Cultivating Open Government Data Platform Ecosystems Through Governance

Lessons from Buenos Aires, Mexico City and Montevideo

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Cultivating open government data platform ecosystems through governance: Lessons from Buenos Aires, Mexico City and Montevideo

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ABSTRACT

Open government data (OGD) initiatives are an emergent platform research topic. There is little understanding how these platforms are governed for the innovation of services using open data, where the cultivation of an installed base of heterogeneous service innovators can lead to increased usage of OGD. In this paper, we draw on established literature from digital platforms research to investigate how service innovation is cultivated in open government data contexts. We employ a comparative case study of open government data platforms in three leading Latin American cities and draw upon the concept of boundary resources taken from platform theory. Our research generates two key contributions. First, we propose a theoretical model, which explains how an OGD platform owner is able to govern the demand and the supply side of its platform to facilitate the cultivation of a platform ecosystem. Second, we develop contributions to practice in terms of a set of recommendations for governments in emerging countries concerning how to establish and manage a vibrant OGD platform ecosystem.

1. Introduction

Open government data (OGD) platforms are an emergent phenomenon of the past ten years. They have become an object of research because of their potential to enable the innovation of better public services, increase transparency and deliver wider social benefits (Davies, Walker, Rubinstein, & Perini, F. (Eds.)., 2019). While recent studies refer to open government data as "platforms" (Ruijer et al., 2017), there is little research on the subject from a digital innovation platform perspective (Danneels, Viaene, & Van den Bergh, 2017; Janssen & Estevez, 2013). This absence is curious when in practice, OGD platforms are frequently used by third party innovators and entrepreneurs, who capitalize on the datasets to provide services to citizens, as we see in transportation apps such as *Citymapper* (Scott, 2015).

In this paper, we employ management and information systems literature concerning digital platforms (Baldwin & Woodard, 2009; Cusumano, Gawer, & Yoffie, 2019; Ghazawneh & Henfridsson, 2013) to understand how OGD can be governed to foster innovation. We argue that platform governance must be applied to cultivate an ecosystem of participating actors on the demand side *and* the supply side of an OGD platform in order to realize innovation using open data. In this ecosystem, third party innovators demand datasets, which are sourced from government agencies, for the creation of services.

Research into the management of commercial digital innovation platforms has largely focused on governing the demand side's use of platform functionality to enable the innovation of quality platform services (Wareham, Fox, & Cano Giner, 2014). However, the governance problem faced by an OGD platform owner is different and broader. First, the underlying architectural focus of the platform concerns the provision of modules as datasets, rather than as functionality, to third party developers who then innovate services based on these open datasets. Second, the platform owner is reliant on obtaining these modules from external contributors on the supply side rather than developing them in-house. Contributors of datasets to an OGD platform are typically government ministries who are independent of the platform owner. The platform owner must then govern the supply side for the provision of quality datasets as well as govern the demand side for the use of datasets in order to build up a healthy platform ecosystem. In this paper, our research question addresses the need to understand: *How does an OGD platform owner govern both its demand side and its supply side to facilitate the cultivation of a platform ecosystem?*

To address the research question, we apply platform theory from strategic management and information systems concerning platform architecture, ecosystem and governance. Adopting this theoretical perspective has three strengths. First, it provides precision as to how key members of an OGD platform ecosystem are cultivated to foster

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innovation. Second, it facilitates explanations of evolution directed at the growth of an OGD platform. Finally, it enables the identification of distinct approaches for the implementation of OGD.

We investigate how platform governance evolves to cultivate OGD ecosystems in the empirical setting of Latin America, a region that is leading the developing world in open data (Open Knowledge Foundation, 2017; World Wide Web Foundation, 2017). Specifically, we compare governance across three different OGD implementations in the cities of Buenos Aires, Mexico City and Montevideo. We design a multiple case study combining several sources of data to investigate the phenomena retrospectively over a six-year period (2010–2016). We then analyze how these cities adapt their use of governance over time to manage both the supply and demand side of their ecosystems.

Our research generates two key contributions. First, in response to a call to address under-theorization in digital government literature (Bannister & Connolly, 2015) and to address questions regarding OGD platform ecosystem management and governance (Danneels et al., 2017), we propose a model describing how an OGD platform owner governs and cultivates both the demand and the supply side of its platform ecosystem to foster innovation. In doing so, our perspective on platform ecosystem is grounded in the management literature (Jacobides, Cennamo, & Gawer, 2018). Our study complements holistic approaches to ecosystem and open government data evolution (Dawes, Vidiasova, & Parkhimovich, 2016; Harrison, Pardo, & Cook, 2012), as well as contextual approaches that analyze open data use (Ruijer et al., 2017). Our second set of contributions is to practice. Here we develop recommendations for establishing a vibrant OGD platform ecosystem targeted at governments of developing countries as well as settings that may benefit from a standardized, lean approach to open data governance.

In the next two sections we position our study in the OGD and digital government platform literature, and introduce theory concerning the governance of service innovation on digital platforms (Ghazawneh & Henfridsson, 2013). We then outline the methodological approach used in our study and present our case analysis to reveal how ecosystems in each of the three OGD platforms were governed. This is followed by a cross case analysis where we present a model for the OGD platform ecosystem governance in two parts. First, we describe common components of the model, which enable ecosystem governance across the cases. Second, we then reflect the model against an OGD platform ecosystem framework (Danneels et al., 2017) to explain how the governance components that we identify are deployed, orchestrated and evolved to govern and cultivate OGD platform ecosystems. We then present our theoretical contributions and our practical recommendations. We conclude our study with a discussion of its limitations and suggestions for future research.

2. Positioning within open government data platform literature

Our interest in researching the governance of OGD platform ecosystems is motivated by the fact that after decade of open data initiatives (Davies et al., 2019), few, if any, economic and social benefits have been achieved. Reasons for this may include: poor quality or incomplete data (Vetrò et al., 2016); mismatches between data that is needed and data that is published (Gurin, Bonina, & Verhulst, 2019); and the existence of technical barriers to participation, lack of skills and user training (Conradie & Choenni, 2014). Sources such as the Open Data Barometer (World Wide Web Foundation, 2018) suggest that underutilization may be also due to the lack of effective platform governance which, if addressed, would help cultivate innovative activity and use.

Unlike the strategic management and management information systems literature (de Reuver, Sørensen, & Basole, 2018), there is a paucity of digital government literature that uses platform theory to research platform problems. Our own review of the literature indicates that as an object of research, articles published in specialized digital

government outlets frequently treat "platforms" as a label for an empirical setting without examining the specific platform characteristics of the empirical object or applying platform theory to generate insights. For example, the term "platform" is used to describe the context of studies concerning government use of or interaction with social media (Hong & Kim, 2016), cloud computing (Paquette, Jaeger, & Wilson, 2010) and general open government research (Nam, 2012). Some studies refer to the wider information systems and management platform literature simply to define or characterize their empirical object as a platform (Ganapati & Reddick, 2018). Few platform studies in *Government Information Quarterly* engage with the wider platform literature to make theoretical points. Exceptions to this include work by Brown, Fishenden, Thompson, and Venters (2017), which refers to platform literature as a means to develop an assessment framework for the impact and role of the Government as a Platform (GaaP) paradigm in the UK, and work by Klievink, Bharosa, and Tan (2016) that uses platform literature to analyze the governance of public-private information platforms and their application to business-to-government reporting in the Netherlands. Finally, Janssen and Estevez (2013) refer to platform literature when describing platform governance characteristics in the context of lean government.

Focusing specifically on the OGD literature, another exception to this state of affairs is the article written by Danneels et al. (2017). The article uses platform literature to define three types of OGD platform ecosystems as evolutionary stages based on a literature review of 146 articles. The authors identify a platform research agenda including the governance of OGD platform ecosystems. We build on their perspective by introducing and applying platform theory from the mainstream literature to explain how an OGD platform can be governed to cultivate an ecosystem to foster innovation.

3. Theoretical foundations: governing open government data platform ecosystems

In this section, we develop a conceptual platform governance framework to facilitate OGD platform ecosystem cultivation drawing on platform theory. To achieve this, first we introduce innovation platforms as a basic type of platform to help describe fundamental architectural features of OGD platforms. Second, we introduce the characteristics of ecosystems around innovation and OGD platforms. Third, we describe the key governance components required for the cultivation of an ecosystem around an innovation platform. Finally, we extend and synthesize our sources to propose a conceptual model for the cultivation of OGD platform ecosystems through governance.

