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Original Research Article

An open platform centric approach for scalable government service delivery to the poor: The Aadhaar case

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ABSTRACT

The efficient delivery of government services to the poor, or Bottom of the Pyramid (BOP), faces many challenges. While a core problem is the lack of scalability, that could be solved by the rapid proliferation of platforms and associated ecosystems. Existing research involving platforms focus on modularity, openness, ecosystem leadership and governance, as well as on their impact on innovation, scale and agility. However, existing studies fail to explore the role of platform in scalable e-government services delivery on an empirical level. Based on an in-depth case study of the world's largest biometric identity platform, used by millions of the poor in India, we develop a set of propositions connecting the attributes of a digital platform ecosystem to different indicators for the scalability of government service delivery. We found that modular architecture, combined with limited functionality in core modules, and open standards combined with controlled access and ecosystem governance enabled by keystone behaviour, have a positive impact on scalability. The research provides insights to policy-makers and government officials alike, particularly those in nations struggling to provide basic services to poor and marginalised. This is also one of the few studies to apply platform theory empirically to the e-government domain.

1. Introduction

E-government has been defined as “the use of information technology to enable and improve the efficiency with which government services are provided to citizens, employees, businesses and agencies” (Carter & Bélanger, 2005, p5). Like the use of IT in the private sector, e-government is evolutionary in nature (Layne & Lee, 2001), which means that, while the initiatives start with online cataloguing and information sharing, the governments involved then move to delivering multiple government services online (Belanger, Carter, & Schaupp, 2005). In developing countries, e-government initiatives face the additional challenge of having to serve a large poor and marginalised BOP (Bottom of Pyramid) population, which severely affects the scalability aspect of the service delivery infrastructure. For four billion people in a number of countries, their station in life allows them very limited access to physical, social and economic infrastructures (Hammond, Kramer, Katz, Tran, & Walker, 2007). The government service delivery challenges in this context are three-fold: i) providing easy access to traditional government-to-citizen services like passports, resident identity

documents or driving licenses, ii) effective targeting and channelization of government welfare initiatives and assistances, and iii) enabling and involving private sectors entrepreneurs in serving the unmet needs of the population for basic services like banking and telecommunication.

Government agencies in developing countries spend a significant portion of their resources for the welfare of their poorer citizens. In the case of India, government spending on subsidy and direct assistance for its BOP citizens is estimated to be US\$ 50 billion annually (Reserve Bank of India, 2012), and it is still growing. Government assistance and welfare services to this segment are associated with high overhead costs, a lack of transparency and leakage, which means they require urgent attention. Similarly, private sector involvement in developing and selling products and services to this segment is at best localised in nature and limited in scope (Lyytinen, 2010), leaving them at the mercy of an expensive but inefficient informal economy (Hammond et al., 2007). Data from the World Bank (World Bank, 2013) shows that, while banking penetration in the wealthiest 20% of India's population is 56%, it is a mere 21% for the poorest 20%. The main difficulty facing the private sector when it comes to provide telecommunication, banking,

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financial and other services to the poor can be attributed to the government's inability to provide the poor with reliable official identity documents (Gelb & Clark, 2013; Yadav, 2014).

In addition, even the popular government initiatives aimed at the poor lose their effectiveness when the size of their operations expand (Milat, King, Bauman, & Redman, 2012). As such, governments in multiple developing countries are actively searching for cost-effective, transparent and scalable service delivery models for their citizens (Layne & Lee, 2001; Reddick, 2004), models that can also address the unique requirements of the poorer section of the population. To achieve this, governments need to be innovative, as government budgets are under threat (Janssen & Estevez, 2013) and traditional methods of scaling up government service delivery, particularly to the poor citizens have not delivered impressive results.

From a more theoretical perspective, we propose using platform and ecosystem theory to see how government service delivery to the BOP can be improved. Digital platforms are identified as being one of the most important sources of innovation and value co-creation (Eaton, Elaluf-Calderwood, Sorensen, & Yoo, 2015) and are often used by businesses to scale the number and reach of their services rapidly with limited upfront investment. Platforms are associated with multiple attributes that can be leveraged to achieve scale, even for services to the poor, for instance modularity (Baldwin & Clark, 2000; Gawer, 2014), reusability for different purposes (Baldwin & Woodard, 2009; Gawer, 2014), openness for integration with external systems (Eisenmann, Parker, & Van Alstyne, 2006; Ondrus, Gannamaneni, & Lyytinen, 2015; O'Reilly, 2010), keystone leadership and lightweight governance (Huber, Kude, & Dibbern, 2017; Iansiti & Levien, 2004a, 2004b; Zhang & Liang, 2011). Although there is a generic acceptance of the profound transformational impact of platforms when it comes to improving government services, to our knowledge, that impact has yet to be empirically examined (Brown, Fishenden, Thompson, & Venters, 2017; Janssen & Estevez, 2013).

Although existing academic research is limited, the concept of platform in government service delivery has been attracting the attention of governments from a number of countries (Brown et al., 2017), including India. Researchers have used the term Government as a Platform or GaaP (Brown et al., 2017; Linders, 2012) to describe this new approach. The concept of i-government, or lean government (Janssen & Estevez, 2013), also views platforms as the primary artefact for achieving the objective of 'more with less'. Based on the concept of GaaP, government divests its role as sole executor and instead works together with a complex ecosystem of individuals, and public and private organizations. Platforms allow governments to orchestrate the interaction within such an extended network or ecosystem at lower risk and with a higher degree of innovativeness (O'Reilly O'Reilly, 2010; Brown et al., 2017; Janssen & Estevez, 2013). Although platforms can be used for many objectives, in this study, we focus on its use to deliver scalable government services to the poor and marginalised sections of the society. As mentioned before, due to the sheer size of India's population, service delivery to this section of the population needs to be scalable (Madon, Reinhard, Roode, & Walsham, 2009; Walsham & Sahay, 2006).

Our specific research objectives are:

- To examine whether platforms can play a role in solving the scalability problem associated with government service delivery to marginalised sections of society (BOP).
- To determine how the various architectural and business model attributes of platforms help achieve scalability.

To do so, we analyse an in-depth case involving the Indian Government-owned identity platform called Aadhaar and the associated ecosystems of government and private organizations.

The remainder of this paper is organized as follows. First, we summarise existing literature on a) e-government, focusing on the use

of ICT for efficient service delivery and b) platform and ecosystem theory, with the aim of creating the required theoretical framework. We also provide a number of propositions linking key platform ecosystem attributes to scalable government service delivery within the BOP context. In section 3, we describe our research approach, including the reason why we chose a single case study, case selection and field procedure. In section 4, we test the propositions and the conceptual model. Finally, in section 5, we discuss the results and limitations of this study and outline future avenues for research.

2. Literature and theoretical grounding

We begin with a brief discussion of relevant e-government literature, to provide the context of our research, before focusing on more generic platform research from a technical perspective. Although the number of studies involving platforms is growing rapidly, we focus only on studies that are relevant from a technology management and information technology perspective. Although we are aware of the interrelation with more strategic and economic literature on platforms focusing on network effect and inter platform competition, that is not the main focus of this study.

