator (Boudreau, 2010). The benefits and spinoffs in terms of innovations are greater with a complete opening of the platform than with a partial opening (Parker, Van Alstyne, 2018). Thus a multi-sided platform can be a real space for open innovation involving multiple actors who design and produce a large family of innovative services (Gawer, 2014; Thomas *et al.*, 2015). By organizing interactions and transactions between several user groups, the multi-sided platform must necessarily manage the opening of boundaries between the company and the stakeholders involved in the business, which poses control problems.

The Boundary Rationale Applied to Multi-Sided Platforms

A boundary is a demarcation between the organization and its environment that can be established according to four organizational objectives: efficiency, power, competence and identity (Santos, Eisenhardt, 2005). In an organization, the role of a boundary is generally to delineate transactions (efficiency), sphere of influence (power), resources owned by the organization (competence), and culture (identity). It therefore implies a form of closure linked to the demarcation it imposes between the internal and the external (*ibid*, 2005). Reflecting on boundaries thus allows an organization to consider whether to internalize the elements necessary for its business (activities, resources, etc.). However, traditional work on boundaries is based on an analysis of the company's physical and tangible environment and its fields of activity, while the development of digital strategies and platforms nowadays involves the emergence of digital boundaries (Bharadwaj *et al.*, 2013).

To the extent that multi-sided platforms can provide a market space that makes technology, tools and services available to organize transactions between different groups of actors (Hagiu, Wright, 2015), it is possible to take an approach focusing on their boundaries. Indeed, a multi-sided platform is an intermediate object that links a company to its market and its partners (Eloranta, Turunen, 2016). When the platform is an open innovation space, it sets new digital boundaries for managing innovation processes (outside-in, inside-out and coupled, Gassmann, Enkel, 2004), both by organising the input of ideas, resources and knowledge from external actors to enrich existing services, and by making available internal technological resources to help external actors innovate. To open up innovation, the platform must therefore delimit and organize transactions, define the degree of freedom and action of user groups (and therefore their sphere of influence, Hagiu, 2014), set the intellectual property regime, make available certain internally-held resources (*e.g.* technologies, tools, services, etc., Gawer, Cusumano, 2014), and convey a specific identity in line with the company's values. The typology of Santos and Eisenhardt (2005) therefore seems suitable for defining boundaries on a multi-sided platform, which are determined by what is controlled and managed by the platform's operating organization or by the external actors present on the platform (see Table 1).

Table 1 **– Boundary rationales in a multi-sided platform**

Type of boundary	**Rationale for positioning the boundary (source: Santos, Eisenhardt, 2005)**	**Application to multi-sided platforms**
Efficiency	Fixed according to transaction costs. Internalization depends on the level of market uncertainty and the level of transaction costs (the higher the transaction costs, the more the company internalizes).	Sets the limit between the resources to be mastered internally to organize transactions between user groups and their participation in transactions.
Power	Fixed according to the competitive environment. The more the presence of actors in the environment can limit the company's performance, the more vertical and/or horizontal internalization can be used.	Determines the relationships with the external environment for platform management and sets limits on the level of power granted to user groups.

Type of boundary	Rationale for positioning the boundary (source: Santos, Eisenhardt, 2005)	Application to multi-sided platforms
Competency	Fixed according to the company's resource portfolio. Internationalization of competencies must maximize the portfolio in stable markets or improve innovation in unstable markets.	Clearly distinguishes between the skills to be mastered internally to manage the platform and those expected by external user groups.
Identity	Fixed according to the company's identity elements (values, culture, etc.). The internalization of activities, resources, etc. depends on the level of coherence with organizational identity.	Determines the identity of the platform and its consistency with the elements (products, services, etc.) offered to user groups.