3.1. Open government data platforms as innovation platforms

Research into digital platforms typically addresses two types of possible underlying platform characteristics: those enabling transactions, and those enabling innovation of apps and services (Cusumano et al., 2019). Transaction platforms mediate matchmaking and exchange between two or more groups of actors, and examples include app stores, dating platforms, social media platforms and sharing economy platforms. Platforms enabling innovation, in contrast, act as "foundations upon which other firms can build complementary products, services or technologies" (Gawer, 2009, p. 54). This second perspective is exemplified by studies of mobile operating systems such as Android, whose functionality is drawn upon by a platform ecosystem of third party developers to build and innovate services. We examine OGD platforms from this second perspective as OGD platforms provide datasets to third parties for the innovation of services.

The innovation of platform services is better understood by considering the functional architecture of a digital innovation platform, which is illustrated in Fig. 1 below. This architecture is modular (Ulrich, 1995), partitioned into a core and periphery (Baldwin & Woodard, 2009), and governed by a platform owner (Wareham et al.,
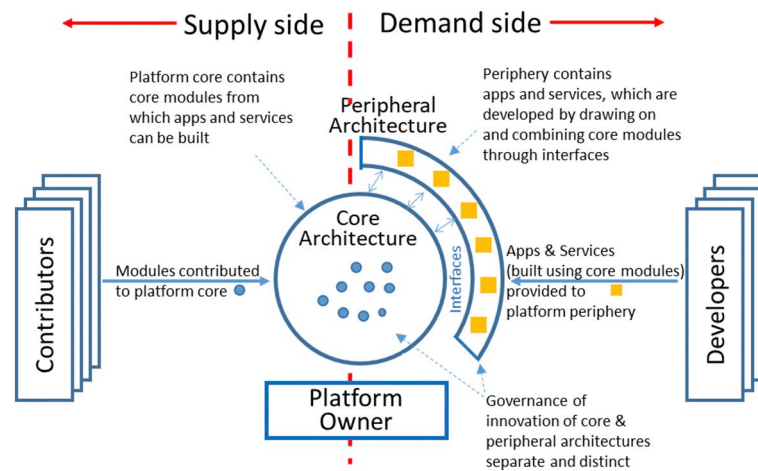
Fig. 1. Overview of innovation platform functional architecture.

2014) who sits at the center of a wider platform ecosystem (Iansiti & Levien, 2004). The distinction between the core architecture and the peripheral architecture of an innovation platform is as follows. The core architecture of a platform contains modules, which can be accessed and combined by third party developers in order to build services. Platform theory (Gawer & Cusumano, 2002) refers to developers as complementors and the services they innovate as platform complements. From an architectural perspective, these services reside in the peripheral architecture of the innovation platform (Tiwana, 2014), whose governance is distinct and separate from that of the core architecture.

From the perspective of OGD platforms, the core architecture contains modules of datasets, which can be accessed by developers, who combine and integrate them in innovative apps and services in the peripheral architecture, which are then consumed by citizens. The difference between an OGD platform and many commercial platforms, such as Apple's iOS, is that the modules contained in the core and used for innovation of apps and services are composed of data rather than functionality.

Innovation platforms are characterized by having platform owners (Boudreau & Hagiu, 2009) who are responsible for governing the innovation of modules in the core architecture as well as the innovation activities of third party developers in the periphery. OGD platforms display a further characteristic, which set them apart from many commercial innovation platforms. Whereas most commercial platform owners develop the modules that make up the platform core themselves, OGD platform owners source the datasets as modules to populate the OGD platform core from contributors, typically government ministries. Furthermore, an OGD platform owner must also govern the suppliers of datasets to maintain the quality of these modules. In this way, OGD platform ecosystems comprise of a supply side consisting of ministries contributing datasets to the core, and a demand side consisting of entrepreneurs and developers who innovate with these datasets and provide apps and services in the periphery.

3.2. Open government data platform ecosystems

The broad set of actors that contribute to the functioning of an innovation platform are organized in a platform ecosystem (Wareham et al., 2014). General notions of ecosystems and ecology in complex social systems have their origins in systems theory perspectives. The analogy with the natural world is used as a setting to describe processes of evolution within social systems. In information intensive fields, such as open government data, it has come to signify complex and heterogeneous systems of institutions, groups of actors, infrastructure and data, which interact, adapt and grow in the context of environmental change (Dawes et al., 2016; Harrison et al., 2012).

In the management literature, the concept of ecosystem was initially adopted in order to describe how networks of organizations compete with each other. In this sense, ecosystems of organizations adapt and co-evolve in order to survive and seek dominance (Moore, 1993). The metaphor was then adapted to describe clusters of interdependent organizations structured in constellations rather than traditional value chains, and to describe the corresponding strategies that are required for these organizations to create and capture value on a sustainable basis (Iansiti & Levien, 2004) in order to maintain viable collaboration. This is the approach generally adopted in the platform literature (Jacobides et al., 2018).

Within the OGD literature, the framework developed by Danneels et al. (2017) provides the most detailed view to date on OGD platform ecosystem dynamics, cultivation and maturity. Their framework characterizes the level of OGD ecosystem sophistication a platform exhibits on an evolutionary continuum across three OGD platform types. The authors apply a set of OGD ecosystem dimensions adapted from Dawes et al. (2016) to assess the degree of ecosystem maturity. However, Danneels et al. (2017) do not identify the governing mechanisms and the way they are applied so that an OGD platform ecosystem can be established, cultivated and matured. We now set out to introduce and extend a conceptual framework of platform governance, which when applied with their model, can be used to address this.

3.3. Components for the governance of innovation platforms

In the digital platform literature, cultivating the growth of a platform ecosystem of innovators and developers is a crucial role of the platform owner. Essentially, it involves simultaneously enabling and facilitating those innovation activities of developers which add to the value of the platform, while restraining those innovation activities that take value away from the platform and which make the ecosystem a less attractive place to participate in (Iansiti & Levien, 2004). Both of these tasks are performed through platform governance.

Boundary resources (Ghazawneh & Henfridsson, 2013) are a theoretical concept that facilitates our understanding of how developers and their innovation activities are governed within the demand side of a digital platform ecosystem. Boundary resources have their conceptual foundation in a synthesis of boundary object theory (Star & Bowker, 1999) and innovation networks theory (Chesbrough, Vanhaverbeke, & West, 2006). They refer to "*software tools and regulations that serve as the interface for the arm's-length relationship between the platform owner and the application developer*" (Ghazawneh & Henfridsson, 2013, p. 174). In this way, they provide components of platform governance, which conceptualize the two major tasks of platform owners. First, platform owners must provide *tools* to help resource and support third parties

develop platform services (Iansiti & Levien, 2004). Examples of tools are application programming interfaces (APIs), which provide developers access to core platform modularity, and software development kits (SDKs), which facilitate developers to build software services. The second governance task of platform owners is to secure the platform and maintain its integrity, which they do by providing *rules for* controlling the quality of third party apps and services developed for the platform. Examples of *rules* include those contained within licensing agreement contracts (Boudreau & Hagiu, 2009). An example of a rule in the context of Apple's iOS developer license agreement is one that prohibits apps containing defamatory content. When rules are broken, the platform owner typically places some form of sanction on the offending developer, in the case of Apple this typically takes the form of an app being suspended from the App Store.

These *rules* and *tools,* as key components of platform governance, incentivize and coordinate the innovation of platform apps and services and are essential for the cultivation of an installed base of third party innovators (Ghazawneh & Henfridsson, 2013). While this established view is used to understand the governance of service innovation on the demand side (Eaton, Elaluf-Calderwood, Sorensen, & Yoo, 2015), the literature has not employed this approach to examine the supply side where third parties can be governed when contributing modules to a platform owner for insertion into the platform core.

3.4. A governance model for open government data platform ecosystem cultivation

The aim of our research is to understand how an OGD platform owner is able to establish and cultivate an OGD platform ecosystem to foster innovation. Specifically, we seek to understand how a platform owner applies governance to enable both sides of a platform ecosystem to carry out their task effectively.

The approach we take is to extend the concept of boundary resources, as components of platform governance, to encompass the supply side of the platform as well as the demand side. We adapt the previous definition so that boundary resources now encompass "*the rules and tools that serve as the interface to govern the arm's-length relationship between the platform owner and different members of the platform ecosystem*". This extended model is illustrated in Fig. 2 below, and the key constructs that we use in our analysis are summarized in Table 1.

For the purposes of our research, the principle members of the ecosystem that we investigate are threefold. First, we consider contributors on the supply side, who provide modules of open data to the OGD platform core. These are typically government ministries that have

datasets to share. Second, we examine developers on the demand side, who take modules of data from the platform core to innovate apps and services in the periphery. Finally, we analyze the platform owner, who governs the relationship within and between these two sides. The platform owner typically encompasses the agency or organization that leads and controls the OGD program.

