Can North-made IOT solutions address the challenges of emerging cities in the South? The case of Korean born Smart transportation card implementation in Bogota

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Abstract:

Over the course of the last ten years, the urban population in the Global South has grown at a rate of 1.2 million people per week, putting the developing countries at the center of the urban development in 21st century. This rapid urbanization resulted in the emergence of serious challenges, such as provision of decent mobility, requiring innovative solutions. Currently, many northern cities use Internet of Things (IoT) solutions for answering urban challenges, but there are certain doubts about their transferability to southern cities. This paper aims at studying the transferability of IoT solutions from urban north to urban south. We firstly discuss the impacts of one prominent example of IoT solutions in urban transportation sector, by presenting the ability of Seoul to manage the complexity of its public transportation system with the introduction of a Smart Transportation card. Then, we examine the key factors that enabled Bogota to benefit from the same technology, originally designed for Seoul, for resolving the challenges they were facing in their Transportation system. This case study, we hope, sheds more light on the impact of IoT solutions for cities, which usually have origins in north, on addressing the challenges of urban south and reaching the development goals.

Keywords: IoT, smart card, urban transportation, development, technology transfer

Introduction

In 2014, 54% of the world population was living in urban areas. By 2050, cities are expected to absorb another 2.5 billion inhabitants, 90% of which will be concentrated in Asia and Africa (United Nations, 2014). Over the last ten years, the urban population of the Global South has been growing at an average rate of 1.2 million people per week (UN Habitat, 2013), bringing developing countries to center stage on issues relating to urban development. Within this context, it has become evident, that as growth and development are inevitable, cities will increasingly become a playground for development policies.

Cities are becoming increasingly complex environments (Hillier, 2009), which can be seen as a result of urbanization and growth (McHale and al., 2015), and increasingly, due to the development of urban networks (e.g. transportation, telecommunication, water and waste, energy) established to facilitate the dissemination of physical (e.g. goods and people) and immaterial (e.g. finances and information) flows. The operation of these varied technical infrastructural networks produces immense quantities of data, for example the frequency of trains on a subway line, the flow rate of wastewater in a sewage system, or the amount of waste collected every hour.

In order to manage complexity characterizing urban areas collecting and processing the data produced by urban technical systems can be an important step towards development processes. In order to fully benefit from these data, solutions that enable efficient data collection from urban infrastructures must be in place, going towards the creation of an interconnected network (Internet) of physical components from the urban infrastructures (Things) that corresponds perfectly to the definition of the Internet-of-Things (IoT) (Dijkman and al., 2015). For example road sensors can measure pollution particle concentrations in the atmosphere and communicate with intelligent road gates that directly adapt their toll fares in order to decrease the number of cars on the roads and improve air quality.

In the academic literature, IoT solutions are viewed as an efficient way to deal with much of the complexity associated with urban systems (Schaffer et al, 2011; Hernandez-Munoz et al, 2011; Zanella et al, 2014) and smart city is perceived as the place where computing technologies are used to create one single interconnected, intelligent and efficient entity (Washburn and al., 2010); from a broader point of view, implementing IoT solutions can be seen as the process employed in order to make cities smarter. In this paper, in accordance with the existing literature (Komninos et al, 2014; Jin et al; 2014), we recognize the smart city as an urban representation of the Internet of Things. Within this scope, we wish ultimately to understand if the "Smartization" of urban areas can help to reach development goals.

Diffusing IoT solutions in urban contexts, or making cities smarter, is directly connected to several development goals. Firstly, they contribute to making the advantages created by Information and Communication Technologies (ICT) accessible to all populations (goal 8F of MDG). IoT solutions also integrate the principles of sustainable development (7A). For example, they can use and process data generated from the transportation infrastructure operations to determine the optimized number of buses that should run during off-peak periods. Furthermore, these solutions can contribute towards the SDG 11 by making, cities more resilient, sustainable, safe and inclusive (UN, 2014).

This research seeks to explore IoT solutions realized in former developing countries, that have since progressed and are now considered developed states and part of the "North"; more specifically the aim is to outline the conditions required to reproduce these successes by answering the following question: **Can the South learn from the North regarding the implementation of successful Internet-of-Things (IoT) solutions?**

To answer this question we will conduct a comparative analysis between one case from the North and one from the South, which were involved in the implementation of the same IoT device in their urban transportation systems. We examined, for the northern case, the case of the "T-money" smart card implementation in Seoul Public Transportation System, and for the southern case, the example of the "Tu llave" card implementation in Bogota transportation system. Both cases will then be analyzed with reference to the Innovation Management literature in order to understand the extent to which technology can be a driver for institutional changes in urban transportation systems, in order to foster development.

