Smart City Research Risk Evaluation

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Although they offer major advantages, smart cities present unprecedented risks and challenges. There are abundant discrete studies on risks related to smart cities; however, such risks have not been thoroughly understood to date. This paper is a systematic review that aims to identify the origin, trends, and categories of risks from previous studies on smart cities. This review includes 85 related articles published between 2000 and 2019. Through a thematic analysis, smart city risks were categorized into three main themes: organizational, social, and technological. The risks within the intersections of these themes were also grouped into (1) digital transformation, (2) socio-technical, and (3) corporate social responsibility. The results revealed that risk is a comparatively new topic in smart-city research and that little focus has been given to social risks. The findings indicated that studies from countries with a long history of smart cities tend to place greater emphasis on social risks.

Keywords: smart city ; risk ; systematic literature review ; urbanization

1. Introduction

Urbanization is defined as a multidimensional process in which large numbers of people rapidly and permanently concentrate in a relatively small geographic area to form cities [1]. Such rapid growth is the underlying source of urban issues, due to the additional pressure on urban infrastructure and natural resources [2]. The sustainable social, economic, and environmental development of cities and the provision of adequate resources for citizens can become a real challenge for governments [3]. Thus, governments and city authorities are now considering novel approaches to meet citizens' demands, focusing on the efficient utilization of resources while minimizing adverse impacts on the natural environment [4]. Approaches for a green city, sustainable city, carbon-neutral city, and smart city have been introduced to revolutionize the use of natural resources and urban infrastructure to address urbanization problems [5]. The smart-city concept—the latest trend—integrates information technologies into urban areas, to overcome urban challenges, improve sustainability in cities, and enhance citizens' quality of life [6].

The concept of a smart city was first introduced in the 1990s [7]. Since then, various scholars and industrial bodies have tried to develop a proper smart-city definition. Although there has not been a clear and comprehensive definition of a smart city established, some common characteristics exist among all smart cities. Nam and Pardo [8] emphasized that the smart city should consider technology, human, and institutional factors as its core components. Bergh and Viaene [9] further defined a smart city by suggesting two main types of a smart city: (1) technology-oriented infrastructure-intensive city, such as Seoul in South Korea and Santander in Spain; and (2) citizen-oriented city, such as Montreal in Canada and Amsterdam in Netherland. The principal features of any smart city consist of integrating digital technology into urban areas, involving residents in policymaking, emphasizing environmental sustainability, and utilizing entrepreneurship and human capital for urban development [10]. While technology is regarded as a hardware and software infrastructure, the human element comprises social capital, diversity, and collective intelligence. The institutional factor addresses smart-city governances, policies, and regulations. There is a census among researchers about what a smart city should consider and improve, which are technological advancements and improved human well-being. Subsequently, another research defines a smart city based on six dimensions: smart people, smart living, smart governance, smart mobility, smart environment, and smart economy [11].

In alignment with smart city research and studies, currently, 250 smart-city development projects in 178 cities are being undertaken worldwide [12]. Two major approaches exist to develop a smart city: (a) New Smart City Development and (b) Traditional City Transforming. The first approach is to develop a new smart city from scratch on vacant lands. The most recognized cases of this type are New Songdo in South Korea and Masdar in the United Arab Emirates. For example, the New Songdo smart city has no food rubbish bins and trucks on the roads, since all food wastes from kitchens are directly conveyed to the food-waste processing center, without leaving any environmentally non-friendly footprints. In the Masdar smart city, autonomous shuttle services and rapid charging stations for electric vehicles are used for smart transportation. The second approach, which is currently more frequently adopted, is to upgrade an existing traditional city and transform

it into a smart city. Some well-recognized examples of this type of development are Singapore and Barcelona. Singapore has developed a platform that bundles all government services from different departments for citizens in a single mobile phone application, and Barcelona implemented wireless sensors in the undersurface of roads to show empty parking spaces, in real time, to drivers, via a mobile phone application.

While the above examples explicitly illustrate some benefits of smart cities, there are more considerable advantages for smart cities, including effective data-driven decision-making, enhanced citizen engagement, safer communities, reduced environmental footprint, and economic prosperity [13][14][15]. The real-time information collected through electronic sensors and connected devices allows the city authorities to make well-informed decisions. Collaboration tools, such as mobile phone applications and web portals, help citizens provide their viewpoints directly to the government and improve citizen involvement. Other technologies, such as surveillance cameras, car license plate recognition, and gunshot detectors, can increase security and provide a safer place for communities. Deployment of air-quality monitoring sensors and smart waste-collection technologies reduce the adverse impacts on the natural environment. Lastly, the private sector partnership with governments in smart-city projects can increase economic development opportunities.

Although they present outstanding opportunities, the incorporation of advanced technologies into urban systems introduces new risks and issues, such as unequal access to smart-city data, a high cost of implementation and maintenance, and an increase in potential cyber-attacks [16]. Shifting a well-established urban system to a smart city is a complex and fundamental change. Addressing these issues calls for a robust plan that incorporates a rigorous risk-management framework [17]. Nevertheless, technology has been significantly overtaking innovations in risk-management and governance methods. Therefore, the integration of advanced risk-management practices into planning stages will ensure the long-term resilience of smart cities [16]. The implementation of effective risk-management processes can mitigate risks and assist governments in proactively dealing with the challenges arising from urban transformation [18]. The value of risk management in smart-city transformation processes has been emphasized by researchers, industry standards, best practices, and International Organization for Standardization (ISO 37106) [18][19]. However, a question remains unanswered: What are the risks of smart cities?