The platform owner uses *tools* and *rules* to govern contributors on the supply side and developers on the demand side. It designs *tools*, as governance components, to resource both groups to help them carry out their respective tasks. It designs *rules,* as governance components, in order to regulate how both sides carry out their tasks and to control the outcome of those tasks. Our research uncovers what types of tools and rules an OGD platform owner designs, how they use them and how these tools and rules interact. Furthermore, we account for contextual factors, which enable functioning tools and rules to emerge.

4. Methodological approach

Our intention is to develop a general understanding (Gregor, 2006) of how tools and rules, as components of platform governance, are developed and used in the cultivation of open data government platform ecosystems. Consequently, we conduct a qualitative cross-case comparative study (Yin, 2003) to infer generalizable insights concerning the phenomenon that we wish to study (Eisenhardt, 1989). We study the development and evolution of components of platform governance in three open government data platforms situated in Buenos Aires, Mexico City and Montevideo. These cases were selected based on their potential to provide rich insights to our research question (Flyvbjerg, 2006) as these cities host Latin America's leading deployments of OGD.

4.1. Data collection and data analysis

We collected multiple sources of evidence covering a longitudinal six-year period of analysis (2010–2016). Our approach combined observations in vivo (from meetings, informal conversations, and day-to-day government practices), semi-structured interviews conducted from 2014 until 2018 to elicit memories and interpretations, extensive archival data composed of documents, legislation, blogs, social media outlets, and reports from the cities, as well as available data from OGD platforms. Table 2 below summarizes our sources of data.

We conducted analysis in three broad steps to build theory from our case studies. The first step consisted of "within-case analysis" (Eisenhardt, 1989), where we used an open coding procedure to
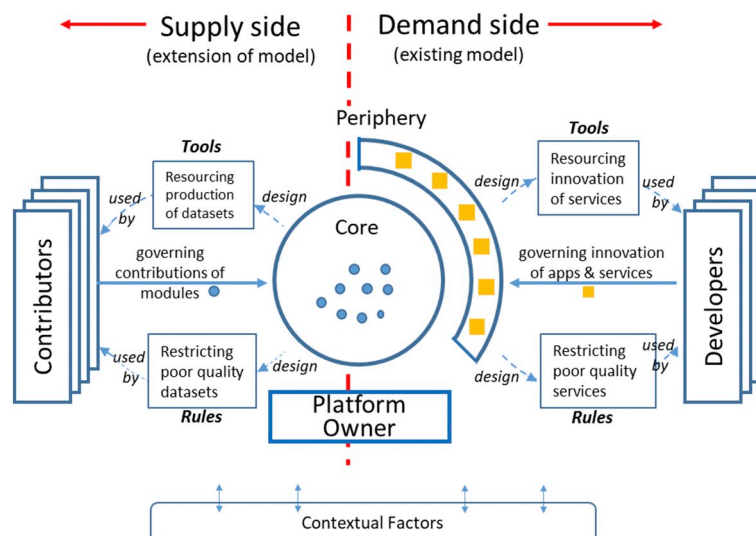

Fig. 2. Conceptual model of open government data platform ecosystem governance.

Table 1

Key constructs used to analyze the governance of open government data ecosystem cultivation.

Construct	Description
Core architecture	Central part of an innovation platform's architecture that contains modules of functionality or data from which apps and services can be built.
Peripheral architecture	Additional part of an innovation platform's architecture, separate to the core, where services and apps reside to complement the platform. These services are constructed using modules from the core architecture. The governance of the peripheral architecture is separate from the governance of the core.
Platform owner	Institution(s) that have the responsibility and authority to govern the interactions between an ecosystem of actors and an innovation platform, as well as control platform evolution.
Contributors	Actors who provide modules of functionality or data to the core architecture of an innovation platform and who are governed by the platform owner in this role. The provision of new modules is essential for the ongoing evolution of an innovation platform. Contributors of datasets to an OGD platform typically represent government departments and ministries.
Developers	Actors who take modules of functionality or data from the core architecture and combine them with others to build apps and services, which reside in the peripheral architecture. Developers typically represent entrepreneurs, transparency advocates and members of the civic technology community. The interaction of developers with a platform is governed by the platform owner.
Tools	Components of governance provided by the platform owner which resource and enable ecosystem members to carry out their ecosystem role.
Rules	Components of governance provided by the platform owner, which constrain ecosystem members from carrying out actions that may harm a platform and thereby help to secure it.

Table 2

Multiple data sources across cases.

Interviews
26 semi-structured interviews with open government data teams, data providers and data re-users; 22 conducted in 2014, 2015 and 2016 during visits to the field and regional meetings; 4 follow up interviews over the phone conducted during 2018.
Participant observation
3 days with the open data team in Buenos Aires (1 day in August 2014, 2 days in September 2015) and 1 day with the team in Mexico City (October 2014)
6 international meetings: participation and feedback from platform owner and its key stakeholders from all three cities during 4 annual open data regional meetings Abrelatam/ConDatos in 2014, 2015, 2017 and 2018, and the International Open Data Conferences in May 2015 and November 2018.
Secondary data
Policy and government documents (e.g. legislation), blogs, social media outlets, and city reports, covering the period 2010–2016.
Data from the open government data portals
Number of datasets available, listed functionalities and available mobile and web applications over time.

capture and code resourcing tools and securing rules, contextual factors and the events linking the two. The outcome of the first coding step resulted in three timelines depicting the emergence of platform governance components in Buenos Aires, Mexico City and Montevideo with an unstructured list of factors and events deemed relevant to the unfolding of each story over the period of the study. In the second step, we applied a cross-case analysis to look for patterns across the cases, and drew on theoretical literature concerning platform governance (boundary resources) to search for suitable dimensions to cluster codes from our first phase. We also drew on Zuiderwijk and Janssen (2014) to pay attention to existing policy environment, policy content and available performance indicators across cases. In the third and final step, we examined the process of the development of tools and rules and their evolution across the cases. To do this, we developed a view of the overarching patterns across the three cases, and contextualized these findings within existing literature (Eisenhardt, 1989) concerning OGD platform ecosystem evolution (Danneels et al., 2017). The steps were iterative and reflexive, and resulted in the conceptual model we present in our discussion section.

5. Cultivating open government data platform ecosystems

In this section, we describe how OGD platform ecosystems were cultivated in each of the three cities we study, using the multiple sources of data that we presented in the previous section. Taking each city in turn, we identify how the respective OGD platform was established, how governance components were put in place to facilitate the supply of datasets and the demand for datasets, and finally how each platform evolved over time and the outcome of ecosystem cultivation.

The case findings are then used in the next section to build a generalized governance model.

5.1. Buenos Aires

5.1.1. Establishing the platform

The open data initiative in Argentina's capital Buenos Aires (approximate metropolitan population 13 million) formally launched in March 2012, when the government passed the Open Government Decree 156/2012. The Decree put forward guidelines for a policy based on transparency, collaboration and citizen participation. The decree was a key factor in enabling the creation of the Office of Innovation and Open Government within the Ministry of Modernization (hereafter, the Office). The ministry is recognized for having "policy entrepreneurs" who created innovative solutions to policy issues (Fumega, 2014). The Office served as the platform owner and led to the implementation of the open data initiative, which then resulted in the launch of an open data portal later in 2012 (*data.buenosaires.gob.ar*). The portal was built using CKAN version 1.0, an open source data management application that the team in the Office adapted and customized.

5.1.2. Facilitating the supply of datasets

In order to resource the open data platform, the Office had informally started to identify and collect digital data sources in different areas of the government one year ahead of its official launch. With the initial datasets identified, the team provided a set of securing rules (ad-hoc guidelines) to help the ministries transform the datasets into suitable machine readable, reusable and open format datasets. At the launch of the open data portal, the platform contained 40 unique datasets, which were largely sourced from the ministries of transportation, education and culture. Later in May 2012, Ministerial Government Resolution 190-MMGC/2012 assigned specific powers to the newly created Office to convert these ad-hoc guidelines into more formal protocols and procedures that the data providers in the ministries then followed.

Over time, the Office introduced a number of tools and rules to facilitate ministries to contribute datasets to its platform. First, it developed social tools as a means to facilitate interaction with ministries for eliciting valuable datasets. For example, one-day events such as *GovCamp* introduced public servants to the new open data initiative and expanded the network of potential open data champions across the government. Second, the office developed information tools, which provided procedures and instruments for the construction of data sets. These included artefacts such as dataset templates that facilitated the collection and formatting of data. Finally, the office put in place technical agreements containing rules. These rules covered several areas governing dataset names, formats, sources and who was responsible for subsequent dataset updates. These technical agreements encouraged

ministries to convert their data into usable OGD datasets.

