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Performance of an internet of things project in the public sector: The case of Nice smart city

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1. Introduction

The study of the smart city concept (e.g. Caragliu et al., 2011; Chapin, 2012; Morandi et al., 2015) suggests that one common model does not exist but different approaches or phases which encompass the implementation of intelligent mobile applications, interactive display screens in the city, or a ubiquitous Wi-Fi infrastructure. Recently, Richter et al. (2015) suggest to consider smart cities as an environment for entrepreneurship and an answer to the decrease of public investments capacity. The Internet of Things (IoT) is the most hyped technology in growth today according to Gartner (2015) and provides a lot of possibilities for the private organizations to develop services claimed by the City Hall to support the urban development (Hoppe et al., 2013). Nevertheless, the fact that many IT projects commissioned by governments and executed by private companies failed, have motivated researchers to investigate the underlined problems of governance and poor performance (Patanakul, 2014).

Rong, Liu, & Chen (2016) and Rong et al., (2014) analyse the governance of public-private partnership in the specific cases of the implementation of IoT projects for the city. Nevertheless, the literature is scanty to holistically evaluate the impacts of a smart city IoT-based project. In our study, we propose to fill this gap. By evaluating the benefits of an IoT project through the prism of societal, environmental and economic perspectives, we determine and classify the contribution of the different stakeholders and conclude on a governance model for this type of project. Our findings highlight also the important role of the citizens in the performance of this public-private partnership. Our methodology is based on the evaluation of an IoT-based parking solution developed in Nice (France) classified 2nd in the Juniper Research World ranking of smart cities behind Singapore (Juniper, 2016).

2. Literature Review

2.1. IoT platform of services

Platform is a very popular term in the scientific literature. Cusumano and Gawer (2002) and Gawer (2009) show the first usage of the term was in the context of new product development and incremental innovation around reusable components or technologies. Then, the term was used to describe management phenomena like industry supply chains, markets or constellation of industries. For our study, we consider a platform as a cluster of technically standardized components that are used together with complementary components for making services (Greenstein, 1998). While in the 1990s and early 2000s, Windows, Java and .Net were described as platforms, today Android and iOS are considered as first-class ones (Engelbrecht et al., 2015). Many, if not most, start-ups build their complete service portfolio with smartphones as the primary user interface that they consider as the state-of-the-art. They communicate with their customers, find new ones as well as retain them as services developed around social media platforms like Facebook or Twitter (using for example targeted e-coupons campaigns). Previously, those services would have been designed as web applications and their go-to-market would have been to address their clients alone. Today, the strategy is to use these very famous and crowded platforms.

Sundmaeker et al. (2010) named Internet of Things (IoT) as the third phase of the internet revolution, after the World Wide Web (www) in the 90’s and the mobile internet in the 2000’s, stressing this last technology as the most disruptive one. McKinsey (2014) estimates that there exist more than nine billion connected devices in 2014 and outlooks 50 billion by 2025. This growth of connected devices creates endless possibilities in terms of how to apply the IoT emerging technology. Connected cars, smart connected homes, smart electricity grids and meters, smart parking solution, connected pacemakers and data-driven maintenance in factories are just among a few of the possible use cases (Sundmaeker et al., 2010). For our study, we name an IoT platform of services as performing the following three functions: (i) managing and controlling devices connected to it, (ii) gathering and storing data from those devices, and (iii) offering tools to develop, publish and use applications benefiting from the gathered data (Balamuralidhar et al., 2013).

2.2. IoT platform based smart city

Scientists observe two major trends that lead to a human congestion in the city: the global population is increasing drastically and the inhabitants move from rural to urban zones (UNPD, 2001). In Europe, in 2009, the urban population was yet 70% of the overall (DESA, 2009). Due to this frenetic expansion, cities are responsible for 75% of the overall resource consumption even if they occupy only 2% of the land (Madlener and Sunak, 2011). The City Halls are coping with preserving the environment, giving acceptable conditions of life to the citizens sharing a space smaller and smaller and with resources more and more limited. As a possible answer, they deploy connected sensors (IoT devices) at different places of the territory to collect and analyse the data for better urban planning and development. Cities that use the technology to improve the quality of life for their citizens are usually called Smart Cities (Caragliu et al., 2011).

