Mapping negative unintended consequences of disruptive technologies use in smart cities.

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Mapping Determinants of Unintended Negative Consequences of Disruptive Technologies Use in Smart Cities

Research Paper

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Abstract

Smart cities governance (SCG) consists of both to foster technology-enabled innovation, and to utilize disruptive technologies (DT) outcomes and impacts to increase public value of urban services. Despite widespread discussion of DT benefits, scientific literature identifies multiple determinants of unintended negative consequences (UC) of DT deployment in smart city initiatives. By considering UC as the negative aspects resulting from underestimating or ignoring the scale of such consequences, this study analyses the objectives of SCG and the negative unintended effects of five selected DT initiatives on these objectives’ implementation. The main contribution of this paper is the identification of determinants of negative UC of Smart City disruptive technologies initiatives and identifying the structure of their impact on the SCG objectives. The results indicate the need to establish a new governance framework of UC in smart cities as a tool to support local governments dealing with the changes caused by DT use in the smart city ecosystem.

Keywords: Smart City, Disruptive technologies, Governance, Negative unintended consequences.

1. Introduction

The global trend of rapid urbanization is resulting in an increase in urban areas and the number of urban residents. Cities struggle to achieve government more accountable, transparent and effective, as well as to ensure the quality of life by delivering urban services that create public values to a large volume of city dwellers and smart city ecosystem stakeholders. With the size and diversity of the population, social dynamics, multiple stakeholders in the city ecosystem, and technological advancement, governors turn their attention to emerging fields of digitalisation such as Big Data, Internet of Things (IoT), Open Data, Blockchain, and artificial intelligence (AI), to facilitate public value delivery (Bibri, 2019a). Given this view, smart cities are perceived to become incubators of innovation. This is also supported by the augmenting through time taxonomies of smart cities solutions (Alexopoulos, Pereira, et al., 2019). Therefore, smart cities governance objectives are both to foster technology-enabled innovation, and to utilize disruptive technologies (DT) outcomes and impacts to increase public value of urban services. Consequently, smart city governance becomes a complex issue comprised by challenges not only to innovative solutions, project management, capacity and funding, but also with a generic lack of understanding on how DT impact governance objectives at present and in future. Despite widespread discussion of DT benefits, scientific literature identify multiple negative unintended consequences (UC) of emerging technologies deployment in smart cities such as digital divide, lay-offs, gentrification, and

social inequality, and those related to technical challenges such as data governance, interoperability, and IT infrastructure development. While work on smart city and DT initiatives have developed into a mature academic field, there has been no focus in the research literature on how such UC can negatively affect the implementation of the fundamental smart city governance objectives. In this sense, the use of disruptive technologies needs to be studied carefully along the various stages of the innovation funnel, integrating the potentials of such technologies in a city’s service provisioning with responsible research and innovation (Pereira et al., 2020).

To address this problem, we searched for smart city governance objectives and UC of disruptive technologies in smart cities. There is a wide range of publications addressing smart city governance with particular emphasis on e-governance (Finger and Pécoud, 2003; Godse and Garg, 2007; Potnis, 2010; Rossel and Finger, 2020; Xiao-Hua, 2009); e-governance for smart cities (Kumar, 2015); smart governance (Anthopoulos and Reddick, 2015; Gil-Garcia et al., 2013; Tomor et al., 2019); smart governance for smart cities (Pereira, Parycek, et al., 2018); and governance of smart cities (Ruhlandt, 2018). However, e-governance prevails among governance types, since smart cities focus not only on technology application for urban services and administration, but also democratic processes and the relationships among citizens, civil society, the private sector, and the local government to achieve better policy outcomes, higher quality services, and greater civic engagement (Dawes et al., 2012). Since, the concept of “unintended consequences” is rather blurred and takes into account both different types of consequences (positive and negative) (Helbig et al., 2005; Pereira, Macadar, et al., 2017), different aspects of these consequences (presence or absence of intention of their occurrence or only the nature of the consequences) (Bouchard, 2016; Gravier and Swartz, 2009; Tarafdar et al., 2015; Zuiderwijk and Janssen, 2014), this study narrows down the definition of UC to the negative ones which are resulting from underestimating or ignoring the degree of complexity (scale) of such consequences. This study addresses UC of five selected emerging fields of digitalization in smart cities, which are of high importance (Bibri, 2019b), namely: Internet of Things (IoT), Big Data, Artificial Intelligence (AI), Open Data (OD), and Blockchain (BC).

