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Towards an Integrated Framework to Measure Smart City Readiness: The Case of Iranian Cities

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Abstract: This paper introduces an indicator system to measure and assess smart city readiness. Analyzing smart city initiatives in Iran as case studies, the theoretical framework we present reflects on how cities explore the possibility of becoming smart, and prepare themselves to begin implementing the transition towards becoming a smart city. This theoretical framework is then applied to four Iranian cities aspiring to become smart and that already possess credible smart city brands. The findings reveal that the most significant difficulty in Iran is associated with the political context. The changing urban governance model is the most important factor in Iranian smart cities' readiness. Utilization of open data policies and data sharing, as well as making reforms in government structures are all considered a sine qua non to gain momentum. Based on the results of our empirical analysis a Theory of Change is developed to address the cities' technological, socio-economic, and political readiness vis-à-vis the desired transition. The framework for measuring smart city readiness and the Theory of Change provide practical guidelines to developing systematic roadmaps for developing and implementing smart city policies.

Keywords: smart city; urban transition; theory of change; technological readiness; social readiness; political readiness; Iranian cities

1. Introduction

Conferences, seminars, and statements of executives and government officials and academic articles around the smart city topic reflect growing attention to formulating programs associated with smart city development [1]. Growing urbanization, economic competition, citizens' expectations, and environmental challenges, along with rapidly improving technological opportunities, are the main drivers [2–5]. Some pioneering cities have gained valuable experience from which both positive and negative lessons can be drawn. Followers can learn from these and join in this emerging trend. The Iranian government, as one of these followers, has always mentioned globalization in its policy documents and visions and recently smart urban development amidst globalization appears in many policy documents drafted by Iran's largest cities. Tehran, Mashhad, Isfahan, Shiraz, Urmia, and Qom are the largest Iranian cities and are using a smart label in their profile. This is part of an overarching national smart city program [6]. Some of Iran's neighboring countries have taken considerable steps to develop smart cities of their own. They have used Internet of Things (IoT) solutions to solve urban management problems by learning from strategic and technical approaches to develop 'smart-city' capabilities, in particular based on good practice. For instance, in the UAE, Dubai has made significant progress in recent years [5,7].

In their paper Noori and De Jong (2018) examined the credibility of the city brands adopted by Iran's largest cities. The results reveal that, among the cities with a smart profile, only four cities (Tehran, Mashhad, Isfahan, and Shiraz) actually have credible brands. Credibility is defined in terms of six factors contributing to credibility of a city brand: (i) generate feelings of loyalty; (ii) facilitate the development of an overarching strategy or policy; (iii) evoke positive feelings; (iv) demonstrate uniqueness or distinctness; (v) allow for different, yet non-contradictory, messages to various stakeholders; and (vi) logically connect past heritage, current profile, and future ambitions [6]. Still, the question remains on whether these cities are truly ready to become smart? In view of the fact that the formulation and implementation of a smart city policy, like any other policy, needs to be tailored to the contextual conditions and would require infrastructures, assessment of the readiness of these cities to participate in this global trend is essential [8]. Therefore, the present study aimed to provide a systematic, integrated theoretical framework that can be used to measure smart city readiness and, based on that, a Theory of Change which cities can consider when they prepare themselves for their transition to become 'smart'. Basically, they can learn from pioneers and good practice, and localize the policies and solutions since each city has its own unique features and challenges, as well as requires its very own set of solutions [9].

The literature on smart cities has steadily been growing recently [10–14]. Multiple studies have addressed the transition process cities engage into becoming smart [15–18]. But less attention has been awarded to the readiness of cities into becoming a smart city [19]. In their overview study, Ibrahim et al. (2018) assessed city readiness for change during the transition process into becoming smart sustainable cities by focusing on local assets [18]. In another study, Achmad et al. (2018) evaluate city readiness considering technological, social, and political conditions for change. The study showed that the smart city enablers are particularly brainware, hardware, and software. The authors hold that these are indicators that should be assessed for evaluating smart city readiness [8]. Although Ibrahim et al. (2018) discern different aspects of readiness, like the non-technical readiness, the study itself focuses predominantly on technical aspects, and, in particular, stresses the examination of readiness for Information and Communication Technology (ICT) [18]. The Smart Cities Council (2013) has investigated the barriers to smart city development from working on smart city projects all across the world. Their results show that a frequently emerging barrier is the lack of a system-wide view and integrated approach [20]. Developing a smart city requires integrating technological and non-technological contexts and create a holistic vision. This present paper aims to add non-technological aspects to the readiness mix to enable urban governments in developing a more comprehensive ex ante assessment of their smart city readiness.