Managing the Opening of Boundaries within a Multi-Sided Platform

From an open innovation perspective, there is a tension between the need to open up innovation and the need to control and close off boundaries (Enkel *et al.*, 2009). Indeed, the processes of openness at work (inside-out, outside-in and coupled) require a certain porosity of boundaries in order to make internal resources available to the outside or to integrate external resources and knowledge into the company's internal processes and activities (Gassmann, Enkel, 2004). While most research has focused on boundary management within the organization or in external physical environments (*e.g.* Jacobides, Billinger 2006; Lakhani *et al.*, 2013; Perlow, 1998; Tushman, 1977), little research has focused on digital boundaries, including managing and controlling their opening on a multi-sided platform. Although some research (*e.g.* Parmentier, Gandia, 2013; Hafkesbrink, Schroll, 2011) focuses on managing different types of openness (technological, knowledge and digital content openness) on a multi-sided platform, this is not a boundary control mechanism. In the literature on multi-sided platforms, there is more focus on global governance and regulatory mechanisms in the relationship between the platform and the market (*e.g.* price, governance structure, decision-making rules, platform accessibility, etc., Hagiu, 2014; Gawer, Cusumano, 2014; Parker, Alstyne, 2018; Evans, 2012; Eisenman *et al.*, 2011) but without addressing the issue of boundary opening. In the boundary literature, the research identifies more control strategies rather than the more micro mechanisms hosted on the platform. Consequently, the limitations of

the literature do not allow identifying the mechanisms for controlling the opening of boundaries on a multi-sided platform.

Method

This research focuses on the specific case of the collaborative economy, which is particularly relevant in addressing the issue of controlling boundary openings, as: 1) it is an innovative economy supported by the development of multi-sided platforms and 2) it is an economy based on collaboration and openness between different types of actors who become producers of business and innovation. Boundary management and boundary control are therefore central to this economy because it is essential for companies to integrate stakeholders into their ecosystem to achieve their economic, social and environmental objectives.

To address our problem, we adopted an exploratory qualitative approach based on a comparative case study (Miles, Huberman, 2003). The exploratory approach is particularly well suited to explore a little-studied phenomenon, as is the case for multi-sided platforms in the collaborative economy and the issue of digital boundary control. The objective was to analyze several cases of multi-sided platforms in order to identify different control approaches to common open boundary types. In this sense, a comparative study with multiple cases (Yin, 1994) was essential. We selected emerging organizations (companies, organizations and SCICs [cooperative companies in the public interest]) to observe 1) the implementation of their multi-sided platform, 2) the open organization of interactions and transactions between users to produce an innovative service and 3) the implementation of digital boundary management and control mechanisms. The choice was made to look at "classic" collaborative economy services: carpooling, hosting, service exchange, equipment exchange, alternative food distribution and alternative content distribution. All cases use a multi-sided digital platform. The aim was to vary the sample in terms of status, size and type of activity in order to have access to a wide range of boundary management practices with a multi-sided platform. The selected cases (see Table 2) have enough similarities to allow a relevant comparison (internal validity) while having enough distinctions to allow generalization (external validity) (Miles, Huberman, 2003).

Our data collection respects the principle of variety (Eisenhardt, Graebner, 2007) because it is based on 14 semi-directive interviews and a large amount of secondary data (websites and press articles). The purpose of using secondary data was to reduce collection bias and increase data reliability through a triangulation process. Based on the collected data, we conducted a lexical

analysis in the form of thematic coding that resulted in 5 categories of data: 1) classification of the platforms' sides (with sub-categories of user groups, interactions, delivered value, value created and value captured), 2) nature of openness, 3) type of boundaries (with sub-categories corresponding to the Santos and Eisenhardt typology, 2005), 4) boundary control mechanisms and 5) innovations (to understand the consequences on innovation). The objective was to group the verbatim by coding categories from the literature review without excluding emerging categories from the cases. The coding was first done individually by each researcher and then compared, with a discussion of the discrepancies. We then grouped these data into tables to analyze the similarities and differences between cases, which allowed us to identify various common types of opening in relation to specific boundaries and various common control mechanisms. The aggregation of these data allowed us to develop Tables 3 and 4, which then led to our interpretation. The value of tabulating the data was also in reducing interpretation bias, by clearly identifying the cause-and-effect links between the nature of the opening, the location of the opening according to the type of boundary, the control mechanism(s) and the possible consequences on innovation. The seven selected cases are presented in summary form below (see Table 2).