Based on the above, we aim at extending smart city and disruptive technologies research into the more complex scale of both fundamental objectives of smart city governance and the negative unintended effect of disruptive technologies initiatives on these objectives’ implementation. The objective of this paper is to provide insights into the scope and variety of determinants of unintended negative consequences (DUNC) in the smart city context and to identify their impact on smart city governance (SCG) objectives originated from the emerging fields of digitalisation. The research objective is investigated by the following research questions: RQ1. How and which disruptive technologies support the governance objectives of smart cities? RQ2. What are the potential determinants of unintended negative consequences of disruptive technologies in smart city initiatives? RQ3. How and which smart city governance objectives could be affected by DUNC of disruptive technologies? The main contribution of this paper is the identification of potential determinants of unintended negative consequences of disruptive technologies in smart cities, and identifying the structure of the impact of DUNC categories on the identified smart city governance objectives.

This paper consists of six sections. Section 2 presents the background on disruptive technologies and unintended consequences. Section 3 describes the research methodology. Section 4 provides the results. Section 5 contains a discussion and recommendations. Finally, conclusions, limitations, and recommendations for future research are drawn in Section 6.

2. Background

This section presents the main concepts and research findings concerning the smart city, smart city governance, disruptive technologies, and unintended consequences. This section is structured into Section 2.1 disruptive technologies in Smart Cities, and Section 2.2 unintended consequences of disruptive technologies use in Smart Cities.
2.1. Emerging Fields of Digitalisation

Technological advances such as Artificial Intelligence, the Internet of Things, distributed ledger systems such as blockchain, and Big and Open Data, have led to unprecedented changes, often disrupting the way goods and services have traditionally been produced and consumed (Brennan et al., 2019), and their successful deployment, especially in the context of smart cities, requires a systematic analysis of the overall system landscape, which demands for a holistic approach (Pereira et al., 2020). The ability to handle large volumes of digitized data in rapid and complex ways through these technologies has also increased our dependency on more open, multi-platform, networked structures that enable other innovations. “Disruptive technologies can be either a new combination of existing technologies or new technologies whose application to problem areas or new commercialization challenges can cause major technology product paradigm shifts or create entirely new ones” (Kostoff et al., 2004, p. 142). In disruptive environments, innovations (being them technical, processual, or commercial) are often unpredictable, ideas are radical, outcomes are uncertain and ill-defined, and the justification for investments in them is difficult to make as markets are either not adequately developed or may be non-existent (Evans, 2017). Paradigm of digital-era governance based on information technology and social change is the main governance model for public administrations (Dunleavy et al., 2006).

**Internet of Things (IoT):** The Internet of Things is expected to “reshape production, consumption, transportation and delivery systems”, triggering a profound socio-economic shift further into the Fourth Industrial Revolution (Brass and Sowell, 2020). At a basic level, “the IoT embeds physical objects in information flows and thereby makes them ‘smarter’” (OECD, 2017). More specifically, the term is generally being used to define inanimate objects, from simple sensors to smartphones and wearable devices, that “talk” to each other without necessarily requiring human input (Leitner and Stiefmueller, 2019). In principle, any object may be tracked on the IoT throughout its life cycle as it “moves through the world” (Burgess, 2017). The IoT impacts various aspects of life for residents, such as health, safety, and transportation; remote monitoring and necessary infrastructure: energy efficiency, improving personal mobility and public transport, as well as enabling real-time responsiveness for emergency services (Cisco, 2016). By combining these connected devices with automated systems, it is possible to gather information, analyze it, and initiate a response, if appropriate (Leitner and Stiefmueller, 2019). According to Cisco IoT could generate USD 4.6 trillion of value added by 2022 in the global public sector, by increasing employee productivity, making military defense systems more effective, reducing costs, improving citizens’ experience with public services, and increasing government revenue (Bradley et al., 2013). Urban infrastructures equipped with digital sensors and control systems (for example, power plants, transport vehicles, and utilities) can be connected to the IoT to analyze the collected data. The datasets collected can be used to analyze the properties of the main data streams themselves - their structure, properties, volumes, dependencies, trends, etc.; to make governmental decisions to improve objects and systems, p.e. to optimize traffic flows, balance the load in the power grid, automatically detect and respond to malfunctions, or design and optimize repair and maintenance cycles (Leitner and Stiefmueller, 2019).

