Big Data Management and Smart City: From Affordance technology perspective view size

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Abstract. Cities are aware today more than ever by the value of new technologies to develop effective and sustainable services for citizens, visitors, and businesses in all areas of the territory, this awareness is based on the inclusion of technology in the socio-economic formula by integrating modern analytical tools to analyze massive urban data to capitalize on valuable insights about key strategic performance indicators for the success of city model. This paper's main contribution is to explore big data analytics adoption in smart city model using affordance theory and providing an example of the use of technology affordance perspective as one of the concepts that has been adopted in a variety of studies that used to describe and analyze the potential enabled affordances for actions that arise from the relationship between a technological artefact and goal-oriented actors of Big Data Management tools and how adopting a high-level big data smart city driven strategy can unlock new technological and business potentials.

1 Inroduction

The use of big data management tools playing a major role in managing traditional city services (water, electricity, public facilities, buildings…etc.) to contribute to sustainable growth, improve the quality of citizens life, the economic development and tourist attractiveness of communities. In this exponential context of the use of Urban Big data management tools where cities must develop a new vision with a clear roadmap to adopt a new cultural and technological shift and develop a broad conception about how adopting the use of Big Data framework can help to handle the anticipated future city challenges. With the emergence of big data management tools and "social" technologies that facilitated the social interactions between citizens and communities. a new vision of government communication has been activated, based on direct bilateral exchange between local administration and citizens without any usage limitations. Within this context cities are invited to develop new management patterns based on the intersection of these main components to improve relations with citizens, promoting tourism, local culture or developing the economic attractiveness and the activity of businesses and traders in the city, based on a broader understanding of delivering and rating new or existing local services, via engaging citizens in a top-bottom participative approach, Among the technologies that has been identified as a key tool that support the smart city vision goals, is Big Data Analytics tools, that comes to present key answers to those essential lived challenges in the city by adopting the classic big data framework pillars and the technology affordance perspective. This article explores how big data technology can play major role in defining the smart city model, discuss at what level governments and city administrations are ready to adopt this new technological and cultural shift related to the use of big data tools in managing city services, and analyzing urban data, but also highlight the management mechanisms to be used to achieve desirable transformational outcomes, and encountered challenges by adopting the theory of technology affordances. Following this introduction, the next section starts out by aligning the concepts of Big data management and Smart city together and presenting different links between them, the subsequent section presents the technology affordance model and establishes its usefulness as an important factor to understand the technology potential that comes from a goal-oriented behavior and turns into concrete actions, the goal of this section is to explore the different challenges when applying smart city model in intersection with different stages of technology affordance perspective and the classic Big data framework. Finally, the last section offers up some conclusions about the future of management of big data tools in relation of smart city concept.

2 Big Data and Smart Cities

Today, advances in technologies ranging from sensors to big data to artificial intelligence are making smart cities a reality. In theory these smart, and connected cities could reduce pollution, improve cleanliness, solve parking problems, and save energy. In practice, however, the implementation of this concept faces several problems. However, thanks to Big Data

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analytics tools, this utopian project could finally come to fruition. This reality has been approved via many applications that comes to answer these technical and organizational challenges related to business and socio-economic questions. and confirm the importance of employing technologies in several domains of city to improve the delivery of public services, attend citizens demands, and measure the consumption of city resources. These emerging, and continuously growing initiatives are known as Smart Cities, which aims to increase the overall citizens quality of life, to better the way citizens and local community interact with urban spaces, services, and with each other.

2.1 The adaptive city

The world population is expected to reach 9.7 billion people in 2050 according to the latest UN studies, compared to 7.7 billion today. Some projections also specify that, within 30 years, the city will constitute the living environment of 2/3 of humanity. This rapid urbanization phenomenon raises major economic, social, and environmental challenges that the smart city model must meet.

Based on its original design that include the integration of smart and connected tools, artificial intelligence and IoT, the smart city must adopt an agile model of living and that take advantage of technology for more livable and sustainable cities.