Table 2 – List of the collaborative economy multi-sided platforms studied

Platform *(Acronym)*	Size No. employees	Description	Data
Mutum (Mutum) Launched in 2014	14 then 1	Platform for exchanging objects for alternative consumption. Specific vocabulary: Mutum is the name of the alternative currency created by the platform.	2 interviews, website and press articles
Open Food Network France (OFN) Launched in 2015	2	The platform allows local producer and consumer groups to organize their logistics and transactions by supporting an alternative food distribution system. Specific vocabulary: Hub is the name used to describe the many producer and consumer organizations.	2 interviews, website and press articles
RidyGo (RidyGo) Launched in 2015	–	Platform for short carpooling trips with social objectives of redistributing value to the most disadvantaged. Specific vocabulary: Credit is the name of the alternative currency created by the platform.	2 interviews, website and press articles
1D Touch (1DT) Launched in 2014	10	Multimedia streaming platform focused on independent artists and labels. Specific vocabulary: the Capsule is a contextualized music playlist created by users and libraries.	3 interviews, website and press articles
Open Car (OC) Launched in 2016	3 then 35	Free local carpooling platform with driver remuneration in the form of gifts from local merchants. Specific vocabulary: OP is the name of the alternative currency created by the platform.	1 interview, incubation document, website and press articles
SkillTroc (SkillTroc) Launched in 2016	2	Platform for peer-to-peer knowledge exchange. Specific vocabulary: Time credit is the name of the alternative currency created by the platform.	2 interviews, website and press articles
Guest to Guest (GtoG) Launched in 2011	80	Housing exchange platform for alternative travel. Specific vocabulary: Guest Points is the name of the alternative currency created by the platform.	2 interviews, website and press articles

Results

Our research focuses on control of the opening of digital boundaries on a multi-sided platform. The comparative analysis of these seven cases from the collaborative economy allows us to identify three main results: 1) the identification and classification of types of boundaries and the nature of openings on multi-sided platforms, 2) the identification of mechanisms to control the opening of boundaries on multi-sided platforms and 3) the consequences of boundary control on the management of open innovation.

Type of Boundary and Nature of Opening in Multi-Sided Platforms

The cases studied show that the four types of boundaries in the Santos and Eisenhardt typology apply well to the case of multi-sided platforms. The multi-sided dimension makes it possible to precisely classify the interacting user groups and the nature of the resources used or exchanged on the platform via the opening processes. It is therefore possible to identify the nature of the opening through the platform's managing organization and to locate this opening via the type of boundary (see Table 3).

Table 3 – Nature and location of the opening on the multi-sided platforms studied

Case studied	Nature of opening	Location			
		EFF	PV	CMP	ID
Mutum	**Open content**: users (lenders and borrowers) provide the objects to be lent, organize the loan flows and perform the lenders' evaluation. **Open governance:** capital is open to users, who can take part in decisions (failure). **Closed technology and services**: the company provides the platform and support tools, a virtual currency system (Mutum point) and services.	X	X		X
Open Food France	**Open content**: users (food actors in local network) create hubs, manage the network of local actors and manage the point of sale (orders, invoices, product catalogue, etc.). **Open technology**: the company provides the platform and Open Source tools (free access to code) **Open governance**: country divisions that are independent but collectively participate in the strategy. At the local level, hubs are independent but collectively participate in governance	X	X	X	X
RidyGo	**Open content**: users (passengers and drivers) offer and organise short-distance carpooling trips. **Open governance**: users can participate in decision-making alongside the company's employees. **Closed technology and services**: the company provides the platform and support tools, a virtual currency system (credits) and services (support, notification, etc.).	X	X		X
1D Touch	**Open content**: the prescribing partners manage their local pages with thematic capsules (curated content from local artists in collaboration with the partner). **Open governance:** partners are involved in governance (election of the board of directors and collective decision-making). **Closed technology and services**: the company provides the platform and support tools, as well as a service to support partners and prescribe content.		X	X	X
Open Car	**Open content**: users (passengers and drivers) propose and organize short-distance carpooling trips, and then evaluate drivers. **Closed technology and services**: the company provides the platform and support tools and the point system to convert into gifts and services (insurance, corporate service).	X	X		
Skill Troc	**Open content:** users (experts and learners) propose and organize workshops, create and consult training tutorials, provide feedback and monitor their activity. **Closed technology and services**: the company provides the platform and support tools, a virtual money system (stars) and services (pedagogical support, etc.).	X	X		
Guest to Guest	**Open content**: users (hosts and guests) provide accommodation, organize and carry out rental and exchange flows and finally evaluate hosts. **Closed technology and services**: the company provides the platform and support tools, a virtual currency system (guest points) and services (verification, insurance, bonding, etc.).	X	X		