2.1. E-government

E-government involves the use of ICT technologies to improve the services provided by governments and public sector organizations (Janssen & Estevez, 2013). Layne and Lee (2001) described e-government service delivery as an evolutionary process with four stages or maturity levels. Their model can be used as a recommended roadmap or template for governments to identify and implement relevant e-government initiatives (Bannister & Connolly, 2015). The stages are (1) cataloguing, (2) transaction, (3) vertical integration and (4) horizontal integration. During the vertical and horizontal integration of services, government services are transformed through a combination of process redesign, IT infrastructure adaptations and organizational change (Layne & Lee, 2001). The vertical and horizontal integration of government services is conceptually similar to transformational government, which involves working with partners and active citizens as well as the co-creation of services. In that regard, platforms can be enablers, supporting development of varieties of complimentary services with limited integration and coordination effort (Janssen & Estevez, 2013). The two broad theoretical constructs of i-governance and GaaP highlight the central role of platforms in the delivery of government services. I-governance (Janssen & Estevez, 2013) concept emphasizes: a) the use of technical advancement in reducing the size of the government b) the use of platform to share government resources with relevant partners c) orchestrating a large ecosystem of partners, and d) focusing on facilitation and control instead of execution. Similarly, research into GAAP (O'Reilly O'Reilly, 2010; Brown et al., 2017) focuses on collaborative technology, participative government and citizens' involvement in service design and innovation (Millard, 2013). Thus far, some researchers have looked at platforms in a specific e-government context. The role of platforms in diminishing silos within government (Millard, 2013) is also acknowledged. Linders (2012) talked about equipping common citizens with relevant data to improve decision-making and involving the ecosystem for co-production through platforms. Co-production and effective partnership with multiple entities would impose the new roles of framer, sponsor, mobilizer and providers of last resort (Linders, 2012). Although these are common themes that have also been researched in more generic platform and eco-system literature focused on business, e-government research also has to look at the diverse and unpredictable behaviour of a larger set of stakeholders. Moreover, while business-driven platform ecosystems focus on maximizing the economic returns of the platform leader and its partners, e-government services are driven primarily by a desire to maximise societal value, which requires a different approach to platform

governance (Schreieck, Wiesche, & Krcmar, 2017). As a result, the results of platform research in a business context cannot be applied directly to an e-government context. In the next section, we briefly discuss the appropriate definition of scalability for our research, as well as relevant aspects of platforms and ecosystems.

2.2. Definition of scalability—Scalable government service delivery

In information technology, scalability is considered an important attribute of systems, processes and networks. Bondi (2000) defines the scalability of a system as its ability: 1) to expand without significant modification to the underlying architecture and b) to perform as expected and gracefully at a higher traffic volume. Scalability is also an important concept in development-related research. Walsham and Sahay (2006) define scalability as the ability of IS projects to expand the size of the operation (moving from a limited number of users towards a much higher number of users, and from a smaller area towards a larger area of operation) as well as the ability to incorporate more complex products and services. Milat et al. (2012) provides a multi-faceted definition of scalability by listing three primary themes: a) higher size and reach, b) moving from a highly controlled experimental or proof of concept (POC) set-up to real-world situation, and c) maintaining effectiveness while being expanded. Based on the latter definition, we defined scalability as the ability of a platform-mediated service delivery initiative to retain its desired effectiveness while being expanded from a small scale, limited variety and under controlled condition towards a scenario that calls for a) working with a broader and bigger target population, b) providing more varied and complex and services c) complying with stringent real-life commercial conditions.

2.3. Platform mediated ecosystems

Platform-mediated ecosystems have become a preferred method of collaboration for innovation and value co-creation (Eaton et al., 2015; Valkokari, Seppänen, Mäntylä, & Jylhä-Ollila, 2017). As a result, the focus has moved from firm-centric innovation towards network-centric innovation (Nambisan & Sawhney, 2011), where the focal firm maintains a stable core but allows generativity and creativity in the periphery by the ecosystem partners (Gulati, Puranam, & Tushman, 2012). When left alone, the core module provides important, but limited and restricted functionalities, but add-on modules by complementary partners greatly increase the platform value (Gawer & Cusumano, 2008; Wareham, Fox, & Cano Giner, 2014), as can be seen in mobile platforms, like Apple Store, which provides over two million mobile applications to consumers (Statista, 2018), mainly from independent developers. The meta-organization surrounding a platform is known as its ecosystem (de Reuver, Sørensen, & Basole, 2018), a concept (Moore, 1993, 2016) that allows us to study how platform leaders collaborate with a larger community of complementors, instead of limiting their partnerships to specific supply chain partners (Rong, Lin, Shi, & Yu, 2013), without having a formal authority over these complementors (Gulati et al., 2012). In the absence of hierarchical and contractual relationship between the participants of the ecosystem (Goldbach, Benlian, & Buxmann, 2018), having a common goal and shared vision becomes critical in managing the partners involved towards a desired outcome. The success of any platform-based ecosystem depends on the platform leader's ability to attract a critical mass of complementary providers (Iansiti & Levien, 2004a, 2004b). Due to the indirect network effect, in a standard multi-sided platform scenario, increased variety and a growing number of applications attracts more users because of the enhanced value-exchange opportunities (Cennamo & Santalo, 2013; O'Reilly, 2010).

In the next section, we take a brief look at technical and organizational attributes of platforms, including scalability, modularity and openness, because they and their relationships are relevant to our study.

2.3.1. Modularity

Modularity is part of overall platform architectural governance and it is actively managed by the platform leader (Gawer, 2014; O'Reilly, 2010). It can be also considered to be the platform's most important technological property (Gawer, 2014; O'Reilly, 2010). Platform modularity is critical in achieving scalability in service delivery. It is leveraged to develop products with greater variety and complexity, to serve a larger user base without suffering performance degradation and to provide an easy path for a greater reach of the services.

Modularity helps transfer the burden of innovation or creating variety of products to a large number of complementors (Tiwana, 2015), rather than placing it on the core firm alone. And although complementors can define their own variation or extension, but platform interoperability ensures their integration in the overall architecture, while at the same time maintaining the integrity of the platform's core functionality. As a result, the government as a platform owner provides the limited but core functionality, while partners from different industries and other government departments implement use cases that are specific to their respective domains.

Related to the discussion presented above, platform modularity reduced the core module's functionality, while expanding the periphery through variety (Gulati et al., 2012). Because the platform core is managed by the platform leader, while the periphery contains the contribution of a number of complementors, this also places the responsibility for delivering the complexity of the services involved among the various partners, rather than on the platform leader alone.

Modular architecture also allows for the extensive reuse of capabilities, with many innovations being developed by varying modules and their interaction. When services scale up, reusability also makes maintaining the platform easier, because resources only need to focus on a limited number of varieties of basic technical artefacts. From a resource and capability perspective, it enables specialization and operational efficiency (Thomas, Autio, & Gann, 2014), which also reduces the costs of the service delivery infrastructure, which in turn improves the cost-effectiveness of the supported services. Cost-effectiveness is an important criteria for a rapid diffusion of services aimed at BOP population.

Modularity also allows the services being provided to evolve over time in accordance with market response, while managing the overall stability (Cusumano & Gawer, 2002; Garud, Jain, & Tuertscher, 2008; Spinello, 2005). When services have to be delivered to a large population, it allows governments freedom from designing or planning or investing ahead of time. In fact, it allows them to include more and more features and functionalities on an ongoing basis without affecting the existing basic services or core offering (Thomas et al., 2014).

Due to its effective portioning of the complexity, a modular architecture also reduces coordination and governance cost and increases resource specialization (Nambisan & Sawhney, 2011; O'Reilly, 2010; Tiwana, 2015), although researchers have also found that too much modularity can erode the distinctness of the modules and of the platform, and reduces the scope for cross-learning and network embeddedness between ecosystem members (Nambisan & Sawhney, 2011; O'Reilly, 2010).