By 2013, the Office had largely exhausted the pool of ministries amenable to cooperating and contributing datasets. To overcome this difficulty and to encourage other ministries to contribute data, the Office lobbied the city authorities to pass new legislation, including Decree 478/2013. This decree established that all new digital data that the government produced, stored or collected should be published in open format on the city's open data platform, unless excluded by specific norms (e.g. personal data laws).

5.1.3. Facilitating the demand for datasets

On the demand side, The Office also took a number of actions using tools and rules to build and cultivate a community of developers using open data. Buenos Aires benefited from an active community of civic technologists and transparency advocates in civil society organizations. Key to attracting developers was the development of tools to help them innovate services using OGD data. First amongst these were datasets, as information tools, and Web Portals and APIs, as software tools, which enabled them to access data. When the platform was launched in 2012, 40 datasets were released and a basic web portal, based on CKAN 1.0, was made available. In 2013, the Office migrated the datasets to a platform based on CKAN version 2.0. This new platform provided an API, as a software tool, through which developers could more easily access datasets and integrate them into innovative apps and services. The Office also sourced an additional 33 unique datasets, which further extended the utility of the platform. By the end of 2015, the Office had worked with government ministries to open up, publish and release a further 95 datasets for the platform. At the same time, the Office released a further three APIs, which enabled more sophisticated developer interactions with the platform.

As the number of information and software tools increased and enabled more sophisticated innovation on the demand side, the Office released and applied a set of contractual rules to control the activities of developers. These took the form of general terms and conditions introduced in 2012 and licensing terms (Creative Commons Argentina 2.5[1]) in 2013. Although these tools were simple, they combined to safeguard potential abuses and govern use of data accessed from the platform.

While the increasing sophistication of information and software tools may have generated more potential uses for the platform, and contractual rules may have helped ensure those uses of OGD were legitimate, neither were sufficient to encourage greater ecosystem participation. The Office developed a number of social tools to address this concern. In this way, they organized the BA Hackathon in May 2012, and then followed this up with a two-month contest to develop mobile apps. These initial experiments with social tools established an embryonic community of entrepreneurs who innovated digital services using datasets from the platform. During 2013, buoyed by an engaged civil society and active civic technology community, the city government continued to build its base of developers on the demand side with further hackathons and app contests. These events saw a tripling in the number of participants and further projects emerged.

During 2014, the Office became more sophisticated in its use of social tools to encourage ecosystem participation. This came about as the Office identified linkages between ministries contributing data on the supply side and the developers on the demand side to facilitate the production of apps and services using open data. This was embodied in the Office's move to make hackathons more targeted towards the needs of specific ministries as data contributors, as well as specific communities of developers. For example, the Office coordinated a Green Hackathon in 2014, which was targeted at generating usage of open data in apps and services to help solve the city's environmental issues. The event gathered more than 500 participants, with 32 projects and 4

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prototypes presented (Borrmann, 2015). While the hackathon was aimed at helping solve issues faced by the Ministry of the Environment, it was also intended to encourage the Ministry to supply, publish and contribute environmental data to the city OGD platform.

5.1.4. Platform evolution and platform outcomes

As the OGD platform in Buenos Aires grew and as the ecosystem of data contributors and developers expanded around it, the structures that supported it evolved. In 2014, the Office of Innovation and Open Government, whose remit had focused on the platform, was transformed into a broader innovation lab, called *LabGCBA* (Gobierno de la Ciudad Autónoma de Buenos Aires, 2014). The Lab brought together a multidisciplinary team and provided an environment where teams from diverse government ministries could go in search of a digital or technical solution to specific problems. This provided further impetus for ministries to open up and contribute further datasets. An example of this type of engagement came about in 2014 when the Lab worked with the Emergency and Road Safety team from the Ministry of Transport, to develop an app that could help identify people at risk of fatality or vulnerability more quickly and effectively.

By the end of 2015, the Lab (formerly the Office) had worked with government ministries to open a cumulative 168 unique datasets offered in eight formats. While there were only 22 active mobile apps officially reported on the government website, there had been much citizen interaction with the datasets through the portal and additional apps using the open data, which were distributed through the major commercial mobile platforms. The governance components deployed over time by the Office as resourcing tools and securing rules are summarized in Table 3.

5.2. Mexico City

5.2.1. Establishing the platform

The first attempt at establishing an open data portal in Mexico City (approximate metropolitan population 20 million) was in 2012. The Administrative Office for the City launched an OGD platform to facilitate access to mandatory data as required in the Mexican Freedom of Information (FOI) Law. There was little support for this platform and interest fell away.

An alternative OGD activity emerged in parallel in 2013 when the city government launched the Lab for the City (hereafter the Lab). The Lab brought together a multidisciplinary team of designers, social scientist, architects, technology experts and policy makers to foster innovative urban projects. The Lab became the coordinator of the broader city's Open Government program. Alongside four Secretaries of the government and a non-governmental organization, it had the mandate to lead the development of the open data policies in the city. This included the launch of a new open government data platform for which it would assume ownership.

In preparation for the launch of the new OGD platform, the Lab bootstrapped both the supply and demand side in order that an ecosystem of data contributors and service innovators would be in place at an early stage. To facilitate this bootstrapping process, the Lab developed a social tool in the form of an initiative called "Code for Mexico City" in June 2013. The initiative selected six groups of fellows, consisting of programmers and tech volunteers, who worked collaboratively over nine months with government agencies to source data sets. Together they built an OGD platform and developed 6 prototype mobile applications based on the data that they sourced (Montiel, 2014). As a result of this work, the open data platform hosted by the Lab and based on CKAN was developed and launched in January 2014.

While the launch of this alternative platform and associated ecosystem was relatively successful, it was established without the government enacting law or policy to institutionalize the process. This changed a year later with the passing of the Open City Law in 2015, which formed the basis of future platform governance.

Table 3
Summary of the tools and rules deployed in the city of Buenos Aires.

	Class of Platform Governance Component	Supply Side	Demand Side
		Description and examples	Description and examples
Resourcing Tools	Information Tools	Dataset Templates 2012: informal template to format datasets	Datasets 2012 - 40 datasets available
			2013 - 73 datasets available 2015 - 168 datasets available
	Software Tools		*APIs*: 2013 – 1 API (from CKAN 2.0) to access metadata 2015 – 3 APIs to access datasets *Web Portal*: 2012: CKAN portal version 1.0 2013: CKAN upgraded to version 2.0
	Social Tools	Initiatives 2012: GovCamp	Hackathons (2012–2015, annually) Apps Competitions (2012–2015, annually)
Securing Rules	Contractual Rules	Formatting of datasets 2012: Technical Agreements concerning format of datasets	Licenses 2013 - Creative commons (Argentina 2.5)
		Quality of datasets 2012: ad-hoc guidelines concerning dataset production to standards 2012: guidelines concerning dataset production to standards from resolution 190-MMGC/2012	Terms and conditions of use 2012: Concerning access & use of datasets
Enabling Factors	Supporting Organizations Open data policies	2014 – City Innovation Lab – LabGCBA 2012 - Resolution 190-MMGC/2012: formal protocols and procedures for datasets 2013 - Decree 478/2013: policy mandating all public data to be provided in open, digital format	
	Broader open government policies/ transparency policies	1994 - BA Freedom of Information Decree 2012 - Open Government Decree 156/2012	

5.2.2. Facilitating the supply of datasets

At launch in January 2014, the Lab had worked with 13 government agencies to source 27 unique data sets for the OGD platform. While the Lab did not develop information tools such as templates to facilitate the production of data sets, it put in place a number of contractual rules on the supply side in an attempt to ensure the provisioning of quality of data. For example, in early 2014 the Lab released specifications for the formatting of datasets as well as guidelines for the production of datasets to particular quality standards. Efforts to engage with agencies to open up and contribute data continued. During the course of 2015, the number of datasets available on the open data portal increased to 72, sourced from 29 government agencies (source: interviews and Lab's open data portal).

5.2.3. Facilitating the demand for datasets

As a result of the Lab's bootstrapping efforts, developers on the demand side of the platform benefitted from information and software tools from the launch of the platform. In this way, their development activities were resourced though having access to 27 unique datasets in 2014, a CKAN 2.0 based web portal and 10 APIs used to access data. Their access to datasets, as information tools, further expanded in 2015 when the Lab was able to release additional datasets. Developers also benefitted from other information tools such as online tutorials explaining how to access and use datasets.