Seoul case

Seoul, the economic and political capital of the Republic of Korea, is one of the most populated urban areas in the world. In 1960, Greater Seoul metropolitan area population was home to 5.2 million of inhabitants (Bae and Richardson, 2011); by 2002 it had grown to accommodate 25 million of people (Kwon, 2010), that is to say approximately half of the Korean population. With a population density of 17,275 people per km^2 (Allen, 2013), the average density of Seoul Metropolitan area is considered to be "1.3 times more dense than neighboring Tokyo city and the sixth densest urbanized center in the world" (Cervero and Kang, 2009).

Consequent transportation problems resulted from the exponential growth Seoul was experiencing. Driven by strong industrial development, Seoul's demographic growth was followed by an impressive economic growth. The per capita income (in 2004 US Dollars), that was about US$ 311 in 1970, rose to US$ 7,378 in 1990, and finished 2002 at US$ 12,531 (Allen, 2013). Automotive manufacturing became an especially powerful sector (Samsung motors, Hyundai, Kia Motors), and because of the rising household economic power, more and more citizens started to buy private cars, eventually leading vehicle ownership to rise from 2 cars per 1,000 persons in 1970 to 215 per 1,000 persons by 2003 (Pucher & al, 2005). Unfortunately, Seoul's road infrastructure did not adapt to this impressive increase in car ownership. As a result congestion became significant forcing all vehicles to reduce their speeds, increasing travel times, and having a negative impact on bus transportation system, on which Seoul was heavily dependent at that time. Because of a decreasing quality of bus services, Seoul urban dwellers started to look for other modes of transportation to move within the city limits.

To efficiently tackle the rising population problem that was impacting the public transportation system, the first initiative of Seoul Metropolitan Government (SMG) was to plan the construction of a performant urban rail. Following six years of discussions, planning and construction, the first 8 kilometers of Seoul Metro were inaugurated in 1980. The primary goals of which were to assess the will of the municipal government to improve the transportation system, and also to prove to the world their capacity host the next Olympic games in 1988. Indeed, in order to have the chance to be selected by the International Olympic Committee, Olympic bidders were supposed to develop a functional urban rail system to facilitate public to access the games.

The new Seoul Metro system constituted an alternative mode of transportation for Seoul citizens, who graciously welcomed its development, but in the end, it served no benefit to the Seoul Bus system (Purcher & al., 2005).

In fact, Seoul Urban dwellers were instead able to choose between multiple different transportation modes. The new Metro system was known to be convenient, and the enhanced affordability provided by cars was a reality. Inevitably, travel times associated with bus transport increased because of congestion caused by private car ownership rise, resulting in the rapid decline of bus usage.
Consequently, private buses operating under a license from SMG, started to do what was most profitable for them. Due to a lack of management by the authorities, the operating companies started to compete for the most profitable routes, deciding to cancel those that were non-lucrative and began behaving in an unprofessional manner with customers, for example refusing to pick up elderly or disabled passengers, driving recklessly, putting as many passengers as possible onboard, and giving the driver the ability to decide on which stops he should let users board and exit the vehicle (Allen, 2013). As a direct consequence, 31 bus companies went bankrupt from 1995 to 2002 (Seoul development institute, in Purcher & al, 2005).
In 2002, the only adjective that could sum up the public transportation fare system in Seoul was “fragmented”. Integration between the privately operated bus services and the publically operated metro lines was inexistent but more than that, cooperation was equally inexistent between different bus operators. Due to the numerous transfers between routes and transportation systems required during daily commutes, Seoul urban dwellers were spending tremendous amounts of money on public transportation fare payments. An additional fare had to be paid for each transfer, which were quite frequent because of the impressive urban sprawl of the Korean capital, resulting from its exponential urban growth in the second half of the 20^{th} century.
Evidently there was an urgent need for fare integration across the whole metropolitan area, and across all bus and metro operators. Indeed, this was one of the main campaign promises of the newly 2002-elected mayor, Mr. Myung-Bak Lee, who saw an opportunity to shift Seoul Citizens back from their private cars to public transportation, and more specifically to the bus system. To support this integration, a new fare scheme was devised by SMG, as part of a broader public transportation reform, that would be supported by an integrated smart card ticket system (Park et Kim, 2013). The first step of the creation of an integrated transport system was to change the ownership of the bus operation system in order to create a semi-public bus system.
To do so, SMG first created the “Public Transport Promotion Task Force”, led by the head of Seoul’s transportation Sector, which was composed of Seoul city officials and researchers from the Seoul Development Institute who were to conduct the transportation reform from an expert point of view. Following the Institute urban transportation research division head guidelines and based on the advice from the Task Force, the Seoul Bureau of Transportation and the Transportation Policy Advisory Committee (TPAC) then created the Bus System Reform Citizen Committee (BSRCC) (Kim, Cheon et Lim, 2011) on June 28th 2003. The aim of which was to solve conflicts between involved stakeholders, and was composed by an array of 20 professionals (Kim & Dickey, 2006):