**Artificial Intelligence (AI):** Artificial Intelligence use in the smart city refers to the use of the huge amount of data collected through IoT devices, applying analytical algorithms and techniques to learn from data to create public services and value (Kankanhalli et al., 2019). A number of AI techniques can potentially improve the policy-making process, including optimization and decision support techniques, data and opinion mining, game theory, and agent-based simulation (Sharma et al., 2020). AI potentially fulfill two principal functions: support human decision-making: advisory role in decision-making, complementing, and, over time, substituting traditional “decision-support systems” through assembling relevant data, identifying pertinent questions and topics for the attention of policymakers, and in helping to generate written advice; take on routine, repetitive function to automate administrative processes: executing simple rule-based tasks to increase efficiency and free up the capacity of human staff to concentrate on higher value-added activities (Leitner and Stiefmueller, 2019). Therefore, the adoption of AI calls for fundamental re-thinking of the data governance mechanism since data governance shifts from a single organization to multiple networked organizations (Janssen et al., 2020).

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Blockchain (BC): The concept of blockchain was developed in 2008 (Nakamoto, 2019) and is defined as a framework of a database technology that is fully distributed (Erdem et al., 2019). Blockchain offers the immutability feature through cryptography and hashing which makes the distributed ledger permanent and unalterable, resulting in safe data transfer and storage process (Shaikh and Mohammad, 2020). Moreover, due to the decentralized model of the network, BC offers various benefits such as security, data anonymity, immutability, and lowering operational cost (Shaikh and Mohammad, 2020; Sun et al., 2016). Due to the decentralization feature, BC is an important technology to apply in smart city governance. The main challenges of urban areas are to provide environmental sustainability (Truby, 2018), scalability, latency, network bandwidth usage, data privacy, and security to innovative solutions (Sharma and Park, 2018). Blockchain adoption is evidenced by scholars among many sectors (Alexopoulos, Charalabidis, et al., 2019) including smart healthcare (Griggs et al., 2018), smart grid (Gai et al., 2019), smart transportation (Yuan and Wang, 2016), smart government (Ojo and Adebayo, 2017), and smart tourism (Nam et al., 2019), smart building (Shaikh and Mohammad, 2020).

Big and Open Data: Big data (BD) defined as a high volume, high velocity and high variety of information which usually cost-effective and innovative for increasing insight, proper decision making and maximum output (Sarker et al., 2018), but for different domains could be emphasized the specific features of this phenomena, namely: (i) data sources such as (George et al., 2014) for management; (ii) new data capabilities (Pirog, 2014) for public policy; (iii) data gathering technological innovations (Clark and Golder, 2014) for political science; (iv) data structure (Lazer, 2009) for computational social sciences; (v) data analysis aspects such as “managing and using information from extremely large data sets can help reveal trends and patterns among people and institutions from various different perspectives” (Brennan et al., 2019, p. 4), data participation in decision making process such as “way risks are identified, assessed and dealt with calls for firms to invest in appropriate information and data management technologies and human resources” (Brennan et al., 2019, p. 5) for governance.

Open data (OD) refers to any data and content that can be freely used, changed, and transmitted by anyone for any purpose (Pereira, Macadar, et al., 2017). Open Government Data (OGD) refers to data sets including big datasets that government agencies provide for usage by third-party (Crusoe and Melin, 2018) “...under an open license, machine readable, and provided in an open format” (Charalabidis et al., 2018, p. 125). Due to this broad definition, numerous urban initiatives labeled “open data” can be found, which differ in all of these aspects but share the characteristics of an information source that is meant to serve the broader public (Alexopoulos et al., 2017). Despite widespread discussion of OGD use, there is no common understanding as to the type of data, format of data, thematic focus, or the target group (Charalabidis et al., 2018). There is however a broad consensus on OD features such as availability, reusability and ability to redistribute, and universally participatory without discrimination by field, person, or group (“Open Knowledge Foundation (OKF)”, 2012).

2.2. Unintended Consequences

Since emerging technologies adoption is often associated with innovation, new product, and services, and new markets development, there is an urgent need to investigate the side effects of technological change in the urban environment. Emerging fields of digitalisation in the smart city create unintended consequences (UC) for communities, society, economies, and industries. These disruptions may result in job losses, privacy breaches, lost revenues, value changes, and many other negative externalities addressing various domains and stakeholders of smart cities. Thus, the concept of UC is complex and worth deepening explanation. The cause-based view on the definition of UC focuses on the limit one’s ability to anticipate the consequences of purposeful action to achieve a particular goal: ignorance, error, and ideological blindness (Porvin and Pollock, 2020). The outcome-based view addresses what is intended, anticipated, or foreseen to happen in the future (Merton, 1936). More specifically, the deepening understanding of the UC is the better-suited tool to predict the expected (potential) negative consequences and to categorize the impact on the local government policy objectives.