IoT allows the collection of data which transformed into information makes possible to monitor and manage the urban services of bicycles pool sharing, public parking, water consumption, air or noise pollution or vehicular traffic (Vojnovic, 2014). They generate business opportunities for companies or entrepreneurs who develop through a common platform, services to the citizens or the public authorities (Grimaldi and Fernandez, 2016; Richter et al., 2015). They are perceived as the biggest incentive for building smart cities (Badalian, 2015; Gubbi et al., 2013) and their deployment responds to five types of urban needs (Jin et al. , 2014):

1. Vehicular traffic information allows the citizens to know the path and the travel duration to reach their destination based on the current intensity of traffic and the average speed of the vehicles. Government can use this information about blockage or accidents to take in real time actions to manage the traffic, alert the police, traffic authorities or hospitals.
2. Weather conditions information like temperature, rain, humidity, pressure, wind speed and water levels at rivers, lakes, dams and other reservoirs allows the authorities to prevent flood, snow melting and dam breakage and correctly manages water reservoirs in advance to meet the need of the water to the citizens.
3. Nearest free slot of car parking information aims at reducing the fuel consumption of vehicles and decreasing the time wastage which can be spent differently, in the market place or in other activities such as leisure or sport.
4. Environment pollution information including gases information such as metals, carbon monoxide, sulphur dioxide, ozone allows to generate alerts when any of this polluted gas is exceeding authorized threshold in the environment. It allows to take necessary actions to protect children, old age people, people for physical exercise or already sick people.
5. Cameras installed in the city monitor the human activities and provide relevant information for security concerns. Even if it is very challenging to analyse the videos and it needs the use of analytics software, the benefit is to detect any mishap with anyone at real time such as robbery, car stolen, purse stolen, fighting, or to react against any illegal demonstration or people gathering.

Each company who uses the platform to offer its services, has his own industry value chain (Porter, 1991) and the consequent platform is described as a ´socio-technical system of systems´ (Ojo et al., 2014) more complex structure than the Porter’s one. The question of its governance becomes so a paramount issue.

2.3. Governance of an IoT platform of services (Smart City platform)

According to a definition of the World Bank (2017), governance ´includes (i) the process by which those in authority are selected, monitored and replaced, (ii) the capacity of the governing body to effectively manage its resources and implement sound policies, and (iii) the respect of citizens and the state for the institutions that govern economic and social interactions among them´. Broadbent and Weill (1997) argue that ´IT governance is about who is entitled to make major decisions, who has input and who is accountable for implementing those decisions. It is not synonymous with IT management. IT governance is about decision rights, whereas IT management is about making and implementing specific IT decisions. ´

Before the emergence of IoT technology, the question was raised with the issue of Internet and the corresponding working group defined governance as ´the development and application by governments, the private sector and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures, and programmes that shape the evolution and use of the Internet´ (World Bank, 2005). Weber (2009, 2013) offers a vision of the governance related to an IoT platform of services. He concludes to the concept of ´multi-stakeholder governance´ as the new way forward in favour of the inclusion of the whole society. He adds two main approaches are possible: a top-down/centralized one where a single body is coordinating the rest of the actors or a bottom-up one leveraging horizontal exchanges between actors. He adds however that it does not exist a best approach but each context needs a customized solution based on the technical environment and the given societal situation. Sambamurthy and Zmud (2000) propose a platform logic model to describe the IT governance for both situations. They based their analysis on three elements that they call IT activities, integration and relational structures.

In an IoT platform of services, the activities are performed by each participant who is specialized in a task. What platforms have added is to allow a mediation between heterogeneous smart devices that diverse applications are enabling them to interoperate and to constitute an integral part of the solution (Basole, 2009). The relational structure is an e-architecture based on standard internet technologies that make the smart things and people are all connected and can communicate with each other (Atzori et al., 2010). The integration architecture is top-down, led by the City Hall that defines and builds the structure that the urban companies use to develop their activities in a fast and agile way.

Schwarz and Hirschheim (2003) propose to add the success of the governance arrangements as a new dimension of the platform logic model issued by Sambamurthy and Zmud (2000). Agarwal and Sambamurthy (2002) echo these works and agree the success criteria is a relevant aspect of the governance stressing this is not a trivial issue to make IT respond successfully to the environment within which it exists. We consequently notice that one of the most critical governance challenges for an IoT platform is to evaluate the performance and the real impact for the different parties involved. Since the IoT platforms are relatively new (Murthy & Kumar, 2015), only few studies have been conducted to measure their benefits. However, the type of gains is different if it concerns citizens, public sector or private company. As a possible answer, Caragliu et al. (2011); Meijer and Bolivar (2015); Miller and Hanzel (2007) suggest that satisfying the growing needs of the city require city managers to balance three overriding concerns, namely quality of life, environment and competitiveness. We agree on their proposition and decide to evaluate the performance of an IoT project through the achievement of societal, environmental and economic objectives while classifying the contribution of the different stakeholders to conclude on a governance model for this type of project.

2 Methodology

To answer to the question, we decide to orientate our epistemological works on selecting the case of a Smart City which for its topology make possible the extrapolation of our findings to others in the world (to some extent as we detail in the conclusion section). For our study, we have decided to analyse the case of the IoT platform installed by Nice city, the French Riviera capital classified 2nd in the 2016 Juniper Research World ranking of smart cities behind Singapore (Juniper, 2016). The active role of the Nice City Hall in spite of weak capacity of investment, the huge number of private companies and active citizens and the ambition demonstrated in the IoT project make us shortlisted this urban organization amongst others.