- 4 Seoul Officials (SMG, Seoul Metropolitan Police Agency, Seoul Metropolitan Government Council)
- 4 bus industry professionals (Seoul Bus Transportation Association, Seoul Community Bus Transportation Association, Seoul Bus Transportation Trade Union)
- 4 people from civil groups (green consumer networks, Citizens Coalition for Economic Justice, networks for green transportation)
- 8 experts (lawyers, accountants, transportation experts, etc…)

After a long series of formal and informal meetings between the CEOs of bus companies and SMG, Seoul Mayor and the Chief of the Seoul Bus Transport Association, representing the 57 bus operating companies of Seoul, signed an agreement approving the bus reform and stating the change of the operational content of the companies’ operating licenses. Once signed, it was just a matter of time to have the IoT technological vector (smart card) implemented.
This Radio Frequency Identification (RFID) technology-based smart card was aimed at supporting the creation of a new integrated distance-based Automatic Fare Collection (AFC) system with a free transfer across mode (Kim et Shon, 2010). It was also supposed to streamline traffic flow at metro ticket gates, make it easier for bus drivers to meet their schedules by reducing delays caused by cash transactions for fare payments at vehicle gates, ensure complete transparency regarding the operations of bus drivers, and finally as an IoT device, the smart card would serve to obtain data about public transportation use by the citizens (Park et Kim, 2013). With this data, the transportation operators were able to analyze demand, and implement measures to optimize operations such as bus frequencies at peak hours or saturation rates of subway station entry gates.
The device was implemented and operated by a Special Purpose Company, called Korea Smart Card Corporation (KSCC), created in the form of a Public-Private Partnership by Seoul Metropolitan Government and a consortium of technological firms, led by LG CNS, a subsidiary of the LG Group, where all the investment was coming from the private sector. The new integrated system was inaugurated on July 1^{st} 2004, and in 2009 the penetration rate of the card in Seoul Public Transportation system payment methods accounted for 97.10% of the 32 million trips processed each day.
The card drastically improved the conditions of the urban transportation system, by fulfilling the task for which it had been designed (easing traffic flow at entry gates/bus entrance), but the most significant impact it had was

due to the free transfer policy it supported, enabling Seoul urban dwellers to save huge amounts of money. The IoT device allowed the city of Seoul to transform its transportation system from a developing country state to a world-class transportation system, perfectly illustrating how technology, and more specifically IoT devices, can serve as a driver of system wide changes.

Bogotá case

With almost 10 million inhabitants, Colombia's capital is the most populated city in the country (Munoz-Raskin, 2010). The economic situation in Colombia, specifically in Bogotá, is significantly less developed than Korea and can be characterized as belonging to the Global South (Cervero, 2013).

Prior to 2000, the Metropolitan Area of Bogotá was characterized by a fairly complex transportation system. Bus service was managed by 64 different companies operating around 21'000 vehicles citywide. Private bus operators were often leasing their routes (previously obtained on concessions-based contracts) to third-party bus owners (Cain and al, 2006), creating a complex structure for bus operations.

At that time, obsolete vehicles ran the bus system. There was very little concern for public safety and organized transport networks, and bus stops barely existed. The income of the bus drivers was directly linked to the number of passengers they carried. Locally known as the "penny war" (Ramos, 2015), the situation created chaotic competition between all the bus companies and serious safety risks for pedestrians (World Bank, 2010). For the 1998 newly elected mayor, Mr. Peñalosa, the issues the transportation system was facing were deeply embedded within the institutional structure of the sector. In response, with the aid of external consultants and experts and in cohesion with the Bogota Mass Transport System plan of the Colombian National Development plan (Lara and Gutierez, 2012), he designed a Bus Rapid Transit (BRT) project called Transmilenio (Ardila, 2004).