In the context of digitalisation processes, unintended side effects (unseens) can be defined as a “genuine feature of any fundamental technology innovation, which has intended positive but also negative
The second set of keywords characterizes selected terms and definitions of determinants of unintended negative consequences (object), such as: “challenges”, “risks”, “threats”, “barriers”, “consequences”, “unintended consequences”, “unseen”, and “negative”. The second set of keywords characterizes selected types of DT (subject), namely: “big data”, “IoT”, “blockchain”, “artificial intelligence” OR “AI”, “disruptive technologies”, “emerging technologies”, “emerging fields of digitalisation”. The third set of keywords provides the context of our research, specifically: “smart city”, “governance”, and “e-governance”. In the search strategy we used these keywords sets both together, in pairs, and separately.

According to (Scholz et al., 2018) unseens need to be clearly distinguished from barriers that negatively affect development. Since there is much fog over the definition of unintended consequences (Helbig et al., 2005; Pereira, Macadar, et al., 2017) this paper narrows down the concept to unintended consequences as a negative outcome, incorporating the logic of “intendedness” associated not only with ignorance - conscious or unconscious activity resulting in the negative outcome, but also with ignorance of the potential complexity of resolving such consequences.

3. Research Approach

This section aims to describe the methodology adopted in the current study. Method-wise, a three-fold triangulation approach was used. First, the literature review was conducted to collect the SCG objectives and the determinants of unintended negative consequences of selected DT use in SC context. Second, to assess which SCG objectives could be affected by the DUNCs and how strong the impact of every determinant of unintended negative consequences on each SCG objective, the expert's knowledge was used. As the method of inquiry, we chose an online expert questionnaire to collect data directly from five academics, involved in a number of research and consulting projects pertaining to digital transformation, smart city and e-governance. Third, we used the machine learning (ML) algorithm and statistical analysis to process and summarize the results, received by both literature review and expert's assessment methods. Section 3.1 provides information on literature selection and collection. Section 3.2 describes the strategy of analysis collected information regarding the research questions.
Totally we identified 1256 non-duplicate results in the Scopus database within 2000-2020. In the second step, we removed duplicates, and excluded non-English positions. As a result, 376 articles were excluded. In the third step, we identify eligible publications by titles/abstracts screening, using the concept-centric approach (Webster, 2002). For example, the list of broad (i) smart city governance disruptive technologies adoption, resulting from the first screening cycle, was used to identify the presence or absence of the theme in each paper on (ii) determinants of unintended negative consequences concerning AI, IoT, Blockchain, and Big & Open Data emerging technological initiatives. Thus, 162 full texts were under evaluation. When analysing the articles full text, in the fourth step we simultaneously discovered the forward and backward citations to enhance the search results (Webster, 2002).

Finally, 198 papers were included in the quantitative synthesis addressing research questions as to (1) the outcomes of DTs used in a smart city context, (2) the scope of the determinants of unintended negative consequences of disruptive technology use in smart city, and (3) SCG objectives.

3.2. Data analysis

To derive the main research findings, the following qualitative and quantitative data analysis steps were realised. First, to answer RQ1, (1) coding of gathered literature to extract the list of the main SCG objectives was performed. As a result, 20 SCG objectives were extracted. Then (2) five independent experts mapped the impact of DT initiatives outcomes on specific SCG objectives. To allow the experts to give their opinion, the questionnaire in the form of a cross-table was developed, where rows address the list of SCG objectives, and columns the DT outcomes. At first, experts were asked to indicate the presence of impact of DTs on listed SCG objectives, resulting in exclusion of two objectives from further analysis. Then, the experts were asked to tick the table cell if they strongly agree with the statement “particular DT impact on specific SCG objective”. The results were iteratively discussed, refined and approved by experts. (3) Based on mapping results SCG objectives were grouped into four clusters using the hierarchical agglomerative algorithm. The Silhouette coefficient was used to evaluate the clustering quality.

Second, to answer RQ2, (1) coding of gathered literature to extract the list of all DUNCs was performed. (2) The received list was discussed and refined to narrow down at the intersection of both the research context-object and subject-context. (3) Experts grouped the final list of the determinants into categories. The categories and groupings were refined iteratively until every UC was clearly and unambiguously categorized. Finally, 93 determinants of unintended negative consequences grouped into 7 main and 12 sub-categories were identified.