Based on the discussion presented above, we formulated the following proposition:

Proposition 1. Modular platform architecture, along with limited functionality in the core module of a platform positively impact the scalability of e-government service delivery to the poorer sections of the society.

2.3.2. Platform openness

To the best our knowledge, existing studies in e-government have thus far not fully examined the impact of platform openness. The openness of a platform ecosystem is implemented on a technological and on an organizational level (Eisenmann et al. 2009; Nikayin, de

Reuver, & Itälä, 2013). Cabigiosua et al. (2013) defined three levels of technological openness: open interfaces based on industry standards, closed proprietary interfaces and stable interfaces. While completely open platforms are based on industry standards and do not charge the partners for consuming their interfaces, completely closed platforms depend on proprietary standard and complex license agreements. Stable interfaces are specific to a particular requirement, albeit frozen and documented (Cabigiosua et al. 2013). Technological openness is closely related to organizational openness and it affects the entry of the partners into the ecosystems based on their complementarity and capability (Boudreau & Hagi, 2009; de Reuver & Bouwman, 2012; Thomas et al., 2014). From an organizational openness perspective, in a closed ecosystem, granting access to new members is not automatic and there is a level of approval involved (Gulati et al., 2012). The boundaries of open ecosystems are less stringent and involve self-selection and self-certification mechanisms when it comes to accepting new members and their contribution (Gulati et al., 2012; Jansen & Cusumano, 2013).

Theoretically speaking, open platforms are more suitable for innovation, because they make it easier for new partners to enter and participate in value creation, thanks to the modest levels of initial and ongoing investments (Baldwin & Clark, 2000; West, 2003). As such, open platforms increase the variety of participants, resulting in larger number of participants and different products (O'Reilly, 2010). On the downside, in completely open platforms, where there is no effective control, platform owners can find it difficult to defend the platform's integrity and vision. Openness without control may allow participants offering similar modules and subsystems to join the platform ecosystem. The lack of complementarity and competitive crowding is likely to have a negative impact on network-based value creation (Boudreau, 2012). A completely open platform configuration can also lead to production of low-quality add-on products, which in turn can lead to poor customer experience and damage the platform's reputation (Boudreau, 2012). An open ecosystem also reduces trust among participants and makes knowledge sharing more difficult (Nambisan & Sawhney, 2011). Between the complete open and closed versions, platform owners can adopt different levels of controlled openness to match their strategic objectives. Most platforms use a hybrid strategy by combining the benefits of open architecture with an ability to control and differentiate (Ballon & Van Heesvelde, 2011) through rules, entry and exit criteria. To realize a scalable government service delivery for the poor, which involves exposing important data to partners, it is important to include trusted and verified partners, while at the same time keeping integration and governance cost very low. Based on that, we can propose:

Proposition 2. Controlled platform openness (technically open but organizationally controlled) in a platform ecosystem positively impacts the scalability of e-government service delivery to the poorer sections of the society.

2.3.3. Cost-effective ecosystem governance

While working as a platform provider, the government frames the rules, monitors and ensures their compliance and increases the moral of the participants (Linders, 2012). The importance of arranging, monitoring and managing the complex network of collaborators from the public and private sectors is acknowledged by many e-government researchers (Janssen & Estevez, 2013). While the governance of the participants in a platform is a relatively new topic in e-government literature, there is room to learn from more generic platform and ecosystem research. Within a platform ecosystem, the platform leader and various complementors have their own reasons, business objectives and industry logic, and they are also not linked through a formal authority as the norm in a traditional form of organization (Gulati et al., 2012). Because there may be many complementors in a platform ecosystem, the dyadic mode of governance becomes very expensive (Huber et al., 2017). As such, researchers are looking for a cost-effective method of governance that does not depend on a contractual or hierarchical

method of control. A shared vision, adequate information exchange and a collaborative approach help reduce cognitive distance and develop a shared world view among participants (Lusch & Nambisan, 2015). Input control or careful selection of partners plays an important role in developing the overall culture and belief system (Mukhopadhyay, Bouwman, & Jaiswal, 2015; Mukhopadhyay, Nikou, & Bouwman, 2016). Other than shared values and world-views, a platform needs agreed protocols, rules for the exchange of resources, and mechanisms of coordination and conflict resolution (Mukhopadhyay et al., 2015, 2016; Nambisan & Sawhney, 2011; Tiwana, Konsynski, & Bush, 2010), which Lusch and Nambisan (2015) call the architecture of participation, which brings clarity and transparency to the collaborative value creation. By designing ecosystem-wide rules and emphasizing the shared world views or values, ecosystem governance can be standardized, providing the platform owner with a cost-effective way to manage the ecosystem effectively, due to the arm's length relationship between the platform owner and complementors (de Reuver, 2011; Huber et al., 2017). To achieve scalability in service delivery for the poor, it is important to onboard and manage a large number of complementors in a cost-effective way, which is something that the ecosystem mode of governance ensures.

Based on the discussion presented above, we can propose;

Proposition 3. Cost-effective ecosystem governance positively impacts the scalability of e-government service delivery to the poorer sections of the society.

2.3.4. Keystone leadership approach

Many platform ecosystem researchers have highlighted the importance of 'platform ecosystem leadership' in initiating, organizing and sustaining collaborative value creation (Nikayin et al., 2013). Platform ecosystem leadership includes a) attracting the best complementors to the ecosystem, b) facilitating and providing adequate incentive for rapid innovations (Kim, Kim, & Lee, 2016; McIntyre & Srinivasan, 2017), and c) keeping complementors on board in the longer term. Ecosystem literature provides many possible roles for the focal organizations, the primary ones being keystone and dominator (Iansiti & Levien, 2004a, 2004b). Keystone roles are marked by sharing high value common asset with partners, implementing fair value appropriation mechanisms, and avoiding competition with complementors (Zhang & Liang, 2011). As a result, keystones are able to attract large number of complementors, nurture the long-term health of the ecosystem and stimulate innovation. Dominators are focused primarily on extracting maximum value out of ecosystems, which means the health of the ecosystem suffers in the long run. After studying multiple ecosystems and the strategy of their leaders, Rong et al. (2013) identified three potential strategies: open, dominating and opportunistic. Open strategies provide a similar conceptual understanding to that of keystone roles and is most suitable for leaders in the initial conceptual phase (Rong et al., 2013), when ecosystems are designed and formed. Unlike private players, government leadership of a platform ecosystem is not focused on extracting maximum value for itself, but rather on increasing the societal benefits for the people (Schrieck et al., 2017), in particular the poorer sections of society. Especially in developing countries, governments do not possess enough resources to provide services for poor people, which is why they need to work together with partners and complementors.

Based on the discussion presented above, we forward the following proposition.

Proposition 4. The keystone leadership practiced in a platform ecosystem positively impacts the scalability of e-government service delivery to the poorer sections of society. To summarise, in the section above, we discussed key concepts like platform attributes (scalability, modularity, platform openness, keystone strategy and ecosystem governance) in relation to the focus of this study. In the next section,

we take a more detailed look at the research approach of this study.

3. Research methodology

When it comes to answering how and why questions and when dealing with contemporary phenomena in a real-life context, case studies are a preferred method in social science research (Eisenhardt, 1989; Yin, 2009). In terms of the suitability of case studies as a method, they are considered to be the most appropriate tool in the critical and early exploratory phase of any management theory (Eisenhardt, 1989; Yin, 2009). Consequently, we chose a case study approach to provide in-depth insights into our research object.