2.1 The case study of Nice city

In 2010, Nice presented an ambition of sustainable, environmentally friendly economic development for the city. This vision led to the smart city project called ’Connected Boulevard’, initiated by Nice Cote d’Azur metropolitan authorities and Nice City Council. The purpose of the project was to improve the efficiency of public and private transportation within the city, in addition, to provide citizens with new services and facilitate the economic growth of the private sector. From June 2011 until end of 2015, thousands of wireless sensors were installed in streetlights, dumpsters, parking spots and high traffic roads around the city. The sensors were constantly monitoring and sending data about the activity in the city. The network of sensors was tied and managed together by a cloud-based software platform that made the solution ubiquitous in the whole city. Nice IoT platform of services has a multi-functional purpose and is not only application/service provider oriented. It adds value to citizens by providing real-time information on traffic, transportation, wastage, air/water quality etc. countering the problems faced by cities due to rising population and urbanization. Additional services to improve city management and the everyday lives of the residents of the city were deployed during 2012-2015. They included smart street lighting and smart waste management.

2.2 Nice IoT-based governance model

Faced with unprecedented budget issues, Nice City Hall decides to create a more effective and efficient operating model by moving away from top-down management and breaking down ´siloed´ service functions and departments. They develop a new vision of provisioning the service from a products-and-services procurement model to a ´service per use´ one (Hoppe et al., 2013; Scott and Scott, 2015). The development of the technology infrastructure and management of the data are out-tasked to a public-private partnership whose objective is to leverage the data and provide actionable insights related not only to the performance of the different flow networks (cars, people, light, waste....) but also to the level of interactions between the networks and the environment around them. The source, configuration, and delivery of IT capabilities i.e. the relational structure of the IoT governance is based on an inter-organizational relationship between private companies (Choudhury et al., 1999).

Nice city managers lead the collaboration between industries and companies that were not connected before. They act as hubs where the contributors of the IoT platform are the providers of the solution components. The integration structure is done by the City Hall that binds together a multi-stakeholder’s relational architecture into a coherent organizational form (Brown and Sambamurthy, 1999).

2.3 The parking services component of the IoT platform

Tesoriere et al. (2014) argue the public parking is becoming an expensive resource in almost any major city in the world, and its limited availability is a cause of the deterioration of the urban mobility. Assadian and Nejati (2011) add mobility service is one of the major challenges to cope to improve the quality of citizens' life in big cities. They develop their argument saying that traffic, congestion and accidents reduce urban productivity. Accordingly, we decide to analyse the solution of parking services offered by the IoT platform and to operationalise the quality of citizens' life through the variable of traffic accidents rate. Debnath et al. (2014) developing a smart transport systems framework compare 26 cities in the world (London, Paris, Singapore, Seattle, ...) and determine a ´smartness´ ranking. They include indicators like traffic accidents rate, traffic density or speed. Their approach corroborates our decision to choose the traffic crashes factor as a proxy of good living in the Smart City.

Hypothesis H1: the implementation of an IoT platform that shares information about parking services in the city improves the quality of life for the citizens by reducing the number of traffic crashes.

Nice IoT-based parking solution leverages the Cloud network and Wi-Fi connections deployed by Cisco. Urbiotica, an IoT company based in Barcelona provides the most central element of the solution developing and installing the physical sensors attached to the parking slots. Prismtech provides the software to develop the platform of services where all the components are integrated. The technical management of the project is done by Mentis services, a French and local company. Inqbarna provides the mobile application and enables that the parking availability information is also available on a mobile companion and through two different versions: IOS and Android OS (after the second phase of the project as we will explain later). The solution includes other application developers to offer a rich-content application like Meteosim the weather applications developer, Mappy the geographic information systems provider and, GeekGaps the translation service developer. The local and central French governments through its policies of open-data provide with information about the number of traffic accidents and the air pollution condition. The figure 1 draws the parking component of the Nice IoT platform.

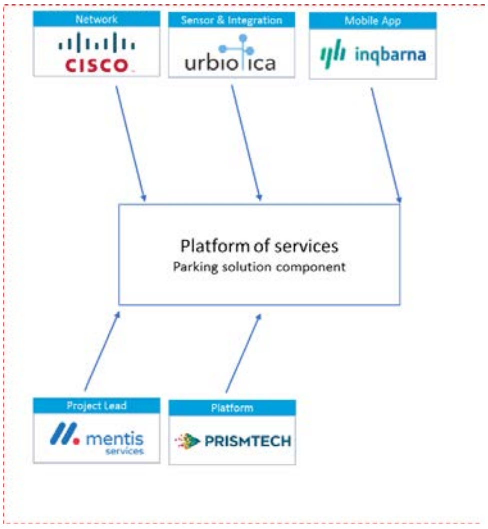


Figure 1: Nice IoT-based parking solution

2.4 Hypotheses H2 and H3

Tesoriere et al., (2014) observe that the so-called ´traffic cruising´ (i.e. vehicles in the traffic flow that are seeking for free parking) results in a 20–45% increase in the pick of the traffic flow, the generation of queues and causing the deterioration of air condition. Emmino (2012) presenting estimates from San Francisco project confirms that cruising is the reason for 30% of traffic in downtown, but concludes a smart parking solution can largely reduce it. Therefore, we decide to analyse the impact of the parking services offered by the Nice IoT platform on the air quality respired in the city. Since epidemiological studies converged that NO2 high proportion level is associated with adverse effects on respiratory health (Brunekreef et al., 1997; English et al., 1999; van Vliet et al., 1997), we decide to measure the environmental success of the parking solution through the reduction of the NO2 pollution rate in the atmosphere.