The aim of this study is to examine the contextual conditions and readiness of cities to become smart. Consequently, our research questions (RQs) are the following:

How to determine whether cities are ready to transition into Smart Cities? What does an indicator system measure to determine whether a city is ready to become smart? And to what extent do Iranian cities meet the minimum requirements for becoming smart?

To address these questions, we conducted a qualitative study based on two theoretical frameworks: first, one presented by Dameri et al. (2019), which identifies a list of global and local smart city features; and second, the framework for smart city design variables presented by Noori et al. (2020). We add social and institutional variables based on a literature study and our intention to compensate for the shortcomings of current theoretical frameworks and develop a more holistic integrated theoretical framework. We apply this to four cases in order to analyze their specifications in terms of being ready to become smart cities. The contribution of this article is in highlighting the role of technological, socio-economic, and political readiness of governing an urban transition process towards a smart city with an indicator system to measure smart city readiness.

The structure of this paper is as follows. Section 2 maps the academic literature to explore more in-depth insights on cities' readiness for transition into smart urbanism and also presents the urban transition theory and the theory of change. Section 3 presents the research design, methodology,

and data collection and shows our adjustment and elaboration of existing theoretical frameworks to develop an indicator system subsequently applied the case studies. Section 4 provides the analysis and exploratory insights on Iranian cities' readiness to become smart cities. In Section 5, the results of the study are presented and discussed. Finally, in Section 6, the conclusions and suggestions for future research are presented. In addition, policy recommendations are provided for 'smart initiatives', particularly Iranian smart initiatives, to find out how they can prepare for their transformation.

2. Transition Towards a Smart City and Readiness for Change

2.1. Urban Transition

Transforming a city into a smart city first of all requires consideration of the readiness of a city for change [19]. The term 'change' refers to both technological and non-technological changes in the urban context. The transition discourse appears when a specific way of knowing long-term transitions is considered [21]. Frantzeskaki and De Haan (2009) view 'transition' as a societal process of fundamental change in culture, structure and practices [22]. According to Geels and Schot (2007), transitions are changes from one socio-technical regime (which pertains to a networks of actors and institutions, and cultural or social norms along with technological trajectories) to another [23]. In the quest for an urban transition into smart cities, change is primarily described using insights on transitional change of socio-technical regimes in urban environments.

According to Jhagroe (2016), 'urban transition' can be defined as the creation and normalization of urban regimes and practices in the replacement and reforming of other urban regimes and practices [21]. In this sense, it fits the more general definition of transition coined by Geels and Schot (2007) and applies it to the urban domain. To conceptualize the notion of urban transition, one needs to know how the transition process is initiated, guided, and how it evolves over time. Smith et al. (2005) point out that regime change is the result of internal or external pressures on the regime, which can range from political, economic, social, environmental, to technological pressures. They argue that the resources available inside and outside the regime should be coordinated to adjust to the pressures [24]. By combining the availability of resources and the degree of coordination, Smith et al. (2005) developed a two-dimensional framework for a typology of four transitions. They argue that system-level change requires coordination of different actors and resources [24]. Stripple and Bulkeley (2019) also highlight the alliance between different actors in the process of a transition to promote certain transition pathways [25].

Over the past decade, the concept of urban transition has been used in a growing number of studies addressing ecological modernization of cities [19,21,24,26]. A momentous discourse is the one on sustainable technology transitions, which is supposed to be one of the main contributions of smart cities development. Smith et al. (2005) understand sustainable technology transitions as changes mediated by the resources, interests, and expectations of institutionally embedded networks of actors [24]. In an investigation of Asian development pathways and sustainable socio-technical regimes, Berkhout et al. (2009) stress the absence of linkages between different government levels (i.e., between the local, regional, and national levels) in socio-technical systems as an obstacle in sustainability transitions [27]. All the studies mentioned above stress the importance of contextual factors, resources, and networks of actors in transition processes [28].

2.2. Technological Readiness

Several scholars argue that technological readiness is an essential condition for transition towards smart cities [8,19,29–33]. In their study, Ibrahim et al. (2018) stress the importance of checking city readiness for change before planning a transition process. 'Technological change' is obviously part of this urban transitional change, including the adoption of emerging technologies and providing appropriate and adequate infrastructures. In the Smart Sustainable City transition roadmap, these authors propose to add two pre-phases that pertain to 'city vision' and 'city readiness'.

In the 'city vision' phase, city priorities are identified through current city state analysis, vision and strategies, and identifying stakeholders. During the 'city readiness' phase, the readiness of ICT-based infrastructures, non-ICT-based infrastructures, and availability of any previous Smart Sustainable City initiatives are checked. In terms of ICT-based readiness, the authors propose to assess the hardware and software infrastructures, as well as ICT-related skills [18]. In 2009, the International Telecommunication Union (ITU) presented an ICT development index (IDI) that combines eleven indicators on ICT access, use, and skills, capturing key aspects of ICT development in one measure that allows for comparisons between countries and over time [34]. Among many studies [4,15,23,26], the smart city readiness guide presented by the Smart Cities Council (2015) appears to be the most comprehensive guide for assessing technological readiness.