We are aware of existing criticism regarding case studies in terms of their validity and reliability (Campbell, 1975; Miles, 1979; Daft & Lewin, 1990; March, Sproull, & Tamuz, 1991; Yin, 2009). However, Yin (2009), Eisenhardt (1989) and Miles and Huberman (1994) have suggested a number of strategies to overcome these limitations. We have followed many of them like creating a case study protocol—a report that specifies how the entire case study has been conducted, from conceptualization, via data collection to coding procedures, showing how we went from the initial research questions to the final conclusions, while at the same time ruling out alternative explanations.

A core decision has to do with the design of the study (i.e. a single versus multiple case design) (Yin, 2009). For this study, an in-depth analysis of a single holistic case was conducted (Yin, 2009), because similar cases discussing platforms focusing on government service delivery to the poorer sections of the society (in a large country) are hard to find. Moreover, the case involved can be viewed as a ‘critical case’ (Yin, 2009), in that it is unique in nature and extends, validates or rejects an existing theory. Based on these criteria, we selected the ‘Aadhaar Identity Platform’, which is owned by the Government of India, and the associated ecosystem for our study.

India is the second most populous country of the world and, at the same time, it is the home to a large segment of world’s 2.6 billion moderate and extremely poor people (Arnold & Valentin, 2013). Other than a lack of economic development, prior to Aadhaar, India faced two other major challenges in terms of the economic advancement of this section of society. First of all, poor people were unable to participate in the formal economy or use commercially available essential government or private services (i.e. access to banking, mobile telephony or acquiring driving license) due to a lack of identity (Yadav, 2014). As the *Economist* (2012) explained: “Poverty has many causes, and no simple cure. But one massive problem in India is that few poor people can prove who they are.” Secondly, the lack of verifiable identity resulted in massive corruption, leakage and erroneous targeting in government welfare and subsidy schemes. In addition to addressing these two issues, Aadhaar also guaranteed that the cost of identity creation and authentication is within the reach of the poorer people in Indian society.

We are not aware of another case study comparable to the one conducted in this study. The platform highlighted in the case develops and manages the core identification and authentication services, keeping in mind the challenges faced by the poorer sections in the society. The capabilities provided by the platform are also used to provide government assistance in different forms, as well as to allow people access to basic commercial services like bank accounts and mobile telephony. The single case we chose allowed us “to explore a significant phenomenon under rare or extreme circumstances” (Eisenhardt & Graebner, 2007, p27).

3.1. Field procedure

As described in our case study protocol, we first collected and reviewed available secondary public information, to understand the background of the selected platform and services, the chronology of the

events in establishing the platform, and the technical aspects of the platform and multiple organizations involved in the ecosystem. The identity platform known as Aadhaar is developed and managed by UIDAI (unique identification Authority of India), a government of India offshoot. UIDAI had provided a list of documents via the official UIDAI website (<https://uidai.gov.in/>) and the UIDAI developer portal (<https://developer.uidai.gov.in/>). The documents contain information related to the establishment of UIDAI, chronology of events, strategy, architecture, product and service details, interface specification, partner details for biometric devices, ongoing new initiatives (UIDAI, 2014a, 2014b; 2016; 2012a, 2012b) as well as all relevant press releases. Because UIDAI and its Aadhaar initiative are well known and have been covered adequately in the press, the media expressions involved were included in our research. We also transcribed interviews with the founding team members of Aadhaar from a secondary source (Ramnath & Mendonca, 2016). In addition to collecting the secondary information, the first author also observed the enrolment process in one of the Aadhaar enrolment centers for a detailed understanding of the process in July 2016

To supplement and contextualize the understanding from the documents and observation, we conducted semi-structured interviews with five key stakeholders from multiple organizations that are part of the core ecosystem. One of the interviews was conducted face-to-face, the others by telephone. When we quote the interviewees, we omit their name and only include their function. Most interviews lasted one hour and later the information was augmented and enriched by multiple short discussions, primarily by telephone. We used the semi-structured interview protocol, developed as part of the case study protocol, although the participants were allowed to discuss other topics. When additional interviews did not result in new insights, and saturation was reached, we refrained from further interviews. The information from secondary documents and observations, and from the multiple interviews allowed us to triangulate the information (Danneels, 2011). The interviews were conducted between August and November 2016, and they were followed up with short discussions on specific queries. The data collections for the case was completed prior to the supreme court of India ruling on the validity of Aadhaar data for providing multiple government and commercial services (*Economic Times*, Sep 27, 2018).

We used Atlas.Ti for multiple rounds of coding, in each round codes were consolidated after merging similar codes and removing irrelevant codes. The case was analyzed in two phases. In the descriptive phase, we described the platform, the ecosystem and the key services being provided. In the second, more analytical phase, we looked for connections between the scalability of the services and the other four key platform ecosystem concepts. This allowed us to test the four propositions we developed during the literature review. Throughout the analysis phase, memos or brief analytical notes were generated to express emerging insights and relationships between multiple key concepts, and in order to be consistent in our analysis.

4. Results

The nationwide unique identification project of UIDAI or Aadhaar program was initiated in early 2009 by the Government of India with the aim of providing identification to all residents of India. Compared to other –off-line – identification documents, Aadhaar identity can be verified and authenticated in an online, cost-effective way. Because it operates online, Aadhaar was expected to deal with duplicate and fake identities and should ideally be accepted as proof of identity and address for all purposes and by all government and private agencies.

4.1. Aadhaar: Unique identity of residents—Online creation and verification

Aadhaar enrolment is open to all Indian residents and it was conceived with a view of addressing the difficulties the poor face due to a

Table 1
Key ecosystem participants in Aadhaar enabled service delivery.

Participant in ecosystem	Activity descriptions
Registrar	Partner of UIDAI for collection of resident data (demographic and biometric) for first time enrolment as well as for ongoing updates.
Enrolment Agencies	Collect, update data on behalf of registrars and send them to UIDAI for processing.
Training and Certification Agencies	Develop training material, conduct training and certification for relevant resources.
Authentication Service Agencies (ASA)	Provide network connectivity services to AUAs (Authentication User Agencies / application developers) respectively, to enable integration with UIDAI's CIDR (Central Identities Repository).
Authentication User Agencies (AUA) / Application developers	Leverage the Aadhaar authentication service for unique identification of their beneficiaries & customers.
Biometric (ABIS) solution provider	Involved in capture and de-duplication of new biometric during enrolment and biometric verification during authentication.
Device Providers	Provide compliant enrolment and authentication devices to agencies.
STQC (Standardization Testing and Quality Certification)	Manage the specification and certification requirements for biometric and other devices and equipment used by ecosystem partners.
NPCI (National Payment Corporation of India)	One of the key complementors. Developed Aadhaar Payment bridge or direct money transfer applications using Aadhaar identity as a financial address.
UIDAI (Government organization)	Platform ecosystem leader, its core activities are: <ul style="list-style-type: none"> ● Architecting and developing the entire solution. ● Issuing Aadhaar id to residents ● Setting standards, guidelines for different functional areas ● On-boarding different partners ● Facilitating development of new services based on Aadhaar authentication

lack of proper identity (UIDAI, 2014b). Aadhaar introduced a universally accepted and electronically verifiable identity for all India's residents. As part of the Aadhaar enrolment, all citizens are provided with a 12-digit identification number. The Aadhaar core application links the citizens' demographic profiles to their biometric attributes (fingerprint, iris) and creates a unique, digital attribute for each resident, as well as offering a platform for complementors to build additional services on top of the identity services.