Hypothesis H2: the implementation of an IoT platform that shares information about parking services in the city improves environment condition decreasing the NO2 pollution.

The IoT solution aims at making easier the search of a parking slot and citizens who did not want to take their car unwilling to spend too much time ´cruising´, may change opinion trusting to this technological advancement to park easily in the city. Business wise, it is so an opportunity to generate new parking revenues. We decide to test the business value creation offered by the Nice IoT platform analysing the revenue perceived by the parking services company. For this purpose, we consider the rotation of parking slots (empty-full-empty) as a proxy of this incremental economic value.

Hypothesis H3: the implementation of an IoT platform that shares information about parking services in the city increases the revenue captured by the parking company that provides the service.

We totally extracted more than 32 million transactions from the platform. It was an excessive volume of data for a standard office tool so that we decided to utilize a relational database to generate the datasets for the different hypotheses.

2.5 Data and instruments for the Hypothesis H1

To test H1, we define a model considering four different geographical areas. The first zone is our reference and is a specific downtown zone of Nice city, unique receiver of the parking sensors implementation. We call it in our paper ’Nice City Inside’ and compare it to three other geographical areas: a peripheral zone of Nice that is not impacted by the IoT Platform implementation that we call ’Nice City Outside’ and two other French cities with no similar smart city project: ’Marseille’ and ’Toulon’. We choose these two cities for their common characteristics with Nice: southern part of France, population size, on the coast of the Mediterranean Sea and sunny climate. Comparing ’Nice City Inside’ area with these three control groups permits to analyse the role played by the IoT platform implementation.

We choose the number of traffic accidents as the variable to evaluate the impact of the IoT platform that shares information about parking services in the city on the transport services. We use the data coming from the French government website called ‘data.gouv.fr’ that offers official records of traffic daily accidents in France. The period considered is between 2010-2014. We consider also for this study a timing scale based on two phases of the project: the one covers 01/06/2011 to 31/12/2012 when the number of sensors varies between 0 and 1.588 and another one afterwards: 01/06/2013 to 31/12/2014 when the number of sensors is between 1.612 and 4.953. Each phase has a similar calendar profile (from June to end of the following year) and counts 19 months. Comparing these two phases aims at isolating the role of the unique fluctuating variable which is the number of sensors and so, eliminating other factors that may play a significant role in the pollution or the traffic congestion of the city. Doing so, we concretely neutralize parameters like holiday period, national or local feast, seasonality of the business activities, or daily workers’ commutation.

Each observed phase has 579 days or points. We need to compare the data coming for the 4 geographical areas as already mentioned. We aggregate the traffic accidents data at month level to be consistent with the standard rules used to publish traffic statistics in the country. The 579 observations for each of the 4 areas become 19 points by phase. We build a matrix compiling for the four areas 19 traffic evolution rates dividing month-to-month the number of accidents between the two parallel phases of the study. The total sample size is so: 4 x 19 = 76. Since the size of the sampling is low, we need to verify if it follows a normal distribution so as to apply the corresponding statistical models. The Shapiro Test returns us that in spite of less than 30 coordinates, the four areas follow a normal distribution. Therefore, we can conduct a T-test analysis and check if the mean rate of ’Nice City Inside’ data is statistically lower to the other three areas. By this way, we determine if the implementation of the IoT platform in ’Nice City Inside’ has the effect to reduce the numbers of traffic accidents.

2.6 Data and instruments for the Hypothesis H2

We measure the impact of the IoT platform that shares information about parking services in the city on the urban living services analysing the evolution of the NO2 pollution. The French governmental organization ’Air Paca’ has several air pollution sensors installed in the South Region of France. In Nice, they have four sensors installed 1) In the city, 2) along the highway M6098 connecting the city to the airport, 3) in a suburban area outside the city centre and 4) close to the airport. The different sensors are categorized according to the nearby environment, such as traffic, industrial or urban. Nevertheless, no pollution sensor has been installed in the ’Nice Inside Zone’ and consequently we can’t measure directly the pollution in this specific area.