In contrast to the efforts made by the Lab to resource the demand side, there were few attempts by the platform owner to secure and protect the platform at launch in the form of contractual rules. In the first year of the platform, developers were largely ungoverned in terms of how they used available open data. The situation changed in October 2015 with the passing of the Open City Law, which established the basis, rules and governance structures of open government, open data and participation. This law set the basis for contractual rules such as licenses and terms and conditions of use to secure the demand side. It also established the creation of an Open City Council, with

representation from government and civil society, to take over responsibilities for the implementation of the law. These responsibilities included the task of defining specific rules concerning the use of open data, such as the conditions of publishing and reusing datasets. In spite of this mandate, the Open City Council had yet to be formed by the end of 2016.

Mexico City benefitted from a civic technology community as well as a number of digital entrepreneurs who could potentially contribute to the demand side of the ecosystem. However, this network of transparency advocates was scattered and uncoordinated. To bring cohesion to this network, The Lab organized a series of hackathons, called "HackDF", as social tools to encourage engagement with the platform. The first HackDF gathered around 500 participants who worked in teams for 48 continuous hours with the support of "Code for Mexico City" fellows, volunteers from the Lab, and government leaders who acted as mentors. At the end of HackDF, there were 53 projects and six winners that built solutions based on open data. Following the hackathon, there was significant activity around the OGD platform. The datasets had 6000 downloads and the APIs more than 3 million requests in the first four months after the launch of the platform (Laboratorio para la Ciudad, 2014). During 2015, the Lab continued to use hackathons as a social tool to resource and grow the demand side. It also attempted to coordinate its use of resourcing tools. For example, it ensured that 72 datasets (information tools) were in place by the time of the second HackDF (a social tool). The Lab also collaborated with data scientists from a non-governmental organization—Codeando Mexico—to ensure the quality and usability of the datasets in advance of the second hackathon. The second HackDF brought together 441 participants along with 100 mentors. These activities resulted in four teams having follow up meetings with government agencies to further develop their ideas (Laboratorio para la Ciudad, 2015).

5.2.4. Platform evolution and platform outcomes

In Mexico City there was little evolution in the structure and

Table 4

Summary of tools and rules deployed in Mexico City.

	Class of Plat-form Governance Component	Supply Side	Demand Side
		Description and examples	Description and examples
Resourcing Tools	Information Tools		Datasets 2014: 27 datasets available 2015: 72 datasets available Support 2014: tutorials on how to use the data
	Software Tools		2014: 10 APIs to access data 2014: Web Portal launched (CKAN)
	Social Tools	Initiatives: 2013: Code for Mexico City	Hackathons 2014 and 2015: HackDF Initiatives: 2013: Code for Mexico City
Securing Rules	Contractual Rules	Formatting of datasets 2014: Dataset format specifications Quality of data 2014: guidelines on dataset production to standards (defined by the LAB)	Licenses 2015: Open City Law, Article 10 Terms and conditions of use 2015: Open City Law, Article 10
		Publishing & reusing datasets 2015: Open City Council rules	
Enabling Factors	Supporting Organizations Open data policies Broader open government policies/ transparency policies	2015 - Open City Council 2015 – Open City Law (art 10) - established the basis, rules and governance structures of Open Data and participation as well as Open City Council 2001 - Mexico Freedom of Information Law 2012–2015 - Open Government Program 2015 - Open City Law	

institutions that owned the OGD platform. Unlike the case of Buenos Aires, the scope of the platform owner did not change. Unlike the next case of Montevideo, the hosting of Mexico City's platform did not change either. By the end of our study the platform contained 72 unique data sets. Unlike the other cities, Mexico City lacked a coordinated approach to governance to galvanise its ecosystem. As a consequence, the overall third party innovation based on open data was limited. For example, the mobile apps available on the platform at the end of 2015 were the same as those resulting from the Code for Mexico initiative in 2013. The resourcing tools and securing rules deployed over time on both sides of Mexico City's OGD platform ecosystem are summarized in Table 4.

5.3. Montevideo

5.3.1. Establishing the platform

The Uruguayan capital of Montevideo (approximate metropolitan population 1.4 million) was the first city in Latin America to have an open data policy. Their OGD platform started as a bottom up movement amongst a small group of midlevel public servants in 2009. An Open Data Working Group was later created informally within the government and began to bring open data into the city's government agenda. It later convinced the City authorities to pass the Municipal Resolution 640/10 in February 2010 to establish an open data policy more formally. Montevideo's open data Resolution stated a commitment from the government to release open data and set specific rules to publish the data in open format. The Resolution also established a working group to lead the publication of open data on a portal (datos.montevideo.gob.uy) hosted by the Department of Technology and Software Development.

5.3.2. Facilitating the supply of datasets

By 2012, the Open Data Working group worked to gradually made available 42 datasets on the city portal. There were a couple of factors that facilitated the relative ease by which datasets were obtained. The first concerns the small size of Montevideo's city government, and the fact that members of the Open Data Working group were mostly

software engineers, which made it easy for them to connect with their colleagues in the various city government departments and ministries to obtain data. The second concerns the enthusiasm by which the government had adopted transparency and the notion of open data embodied in the Resolution of 2010. Whilst there were governance rules in place concerning the formatting of datasets, quality of datasets and rules for data re-use, it was relatively straightforward for the working group to continue getting hold of and updating data sets from their colleagues.

5.3.3. Facilitating the demand for datasets

With the 42 datasets in place when the portal was launched in 2012, the City gradually saw the emergence of OGD-based applications. In contrast to the other cases, Montevideo did not pursue the use of formal social tools, such as Hackathons, to resource developers on the demand side of the platform. Instead, the Open Data Working Group informed developers and other interested parties, such as NGOs, about updates and new releases of datasets via email. Email also provided an informal means for the Open Data Working Group to provide support to the demand side. There was, however, frustration within the government and the Open Data Working Group as the number of queries and site visits and subsequent downloads of datasets was below their expectations.

In the absence of formal tools provided by the government to resource developers on the demand side, a number of informal tools were established instead by civil society organizations. Our interview data indicated that Montevideo benefited from the presence of a strong civil society organization called DATA. DATA played a significant role in advancing open data related initiatives in the city. For example, in 2013, DATA held a regional open data conference in Montevideo with the support of the authorities. The same NGO also established a website (www.quesabes.uy) to help direct freedom of information requests to appropriate government departments. Overall, this contributed to the national government passing the Law 19,355/2015 in 2015, which established an obligation for government agencies to release their freedom of information replies as open data.

Table 5
Summary of tools and rules deployed in the city of Montevideo.

	Class of Plat-form Governance Component	Supply Side	Demand Side
		Description and examples	Description and examples
Resourcing Tools	Information Tools	Dataset Templates 2014: Adopted from national OGD platform	Datasets 2012: 42 datasets available 2015: 47 datasets available Support 2012: Emails as a means to promote datasets and provide support
	Software Tools		APIs 2014: 3 APIs (from CKAN 2.0) Web Portal: 2012: in-house developed portal 2014: migrated to the National CKAN open data portal
	Social Tools		
Securing Rules	Contractual Rules	Formatting of datasets, quality of datasets and data re-use From 2010: standards of practice follow the 8 open data principles (Resolution 640/10)	Licenses 2014: Uruguay Open Data License Terms and conditions of use 2010: principles to publish and reuse open data (Resolution 640/10)
Enabling Factors	Supporting Organizations Open data policies	2010 – Montevideo Open Data Working Group 2010 - Resolution 640/10 set 8 specific principles to publish open data, based on open government data principles of 2008 2015 – Law 19,355/15 establishing the obligation of government agencies to release their freedom of information replies as open data	
	Broader open government policies/ transparency policies	2008 - Uruguayan Access to In-formation Law	

5.3.4. Platform evolution and platform outcomes

In 2013, the city's Open Data Working Group agreed to share their datasets with Uruguay's national e-government agency. The city published their datasets on the national CKAN-based open data platform (datos.gub.uy) from 2014. The Open Data Working Group's decision to merge their platform in this way was largely driven by a desire to drive cost efficiencies through the sharing of resources.

By the end of 2015, the government reported that the city of Montevideo had made available 47 unique datasets, which were mostly related to geomatics. Approximately 20 mobile or web-based applications using open data had been developed. For example, the government developed a public transport application called "*ComoIr*", which was downloaded 50 thousand times from the Google Play marketplace. The governance components deployed over time by the Open Data Working Group are summarized in Table 5.