4.2. Service delivered to poor through Aadhaar ecosystem

Instead of being the sole entity responsible for delivering services to its citizens, the Indian Government involved a network of heterogeneous actors from multiple government agencies and private sector enterprises through the Aadhaar platform. As a platform leader, the government designed the platform's architecture, organized the collaboration with the participants in the ecosystem and carefully managed the outcome. To attract a broad network of capabilities, the government allowed private sector actors to use the capabilities of its platform, through API, to develop more complex and innovative services.

In an interview, the founder Chairman of Aadhaar explained the present and potential use of the Aadhaar platform: "Aadhaar has three waves of usage, first is the government usage, justification for the government to fund this project. The second usage of Aadhaar is in regulated industry, like banking, telecom, and capital market, pension, where regulators have allowed Aadhaar as a valid KYC (Know Your Customer) document. Third wave is pure private and innovative usage, which is yet to pick up fully; where trust can be provided as a service" (Founder Chairman) (Ramnath & Mendonca, 2016).

We would further detail the usage of Aadhaar platform by government agencies and private sector enterprises. Aadhaar's capability is used to streamline the service delivery for the poor in three innovative ways:

4.2.1. Beneficiary identification for welfare programmes

Multiple government welfare programs can use a single identity provided by the Aadhaar platform. Utilising Aadhaar's online authentication capability to remove duplicate and fake beneficiaries, government welfare programs can use scarce development funds in a more effective way. Linking Aadhaar's information to the public distribution systems (PDS) of multiple states has led to major efficiency improvements and waste reduction in subsidized foods and essential items distribution. Aadhaar's biometric-based attendance and presence

tracking of beneficiaries has streamlined a) pension and similar benefits, where periodically the existence of the beneficiary is ascertained b) programs, where assistance is transferred based on the beneficiary's attendance.

4.2.2. Direct benefit transfer to bank account of the poor

Before Aadhaar, cash transfer to beneficiaries of government welfare schemes (like pension, scholarship, wages) was done manually, which was time-consuming, expensive and error-prone. In addition, benefits often never reached the actual beneficiaries but, instead, ended up with other individuals or were fully or partially siphoned off by intermediaries. Using the Aadhaar platform and Aadhaar payment bridge (APB) applications, government can transfer the cash benefits directly to the bank accounts of beneficiaries at any bank. APB is an electronic benefit transfer application that was developed by National Payments Corporation of India (NPCI), one of the important Aadhaar ecosystem partners.

4.2.3. Enabling mobile, banking and other regulated service delivery to the poor

Due to the high level of competition, the costs of mobile services in India are among the lowest in the world. Nevertheless, the poor have traditionally found it difficult to meet the regulatory requirements for obtaining a new connection, while mobile providers have faced higher customer acquisition costs for low-value customers. After Aadhaar introduced its authentication API, most telecom service providers have developed e-KYC (electronic Know-Your-Customer) applications, which uses the identity information provided by the Aadhaar platform for a cheaper, quicker, stronger and paperless on-line customer verification process. Banks, insurance providers and other organizations in regulated industries also use the identity data provided by the Aadhaar platform for on-line customer verification. Because most poor residents are included in Aadhaar's enrolment, e-KYC applications in multiple industry have helped them to access these services and participate in the formal economy.

4.3. The ecosystem surrounding the Aadhaar platform

The key ecosystem players and their primary activities are presented in Table 1, with the aim of understanding their capabilities and roles.

With UIDAI as the ecosystem leader, the ecosystem as a whole can be divided conceptually into two domains, the former being the

enrolment domain, consisting of registrar, enrolment agencies, training and certification agencies. Other than the enrolment agencies, STQC (Standardization Testing and Quality Certification) and multiple other training & certification agencies involved in quality control, training and development of common standards and guidelines are part of the enrolment domain. The second domain is the authentication service domain; NPCI is part of this domain, having developed the Aadhaar Payment bridge (APB), which has enabled Aadhaar number-based money transfer to bank accounts. The other key players in this domain can be divided into two categories: authentication service agencies (ASA) and authentication user agencies (AUA). ASAs have secured network connectivity to the UIADI data center. Multiple authentication user agencies (conceptually similar to the complementors) use the authentication capabilities of the platform through authentication service agencies to conceptualize and develop multiple complementary services. The technology advisor articulated the importance of having a thriving ecosystem in the following quote. *“Whatever we do for Aadhaar, we will do it for both government and private sector to create a large ecosystem. At that time of initial planning, it was natural to build Aadhaar only for government usage. At that time, there was no compelling reason to open it up for innovative private usage. Even when the platform was ready, it took a few years for a compelling application in the commercial sector to emerge. However, due to our focus on developing a platform-centric ecosystem, we made provision for both public and private sector players.”* (Technology Advisor).

The diagram shown in Fig. 1 shows Aadhaar as a two-sided digital platform, with a set of core functionalities and a set of available APIs for its complementors. As a two-sided platform, it establishes trust between residents and multiple (government and private) service providers offering services or financial assistance.

4.4. Scale of Aadhaar platform

The key parameters related to the definition of scalability provide the following insights with respect to Aadhaar. First, with regard to size, we see that 1.171 billion Indian residents were enrolled in the database, which covered 99% of all Indian adults on August 15, 2017 (UIDAI, 2017). According to the Economic Times (2017), the total

number Aadhaar authentication transactions until the end of July 2017 was 8500 million, and it processed a total of 900 million transactions in the month of July 2017. The former UIDAI Chief, A.B. Pandey, mentioned that *“the online authentication platform is capable of handling 100 Million transactions daily”* (Economic Times, 2016), indicating the platform's ability to process high throughput, a high volume of transactions and a large number of users.

In terms of reach, Aadhaar enrolment centers are available all over India. The total number of languages supported by the platform is nineteen (UIDAI, 2014a). The existing coverage of 99% of all adults in India, indicates a significant reach within its area of operation. While discussing the success of Aadhaar platform, the former chief architect highlighted this.

“1 billion enrolment in 5 and half years demonstrates the success of our enrolment strategy. The system enrolls a million people a day, with a 10-hour work day, or 36000 seconds, that means 30 people per second.” (Former Chief Architect).

The volume of enrolment and authentication indicates that the services enabled by Aadhaar ecosystem are being used in real-life settings throughout India. In addition, regulators in multiple industries (finance, telecom) have accepted Aadhaar data as valid documentation for people wanting to open new accounts. The online authentication capability of Aadhaar has allowed banks and financial institute to reduce expenses for the ‘know-your-customer’ (KYC) process. By using Aadhaar-enabled electronic KYC, mobile service providers can save 22 Indian rupees or 0.34 US\$ every time when signing on a new customer (UIDAI, 2012b). Aadhaar-based direct money transfers has multiple benefits for both sender and receiver, including low cost, reduced processing time, better security and prevention of misuse.

Also, as mentioned earlier, the Aadhaar platform has reduced number of fake and duplicate identities. Aadhaar-enabled biometric authentication has reduced the inappropriate use of social benefits.