As a workaround, we conduct a two step-based approach a) conducting a regression linear between NO2 pollution and the number of accidents taking as reference the highway M6098 sensor and b) leveraging H1 test that checks if a relationship exists between number of accidents and the IoT platform implementation. The combination of these two steps (pivoting around the number of accidents variable) make possible to test H2 i.e., if a relationship exists between the NO2 pollution and the IoT platform implementation. The highway M6098 sensor is chosen since it is the unique in Nice to be tagged as traffic by Air Paca. We collect data of pollution from the start of 2012 until end of 2014 that we aggregate according to the 24 hours of a full day to have a consistent sampling.

2.7 Data and instruments for the Hypothesis H3

To test H3, we decide to estimate the creation of economic value for the parking services company using the variable of rotations from empty to full parking position. Indeed, the more rotations are produced, the more financial revenue is generated since the parking is occupied. For this hypothesis, we work closely with Urbiotica which feeds us with sensor’s location and installation date and parking event transactions. These data are extracted from an Apache Hadoop database (big data analytics) designed by them for Nice and which contains each transaction event, its timestamp, its location and its nature (a car is leaving or arriving at a parking spot). By combining the arrival and leaving event, we are able to calculate the duration of a parking session and count the rotations.

We collect the rotation counts between 01/06/2011 and 31/12/2014 considering the two phases of the project. We aggregate the rotation counts at day level and calculate the rotation index dividing the daily rotation counts by the correspondent number of sensors. This index aims to evaluate if the rotation of the parking slots goes faster than the automatic increase of rotation counts due to the on-going deployment of new sensors all along the implementation project. The mobile application ’Nice City Pass’ developed by Inqbarna went live in 01/06/2013 i.e. two years after the start of the ’Connected Boulevard’ project and at the beginning of the second phase. Therefore, the analysis of the rotation index during the second period of the study and the comparison with the first phase indicates how the users moderate the process of value creation. In other words, we assume that the daily rotation index provides also on the pace of the users’ adoption of the IoT platform through the mobile channel. We test H3 using multiple regressions between the rotation index and the number of sensors.

3 Results

3.1 Results of the Hypothesis H1

After processing the 579 observations, we got a sampling of 76 aggregated data split across the four geographical areas (Nice City Inside, Nice City Outside, Toulon and Marseille). The Shapiro Test returns us that in spite of less than 30 coordinates, the four areas follow a normal distribution. Therefore, we conduct a T-test analysis whose results are in the table 1. The first two parts of table 1 shows at 0.9 level of significance that the means of the number of accidents of ’Nice City Inside’ is statistically significant lesser than the two other cities Toulon and Marseille without IoT sensors in the car parks. Therefore, the implementation of an IoT platform that shares information about parking services in the city reduces the number of traffic crashes. H1 is therefore validated. On the other hand, the third part of the table 1 shows that the null hypothesis of the two independent samples means between 'Nice City Inside' and 'Outside' is accepted. In this case, we carried out the Welch's t-test because the variances of the two sample are not equal. Therefore, there is no statistical significant difference in the mean between the samples 'Nice City inside' and 'Outside'. These results suggest that the average evolution rate of accidents in both zones of Nice city are the same.

Table 1: Results of t-test and Descriptive Statistics for Accidents by Sensors

	Sensors						90% CI for Mean Difference		
Part 1	Nice City inside			Toulon					
	M	SD	n	M	SD	n		T	df
Evolution rate of accidents	.85	.22	19	.99	.20	19	-Inf, -.06	2.19*	36

	Sensors						90% CI for Mean Difference		
Part 2	Nice City inside			Marseille					
	M	SD	n	M	SD	n		T	df
Evolution rate of accidents	.85	.22	19	.97	.10	19	-Inf, -.05	2.19*	36

	Sensors						90% CI for Mean Difference		
Part 3	Nice City inside			Nice City Outside					
	M	SD	n	M	SD	n		T	df
Evolution rate of accidents	.85	.22	19	.92	.16	19	-.18, 0.03	1.23	33

* p < .1

3.2 Results of the Hypothesis H2

After analysing the gathered data visually, we decide to create two models separating the number of accidents data between weekday and weekend periods and to conduct two simple linear regression analysis to test the relationship between the number of accidents and the NO2 pollution. All the results are presented in the table 2. There is a positive relationship between traffic accidents and NO2 pollution and the NO2 variable explains 41% of the traffic accidents variance during the weekends and 51% during the weekdays.

Table 2: Results of Simple linear regression analysis

	Weekends	Weekdays
Intercept	-21.402	-9.475
NO2	1.359***	1.442***
R-squared	0.413	0.508
Adjusted R-squared	0.408	0.501

n	138	69

***p<.001

We have demonstrated with H1 that the sensors implementation and the traffic accidents are negatively correlated. Moreover, the table 2 shows the positive relationship between the NO2 pollution and the traffic accidents variables, so pivoting around traffic accidents we conclude the NO2 pollution decreases along with the sensors implementation. The implementation of an IoT platform that shares information about parking services in the city decreases the NO2 pollution improving environment condition. H2 is therefore confirmed.