6. A governance model for open government data platform ecosystem cultivation

We now abstract our case findings to explain how governance can be applied to cultivate an OGD platform ecosystem in a more general sense. This is achieved in two parts. First, we elaborate on our earlier conceptual model of OGD platform ecosystem governance by incorporating the various classes and types of governance components (tools and rules) that we observed across our cases. Second, we explain how these governance components are deployed to cultivate an ecosystem. We achieve this by applying a framework characterizing OGD platform ecosystem maturity (Danneels et al., 2017) to our model and empirical data.

6.1. Tools and rules to govern an open government data platform ecosystem

By abstracting our classification of platform governance components across the three cases, we propose a model to describe governance components used in cultivating an OGD platform ecosystem for the innovation of apps and services using open data. The model allows us to analyze interactions between components on both sides, which in combination with contextual factors, facilitate the successful establishment of an OGD platform ecosystem. Our model is illustrated in Fig. 3 below.

In the center of the model, we present the platform's core architecture, which contains modules of datasets that are managed by the platform owner. The platform owner creates and manages platform governance components, which it uses to control the activities of contributors and developers on the supply and demand side respectively.

On the demand side, the OGD platform owner uses three different classes of *tools* to resource developers. The owner provides *informational tools* as datasets as well as support such as manuals and videos. The owner provides *software tools* such as APIs and web portals, which enable developers to access datasets from the OGD platform for the development of apps and services. The platform owner also enables *social tools* such as hackathons, competitions and other initiatives, which encourage developers to engage with using datasets. The owner uses *rules* to govern the way that developers use OGD datasets to secure the platform and ensure that it is not abused. These securing components of platform governance take the form of *contractual rules* such as licenses and terms and conditions of use, which place constraints on how developers can use OGD.

On the supply side, the platform owner uses governance components to manage the sourcing of datasets, which form the basis of service innovation on the demand side, from government ministries acting as contributors. We identified two classes of tools used to resource government ministries. The first concerns *informational tools* such as dataset templates. These were used by ministries to ensure that data is sourced in the appropriate form. The second concerns *social tools* such as initiatives like "Code for Mexico City" which were used to involve interested ministries with groups of developers to encourage service innovation on OGD platforms. The platform owner uses *contractual rules* to secure the provision of quality datasets to enable a viable OGD platform. We uncovered three types of contractual rules: agreements for
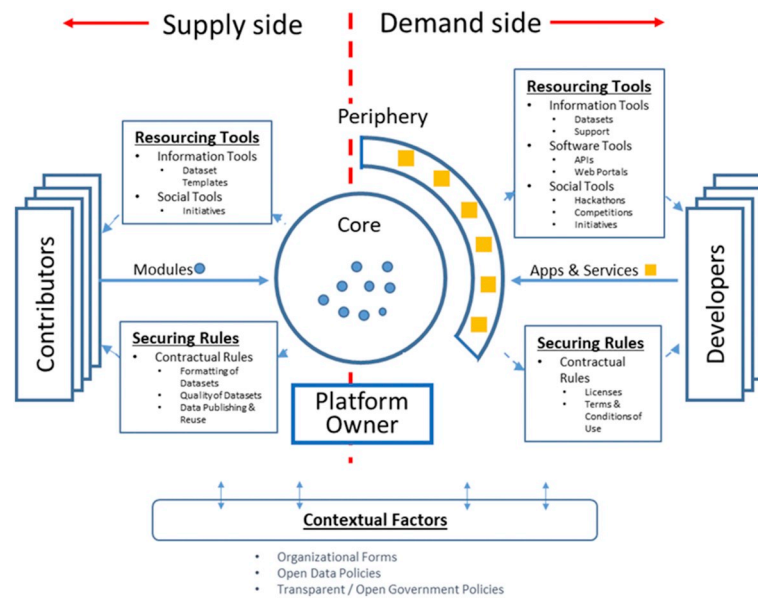
Fig. 3. A governance model for open government data platform ecosystem cultivation.

specifying the format of datasets; guidelines for the production and quality of datasets; and rules concerning the publishing and reuse of datasets.

We also observed a number of contextual factors across our three cases, which facilitated the establishment of governance components. First amongst these were supporting organizations, which play a crucial role in the establishment and ongoing development of an OGD platform. These were exemplified by the innovation Lab in Buenos Aires, the Open City Council in Mexico City and the Montevideo Open Data Working Group. Second, we observe open data policies enacted by city governments as resolutions, decrees or laws and which mandate government ministries to open up their datasets. This is illustrated for example by the Open Government Decree 156/2012 in Buenos Aires, the Open City Law (art 10) in Mexico City and the Municipal Resolution 640/10 in Montevideo. Third, we found broader open government and transparency policies, which mandated the opening up of government data. These included the Open Data Decree 156/2012 and the Freedom of Information Law in Buenos Aires, the Open City Law in Mexico City and the Uruguayan Access to Information Law.

6.2. Different approaches to cultivating an open government data platform ecosystem

We now examine how the rules, tools and contextual factors identified in the previous static model are deployed to govern and thereby cultivate a platform ecosystem for the innovation of services using open data. To do this, we compare the deployment and use of governance components across our cases and draw on the framework developed by Danneels et al. (2017). Their framework characterizes different stages of OGD platform ecosystem maturity, or cultivation, across the following four dimensions: 1) enabling actors; 2) governance intervention; 3) interactions; and 4) dynamics over time. These dimensions help to reveal how resourcing tools and securing rules were deployed differently in each case over time, as well as explain how differing paths of OGD ecosystem cultivation emerged. Overall, this analysis allows us to derive general observations on the use of tools and rules for cultivating OGD ecosystems. The dimensions of the framework (Danneels et al., 2017) and a summary of the analysis that follows is presented in Table 6.

6.2.1. Enabling actors
All three cities benefit, to varying degrees, from enabling actors who

interact and contribute to forming an OGD ecosystem for the innovation of apps and services using open data.

In Buenos Aires, open data re-use occurred through a network of third party innovators. This was reinforced by intermediaries, such as data journalists and transparency NGOs, who worked and expanded available raw data for further analysis. With intervention through social tools, the open data and civic technology community grew over time, becoming active and interacting independently of the platform owner. In Mexico City, whilst open data re-use also connected several groups of actors, the network of civic tech entrepreneurs and data re-users had weaker ties and was more dispersed. Consequently, without focused governance intervention from the government, there was less engagement with the OGD platform. Mexico did benefit, however, from strong intermediaries, such as the Lab for the City and Codeando Mexico, which helped foster the open data network. Montevideo benefitted from a small but active network of developers and civic tech organizations that was characterized by its strong internal ties. This facilitated the adoption of OGD for reuse and innovation, despite limited proactive intervention from the platform owner to engage them in data re-use.

The supply side of our case studies tells a similar story. In the relatively small city of Montevideo, there was a tightly knit and strong information systems culture and IT expertise across the city government, which enthusiastically supported open data and open government policies. In contrast, the governments of Buenos Aires and Mexico City possessed a broad range of rich data, but this was contained within isolated ministries whose motivation for engaging with their respective platforms was varied.

Looking across the cases it would appear that larger cities with more dispersed ecosystems of actors with weaker ties are those in most need of support by platform owners and might benefit most from the "arms-length" management provided by tools and rules as platform governance components. In this way, the tightly knit communities of developers and government ministries in the relative small city of Montevideo participated in OGD with relatively little platform owner intervention. In contrast, the dispersed ecosystems in the larger cities of Mexico City and Buenos Aires responded well when the platform owner was active in governance, and they tended not to respond when the platform owner was not involved.

6.2.2. Governance intervention to ensure platform sustainability
In all three cases, governments intervened to cultivate the ecosystem to generate service innovation. This was mainly realized

Table 6
Interplay of governance and platform ecosystem cultivation across cases.