Legend (boundary): EFF (efficiency), PV (power), CMP (competency), ID (identity)

The results show that the platforms studied mainly open up the dimension of digital content by providing tools enabling users to create, put online and manage information (product information, services, profile, knowledge, evaluation, feedback, etc.) as well as organise exchange services and transactions. The opening of boundaries focuses mainly on the objectives of (1) efficiency, through the outsourcing of transaction management by users themselves and (2) power, in particular by giving users the power to evaluate in order to outsource part of the community's moderation. This is the case with Mutum, Open Food France, RidyGo, Open Car, Skill Troc and Guest to Guest platforms. These platforms also show a lack of openness in terms of competency and a closing of technology and support services (often additional services related to security and support). The 1D Touch and Open Food platforms, are however, exception in digital content and technology. For 1D Touch, local partners do not provide artistic content, but publish it in the form of an "artistic capsule" (thus opening the competence boundary). For Open Food, the platform is Open Source (opening up technology). Finally, the Mutum, Open Food France RidyGo and 1D Touch cases show an opening of their platforms' governance, which implies an opening of the boundary on power and identity insofar as users become actors in the strategy (with value building and decision-making power). Users then share and adhere to strong identity values, particularly social and environmental values, which give a shared meaning to the platform and the community.

Boundary Control Mechanisms on a Multi-Sided Platform

The comparative analysis of these cases shows the establishment of common control mechanisms, which depend on the nature of the opening within the boundaries (see Table 4). Indeed, most of our data show closed boundaries on a technological level coupled with an opening of digital content and governance (for the most part).

Table 4 – **Mechanisms for controlling the opening of boundaries in the cases studied**

Case	Mechanisms for controlling the opening of boundaries			
	Efficiency	*Power*	*Competency*	*Identity*
Mutum	- tools for uploading objects and lending transactions - pool of lenders - virtual currency to regulate transactions	- lender assessment tool - equity financing (failure)	*No opening*	- equity financing - tool for creating private communities - sponsorship and ambassadorship
Open Food France	- online shop management tool - profile and network creation tool	- collective governance at local and international level - common platform design	Open Source platform and tools	- collective management (organization) with partners - assembly in a web forum via Loomio
RidyGo	- tools for offering and managing carpooling trips - carpool credit - personalized notifications via route analysis	- selection of beneficiaries of social credits (free subsidised journeys) - carpool transport check	*No opening*	- collective decision-making (SCOP) - partnership with social actors/ services - solidarity through the travel subsidy
1D Touch	*No opening*	- collective decision-making process - lobbying on regional institutions - common strategy	- tool for creating thematic capsules - content curation	- collective management (SCIC) - mission sharing - assembly in a web forum via Loomio
Open Car	- tools for offering and managing carpooling trips - star system to exchange for gifts	- driver evaluation tool - sponsorship tools for retailers	*No opening*	*No opening*
Skill Troc	- workshop proposal and management tool and tutorials - virtual currency (stars)	- expert assessment tool - feedback tool in the workshops	*No opening*	*No opening*
Guest to Guest	- offering and management tool for home exchanges and rentals - virtual currency (guest points)	- accommodation and host assessment tool - verification of the identity of members (green dot)	*No opening*	*No opening*