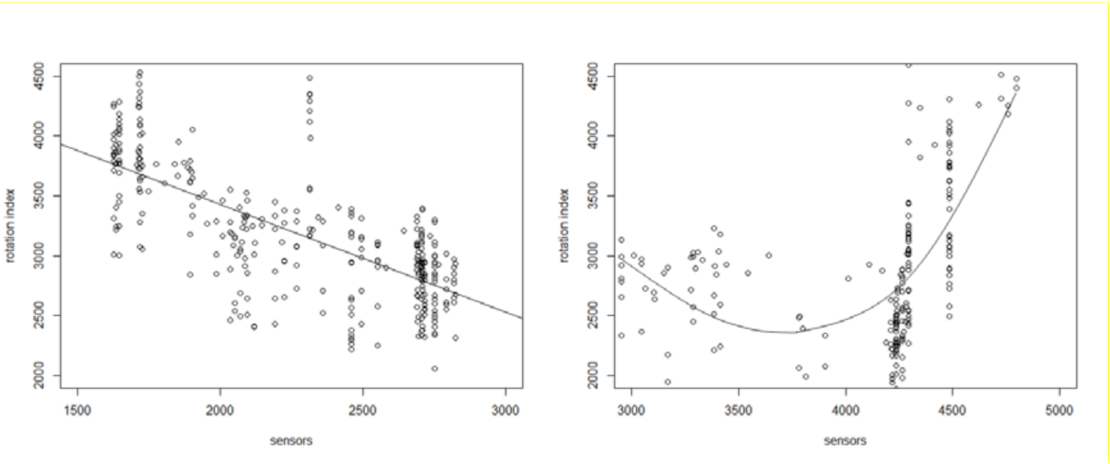
3.3 Results of the Hypothesis H3

After analysing visually, the gathered data between the daily rotation index and the number of sensors, we decide to conduct a simple linear regression for the first phase of the project and a quadratic regression analysis for the second one. The results are gathered in the table 3. In the first phase, the rotation index decreases over time with a significant drop and the results of the regression analysis shows that the sensors implementation explains 50.4 % of the rotation index variance. In the second period, the results of the regression analysis indicate that the rotation index increases over time in a quadratic way. Focusing on this second phase, we highlight a non-significant slope after the go-live of the mobile application for around 6 months (between 3.000 and 4.000 sensors milestones) then an important increase over time (with a factor of 4.9) between 4.000 and 5.000 sensors milestones. Moreover, the implementation of the sensors explains 70.4% of the rotation index variance in phase 2 and 50.4% in phase 1. The dependency between the number of sensors and the rotation index is visualized in the scatter plots of each period (figure 2).

Table 3: Results of Polynomial linear regression analysis

	Phase 1	Phase 2
Intercept	5233.4	-1.179e-14
Number of sensors	-.902***	-9.391***
Number of sensors squared		9.926***
R-squared	.504	.704
Adjusted R-squared	.503	.702
n	332	241

***p<.001



Phase 1 Phase 2

Figure 2: Sensors versus rotation index of both periods

The results of the table 3 show the relationship between rotation index and sensors is positive once 1) all the IoT platform is fully available including the 'Nice City Pass' phone application and 2) after a stabilization period of around six months (after 4.000 sensors milestone) in the phase 2. This means that under these two conditions, the more sensors are implemented, the more rotation of parking slots occurs and consequently, the more revenue is accrued for the parking private company. In other words, the implementation of an IoT platform that shares information about parking services in the city increases the revenue captured by the parking company that provides the service. The hypothesis H3 is confirmed but taking into consideration these two previous conditions.

4 Discussion

The aim of our study is to evaluate the performance of an IoT project through the achievement of societal, environmental and economic objectives while classifying the contribution of the different stakeholders to conclude on a governance model for this type of project. We issue three hypotheses that we translate into the case of Nice city.

4.1 New business model of the parking services company

Porter (1991)'s strategic management works reflect it is the managerial responsibility to achieve competitive advantage through optimizing internal resources while capturing external opportunities and avoiding external threats. The business model of the parking services is not strictly aligned with this theory since the IoT sensors deployed by Urbiotica and the mobile application developed by Inqbarna are both external resources but their actions increase the revenue captured by the parking company. We thus observe the parking company can’t be considered as a stand-alone business but depend on others for its performance. The relational and integration structure (Schwarz and Hirschheim, 2003) extends the simple collaboration between providers specializing in a task. We observe a phenomenon which has been previously analysed in the Strategic Management literature as the conditions of a business ecosystem (Iansiti and Richards, 2006) where each participant has its own role and purpose but strives for a shared goal. This objective is here to provide information to the citizens about the parking slots availability in the city.