Third, to answer RQ3, a second measurement tool was developed, where rows provide the list of SCG objectives, and columns the 7 main categories of DUNCs. Thus, (1) experts evaluated the strength of impact of every DUNC on each SCG objective through 4 points ordinal scale, where rank 3 means “high impact”, rank 2 “medium impact”, rank 1 “low impact”, and rank 0 “no impact”. (2) To summarize the received results, the basic statistical analysis was performed. The Cronbach alpha coefficient was reported as a measure of results reliability evaluation for both questionnaires, applied in the study.

4. Results

This section aims to present the main results of this study. Section 4.1 provides the results including the analysis of interdependence on DT benefits to SCG objectives. Section 4.2 presents the categorization of determinants of unintended negative consequences of DT use in smart cities. Section 4.3 maps the DUNCs to SCG objectives.
4.1. Smart city governance objectives vs. disruptive technology outcomes

To answer RQ1, a list of twenty SCG objectives has been established through the literature review. Eighteen of them are categorized into four clusters allowing to identify their differences in terms of DT outcomes impact (Silhouette Coefficient for four clusters is equal to 0.83). Category 1 is focused on Citizens centered transformation; mainly reflects the impact of OD, IoT, and AI outcomes (28.6% of all extracted outcomes). Category 2 is focused on Decision-making processes; is supported by four (except Blockchain) DT types most equally, but the most powerful influence is exerted by AI (42.9% of all extracted outcomes). Category 3 is focused on Smart urban collaboration; is supported by only OD and Blockchain (17.1% of all extracted outcomes). Category 4 is focused on Smart administration; is supported by BD, OD, and AI (11.4%). The results indicate that the largest number of SCG objectives are supported by OD and AI outcomes (per 28.57% and 25.71% accordingly); Blockchain outcomes impact only on 11.43% of SCG objectives. The structure of DT’s impact on SCG objectives presents Table 1. Ticks in the table cells mean the outcomes of DT deployment, placed in the column, have an impact on correspondent SCG objective, pointed in the row. Since the questionnaire tool did not imply a quantitative assessment of the impact degree, the presence of a tick’s mark is interpreted as substantial impact.

<table>
<thead>
<tr>
<th>Smart City Governance Objectives Category</th>
<th>Smart City Governance Objectives</th>
<th>Big Data</th>
<th>Open Data</th>
<th>AI</th>
<th>IoT</th>
<th>Blockchain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citizens centered transformation</td>
<td>To implement a citizen-centric approach</td>
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<td></td>
<td>To transform of processes and structures</td>
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<tr>
<td></td>
<td>To support impact on society</td>
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<tr>
<td></td>
<td>To realize urban sustainability and resilience in terms of resource availability and disaster response</td>
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<tr>
<td>Decision making processes</td>
<td>To build fair and efficient models of public service design, delivery and transactions</td>
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<tr>
<td></td>
<td>To provide evidence-based decision making</td>
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<tr>
<td></td>
<td>To support understanding of data (on events, conditions, problems and processes)</td>
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<td></td>
<td>To maintain innovation and creativity</td>
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<td></td>
<td>To use simulations and modelling as a decision support techniques</td>
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<tr>
<td></td>
<td>To collect data or observances through search agents</td>
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<tr>
<td>Smart urban collaboration</td>
<td>To increase eParticipation</td>
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<tr>
<td></td>
<td>To ensure privacy and security</td>
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<td></td>
<td>Provide e-democracy and advance democratic expression, and e-Voting</td>
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<tr>
<td></td>
<td>To increase governance accountancy, transparency, effectiveness, and trust</td>
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<tr>
<td></td>
<td>To establish and manage public-private collaboration</td>
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<tr>
<td>Smart administration</td>
<td>To ensure social equality</td>
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<td></td>
<td>To provide integration and storage of data</td>
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<tr>
<td></td>
<td>To build new style of leadership</td>
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</table>

Table 1. Correspondence of Disruptive Technology outcomes impact on SCG objectives

4.2. Determinants of unintended negative consequences of disruptive technologies in smart city

This section answers the research question RQ2. We defined 7 main and 12 sub-categories of 93 determinants of unintended negative consequences of DT use in smart cities (Figure 2). The catalogue of extracted DUNCs accompanied by description and source is part of supplementary material. The results indicate that the largest part of determinants related to smart city governance is the Capacities

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1 Complete list of all sources and definitions is part of supplementary material: Smart City Governance objectives vs. Disruptive Technology outcomes
2 Catalogue of Determinants of the Unintended Negative Consequences of Disruptive Technologies
category (23.65%), and of these, the most significant number of determinants of unintended negative consequences is associated with the Human capacities determinant (16.13% of all DUNCs). The second in terms of the number of collected determinants is the Security & Trust (19.35%) category. In third place are organization Structures & processes and Data determinants categories (per 18.28%). The smallest share of determinants constitutes problems of Policies (4.3%) and Public sector (5.38%) related.