	Buenos Aires	Mexico City	Montevideo
Enabling actors *How enabling actors interact amongst themselves and form OGD networks*	Active community of civic entrepreneurs engaging with open data innovation Reinforced by intermediaries and social tools Autonomous connections established between actors enable open data re-use	Civil society and civic tech entrepreneurs dispersed with weak ties Strong intermediaries, unfocussed social tools Open data re-use limited through weaker connections between actors	Small network of developers with close ties & civic tech culture Strong intermediaries, limited social tools Open data re-use encouraged through connections between actors
Governance intervention *The scope and degree to which the OGD platform owner governs platform with and without government action*	OGD platform owner acts as a central coordination mechanism balancing governance tools and rules effectively on supply and demand side Government intervention establishing platform owner, mandating ministries to open up data, and developing open government and transparency policies	OGD platform owner acts as a central coordination mechanism, lacking focus on both sides at times Some government intervention, but muddled as two parallel portals mandated, and delayed open data policy	OGD platform owner acts as a central coordination mechanism, stronger focus on governance tools & rules on the supply side Government intervention establishing platform owner, clear open data policies established at an early stage
Interaction & communication *How interaction is enabled between platform owner and ecosystem*	Sustained two-way interaction between OGD platform owner and ecosystem Active use of social tools –hackathons and competitions to enable/foster interaction with data re-use and GovCamp on the supply side	Intermittent two-way interaction between OGD platform owner and ecosystem Scattered use of social tools to facilitate interaction with the demand (HackDF), and supply side (Code for Mexico City)	Two-way interaction between OGD platform owner and selected ecosystem groups Effective communications with intermediaries and close ties with intermediaries and developers facilitated by the small city setting
Dynamics over time & contextual responsiveness *How OGD platform evolves over time in response to environment*	Organization of OGD platform co-evolves with changing needs of the ecosystem actors Development of apps, growth of datasets, evolution of data portals & APIs over time Mutually reinforcing growth of ecosystem as governance facilitates new supply side actors and meets needs of new demand side actors	Open data platform mostly static, with some evolution in response to environment Open data platform hosted at Lab for the City, dataset, API growth and government led apps as examples of adapting to needs of the city Struggled to orchestrate governance to ignite mutually reinforcing growth within the ecosystem	Small ecosystem and close ties between members & platform owner resulted in strategy on expanding data sets according to the needs Development of external and government led apps, growth in number of datasets, and joining national open data portal as examples of evolution
Overall level of ecosystem cultivation	*Moderate cultivation.* The most vibrant ecosystem established as represented by number and range of ecosystem members, datasets and uses. Thoughtful governance strategy facilitates the long term viability of platform	*Low cultivation:* Modest number of datasets available, low number of apps generated. Lack of thoughtful and focused governance strategy constraining sustainable ecosystem growth and evolution	*Low to moderate cultivation:* Low number of datasets but fair number of apps innovated. Context enables gradual ecosystem growth and sustainable evolution without a sophisticated governance strategy on the demand side

through the activities of the open data platform owner. In particular, this was achieved using *resourcing tools* and *securing rules* employed by the cities with different levels of orchestration, focus and balance between the supply and demand sides.

On the supply side, Buenos Aires and Montevideo deployed resourcing *information tools* in the form of templates to help ministries provide relevant and quality-driven datasets. In addition, Montevideo put in place strong *rules* such as the Open Data Principles that were helpful to secure the quality of datasets on their platform. By contrast, Mexico City's platform owner engagement with the supply side was less sustained. For example, its efforts to resource the ministries was limited to the Code for Mexico City program. As a result, fewer datasets were made available to the demand side.

On the demand side, all three platform owners provided *informational tools* (datasets and supporting documentation) and *software tools* (APIs and web portals) to resource the developers.

The evolution and sustainability of all three OGD platform ecosystems benefitted from government intervention in the form of broader open government and transparency policies. Buenos Aires benefitted from the city government legislating and giving power to the platform owner, as well as mandating ministries to open up and contribute datasets at an early stage. This was also reflected in the actions of the government of Montevideo that established clear guidelines and principles regarding the publication of open data at an early stage. In contrast, the approach to OGD in Mexico City was muddled as it lacked clear legislation, it ran two portals in parallel, and only limited quality datasets emerged.

A conclusion that can be drawn from these observations is that the cultivation of a sustainable OGD ecosystem benefits from government

leadership through the establishment of a unique platform owner backed up at an early stage with policies concerning open data, and open and transparent government. Both Buenos Aires and Montevideo benefited from having city government providing coherent leadership early on in their respective OGD programs. This was lacking in Mexico City, which hindered the cultivation of its OGD platform ecosystem and service innovation.

6.2.3. Enablement of ecosystem interaction and communication

In all three cities, platform owners played a role using *social tools* to facilitate their interaction and communication with the rest of the ecosystem, as well as between other ecosystem members. Buenos Aires was notable for its sophisticated use of *social tools*, Mexico City also deployed these governance components, while Montevideo was slower to adopt them.

Buenos Aires sustained use of *social tools* such as hackathons and competitions enabled continued interaction and symbiosis between demand side developers, supply side data contributors and the OGD platform owner. Later hackathons in Buenos Aires became more targeted such as the Green Hackathon in 2014, which not only helped address pressing environmental issues in the city, but also helped to enroll and engage the Ministry of Environment to open up datasets. Buenos Aires was also unique in creating *social tools* designed specifically to engage ministries and share learning on the supply side of the ecosystem. In this way, it promoted GovCamp as an event to engage and share learning with and between ministries.

Mexico City made some use of hackathons but was not as sophisticated in targeting *social tools* at specific issues or parts of the ecosystem, leading to less feedback and overall interaction. Nevertheless,

Mexico City was unique in adopting an initiative at the launch of its platform to bootstrap the platform ecosystem. Its "Code for Mexico City" served as a *social tool* to resource both the demand and supply sides of its ecosystem at the launch of its OGD platform.

Montevideo was characterized by strong ties amongst its technical and the civic technology community because of its small size. The need for social tools was negated by frequent interaction already existing within and across its ecosystem. However, even Montevideo started to take part in national hackathons from 2015 after migrating the city platform to the national OGD platform.

The conclusion that can be drawn from this is that social tools, such as focused hackathons and competitions, are effective governance components to connect different actors, both inside and outside government. These tools become more important in the context of large, disparate ecosystems. There seemed to be less of a necessity for social tools to connect actors in Montevideo, where preexisting tightly bound networks within smaller ecosystems enabled interaction. However, in the much larger cities of Buenos Aires and Mexico City, social tools were effective in bringing together larger, more widely dispersed ecosystems.

6.2.4. Dynamics over time and contextual responsiveness

An OGD platform owner's ability to add and evolve its approach to governance over time in response to environmental change may affect its ability to cultivate a platform ecosystem. In this sense, Buenos Aires was most successful at evolving over time, Mexico City less so, and Montevideo somewhat of an exception. All three cities had *informational* and *software tools* as well as *contractual rules* in place to bootstrap the establishment of a platform ecosystem at the launch of their respective platforms. The cities then diverged in their ability to sustain the use of subsequent *resourcing tools* and *securing rules* on both sides to cultivate the growth of their ecosystems.

Buenos Aires not only sustained its introduction of new *social tools* (hackathons and competitions) and *informational tools* (datasets) over time to facilitate continued demand and supply side engagement and growth, its focus also became more sophisticated. Consequently, the steady growth in the creation of new apps and services helped convince previously reluctant ministries to enroll and offer up datasets. Furthermore, Buenos Aires was able to orchestrate the sequencing and timing of new and targeted tools and rules in a way that mutually reinforced and ignited the growth of the supply and demand side of its ecosystem. Mexico City, on the other hand, was less timely and focused in its orchestration of tools and rules. As a result, the growth of the demand and supply side was harder to maintain as it failed to ignite mutually reinforcing growth. In Montevideo, the close ties that bound the OGD ecosystem meant that the platform owner managed to increase the number of datasets to cultivate a gradual ecosystem growth without having to deploy *social tools* and orchestrate growth.

Analysis of these three cases indicates that an OGD platform owner's ability to sequence the introduction of, encourage interplay between and evolve governance components and contextual factors in response to environmental change or need facilitates the cultivation of a platform ecosystem. The sophistication of this approach ranged from Buenos Aires' thoughtful approach to sequencing the introduction of governance components enabling mutually reinforcing growth on both sides of its platform on the one hand, to Mexico City's less thoughtful and slower ecosystem cultivation on the other hand.

6.2.5. Level of ecosystem cultivation

Four observations emerge from analyzing the application of governance rules and tools drawing from the framework proposed by Danneels et al. (2017). First, is a sense that actors in different OGD ecosystems have varying and distinct needs for governance intervention over time. Second, is the observation that platform owners provide differing degrees of governance intervention independent of the needs of the ecosystems that they serve. Third, we see that interaction between ecosystem members is positively influenced by governance

intervention. Finally, we observe the benefits of platform owners being more active in orchestrating governance intervention. When taken together, these observations indicate how varying degrees of platform governance intervention drive different levels of ecosystem cultivation.

Buenos Aires, therefore, exhibited a moderate level of platform ecosystem cultivation. Buenos Aires came to have the most vibrant ecosystem with the largest number of unique datasets on its OGD portal, and growing numbers of applications and services being built. Mexico City's less focused approach to deploying governance constrained sustainable ecosystem growth and evolution, resulting in less engagement from the ecosystem. Montevideo's small size and close-knit OGD communities meant that it was able to cultivate a moderately successful OGD platform ecosystem and resultant service innovation without sophisticated use of governance tools and rules.