4.5. Association between multiple platform characteristics with scalability of service delivery for poor

Central to the case is the connection of platform attributes to

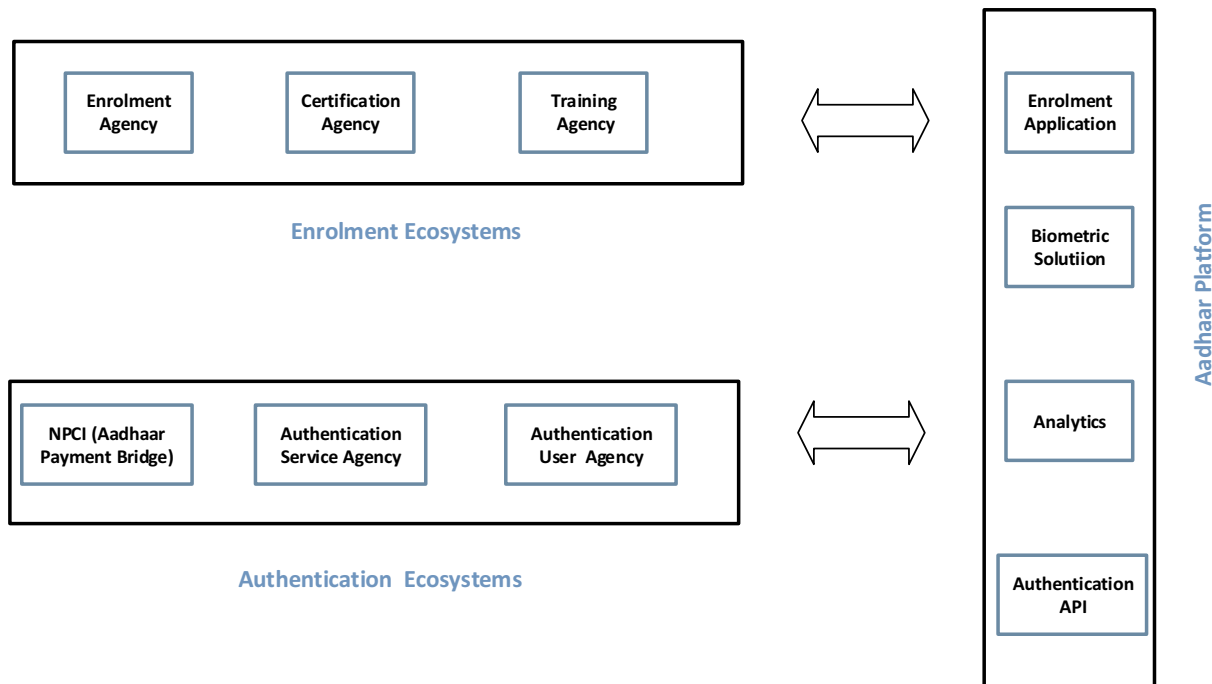


Fig. 1. Overview of Aadhaar Platform and its ecosystems.

scalable BOP service delivery. We test the four propositions, we derived from our literature review linking several key platform attributes (i.e. modularity, openness, ecosystem governance, keystone leadership) with the scalability of BOP service delivery.

4.5.1. Modularity

The Aadhaar core platform is modular in nature and can be divided into four primary modules: enrolment, authentication, biometrics and common support functionalities including analytics. The architecture ensures a stable, limited variety core, while the complementors add variety by developing multiple services, primarily using multiple authentication APIs developed by Aadhaar. There are few architectural decisions related to modularity worth mentioning, which has had a positive impact on the scalability of the services offered by the platform. Primary among them is joining common support functionalities (like reporting, data access and storage, fraud analysis, security) into a separate module, which allowed all other modules to reuse these functionalities. Similarly, centralized lifecycle management of the key master data in a separate module (i.e. location codes for state, districts, village/Town/City, postal codes, mapping between location and postal codes, language codes, and internally generated codes for enrolment agencies, and authentication of service end-users) optimized the onboarding process for new locations, languages and pin codes. In addition, it eliminates data inconsistency, as well as reducing the time, effort and complexity involved in citizen enrolment.

The other key decision has to do with restricting data capture of citizens to a small number of essential demographic data points (i.e. name, address, gender and date of birth and optional information of mobile number and email id), which are stored in the Aadhaar database. There was a great deal of pressure from different stakeholders for the Aadhaar architect team to include more information, but the team instead decided to focus on the essential data required for identity creation and authentication, as illustrated in the quote below.

“The architecture committee formed to decide attributes to be stored in Aadhaar had multiple requests to keep more attributes in Aadhaar database. This is a classic example of many government folks wanting to have more information in the system. We sat through multiple discussions, where our job was to remove every nonessential attribute. We articulated our vision, and we took time to convince people about the simplicity of the systems and ultimately we had only four mandatory attributes (i.e. name, address, gender and date of birth) in Aadhaar.” (Former Chief Architect). The complementary partners are encouraged to capture and store application-specific user data in their own applications. This has made the enrolment activity less complex and it is one of the primary reasons for the high coverage achieved by Aadhaar, which is in tune with the core implementation philosophy of the platform ecosystem, where the focus is to keep the core small and expand the peripheries and reduce complexity. The Aadhaar architecture team adopted a minimalist philosophy while designing and developing the core platform, instead of developing a feature-rich complex application. According to one of the technology advisors, *“there are few seminal innovations that happened in this project. One such innovation is doing minimalist design, instead of making the system as feature rich as possible”* (Technology Advisor). The approach adopted by Aadhaar is in sync with the recommendations in existing literature involving GaaP: *‘A complex system that works is invariably found to have evolved from a simple system that worked. — A complex system designed from scratch never works and cannot be made to work’* (O’Reilly, 2010, p. 21).

As such, in the case of the Aadhaar platform, [proposition 1](#) (*modularity coupled with limited functionality in core module positively impact e-government service delivery to poorer section of the society*) is supported..

4.5.2. Platform openness

The technical architecture of the Aadhaar platform is open and standard-based. The adherence to an open architecture can be deduced from the following: a) standard-based and documented interfaces

between modules, b) no vendor-specific proprietary technology, and c) initiatives aimed at developing and documenting standards, when existing standards cannot be leveraged. For example, the platform leader was forced to develop standards for interfaces for biometric devices (Aadhaar Biometric Capture Device API specification), because of a lack of existing standards. This decision had a very positive impact, as it decoupled the design and development of the enrolment module from internals of biometric devices. Any devices certified to support the published biometric capture device API would work with the enrolment module, creating a fair and technology neutral field for multiple device providers. UIDAI also provided detailed interface specification for different hardware components (like GPS devices, scanners, etc.) and thus opened the market to multiple providers. To enforce standards, UIDAI also developed specific formats for demographic information like names and address field, to accommodate all varieties of names and addresses available in India.

The focus on standard-based openness made it possible to accommodate three independent biometric providers in the ecosystem in the same role. When multiple complementors possess similar capabilities, the platform leader's bargaining power increases; which ensures lower costs, lower risk and a higher technical quality. The following statement illustrates this approach. *“We decided to opt for three biometric companies, who all work for biometric de-duplication. It increased project delivery complexity, but we made sure based on standards all three integrates with our middleware. If we have a problem with one of the providers, we can fall back on the other two. Besides, sometimes one company's solution does not catch a particular type of problem, but the other two might. Then we ask the third company to fix this, and so on”* (Head of Technology).