4.3. Determinants of unintended negative consequences of disruptive technology vs. smart city governance objectives

This section answers the research question RQ3. Based on expert evaluation, the average strength of impact of the determinants of unintended negative consequences on smart city governance objectives were identified. To confirm the significance of the results, introduced in the Figure 3, the following statistics for expert's evaluation sample are presented: (i) the average normalized standard deviation (ANSD) for the entire sample is 0.25; (ii) the ranges of ANSD for each of the smart city governance objectives sub-categories is [0.18; 0.39]; (iii) the Cronbach alpha reliability coefficient is 0.73. Figure 3 represents 12 sub-categories of determinants of unintended negative consequences (Y-axis), sorted in descending of their total average strength of impact on smart city governance objectives (X-axis) with detailing the individual average strength of impact of particular determinants on each of the SCG objectives category.

To summarize, the following assumptions concerning the impact of the particular determinants of unintended negative consequences on specific smart city governance objectives outcomes can be formulated: (1) the top three sub-category of determinants of unintended negative consequences with the greatest total impact on listed smart city governance objectives are Lack of Human Capacities, Lack of Legitimacy & Public Trust, and Low Data Sharing, Discoverability & Interoperability consequences; (2) the least impact is related to Society & Economy issues, and Lack of Financial Capacities; (3) Smart Urban Collaboration is the SCG objectives category most susceptible to the negative impact of DUNCs. Then, in descending order, are Citizens Centred Transformation, Smart Administration and Decision-making Processes categories; (4) the SCG objectives of Smart Urban Collaboration category are highly influenced by determinants of unintended negative consequences from the categories Security & Trust, Capacities and Policies, namely Lack of Legitimacy & Public rust, Lack of Policies & Guidelines, Lack of Human Capacities and Security & Privacy breaches (ranked in descending order of degree influence); (5) the SCG objectives of Citizens centred transformation category are highly influenced by the determinants of unintended negative consequences from the categories Policies, Capacities and Security & Trust, namely Lack of policies & guidelines, Lack of Human capacities, Lack of legitimacy & public trust (in decreasing degree of influence); (6) the SCG objectives of Smart administration category are highly influenced by the DUNCs from the Security & Trust and Data categories, namely Low data sharing, discoverability & interoperability, Lack of legitimacy & public trust, Security & privacy breaches (in order of degree of influence); (7) on the SCG objectives of Decision-making Processes category high influences also show the determinants of unintended negative consequences from the Security & Trust and Data categories, namely Low data availability, quality & relevance, Low data sharing, discoverability & interoperability, Lack of Human capacities and Lack of Technical capacities (in order of decreasing degree of influence).
Figure 2. Determinants of unintended negative consequences of disruptive technologies in smart city
Rizun et al. / Determinants of Unintended Negative Consequences of Disruptive Technologies