2.2 Big Data at the heart of Smart City model

Big data solutions provide functional and technical controls for large amounts of data, it comes to introduce an extra layer into the classic data infrastructure. In addition, big data systems enable the use of new capabilities in cities.

The concept of smart city has introduced fundamental layer of operations related to the following elements:

2.2.1 Infrastructure layer

Represent the infrastructure and equipment as sensors and connected devices used to deliver better city services.

2.2.2 Management Applications

All dedicated applications and information systems used by different city departments like bureau of street lighting or division of waste collection and disposal services or other applications that aims to engage citizens to participate in the creation of data, those applications are used to enable communication by analyzing data and feedback from citizens.

2.2.3 Usage and Deployment Strategy

The idea behind including the necessary elements into smart city, requires deploying a global implementation strategy of the infrastructure and dedicated applications, this layer is considered as a key element to deploy successful big data applications which aims to define the required systems and good understanding of the studied use case.

2.3 Big Data impacts

Cities are collecting more and more data of all types (on flows, inhabitants, energy consumption, etc..). this mass of data constitutes an important asset full of insights and answers. Now in the urban environment, which by its nature considered as the place of flows and exchanges, represents a gigantic source of data, derived by the proliferation of sensors, and connected devices in the life of city dwellers. The help of data in understanding complex phenomena is important. In city these different data sources represents a tool to monitor the state of good understanding of city lifecycle. This world of information requires exploration through new and powerful tool to extract its potential via data mining stages.

Among the use cases of Big Data in the smart city, we cite:

2.3.1 Transport

During public events with a large audience, operators railway lines are faced with several million pieces of data that can be managed with data analytical tools to ensure smooth flow. A concrete example of this application was made during the London 2012 Olympic games (Reference), where the public transport network had to manage 18 million made by spectators from all over the city.

2.3.2 Urban Planning

Big Data helps increase efficiency in the planning and manufacturing of buildings and development of urban spaces. The data can map and predict the impact of infrastructure on urban space with high accuracy. It is also possible to develop models to maximize access to certain areas or services while minimizing the risk of infrastructure overload.

2.3.3 Security

Predictive analytics have been used in several cities around the world to help predict where crime is likely to occur, based on historical and geographic data. In cities like London, Los Angeles, and Chicago.

2.3.4 Sustainable Growth

Regular analysis of the growth of a smart city enables city officials to get continuous updates about needed changes. Continuous updates are the key growth drivers of sustainability because they provide a clear idea regarding the required developments. Data plays a key role in determining the outcomes of development in a smart city.

2.4 Big Data types

In Smart cities, the flow of data is important, their sources are different and their types too, so we distinguish between traditional and structured data from enterprise systems, such as for example weather forecasts, government demographic data, and statistics on the performance of public transport. Also, we cite data from all kinds of social media, that shows how citizen are engaged in the city community. And finally, we mention the machine-to-machine (M2M) data.

2.4.1 Data Diversity

Smart cities, generate a variety of unstructured data. We distinguish the following types:
- Chronological data: stock market, smart cars, smart home.
- Continuous data: sensor monitoring systems, internet traffic,
- Sequential data: retail systems, human DNA, protein structure.
- Graphical data: social networks, website, health systems
- Spatial data: GIS Data, medical imaging, Data satellites and multimedia data like surveillance systems.

2.4.2 Open Data

Open data present one of the main data sources in the smart city system, these smart infrastructures demand an open culture that must benefit everyone. The existence of this huge amounts of data in smart cities, have not to be employed and used for specific needs, by specific public or private organization, but also to serve and contribute the common good via opening the door and engaging the public to participate in data creation.

Smart cities provide data portals based on the following objectives:

- Open public data to allow citizens to each these data in a way to facilitate their life and decision-making
- To support the economic development of the territory by supplying these data to developers who use it to create applications

3 Technology Affordance

Technology affordance term is used to refer to new technologies and what tasks users can possibly perform with technologies at their disposal. The term technological affordance was coined by Ian Hutchby as a reaction against social constructivism. It represents the possibilities and permissions that a technological artefact encloses. These possibilities and permissions emerge during the interaction process between user and the technological artefact.
Technology affordances are introduced as relational constructs; they capture not only the features of a technology, but also how actors perceive and interact with the technology.