Despite a significant number of relevant studies in the literature, actual inclusive evidence for smart-city risks has not been provided and comprehensively identified and understood. A systematic literature review is a valuable research technique to identify, evaluate, and summarize all relevant publications about smart city risks and challenges [20]. Several reviews have been undertaken on smart-city topics, such as the governance components of smart cities [21], the indicators of smart cities [22], the results of smart city development [20], and, more recently, the application of fog computing in smart cities [23]. However, no comprehensive review has analyzed smart-city risks. The present study attempts to address this gap by reviewing the existing literature to identify the emergence, trends, and categories of risk in smart-city research studies over the past two decades. The results will provide a solid evidence-based direction for future research on smart-city risk management, as well as a practical guide for urban decision-makers to deal with relevant risks.

2. Discussion

This systematic review shows that “Technological Risks” is the most commonly researched theme, while social risk is the least studied area. Since some of the articles belonged to more than one theme, they were further classified into the overlapping themes of “Corporate Social Responsibility Risks”, “Digital Transformation Risks”, and “Socio-Technical Risks”. Among these categories, “Socio-Technical Risks” was the most frequent theme.

Although the first article to address smart-city risks was published in 2000, no paper on this topic was published between 2000 and 2010. In contrast to the significant promotion of smart cities within the ICT industry, only a few scholars paid attention to smart-city risks until 2010. This is because the effects of any changes in urban systems take considerable time to appear [24]. Moreover, the proper establishment of smart-city research as a new scientific area goes back to 2009 [25]. Therefore, the implementation of well-established knowledge areas, such as risk management, to the smart city concept was delayed until 2010, making this topic a relatively new research discipline.

The review shows that the United Kingdom (UK) has the highest number of studies in the area of smart-city risk. This result was predictable, since both the first smart city, Bletchley Park [26], and the most advanced smart city, London [27], are located in the UK. Furthermore, the UK has the highest number of smart cities among European countries [28]. All of these factors can reasonably explain the large number of publications in the UK.

The most obvious finding to emerge from this review is that technological risks have been widely investigated in the literature, while social risks have been largely overlooked, even though Vidiasova et al. noted that social risks for smart cities are as significant as technological risks. Technological risks may be overemphasized because technology is the

main driver of smart-city development , and the concept is primarily promoted by leading ICT corporations, such as IBM, Cisco, and Siemens [29]. An alternative explanation is that, while technical challenges are detectible during the implementation stage, the social effects of smart cities might take considerably more time to appear in societies. Therefore, social risks have not yet emerged as a critical issue over an extended period and, consequently, have not been investigated as frequently as technological risks.

Another important finding is that, along with the UK, Italy has the highest number of studies on smart-city social risks. This result can be explained by the fact that Italian citizens are actively engaged with city governance and decision-making processes, and ICT technology is utilized only to enhance residents' quality of life and resolve social problems [28]. The government has also implemented various programs to reduce social risks in their smart cities [28]. These attributes highlight the significance of social aspects in Italian smart cities, so it is hardly surprising that Italy has the highest number of articles on the "social risk" theme.

3. Conclusions and Future Work

The integration of risk management into smart-city strategic plans is vital, as transitioning from a traditional to a smart city is a complex and uncertain process. Various reviews have been conducted on different domains of the smart city. However, there has not yet been a comprehensive overview of the current publications on smart-city risks. Therefore, this study set out to explore the existing literature, to identify the origin, trends, and types of risks in smart-city research studies over the past two decades. Through a systematic literature review, this study identified 85 articles related to smart-city risks. The selected articles were analyzed, interpreted, and categorized, to recognize their common and overlapping themes.

The results reveal that risk is a relatively new topic in the smart-city discipline, which is mostly discussed in the context of countries that have the highest number of existing smart cities. This review determined the three different categories for smart cities: technological, organizational, and social risks. It also identified some overlapping groups, including digital transformation, socio-technical, and corporate social responsibility risks. The review findings suggest that, although various studies address smart-city technological risks, little focus is given to the related social aspects. The reason for the lack of such studies is partially because the primary driving force of smart cities is the technology promoted by major ICT corporations. An alternative explanation is that, unlike technical problems, social issues take a long time to appear. Another major finding is that studies from countries that have a long history of smart cities, such as the UK and Italy, have paid more attention to these social risks.

This study provides a comprehensive overview of the risk subject matter in the smart-city literature and a significant understanding of smart-city risks. It establishes a practical guide for urban authorities to use in their governance processes and also lays the groundwork for future investigations in the field. Future research should focus on exploring the relevant social risks and mitigation strategies, to assist governments in their decision-making processes. Furthermore, socio-technical risks need further examination, to find the best match between the technological and social components of a smart city.

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