5. Discussion of findings

Responding to RQ1, our research contributes to a better understanding of the nature of the impact of DT on smart city governance objectives. We identified four main SCG objectives categories, which are characterized by both (i) Smart City governance objectives contextual similarity and (ii) the similarity of the nature of the DT foreseen impact connected with the possible degree of implementation of these objectives. Thus, (1) Big Data impact is more focused on Decision making processes SCG objectives category due to the facts that Smart Cities use this DT for improving their services (Singh et al., 2014), establishing and managing public-private collaboration (Heeks, 2001; Pereira, Macadar, et al., 2017), and increase citizen centricity through prediction, optimization, maintenance, and provision of public services delivery and governance by AI use (Chatterjee et al., 2018). (2) Open Data impact on all four SCG objectives categories mostly equally, and benefit creation of a government-citizen trust, increase government transparency and democratic control, and supports citizen active participation in government processes (Janssen et al., 2012; Peled, 2011; Pereira, Cunha, et al., 2017); impacts citizen services improvement and supports innovation of services (Agnihotri, 2015; Bertot et al., 2014; Janssen et al., 2012; Singh et al., 2014); and also equal access to OD ensures social equality (Janssen et al., 2012). Furthermore, Big and Open Data provide personalized recommendations to city administrators (Pereira, Eibl, et al., 2018; Pereira, Parycek, et al., 2018; Ubaldi et al., 2019), impact the quality, speed, and measurement of the decision-making process (Janssen et al., 2019a; Ju et al., 2018; Pereira, Macadar, et al., 2017). (3) AI and IoT impact is more focused on Citizen-Centric Transformation and Decision making processes SCG objectives categories due to the fact that allows the building of policy decision; allows city governors to efficiently cope with uncertainty in a smart city environment; substantially increases the speed of government services provision (Kankanhalli et al., 2019); and create an opportunity to predict, optimize, maintain, improve public service delivery and governance (Chatterjee et al., 2018; Soe and Drechsler, 2018). On the other hand, emerging technologies groups such as OD, AI, and IoT are common benefits to SC innovation and creativity by identification of new markets, creation of new insights, simulation of knowledge developments, and more precise issues such as traffic flow optimization, power grid load balance (Agnihotri, 2015; Janssen et al., 2012; Leitner and...
Stiefmueller, 2019); and also benefit the quality of life, facilitate citizen satisfaction, and sustain focus on value-added activities (Janssen et al., 2012; Leitner and Stiefmueller, 2019). The role of BD, OD, and AI to predictive policing and analytics is stressed through the expert evaluation and literature results (Ju et al., 2018; Leitner and Stiefmueller, 2019; Mahmoud et al., 2019); and OD and AI reshape the style of leadership of city governors (Benefeldt et al., 2020). (4) Blockchain is more focused on Smart urban collaboration SCG objectives category and strongly supports establishing governmental trust and security and privacy since it distributes trust and openness in transactions based systems using cryptographic functions, as well as facilitate secure ad-hoc interactions among different city stakeholders (Makhdoom et al., 2020; Nam et al., 2019; Seeck et al., 2019); benefits SCG objective to provide e-democracy allowing blockchain-enabled voting system deployment; and is only one from all DT the does not benefit evidence-based decision making. AI, IoT, and Blockchain benefit organizational processes, and structures (Ju et al., 2018; Kankanhalli et al., 2019).

Responding to RQ2, our work contributes to advancing theoretical knowledge about the scope and variety of the DUNCs in the smart city context. A primary objective of DT adoption in SC is to improve public value delivery to the citizenry by the improvement of effectiveness and efficiency of existing public services and creation of new ones (Andrews, 2019; Löfgren and Webster, 2020; Pereira, Macadar, et al., 2017; Pin-Yu and Hsien-Lee, 2018). As with other state agencies, city governors use DT to facilitate urban processes and services delivery. However, the DUNCs during the adoption of emerging technological fields or in other words the implementation of DT’s in an urban environment may significantly affect the expected public value delivery, and unexpected change of social, economic, political phenomena (Janssen et al., 2020; Mora et al., 2019). Since local governments are accountable for the financial discipline of public expenditures and verified by public opinion, the consequences that impact the urban environment are essential to recognize.

To denote all possible DUNCs of disruptive technologies in SC context, we broadly search for examples in the scientific literature. In this research, we focused only on negative unintended consequences typification. This approach falls in line with (Janssen et al., 2020), however, the literature indicates also the positive effects of DT adoption (Mora et al., 2019; Pereira, Macadar, et al., 2017). Due to the large scope of the studied issue, we concentrate on those consequences that lessen public value delivery. As a result of an extensive literature search, we identify seven categories of DUNCs of DT adoption in the smart city context. The results of conducted research show that the DUNC have a complex nature and reflect both (1) social and technological (Orlikowski, 2000; Orlikowski and Barley, 2001) and (2) urban governance and management contexts of innovation adoption (Sugiyama et al., 2017). Thus, such categories as data, security, privacy, technical capacity formulate the technological context of unintended negative consequences, while categories of organizational structure and processes, social and economic, financial and human capacities, public sector and policies formulate the social one. However, due to the closeness of the occurrence of particular consequences such as "security" and "trust", the catalog presents a unique set of DUNCs in each category. On the other hand, the catalog includes consequences that impact local urban government capacity, processes and structure (internal environment), and those that impact the public sector, society, economy, policies (external environment). This falls in line with several studies (Batubara et al., 2018; Dwivedi et al., 2019; Janssen et al., 2020; Wimmer et al., 2020). However, having a response to what is unexpected and not foreseen is challenging. Thus far, the public governance mechanism for DUNCs of disruptive technologies is required to support local government adopting and adapting to new demands created by modern technologies use.