Carrying on our analysis, we apply the recent works realised by Adner (2013) about the process of value creation and for the first time in the context of an IoT platform-based model. Accordingly, we observe that the IT capacities of this ecosystem can be separated into two streams. Upstream suppliers like Cisco, Urbiotica or Mentis, etc. who form the component of the solution while delivering their proper services. They are integrally part of the IoT platform of services which gives a complete service to the citizens. Downstream suppliers like Inqbarna, weather application Meteosim, geographic information systems Mappy who play a complement role and whose value is integrated by the final user along with the IoT platform one. The figure 3 presents the governance model of the Nice IoT-based parking solution.

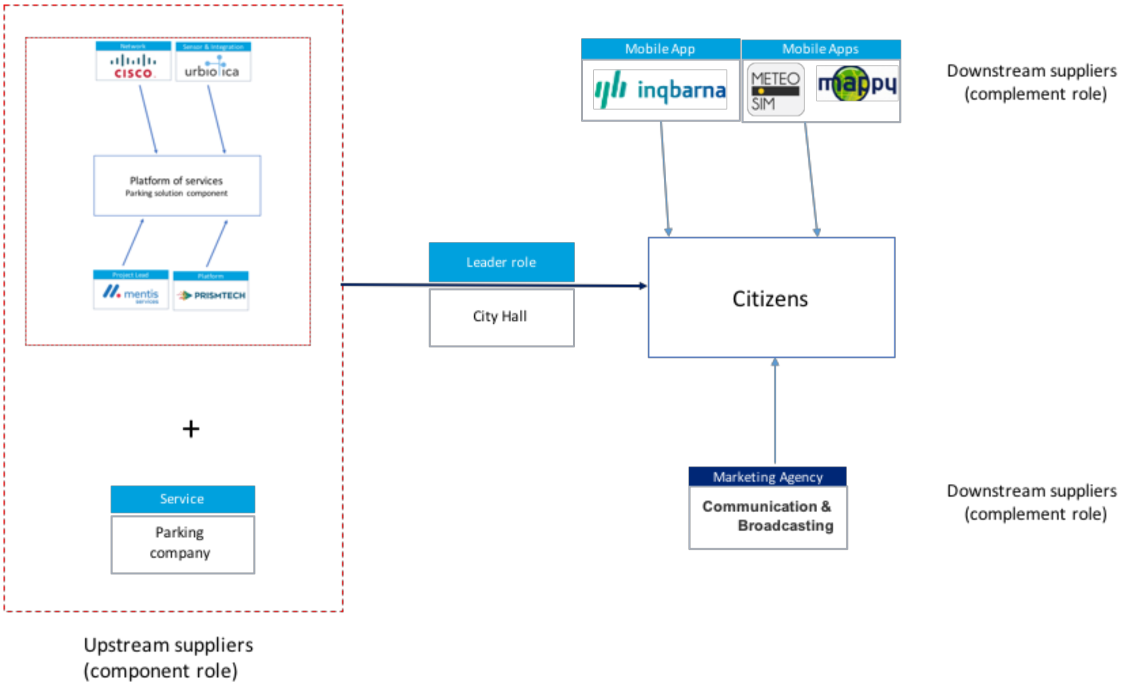
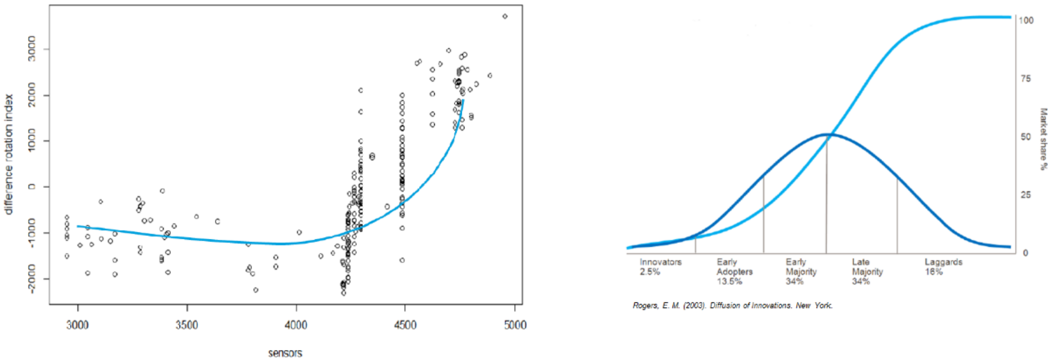


Figure 3: Governance model of the Nice IoT-based parking solution

The results of table 3 also suggest the citizens play an active but complex role in the IoT platform implementation. In the first phase, when the ’Nice City Pass’ is unavailable, there is a negative correlation between the rotation index and the number of sensors. The IoT platform is not adopted by the citizens and its implementation doesn’t increment the parking rotation frequency. The unavailability of the mobile application is a clear bottleneck for the IoT Nice project. Our findings confirm that a phone application plays the role of corner stone for a successful implementation of an IoT platform ecosystem (Zahra and Nambisan, 2012).