7. Theoretical contributions and practical implications

By answering the research question, "How does an OGD platform owner govern both the demand and supply side to facilitate the cultivation of a platform ecosystem?" we claim theoretical contributions to both the open government data and the digital platform literature. Furthermore, the observations that we generate in our analysis also have practical implications for cultivating open government data platform ecosystems.

We make contributions to the OGD platform literature by addressing two specific issues concerning platform ecosystem governance identified in previous research (Danneels et al., 2017): first, what governance features to include in open data platforms; and second, what governance decisions should be made to nurture platform ecosystems. We address the first by developing a model which describes different types of governance mechanisms, in the form of resourcing tools and securing rules, and the contextual factors that underlie them. These mechanisms are used to govern both sides of an OGD platform to facilitate ecosystem governance and the innovation of apps and services using open data. We address the second issue by applying frameworks for analyzing OGD platform ecosystem maturity (Danneels et al., 2017) to our model and empirical data. In doing so, we generate insights into the governance decisions made to cultivate an OGD ecosystem. In developing this model, we contribute to theorization in digital government research (Bannister & Connolly, 2015) by developing two theoretical contributions. Not only do we extend platform perspectives in the OGD literature by providing answers to these two questions, but we add theoretical depth to the OGD literature by introducing and rigorously applying platform concepts from the broader management and information systems literature, an approach which was previously lacking.

In addition, we contribute to wider platform theory by extending the boundary resource model (Ghazawneh & Henfridsson, 2013) from the demand side of an innovation platform to the supply side, where modules are contributed to the platform core architecture to enable the development of platform apps and services. Our extended version of the model invites analysis of the interplay and dependencies between the governance of both sides of innovation platforms, such as OGD platforms, to cultivate a sustainable ecosystem. In this way, our extended approach becomes a useful means to unpick and identify those governance elements that are part of the dynamic nature of an OGD platform ecosystem (Danneels et al., 2017; Dawes et al., 2016).

We believe that our study has implications for how OGD platform ecosystems are cultivated in practice in several settings. First, for emerging economies that normally face higher resource constraints than their counterparts in the developed world (Davies et al., 2019). Second, for those settings in the developed world, which may benefit from a standardized, lean approach to open data governance, especially relevant in contexts of government austerity and cities that may not have access to the same funds as so called "benchmark cities". The observations that we make in our analysis lead to the following

recommendations concerning how to establish and then cultivate a sustainable OGD platform ecosystem.

7.1. Launching with a legitimate and empowered platform owner in place

Governments are recommended to have a legitimate and empowered platform owner in place at platform launch to facilitate the establishment of an ecosystem. Platform owners must be legally mandated and supported with broad legislation concerning open data and open government. Our cases show that when an OGD platform owner is mandated by government at launch to govern ecosystem members, then it has the power to establish and manage a viable and sustainable ecosystem. For example, when broad open government policies concerning freedom of information or when legislation to open up data by default are in place at the beginning, then ministries have stronger incentives to contribute data and participate on the supply side of an OGD ecosystem from an early stage.

7.2. Launching with a viable set of resourcing tools and securing rules

An OGD platform owner will be able to establish its ecosystem more successfully if it puts in place essential tools and rules to foster the demand and supply sides of the platform as well as to maintain platform integrity at launch. This will facilitate the successful establishment of an OGD platform ecosystem. Platform owners should first commence by providing governance to the supply side to ensure that datasets are sourced. In this way, they should provide information tools such as templates to guide the production of datasets. They should simultaneously establish contractual tools on the supply side concerning the quality of datasets and the publishing and reuse of data, which will later encourage its use on the demand side. These recommendations are consistent with the literature that highlights the importance of providing quality datasets on open data platforms (Vetrò et al., 2016), and the need to pay specific attention to the management of datasets and their associated metadata (Kubler, Robert, Neumaier, Umbrich, & Le Traon, 2018). Following this, platform owners can then address the demand side, by putting information and software tools in place such as datasets, guides, APIs and portals which enable the data to be accessed and used. At the same time, these need to be balanced by contractual rules concerning the appropriate re-use of data by developers, and these can be mandated in the terms and conditions and license agreements.

7.3. Developing social tools to cultivate sustainable ecosystems

Platform owners are advised to develop programmes of social tools as a means to cultivating sustainable OGD platform ecosystems. Social tools facilitate interaction within the ecosystem as well as with the platform owner which enables the sharing of learning (Susha, Grönlund, & Janssen, 2015). These are most powerful when used in large dispersed ecosystems and/or large cities. Our study reveals the importance of social tools such as hackathons, apps competitions and initiatives to communicate the importance of the value of open data and to develop communities on both the demand and supply sides. For example, the application of the "Code for Mexico City" initiative was essential for bootstrapping and bringing together both sides of the city's OGD platform in its formative stages. Programmes of social tools can start at a general level to attract widespread interest, before later focussing on and targeting specific needs and interests. Buenos Aires' prudent use of hackathons and competitions brought together and mobilised both the supply and demand side of the ecosystems at a slightly more mature stage of their OGD platform. As their platform evolved further, the Buenos Aires' platform owner tightened the focus of their hackathons and competitions in order to provide more strategic benefit to particular ministries and user groups.

7.4. Mindfully evolving the use of resourcing tools and securing rules to cultivate sustainable ecosystems

Platform owners are advised to put thought into how they evolve their use of resourcing tools and securing rules over time. Platform owners must be aware of the interdependencies between the supply side and the demand side of their platforms, as well as being sensitive to the need to adjust their approach to evolving platform governance depending on the maturity of the ecosystem and the needs of the wider environment. This involves care in three aspects. First, sequencing the introduction of tools and rules in a way that builds on and grows the deployment of previous governance components. Second, focussing and evolving tools and rules to respond to the needs of the ecosystem and environment. An example is already provided with the deployment of the social tools in our cases, and how they evolve to meet the needs of the ecosystem. And third, encouraging interplay and mutual reinforcement between governance components across the ecosystem to ignite growth by facilitating positive cross-side network effects.

8. Conclusions

Our research sets out to explain how an OGD platform owner can cultivate both the supply and demand side of its platform ecosystem for the innovation of apps and services using open data through the application of governance. By developing a conceptual model of OGD platform governance, based on the platform literature, and then applying it to OGD initiatives in three Latin American cities, we identified a range of platform governance components. These governance components consist of different classes of governance tools that enable ecosystem members to carry out their roles, as well as governance rules, which secure the platform ecosystem against harm. In order to determine how governance is applied to cultivate an ecosystem, this model is then reconciled to the case study data using a framework to determine the evolution and maturity of OGD platform ecosystems. Based on this analysis, four recommendations were generated concerning the development and application of tools and rules as platform governance components for the establishment and cultivation of an OGD platform ecosystem. In summary these recommendations concern the need for: 1) governments to legitimize an OGD platform owner when a platform is established; 2) essential governance tools and rules to be established at OGD platform start up; 3) social tools to be deployed to encourage ecosystem interaction with an OGD platform; 4) thoughtful sequencing and orchestration of the development and deployment of tools and rules in the knowledge of their interplay between the supply and demand side of the platform ecosystem. In addition, contributions to theory were also made. First, our understanding of OGD platform governance was developed. Second, models of platform governance were extended to the supply side of a platform ecosystem.

Our study contains some limitations that could be addressed in future work. First, we have developed our model in the context of three Latin American cities that may contain differences in terms of legal frameworks, administrative cultures and civic technology communities when compared to other developing regions of the world. Future studies could examine how the model needs to be adapted to fit the context of other developing regions. An additional benefit of building

accumulated cases is to facilitate the development of a maturity model, which might suggest specific governance tools and rules to deploy at different stages of the OGD platform evolution. Second, our understanding of ecosystem cultivation can be further enriched. Our study chose to account for the level of ecosystem cultivation by examining the quantity of datasets being generated and apps being built. Alternative approaches may instead choose to examine ecosystem cultivation through the effects of governance on the quality of datasets generated and services innovated. A third limitation of our research is the scope of ecosystem that we study. We focussed on the broad activities of ecosystem actors critical to platform innovation, an approach consistent with the management literature concerning platforms, but we did not pay attention to the situated activities within and amongst these actors. For example, individual ministries may have different contact points or idiosyncrasies that may require a different deployment of rules and tools. A more extensive investigation of the role of the wider ecosystem in OGD innovation might prove fruitful and could build on the study we present here. Finally, our study focuses on ecosystem cultivation for service innovation. In future, our research could extend to examine citizen participation.

Author statement

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