Transmilenio was a citywide, city-owned system that was supposed to offer speed and convenience to its users. Buses were to run in dedicated corridors to avoid traffic flows, and riders were to now purchase their tickets at the entrance of bus stations instead of upon entering buses. The project started in 1998 and was operationalized in December 2000. Additional corridors opened every year until 2006 (Heres et al, 2013) and old buses were progressively taken out of these main corridors ensuring a smooth transition so that eventually Transmilenio was the only public transportation remaining on the main routes.

Through concessions, Transmilenio outsourced the operation of the BRT system and feeder lines. Tendering processes were implemented where pre-transmilenio era companies could bid if they had previously demonstrated experience operating the city transportation system. This process resulted in high competition and the birth of new entities composed of existing companies as shareholders and with new partners from other industries responsible for cash investments.

Transmilenio was considered a success in several axes of the city because it improved the efficiency of the transportation system, reduced travel times and afforded significant cost saving for citizens (Bocarejo and Oviedo, 2014). However, the Transmilenio was never developed to integrate all the other transportation lines in the city. It always ran in a regulated manner, parallel to the traditional collective public transport system that were completely unregulated (Ramos, 2015). Transmilenio was operating with its own fare and ticket system (using blue and red smart cards operated by Angelcom) (El Espectador, 2014), and no transfers to other transportation modes were possible. Even among different Transmilenio lines, incompatible ticketing schemes were used so that transfers were not permitted.

In 2006, the city of Bogotá planned to integrate all of the transportation modes through Bogotá Mobility Master Plan, and finally launched SITP (Integrated Public Transport System of Bogota) in 2009,. The plan proposed the development of an organized public transport network that functioned with an integrated fare that utilized a unique payment method to improve local traveling conditions (SDP, 2009).

In July 2011, the city of Bogotá awarded Recaudo Bogotá a concession for the operation of the fare collection and user information of SITP. Recaudo Bogotá was composed of three different shareholders, namely Citymovil (60%), Land Developer (20%), and LG CNS (20%). LG CNS was responsible for providing IT skills and devices for the transportation system of Bogota, to help developing an AFC system in order to integrate Transmilenio with the new feeder routes that were going to be developed later to replace the old unregulated feeder bus lines.

The funding of Recaudo Bogotá, was secured through a $176 million financing package loan by the World Bank, HSBC and Korean Banks (Shinhan and Woori Bank). The loan was supposed to enable Recaudo Bogotá to introduce an easy-to-use electronic-payment mechanism using smartcards, thus eliminating cash from the system and increasing efficiency and security (IFC, 2012). In addition to the smart card implementation, SITP redesigned bus system that ran in parallel to the Transmilenio by forcing private bus companies to conform to the same competitive concession arrangements devised under the Transmilenio (World Bank, 2014). Under these modifications the only means of payment onboard the SITP buses was, and still is, to use the "Tu llave" smart card. SITP drivers get a fixed salary, which is independent of the number of passengers they transport, announcing the end of the "penny war".

Prior to May 2015, Recaudo Bogota and Angelcom had not reached an agreement regarding intellectual property and appropriate financial compensation, and as the old ticketing system operated by Angecom was still in place, the "Tu llave" card was not accepted at most of the Transmilenio bus stations. The two AFC operating companies finally reached an agreement (El Espectador, 2013) stating that Recaudo should pay for the new card readers in all Transmilenio bus stops. Finally in September 2015, long after the initial 2013 launch date, both cards provided by Recaudo and Angelcom were accepted on the whole Transmilenio network. The primary advantage associated with the "Tu llave" card was the possibility of free transfer to, and between, SITP buses (including Transmilenio) and Bogotá Metro. In summary, it appears that the "Tu llave" card was the vector of diffusion for SITP; that is to say it became the integrator of a vastly complex transportation system and regrouped the many stakeholders by enabling them to finally agree on a compromise.

Currently, "Tu llave" card is used (and has to be used, as it is the only mean of payment) in all SITP buses and BRT system, accounting for 75% of all buses in operation in Bogota. Indeed, still 25% of the buses are operating without being regulated, and the city hall is continually converting them. Approximately 2500 buses still run on the old system and therefore do not wish to transfer to the "Tu llave" system. The average number of daily transactions, including validations, recharge and transfers, processed by the "Tu llave" card is around 7 million.