3.1 The value of technology affordances

This theory is considered as main study subject in many articles, as an element that can help to analyze and study a changing element in an existing organizational ecosystem and identify the different outputs related to this changing element.

The real added value of the affordance technology persists in the idea of analyzing the technological artefact as an input factor that can trigger different functional and organizational potentials in terms of developing new understandings, and managerial concepts related to a new introduced technology.

3.2 Technology affordance context

The theory of Affordances received an important attention in Information System (IS) literature (Leonardi 2013; Majchrzak and Markus 2012; Markus and Silver 2008; Seidel et al. 2013; Volkoff and Strong 2013; Yoo et al. 2012; Zammuto et al. 2007). The application of this theory promises to provide new insights in explaining the consequence of IT artefact uses in organizations (Majchrzak and Markus 2012; Markus and Silver 2008) and the related organizational changes (Zammuto et al. 2007; Leonardi 2013; Volkoff and Strong 2013).
In this paper, we provide a comprehensive review and summary of introducing the Big Data factor as a new technolgical artefact in an exisiting ecosystem that aims to analyze and deploy smart city project model and develop new organizational, techo-functional habits related to deploying a new smart city project model, and explore potential that arise between Big data as a technogical actor and and artefact, in the sense of presenting a global intersection between smart city model goals and Big data itself. The result of this intersection will lead us how to explore big data adoption in organizations using affordance theory.

3.3 Big Data as a Technology input in Smart City context

To understand the potential use of technology by
Big data analytics are a set of tools and techniques that help companies, organizations, and cities to get useful business insights from the data, to have global idea about socio-economic problems. Adoption of big data Analytics is a challenging task with high economic and business added value.
Affordance theory can be used to study the usages and effect of big data technology in an organizational context by integrating the following constructive elements:

3.3.1 Technology Characteristics

The main goal of technology affordance is to consider characteristics of the technology, here we study big data analytics as an example, when the technology affordance theory must highlight the main objectives of big data, how it works, and how can be deployed. The main goal of this step is study in details big data as a framework via the classic types of data analytics (Descriptive analytics, Diagnostic analytics, Predictive analytics, Prescriptive analytics).

3.3.2 Organizational goals

City as any organization have a business case and an associated objective. To achieve the objective, the city must adopt a complementary approach in terms of:

- Information technology: to deploy the appropriate technical tools, the city needs to check its readiness for big data analytics. An adoption pattern may help the organization to proceed in a systematic manner.

- City objectives: the city must develop a broader idea about the business case to be studied, a global understanding of the problem can help to clearly identify the different obstacles, example: traffic jam problem, can be identified as a key challenge in metropolitan cities. The city must prepare what are the causes and develop mechanisms to understand it.

3.3.3 Technology affordance framework

Affordance theory provides a structural view of the relevant items that constitutes the global objectives of the smart city. When the organization interact with technology based on defined characteristics with a goal in sight, the affordances can emerge from this step. Each interaction between these two actors generates an information, or a result that presents a potential action or a possibility.

3.4 Technology affordance actors' goals definition

Developing smart city project model, must use a set of technological tools, big data analytics is making of part of these elements. Based on Affordance technology theory we identified two main actors:

- Actor number 1: Organizational actor

City government: the city local administration considered as key responsible for smart city initiatives, in collaboration with different stakeholders from Startups and academic research centers. City administrations have not only introduced new infrastructures, but more than this they are invited to innovate new mechanisms of managing services, monitor, understand, analyze, and plan the city to improve the urban performances in real time.

- Actor number 2: Input actor

Big data analytics: Today, cities started to develop smart cities initiatives, that aims to obtain and store data about their KPIs, cities want to extract valuable knowledge from this data. Many cities are in the process of adopting big data analytics to make data driven decisions.