Next step is during the summer period of 2013, at the beginning of the second phase’, the ‘Nice City Pass’ mobile goes live and till 4.000 sensors milestone (six months later) our results still show a slight descent and the expected growth of rotation index is still not happening (see phase 2 of figure 2). We analyse that even if the mobile application is available, it still needs a period of six months for the citizens to be known, accepted, positioned in their daily life and used. This finding echoes with Moore (2014)’s work about the three stages of the innovation: adoption, implementation and use. In our case, we guess the technology familiarisation is one of the barriers that make difficult the implementation and to cross the famous ´chasm´ of the innovation (Moore, 2014). Then, the next period (after 4.000) shows a positive correlation between the rotation index and the sensors increase. If we visualize the rotation index curb (figure 4), the shape reminds the Rogers’ S-curb diffusion model (2003). Future investigation needs to be done to collect more recent data about this project to confirm if the diffusion process follows the next S-curb theoretical steps of saturation and decline.



Rogers, E. M. (2003). Diffusion of innovations. New York.

Figure 4: Rotation index rate versus Rogers’ diffusion model of innovation

4.2 A safe driver is a connected one

We know that the sensors implementation and the traffic accidents are negatively correlated (H1 validated) but we unexpectedly observe that statistically there is no significant difference of the traffic decreasing rate between ’Nice City Outside’ and ’Nice City Inside’. The impact of the ’Connected Boulevard’ initiative covers the whole Nice city extending its benefits outside the limited targeted zone of sensors implementation. Nevertheless, it does not reach the two other cities dozens of kilometres away. We notice also that even if the citizens pay attention with their mobile companion while driving, they cause less accidents than without doing it. This result contrasts with recent studies.

Indeed, Chan and Singhal (2015); Petridou and Moustaki (2000); Stutts et al. (2001) comment that the primer reason for traffic accidents is distracted drivers, accountable for at least 35-40 % of all accidents. Their research shows that the sources of distraction causing traffic accidents are 25% coming from an outside person, an object on the road or an event like another accident. Amongst the possible objects, they emphasize that searching for a parking spot is one of the most common distraction. Our results show the opposite and opens a controversy debate, suggesting that drivers using their mobile cause less accidents. The reason could be that going straight forward to their ’expected’ parking, they conduct less, are more informed and less stressed and consequently do not act imprudently and react better to any uncontrolled event, causing finally less accidents.

5 Conclusion

Having validated the three hypotheses, we globally observe that an increased rotation of the parking slots which means mechanically an augmentation of the overall traffic improves unexpectedly the air quality condition and reduce the traffic accidents. These results diverge from the conclusions of other studies who state that an increase of the traffic deteriorates the atmosphere condition (Díaz-Díaz et al., 2017; Tesoriere et al., 2014). The case of Nice introduces for the first time a governance model based on a triple-positive correlation between the concepts of business value creation, quality of life, and environment (figure 5). The Nice smart city project has set an innovative governance around an IoT-based implementation project, developing business opportunities for entrepreneurs meanwhile protecting the environment and improving the quality of life for their citizens. The company offering a service in the city captures new source of revenue developed by an ecosystem led by the City Hall and in which other stakeholders provides additional value that it benefits indirectly. This model constitutes a best practice that we recommend to city managers to analyse for a possible replication in their urban area.

We know that our governance model could be extended considering additional variables such as parking slot availability time, street lighting intensity, traffic speed and time needed to find a parking slot. Further investigations by including these factors could investigate if a smart city IoT-based project decreases the parking slot availability time for instance. They could so determine if a connected citizen parks more time and profits better the commercial or leisure opportunities that offers the centre of the city. It could help to understand the external variables that influence the financial health conditions of the urban retail businesses. Finally, our goal was to analyse a possible relationship between three concepts of different nature and our epistemological approach consisted on validating it through the outstanding case of Nice and its solution for parking guidance. Despite the specific characteristics of Nice's situation, a sea-side metropolis of 300+ thousand inhabitants with a large proportion of built or grey infrastructure, we think that our methodology can be reused to analyse the situation of other cities and smart projects in the world and to discuss the new model that our article has introduced.

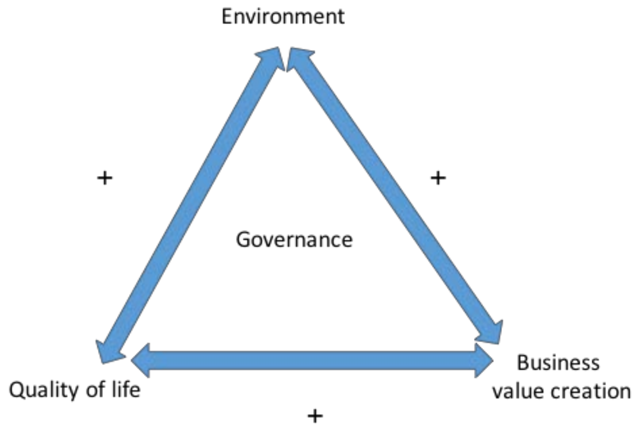


Figure 5: Triple relationship governance model

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