In 2015, during the Korea-Colombia business forum, the Colombian President, Juan Manuel Santos, recognized the significant role LG CNS played in the development of the Bogotá Transportation system. The implementation of the smart card in Bogotá supported the integration of the different feeder lines into the BRT Lines (Transmilenio) operated by various operators. It also enabled more efficient data acquisition regarding the demand for buses in order to plan accordingly.

Analysis

One of the main differences between the Seoul and the Bogotá cases is the fare system that was introduced. In Seoul, the bus reform enabled the introduction of a distance-based fare system, whereas in Bogotá the SITP project relied on the pre-existing flat fare. The integration of the Bogotá transportation system did not go as that of Seoul. Furthermore, Tmoney's high penetration rate into Seoul Public transportation payment methods can be explained by the high convenience of the system. The implementation in Seoul was successful largely due to its ability to save citizens both time and money. The high penetration of "Tu llave" in Bogotá can somewhat be explained by the same reasons, but also because the card offers special deals based on users socio-economic conditions. For example, there is a special fare for low-income households, and the only way to benefit from it is to use the "Tu llave" card. The social dimension seems to be more important in Colombia than in Korea, but why these two IoT devices implementation cases differ will be explained in the below analysis.

Because these two cases deal with the introduction of the same technological innovation (smart transportation card) by the same technological actor, LG CNS, these two cases can provide a good basis for comparative analysis. The following analysis is based on an analytical framework using the demand-pull vs. technology-push perspective on technological innovations. The technology-push argument claims that scientific understanding and discovery determine the rate and trend in innovation, whereas the demand-pull theory explains that demand directs trends and rates of innovation development (Nemet, 2009). These categorizations of innovation process have been studied and developed by many scholars of Innovation Management literature, and management of technology (Di Stefano et al, 2012).

Through analyzing the timeline of the Tmoney card implementation in Seoul, we observe that implementation was not initiated by the political actors who instigated the bus reform, but instead by LG CNS, the main technological actor. In January 2002, prior to the election of Mayor Lee Myung Bak, LG CNS created a business modeling team in order to evaluate opportunities to develop a smart transportation card using RFID Technology. In July 2002, this team completed a full market analysis that confirmed smart card development could be a profitable business venture. In November 2002, LG CNS proposed a project blueprint (Lee and Lee, 2013), further highlighting their motivation to implement the technology (RFID card) that they had been working and developing on their own.

In the case of Seoul, the technological actors foresaw the need for such a technology; they did not wait for demands from the political (SMG) actors to develop the technological device. Without saying that the technological actors motivated the transportation reform to happen, we can clearly say that the smart card implementation in Seoul was not demand-pulled.

The ability for Korean firms to develop technological innovations without having to wait for a demand comes from Korea's post-Second World War period. During South Korea's President Jung-Hee Park's rule, from 1961 to 1979, "preferential treatment" was given to a certain type of companies (called "Chaebols") to encourage them to grow and develop their businesses (Murillo & Sung, 2013). During this time the Korean central government awarded these companies some huge and exclusive projects in the fields of military and construction thinking these companies could be the future leaders of the Korean economy. The government also took many measures to give them tax reductions and accord them loans without risk, effectually acting as their credit guarantor (Murillo & Sung, 2013). These huge projects enabled Chaebols to become extremely wealthy, and thus started investing in R&D following the innovation trend that had been launched by the central government. LG CNS is part of LG, one of the major Chaebols of the Korean economy, from which it inherited the tradition of investing in technological innovation and development. The “foster-innovation” economic climate developed by Korean central administration policies consisted of pushing private firms to innovate on their own and was key in making the Tmoney implementation in Seoul transportation system technology-push rather than demand-pull. Of course all institutional changes, such as change of bus routes ownership, were key in the smart card implementation process in Seoul, but they did not create an explicit demand to develop an adequate technology, as the technology existed (see figure 1). However, if the Chaebols gained this ability to innovate, it is mainly because there was this push from Korea’s central government. This is to underline that, when looking at technological innovations, the relation between technology-push and demand-pull is dynamic, and that it is wrong to exclusively choose one of these, and to omit completely the existence of the second factor (Kleinknecht and Verspagen, 1990).