The multi-sided platforms studied show that the tools made available to user suppliers to help them create and offer value (objects, housing, knowledge, services or carpooling) optimise the efficiency of transactions. Indeed, by outsourcing the cost of producing the service (carried out by the users themselves), the platforms establish a clear boundary between the activities

and resources controlled internally (related to technology) and those controlled by the users externally. The challenge related to the opening of boundaries is attracting a critical mass of user suppliers to multiply the value created and proposed in order to attract user consumers, which favours network effects. The tools made available control the opening of boundaries because they rely on the technical and procedural framework for creating and proposing value (standard data entry form, ergonomic interface, simplified navigation, etc.) and also depend on the provision of additional services (transaction security, insurance, virtual currency, etc.). On the demand side, the tools focus on ease of search and transaction security (verification of supplier profiles, evaluation, guarantees, role of platform regulators).

In more detail, we note that the opening of efficiency and power boundaries is controlled by tools involving similar mechanisms: the framework and simplification of the online posting of value proposals, virtualization of currency, security and transaction evaluations. Only 1D Touch opens the frontier of competence by delegating part of the curation to libraries and media libraries using website building tools, creating thematic vignettes and reading lists. Other open-governance mechanisms are used to manage the boundaries of power and identity. These are mainly legal tools in the form of SCIC and SCOP that make it possible to better manage the platform's stakeholders and debate regulation tools within an online forum (Loomio). The technology is generally closed to external actions except in the case of Open Food France, which opens the competence boundary with a worldwide network of Open Source developers.

Effects of Boundary Opening Control on Open Innovation

The platforms studied, depending on the nature of their business (carpooling, exchange and borrowing of goods, objects, content and knowledge or online shop management), control the opening of their boundaries by setting up common and specific mechanisms. In return, these mechanisms allow users to create value within a technological perimeter controlled by the company that owns the platform, which influences the dynamics of open innovation. The cases studied show that multi-sided platforms are open innovation spaces because they bring several user communities into the same digital space to produce a collaborative service promoting social values and solidarity. The production and evolution of these collaborative services involve externalities through open innovation in four of the seven cases:

- *Mutum:* controlling the opening of boundaries allows users to innovate by creating local and private networks of borrowers (of the neighborhood

type) that provide organizational innovation in the community ecosystem.

- *Open Food France:* by opening up content, technology and governance, the platform facilitates 1) technological innovation, because the partners have participated in the design of an open-source platform, 2) organizational innovation, because outsourcing the creation of hubs makes it possible to organize innovative and ad hoc networks of producers and consumers and 3) service innovation because the platform is evolving under the impetus of collective strategic decisions.
- *RidyGo:* opening governance (power and identity boundaries) allows users to participate in collective decisions about the continuous evolution of the platform, thus contributing to (rather incremental) service innovation.
- *1D Touch:* the outsourcing of the curation of artistic content (skills boundary) allows cultural spaces 1) to innovate in their organization by creating and promoting a unique network of local artists and 2) to innovate in terms of services through the evolution of the platform, which is decided collectively (power boundary).

At the opposite end, the Open Car, Skill Troc and Guest to Guest cases do not show any effect on open innovation because their users are not actors in innovation. Our analysis seems to show that without open governance, users do not have the opportunity to participate in collective decisions that could lead to innovation. Similarly, the lack of openness of boundaries to access users' skills limits opportunities for innovation.

Discussion

Thanks to this multi-case comparative study, our results show that the multi-sided platforms studied have specific, often common, characteristics in terms of boundary opening and control. It is possible to discuss three theoretical points: 1) the opening of boundaries depends on the nature of the opening practiced, 2) multi-sided platforms are dual environments, both open and closed and 3) the multi-sided platform plays a key role in outsourcing the creation and evolution of a controlled open innovation ecosystem. On the basis of the elements discussed, we propose several recommendations to multi-sided platform managers to define and implement the procedures for opening and controlling digital boundaries.