As mentioned before, Aadhaar architecture is a technologically open system. However, in terms of providing complementary partners access to data, it was controlled through rules and entry criteria. The primary reason for controlled access has to do with privacy and security concerns related to biometric and demographic data. As a result, access to the published APIs is not automatically provided to everybody, and only approved partners are given access through a private leased line. Also, the API can only be accessed through whitelisted IP addresses of the partners as well as through a time-bound license key, as explained in the below quote. *“First, we need to have an agreement with UIDAI, post that, the direct connectivity between our data centre and UIDAI data centre is established. We call those published APIs and pass the parameters mentioned in the specification. But we need to conform to all security related mandates, like encrypting information and using certificates”* (Development Head of an authentication service provider). As the founder chairman of Aadhaar explains, *“The ecosystem design was done in a way that to access the online authentication and eKYC API, the agencies need to be approved and regulated, even though the partners can have a private or public sector background”*. Providing controlled access to partners for authentication API has helped UIDAI collaborate with trusted and serious partners, avoid over-crowding of partners and reduce the integration effort. On the other hand, providing the partners with restricted access to people's data addressed common concerns over data security and privacy, as well as meeting existing legal requirements.

We can conclude that [proposition 2](#) is also validated in this particular case.

Controlled platform openness (technologically open but organizationally controlled) has a positive impact on the scalability of e-government service delivery to poorer section of the society.

4.5.3. Ecosystems governance and keystone leadership

To address India's diversity, Aadhaar product document (UIDAI, 2014a) outlines an ecosystem-centric approach involving a set of co-operating partners. Aadhaar's ecosystem strategy tries to balance two competing requirements: a) a rapid scaling up both in terms of area size, the number of residents served and the diversity of the services being offered, and b) maintaining and improving the cost-effectiveness of the services. A detailed analysis of Aadhaar's ecosystem strategy

highlights the following key aspects: a) its focus on establishing common value system, codified rules and transparent performance expectation from its partners. b) ecosystem leader's adherence to keystone role.

To develop and enforce a shared value-systems, Aadhaar focused on including key partners with the right capabilities and attitude, as the following quote explains: *"We decided that we would use the best-of-breed organizations for the various areas we have. The partners can come from government, the private or even the NGO sector. For example, the biometric solution needs to perform 100 trillion biometric matches every day. So, we engage the three best companies in the world for the same job. Due to the very high volume of business, they also agreed to work at much lower cost. We selected partners based on the project need and the partners' capability. As a result, we got the best solution for every requirement and could achieve 1 billion enrolment target far ahead of planned schedule"* (Head of Technology). The large number of biometric matches are caused by the 'de-duplication' checks used during enrolment. For every new enrolment a 'de-duplication' check of all biometric features (10 fingerprints and 2 Iris images) of the person is conducted against all existing profiles or gallery (total number of enrolled residents). The current size of the gallery is over a billion. This approach ensures that there is only one Aadhaar number for each individual.

Once a partner has signed on, to manage the different types of partners (enrolment agencies, device providers, application developers), UIDAI publishes detailed standard operating procedures and guidelines. Similarly, to improve user experience, UIDAI employed multiple training agencies to train operators in enrolment agencies, to make sure that enrolment agencies could achieve efficiency in their tasks and residents are provided with a uniform experience at different enrolment locations. To avoid technical difficulty in integration and possible conflict among partners, Aadhaar management involved its partner STQC to perform interoperability testing and certify any new hardware based on agreed technical standards. Only certified and tested hardware can be used by the platform leader or complementors. For ongoing partner management, the ecosystem leader avoided involvement in day-to-day monitoring of partner's behavior, rather partners were evaluated based on the outcomes achieved on agreed parameters. This also led to internal competition among partners, encouraging them to do better. This approach can be better understood, if we look at how three biometric solution partners were treated. They all had similar capabilities, were allowed to work independently for their assigned work and were judged on their outcome, i.e. throughput and error rate. UIDAI or the ecosystem leader implemented dynamic work allocation algorithm, i.e., the best performing biometric solution provider was allocated more work. This approach allows the best partner to capture a higher value and, in turn, this allows the platform to achieve its performance goal. *"Three companies brought very different approaches, we didn't constrain them, we only looked at their error rates. And as long as those rates are within our specified limit, we do not need to know what algorithm and logic they are using. Suppose one solution, let's say A among A, B and C is suddenly doing much better than B and C (in terms of processing speed and error rate), we use dynamic work allocation. We would take a little bit of work from B and C and give it to A. He makes more money, suddenly he got more incentive to improve further. B and C also go back and work on improving speed and accuracy. So, we no longer need to watch over their shoulders. They are now exceeding our expectation because they are competition with each other"* (Head of Technology). UIDAI or Aadhaar authority also ensured that there is no misuse of resident's data stored in Aadhaar by any of the partners. As mentioned in the openness section, this was managed through a combination of technical design and agreed values and rules, while technical design ensured that partners are not given unlimited access to the database, and can only access a specific user data in a controlled and secured way. At the end of 2017, UIDAI penalized Airtel (India's largest mobile operator) and its payment subsidiary for using Aadhaar data to open payment bank account without the explicit consent of customers (Business Today, Jan 14,

2018).

The other aspect of ecosystem governance worth mentioning is the ecosystem leader's preference for keystone role. It developed the core infrastructure of identity creation and verification, while at the same time deciding against developing any other add-on applications. During interviews, we found that, although there was pressure on UIDAI management to expand the organization's role and include end-to-end service delivery, they decided against that approach, which increased trust among partners, reduced the likelihood of conflict between the platform leader and the complementors, and ensured the long-term sustainability and overall health of the ecosystem. We already mentioned the platform leader's focus on making documentation, information, training and certification facilities available to its partners. In addition, we found that UIDAI has provided key partners access to a partner portal with detailed operational dashboard and statistics. Access to operational statistics enables partners to manage their performance and take corrective actions.

Based on the discussion presented above, we can conclude that our third and fourth propositions are supported.

Proposition 3. Ecosystem governance based on shared values and codified rules of the platform ecosystem leader positively impacts the scalability of the e-government service delivery to poor citizens.

Proposition 4. Keystone role practiced by platform ecosystem leaders by sharing reusable capabilities and not competing with complementors positively impacts the scalability of the e-government service delivery to poor citizens.

5. Discussions on results

As explained earlier before, multiple researchers have associated digital platforms with innovation, cost-effectiveness, scalability as well as agility (Eaton et al., 2015; Lusch & Nambisan, 2015; Sedera, Lokuge, Grover, Sarker, & Sarker, 2016). Empirical research into platform ecosystems has long focused on commercial businesses, but, to our knowledge, it has rarely involved government organizations (Brown et al., 2017), let alone those in developing economies. Most existing studies mention ecosystems: headed by telecom operators or Internet companies, device players and service providers (Ballon & Walravens, 2008). Many researchers have also identified large software players in the role of ecosystem leaders (Evans, Hagi, & Schmalensee, 2008), and most available studies do not consider governments as platform leaders. Although there are numerous conceptual studies (Janssen & Estevez, 2013; Linders, 2012) on how a platform-centric approach can benefit governments, our research is among the first to include a scenario where government agencies can successfully conceptualize and develop a large, scalable platform centric ecosystem.

Scalability has long been identified as one of the main unresolved and persisting issues in service delivery to the poorer sections of the population in developing economies (Walsham & Sahay, 2006). Empirical research focusing on how digital platforms can contribute to such a scalability is scarce and sorely needed. Against this background, our research has observed how platforms developed by government work with a heterogeneous network of organizations from the private and the public sector in providing scalable services to the poor. The case study shows that, while 'Government of India provided the core functions of the platform, like identity, authentication, security and privacy, with the ecosystem, it can impact and improve the service delivery of multiple government programs as well as that of basic commercial services, which are relevant in terms of improving the position of people at the lower end the pyramid. The findings of the research also match the GaaP-related recommendation of O'Reilly: i) starting with a simple and reliable system, ii) exposing data to attract other participants iii) evolving towards a more complex application with significant scale (Margetts & Naumann, 2017; O'Reilly, 2010).