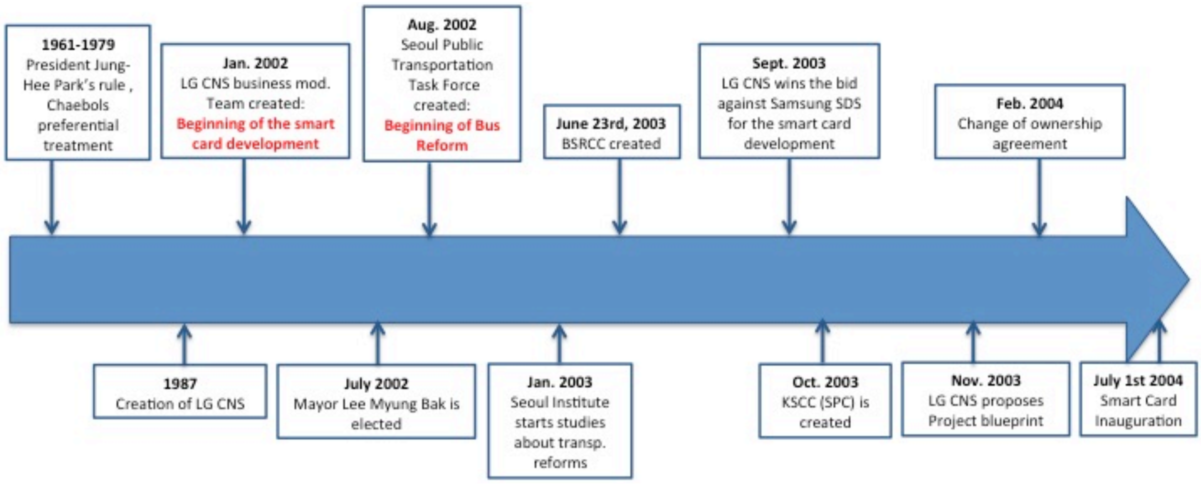

Figure 1: Timeline of Seoul Transportation smart card implementation

We could analyze the case of Bogotá from another perspective; the integration of the transportation system through the SITP project was quite laborious, and did not happen on the whole network at one time (as it did for Seoul, on July 1st 2004). Notably, transportation integration is still ongoing in Bogotá (2500 buses are still not integrated as today). There was a demonstrated need to have a vector for the integration of all public transportation systems in the Colombian capital, and because of its success in Korea, the technologies developed LG CNS were again employed in Bogotá. As such, the implementation of the “Tu llave” card can be regarded as demand-pulled. In Seoul, local technological actors provided the technology; this was not the case in Bogotá where instead foreign technologies were used. In the Bogotá case study, technology acts as an enabler for institutional changes, which presents a strong contrast to the situation in Seoul where institutional changes followed technological development.

In these situations, it is apparent that the technology itself and the associated IoT solutions, are replicable, as the exact same device (Infineon’s Security Microcontroller SLE66 with 4K Memory) was used in both Seoul and Bogotá’s Transportation systems. However, because of the complexities introduced by variable urban contexts, the institutional changes supported by IoT solutions are not so easy to reproduce. More than that, what is not replicable from North to South are the processes making IoT devices come to life. In the North development appears to be much more technology-pushed, whereas a demand-pulled approach is more likely to happen in the South; we believe this is a generalization that can be expanded to other IoT devices implementation in the context of urban transportation systems. For example, smartphone apps for urban transportation might create institutional changes in the North, whereas in the South they will be more likely to support institutional changes. We believe IoT device implementation in urban transportation systems shifts from technology-pushed to demand-pulled when transferred from Northern to Southern urban areas. From the North, the South can learn that IoT solutions can serve as a tool to support institutional changes (even if these institutional changes are different because of different contexts) and improve the provision of urban services, but the South must also recognize that upfront actions and long-term policies are necessary to fully benefit from all aspects of an IoT solution; with this, development becomes technology-pushed rather than demand-pulled, resulting in more straight forward IoT devices implementations.

Conclusion

Further research needs to be conducted regarding the applications of other IoT devices, and more generally in reference to the implementation of technological innovations, in order to assess the generalization of the shift from technology-pushed to demand-pulled when technologies are transferred from North to South. Research must also be conducted in order to analyze the population's perception of such IoT solutions, as in this case the Columbian and South-Korean populations may exhibit different reservations when it comes to data privacy issues.

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