First, the cases show that: 1) the rationale for opening up to digital content is linked to the "efficiency" boundary and the "power" boundary (6/7 cases),

2) the rationale for opening up governance is linked to the "power" boundary and the "identity" boundary (4/7 cases) and 3) the rationale for opening up technology is linked to the "competency" boundary (1/7 cases). There therefore seems to be a link between the nature of the opening and the type of boundary opened. This link shows that openness can be a means of controlling an activity without internally holding the productive resources of that activity (Chesbrough *et al.*, 2006). In uncertain markets, the organization sets its boundaries to control critical resources that create value. When it cannot internalize these resources, it seeks a means of control, such as partnerships, exclusive contracts or technology licensing (Santos, Eisenhardt, 2005). In a business based on a multi-sided platform, closing the technology is therefore a way to control an activity when the competencies sought are located outside the company's boundaries (Gandia, Parmentier, 2017). Therefore, by opening up to other approaches (such as content or governance), the company outsources a form of value creation that is easier to control. Finally, our work enriches Santos and Eisenhardt's (2005) research by showing that boundary types also apply to digital environments such as multi-sided platforms. In addition, the multi-sided nature of the platforms makes it possible to differentiate the approach to openness and the type of boundaries according to the side, thus multiplying the possibilities of efficient organization of openness.

Secondly, in relation to the previous point, we conclude that multi-sided platforms are dual digital environments, both open and closed. Thus, multi-sided architecture is a way of managing the dilemma of openness versus closing within a digital platform by reflecting on the specificities of openness (nature and modes of openness) on each side (Parmentier, Gandia, 2016). Indeed, by considering the multi-sided dimension of a digital business, it becomes possible to organize openness according to the potential of each side, the skills that can be provided by the groups of actors present on each side and their propensity to engage in value-creating behaviours (Eiseinmann *et al.*, 2009). However, the challenge remains to attract a critical mass of users on the "supplier" side to increase the diversity of the proposed value in order to attract a mass of users on the "demand" side in return (Acquier *et al.*, 2017). This notion of critical threshold is important for generating network effects that contribute to producing and maintaining value transactions on the platform (Bakos, Katsamakas, 2008) and maintaining its adoption by new users (Church *et al.*, 2008). Beyond the critical number of users, their long-term presence is also important to maintain the dynamics of openness. In addition, virtual currency systems or even the platform's reputation may constitute assets for the user (not transferable to another platform) and thus represent a cost of change for a user who would like to change platforms (Gawer, 2011). The same is true for the community dimension, which can be

seen as a form of locking in, once the user creates social links on the platform and becomes partly responsible for the production of the service and its evolution (Jeppesen, Frederiksen, 2006). Thus, closings on a multi-sided platform can go beyond the simple technological dimension as long as the company uses mechanisms, tools and intangible elements that can make users dependent on the platform to which they contribute. These elements enrich the literature on management of the open/closed dilemma (*e.g.* Chesbrough *et al.*, 2014; Manzini *et al.*, 2017).

Third, it seems that multi-sided platforms, by organizing and controlling the opening of boundaries to provide users with a means of producing a collaborative service, are able to outsource the creation and evolution of an open innovation ecosystem. Indeed, the platform is above all a digital and software environment that constitutes a technological ecosystem (Tiwana *et al.*, 2010). This technology thus materializes an open (and functional) digital space where complementary communities come together to create value through their interactions (Hagiu, Wright, 2015). Therefore, by providing users with the necessary tools to organize and manage their transactions, the multi-sided platform provides a space for creating a community ecosystem (Koenig, 2012). Moreover, to the extent that the platform provides a market space for the production of a collaborative and social service that offers solidarity, communities interact around a common business mindset (Moore, 1993). In the specific case of multi-sided platforms, there is an interdependence between the community mindset and the business mindset, creating a community business ecosystem (Koenig, 2012). The management and control of this ecosystem then resides in the control of the principal technological elements necessary for its operation (Gawer, Cusumano, 2014) and in the definition of the degree of freedom and range of action of user groups (Hagiu, 2014). From this perspective, boundary analysis on a multi-sided platform provides a better understanding of how to manage a community business ecosystem that is conducive to open innovation. Our research complements the technological analyses of Gawer and Cusumano (2014) and the economic analyses of Hagiu (2014) of multi-sided platforms, emphasizing the importance of boundary management with procedures adapted to strategic objectives and the importance of providing the right tools for value creation to user communities.