Our study is among the first to focus on scalability within the context of service delivery to the poorer sections of society. Based on the unique case study, we presented four propositions that are open for further testing. The fairly specific propositions establish a positive connection between the sub-constructs related to the platform (modularity, platform openness, ecosystem governance and keystone leadership) and a scalable service delivery to the poor. The study indicated that the ecosystem leader practiced a modular and minimalist design philosophy, instead of opting in favor of a monolithic but feature-rich design as is, for instance, prevalent in large government IT projects in India. Our study probably could also offer valuable insights relevant to understanding the failure of IT e-government projects in developing economies. This platform-centric design, providing centralized minimal identification functionality, allowed the system to scale up quickly both in terms of technical as well as operational capability with minimal effort and disruption. The study provides evidence that modular design also allowed reusability of capabilities. Another relevant advantage of modularity is that it allowed architect team to localize the impact of changes, while otherwise any change must be propagated in the entire stack involving much higher cost, time and risk (Gawer & Cusumano, 2002). The choice between a centralized versus a decentralized approach, for instance based on cryptographic techniques and tamper-proof devices, is motivated by the economic reality in the BOP context, in which people and businesses alike have fewer financial and technological resources and the focus of government initiatives is to ensure the delivery of basic services to a large population. Besides, the ability to serve a large – mostly poor population is also an important aspect of this platform, when compared to other successful government initiatives that focus on serving a much smaller but technologically more advanced population (for instance Estonian e-government programs) (Margetts & Naumann, 2017).

The study underlines the importance of including controlled openness, instead of complete openness, when developing the platform. Although complete openness is recommended because it reduces the cost of partners to join the ecosystem (Baldwin & Clark, 2000; West, 2003), the case study shows that a controlled approach may be more rewarding, for a number of reasons. Because the Aadhaar platform is associated with sensitive demographic and biometric information, the ecosystem leader decided only to allow access to selected partners in a secured way. Being a multi-sided platform, this demonstrates a particular type of indirect cross-platform network effect, i.e. the control on service providers has helped generate acceptance among the broader population. From a partner management perspective, the modular architecture and open interfaces allowed many organizations to participate in the innovation process, with limited effort and without completely understanding all the technical complexities of the platform. The clear interface definition and the controlled access allowed the platform leader UIDAI to govern partner selection and access to the ecosystem, as well as to create new innovative use cases without compromising platform or data integrity (Gawer & Cusumano, 2002). Data necessary for complementor services, other than identification and authentication, are managed outside the core platform and are the responsibility of the complementors themselves.

The emergence of a vibrant ecosystem around the Aadhaar platform can be attributed to the multiple architectural and managerial decisions taken by the ecosystem leader. The government's role in this case was that of keystone player with an eye for the interest of all the actors involved, in the best tradition of Government as a Platform. The ecosystem leader insisted on limiting its role to identity creation and establishment, and serving as a process manager to enable other ecosystem partners to provide complementary services. The case study provides evidences of discussions related to extending the ecosystem leader's role to other related areas (service delivery) as well, which in a sense it declined to do. The decision on the part of the platform leader to limit its role to the core activities has encouraged complementary partners to offer a broad variety of services without any conflict within

the ecosystem. Because UIDAI (the platform leader) has no intention of entering complementary markets on its own accord, there have been no visible signs of 'external tension' (Gawer & Cusumano, 2002) with complementary providers. The second important factor is the availability of well-documented and standard APIs. Due to the standard-based approach, the costs involved in the development and design of the platform are among lowest compared to similar programs across the world (Gelb & Clark, 2013).

The platform leader's decision not to use proprietary technology prevented a single partner or a group of partners to exploit the success of the platform for their own benefit, and ensured a fair value distribution among the partners. In this sense, it confirms insights from Iansiti and Levien (2004a, 2004b) that keystone players contribute to the health of an ecosystem as indicated by the penetration of Aadhaar identity among its target population, the number of innovative services developed and the emergence of a larger ecosystem.

The further success of Aadhaar would depend on bringing new partners with unique capabilities on board. There are studies on how input control (Cardinal, 2001; Snell, 1992) can be used to select new ecosystem members (Mukhopadhyay et al., 2015) and this may lead to a more innovative service development. The keystone role played by the Indian Government in the Aadhaar project is in line with the four new roles proposed in the we-government concept (Linders, 2012) (framer, mobilizer, monitor and provider of last resort), which are essential when governments want to treat citizens and other organizations as partners in service fulfilment journey, instead of as consumers of government services.

As suggested earlier, our findings are also relevant from the perspective of i-government and government as a platform. i-government has to do with governments achieving more with less (Janssen & Estevez, 2013); the Aadhaar platform shows how governments may achieve that by orchestrating a large complex ecosystem based on their restricted role as platform providers, while the concept of government as a platform refers to embedding government capabilities in multiple commercial value chains (Linders, 2012) and legitimizing its role as a strong participant in the social ecosystem (O'Reilly, 2010). While governments are not normally in the business of co-developing personal or private goods, they can nevertheless create an environment that is more conducive to private, peer and personal production by 'embedding' their capabilities into the wider ecosystem, specifically in a BOP setting. The fact that digital information and computerized services can often be shared at near zero marginal costs means that the government can open such resources to the public for their own use at little or no additional cost, promising interesting new social uses of existing government resources.

Our study provides insights not only in to e-government research, it also contributes to platform theory more specifically, by emphasizing the importance of the designing architecture and governance of the platform. The provision of core services, like authentication, privacy and security, while keeping an open approach for complementors, both public and private, based on strict standards for APIs and competition between providers, while keeping an eye of common interest and health of the eco-system, is an approach that works in a developing economy, while it may also play a role in preventing overdesigned and complex IT systems in developed economies. Ultimately, the central focus has to be on the interest of the citizens, poor or otherwise.

6. Limitations and future research opportunities

This study has a few limitations, some of which can be turned into research opportunities. The main limitation is that the study is based on a single case within a specific regulatory, cultural and institutional environment, i.e. India, which means that further testing of the propositions, with multiple alternative cases in developing and developed economies, and large-scale samples and within a more international setting, is likely to yield interesting results. This study only establishes

the relationship between attributes of platform with scalability and develops a set of propositions within a specific setting (BOP). The propositions developed on the basis of the case study can be used as input for a quantitative survey, which would also allow us to test the strength of association between these two sets of concepts: platform attributes and scalability.

In terms of research design, this study only covers a limited time span. Our work can be complemented by a longitudinal study focusing on how strategic architectural and governance decisions taken during the planning phase affect the success of platforms (Ondrus et al., 2015). In addition, this study also highlights the fact that the design of technology architecture and business model can play crucial role in success of these platforms. As a result, the phenomenon of Aadhaar platform can also be viewed from the perspective of alternate theories, i.e. theories of platform leadership (Gawer & Cusumano, 2002).

To expand platform theory in government domain, additional studies would have to focus on differences in the government and business contexts. The key among them would be the concept of value creation, value distribution, platform leadership, as government-owned platforms are not primarily focused on maximizing economic returns for their sponsors, but on improving or streamlining government service delivery to citizens and, in the context of developing countries, on the additional objective of ensuring inclusive development of the poorer sections of society.

Furthermore, because government platforms like Aadhaar primarily store people's personal data and ongoing concerns related privacy and security, future research looking at openness and participation without compromising security could also prove to be very valuable.

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