3.5 Technology affordance intersections

To develop a global overview about different types of affordances that arise from Smart City global objectives and big data as two organizational actors, we must implement a consecutive goal-oriented approach that aims to intersect the actors and their interaction goals.

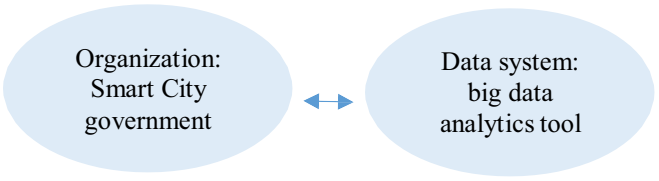

Fig. 1. Smart City and Big Data System actors.

3.5.1 Relevant factors for Big Data Analytics input

In this step big data analytics system is an actor introduced in an existing smart city ecosystem.
The interaction between local government as an organizational, constructive unit, and an actor with big data analytics tools, will had an emergent affordance.

To analyze the emergent results of this intersection, we can consider the following elements for both actors:

- Data: the starting point of big data analytics tool, in this step we must identify to associated properties of the used data, and candidates' source of information's in the city.
- Choice of BDA tool: as an emergent affordance, we must take into consideration the techno-functional choice of a strategic big data analytics tool. A wide range of tools are available in the market, which are different in terms of proprietary of source, open source or not, the city government must develop this kind of experience to start the selection process, through their technical teams or via subcontracted IT vendors.
- Smart City project model characteristics: having clear deployment strategy of big data analytics tools plays a major role in adoption. As any organization, the city government must use a change management methodology to adopt the new cultural and technical shift. High skilled data teams are another important factor to lead the success of the project.

3.5.2 Relevant factors for Big Data Analytics input

The used example of smart city project, Developing new understanding approaches about the general concept of city as a unique connected unity, helped to understand what is exactly a city? and how it should be considered within a rapid technological change context

full of opportunities and challenges, where cities have to exploit different capabilities not only in terms of infrastructures but also to employ technologies in several domains to improve the delivery of public services, attend citizens demands and measure the consumption of different resources.

Discussion

The research used the affordance theory as a key element to study the impact of adopting big data analytics solutions in a smart city model, allowed the authors to reevaluate and implement the affordance theory framework and match it with big data framework and then deploy it via adopting socio-economic challenges of the city, by answering main questions identified as a city objective. The research uses multiple references that used the same theory in different application domains which helped to understand in a broader way how to implement this theory in the smart city context. We consider the good understanding of affordance theory factors in a smart city project is highly important to develop a core smart city model based on the intersection of different actors. We have identified the following actors: Data, considered as starting point of all city data sources, all city data source must be analyzed via big data framework tool. Big data framework: another key factor to understand the city data model, and how can be implemented to answer main questions about city KPI challenges. The research set out to explore the role of adopting Big Data Analytics tools under a smart city vision, by including the socio-economic formula via affordance technology. The authors stay committed to using this theory for better understanding of adopting new technologies in the smart city model and analyze at what level it can impact sustainability in cities and hope to be part of more research and progress in the future. This can be done by uniting researchers from different fields, passionate about sustainability, regardless of changing political and economic landscapes. This study pushes for additional and continuous research for progress in the field and hopes to contribute to the facilitation of these developments, for further sustainability in cities through the mean of affordance perspective.

Conclusions

This research contributes and use the theory of technology affordance, big data analytics has potential to help cities to gain useful business insights. A City must have a clear goal leading to a smart city initiative while adopting data analytics. The adoption of big analytics tool and associated data framework require preparing a set of elements, from having clear smart city deployment strategy, smart city initiative goals to the selection of big data Analytics tools and intersections of these components to have the full view and succeed the implementation of the smart city project. Affordance theory provides an assessment and guidance in terms of organizational objectives between different actors. Its present the main actors as key elements that must discover the capabilities of each other, in the sense of identifying each actor objectives, and then present different potentials or actions that can arise from intersecting their goals.

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