This discussion provides insights for multi-sided platform managers to develop value creation and open innovation. First, the multi-sided platform must be seen as a resource centre conducive to the production of an innovative business. The interest then lies in defining the boundaries of efficiency, power, skills and identity according to the strategic objectives of the company

and the business. This reflection thus makes it possible to decide on its needs in terms of resources (internal vs. external) and therefore openness. It is then necessary to reflect on the nature and processes of openness. Here, the implementation of digital tools can be very effective in opening certain boundaries. Toolkits, for example, are linked to the efficiency boundary. They allow users to create value (content, financial transactions, logistics organization, etc.) but only within the framework of the functionalities defined by the company that masters the technology (Von Hippel, Katz, 2002). It thus becomes possible to precisely control value creation (from a technological and functional point of view) while outsourcing it through open processes in order to gain efficiency (Gassmann, Enkel, 2004). Other tools are also interesting to integrate, such as evaluation tools that are directly linked to the notion of power in that the company gives users the power to reward (positive evaluation) and sanction (negative evaluation) (Stone *et al.*, 2014). It therefore becomes possible to manage potentially value-destroying misconduct (Evans, 2012). The company thus operates a form of partial outsourcing of the community's moderation process, while maintaining control thanks to the tools made available (Parmentier, Gandia, 2013). In the end, managers can control the opening of boundaries thanks to technological tools controlled internally (closed technology) and non-technological approaches to openness (digital content and governance).

Conclusion

Based on the results obtained and their analysis, our study contributes to research on open innovation in digital environments as well as more specific work on multi-sided platforms. We show that the multi-sided platform can provide a dual space, open to both content (content creation and organization activities) and governance, but technologically closed. Therefore, technology is a way to lock users on the platform in order to keep them in the ecosystem and produce an innovative business. The opening is then framed by various different mechanisms (tools for innovation, regulatory and communication mechanisms, etc.) that ensure that the resources provided by the platform's managing organization are made available. It therefore becomes possible to open some sides of the platform (and therefore some user groups) more than others, depending on the contributions these groups make to value creation. Boundary control thus appears to be a regulatory process, or even a governance process in some platforms, but this depends on the type of boundaries, the nature of the opening and the type of platform side. This has positive effects for open innovation. Our study thus contributes to a better

understanding of how to control the opening of digital boundaries as part of an innovative business based on a multi-sided platform.

Beyond these contributions and the resulting managerial recommendations, the study has several limitations that provide future research perspectives. The case analysis reveals specificities related to the collaborative economy sector, which conveys social, solidarity and environmental values. Although our multi-case comparative analysis allows us to include a variety of platform cases useful for identifying common outcomes, the generalization of results remains limited. It would therefore be interesting to replicate the study in other contexts and sectors, with primarily economic objectives, in order to compare the results obtained. Other studies could also further detail the analysis of boundaries, reduced here to the typology of Santos and Eisenhardt (2005). Although this typology is unanimously accepted, the analysis of more informal boundaries on the multi-sided platform, such as knowledge, or the study of the process of delimiting boundaries between communities would enrich this research. Finally, it would be interesting to study the evolutionary trajectories of multi-sided platforms in order to analyse the evolutionary dynamics of boundary control and its consequences on open innovation. Our cases reveal significant strategic decisions and events (buy-outs, failures, etc.) that suggest an evolution in the mechanisms for opening boundaries and their control in the long term. Our studies thus provide encouraging prospects for further deepening the role of multi-sided platforms in the digital orchestration of openness for innovation purposes.

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