Responding to RQ3, the major theoretical contribution of our work is to identify the structure and strength of the impact of DT unintended consequences on smart city governance objectives. Strong human capacities impact on SCG objectives have identified in this study, been raised in the scientific literature (Janowski et al., 2018; Janssen et al., 2020; Pereira et al., 2020; Ronzhyn et al., 2019; Wimmer et al., 2020). Thus, lack of human capacities strongly influences smart urban collaboration, citizen centered transformation and decision-making processes and to a lesser extent impact smart administration objectives. As a result, local governments need to establish education programs on emerging technologies transformation and seek to attract and acquire IT specialists with public
administration background. Identified as the second most influential consequences of the lack of legitimacy and public trust affect mostly smart urban collaboration essential to provide e-Democracy, enhance e-Participation and pursue e-Voting, which is also confirmed by the existing literature (Salha et al., 2019). High assessment of the degree of influence of low data sharing, discoverability and interoperability consequences on decision-making processes and smart administration fall in line with several studies (Dwivedi et al., 2019; Matheus et al., 2020; Ronzhyn et al., 2019; Wimmer et al., 2020). Next, SCG should pay attention to the possibility of DUNCs from missing implementation guidelines and policies, programs of change affect smart urban collaboration and citizen centered transformation to sustain common governance frameworks and governance accountancy, transparency and effectiveness. In this case, our study supports previous findings (Emerson et al., 2012; Hurlbert and Gupta, 2016). Moreover, since data are essential to a smart city (Bibri, 2018, 2019a), data resource, formats, and structure inconsistency mostly affect decision-making processes, that have been investigated by several authors (Janssen et al., 2019b; Mikalef et al., 2020).

A valuable finding is also the fact that this study identifies no impact of social and economic DUNCs on decision-making processes, and evidence of the limited impact of budget volatility and cost issues on SCG objectives. Decision-making processes are under the high impact of following DUNCs categories: data, human and technical capacities. SCG objectives in the smart administration category are under equal impact of DUNC of security and trust, data, policies and public sector. Thus, to increase citizen-centered transformation, local governments need to focus on policies and human capacities. These results support the arguments of (Pereira et al., 2016; Wimmer et al., 2020); security and trust issues are an important matter of local government care towards the establishment of smart urban collaboration.

6. Conclusions

In this paper, the potential DUNCs from emerging fields of digitalisation have been analysed and their impact in SCG objectives were identified through a literature review and experts validation. A total of eighteen smart city objectives have been clustered in four categories, including citizens centered transformation, decision making process, smart urban collaboration and smart administration, which are mainly supported by OD and AI outcomes. Subsequently, this study identified the structure and strength of the impact of 93 DUNCs on the SCG objectives.

The results of this study indicate the need to establish a new governance framework of the DUNCs to support local governments with tools and mechanisms to guide through the changes caused by the adoption of DT in the smart city ecosystem. Since local governments are functioning in three-dimensional reality of what is now, what is expected, and unexpected in the future, such a solution could bring substantive support to city administrators and politicians to plan reactive actions, address the city policies and manage stakeholders.

Further research should concentrate on anticipatory and adaptive governance to foresee, adapt, and manage the uncertainty in a broad socio-technical context, as well as to adapt organization structure and processes to provide reactive public administration. Since we could not identify any governance mechanism for DUNCs in smart cities, this issue should be further researched.

This research has a number of limitations that need to be acknowledged. First, in order to identify the impact of DTs in SCG objectives, they have been treated as separate categories despite the fact that one smart city initiative could include or result in several of these categories. Therefore, considering the complexity of the nature of the DTs and the scope of this research, an holistic view of DTs in smart cities should be further studied, and technologies that were not included in this research could be additionally analysed. Second, this research has narrowed the scope to DUNCs, since in order to determine if something was unintended a clear perspective and deep knowledge and insights into the process of developing and implementing the disruptive technology would be necessary. Future developments of this study could include exploratory research on the identified DUNCs in smart city, as well as to positive outcomes of DT in the context of smart cities. Finally, a higher number of experts could provide additional insights, especially considering a broader context of cities’ perspectives.
References


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Rizun et al. / Determinants of Unintended Negative Consequences of Disruptive Technologies