The definition of the smart city behind this smart city readiness framework by the Smart Cities Council (2015; p. 6) is: a city that uses information and communications technology (ICT) to enhance livability, workability, and sustainability [2]. The definition shows that the core enabler of smart cities is ICT, and the ultimate goal is to establish a better future city to live and work in, while preserving, the environment. The framework holds that all the city functions (including energy, transportation, telecommunication, health, human services, waste management, payments, and finance, as well as public safety) that smart cities promise to improve are enabled through the power of technology [2]. It proposes different technology enabling indicators to assess smart city readiness to provide insights in where to start and where to end up for decision-makers.

In the present paper, in order to assess the technological readiness based on urban transition concepts, we started with an analysis of the current situation of the available technological resources. For this purpose, we relied on an Input-Output (IO) model of smart cities that determined the key resources for smart city development process [1]. It proposes different design variables for ICT infrastructures as one of the key resources in the development process. For developing a smart city technological readiness framework (see Table 1), we also deemed it necessary to pay attention to insights pertaining to the smart city readiness guidelines presented by the Smart City Council [2] and IDI issued by ITU [34].

Table 1. Smart city technological readiness framework (adopted from the Input-Output (IO) model of smart city [1] and the smart city readiness guidelines [2]).

Smart City Attributes	Design Variables	Indicators (Presence of)
ICT and Data resources	Data aggregation	Big data establishment
		Sensors and actuator equipped devices, CCTVs & cameras
	Connectivity	ICT Development Index (IDI)
	Data processing	Data science centers
	Data real-time analysis	Data visualization platforms
Data management capabilities	Establishing a data authorization	Data Laws
	Security	Establishing a cyber security framework

The key purpose of developing ICT infrastructures for smart city development concerns: (1) connection to things that facilitate collecting data; (2) connection to things for targeted information; and (3) connection to things for data serving in smart applications. The IO model emphasizes that, along with the required resources, there is also a need for dynamic capabilities to manage these resources. A vital resource for smart urbanism that needs to be managed is data. Watts et al. (2009) state that the complexity of managing data increases with increasing data volumes. The aim of big data management is to ensure the quality of data and transforming data into knowledge [35]. But this is not the only purpose of data management; there also are concerns about the misuse of data and cybercrime. Issues like data theft, data ownership, data accessibility, and privacy issues can arguably be managed by establishing data authorization and cyber security platforms [12,36,37].

2.3. Socio-Economic Readiness

Urban transitions influence the societal system in several ways, but this is not to be considered one-way traffic. In fact, it is an interaction between the societal system and technology regimes governed through authorization. Change in urban transitions requires input of human resources to make the transition happen, and the new urban regimes and practices need to be supported by social networks [23]. The central activities for smart city readiness may be to provide human resources for the smart city development process and to support formation of social networks around the smart city development process. Context matters in this regard [9]. Using a knowledge-based conceptual vision of the smart city is a fundamental requirement for improved decision-making [38]. Providing the required knowledge for smart city development can either be extracted from data flows (explicit knowledge) or from human capital (including tacit knowledge) [38]. Nam and Pardo (2011) even argue that human factors form the core components of a smart city, along-side technology and institutional factors. Human factors entail concepts like social learning, creativity, and education [13]. However, knowledge alone is not sufficient. Knowledge and creativity can, rather, be viewed as two enabling wings of innovation fostering smart solutions [39]. Based on these arguments, the IO model proposes resources to provide both human and entrepreneurial infrastructure as: educated and trained people, an innovation environment, and a supporting system for innovative companies and startups. The output in the IO model pertains to smart applications (in terms of energy, mobility, healthcare, governance, and citizens) [28].

In the context of smart cities, innovation studies provide insight into which type of citizens are most likely to support smart city technologies and policies and be involved in the development process. Sepasgozar et al. (2019) found that the culture and needs of urban citizens are important factors for acceptance of related urban service technology [40]. Dameri et al. (2019) enumerate geographical localization, culture, mentality and values of people, educational level, different ideas of quality of life, national laws, and territorial governance models as characteristics that are specific to smart cities [9]. In an extensive survey, Calderon et al. (2018) also mention the knowledge level citizens have about the smart city concept and smart technologies for checking smart city readiness in Latin American cities [29].

Insights taken from the previously mentioned literature led us to conceive the following framework for social readiness of city residents to smart city transitions (Table 2).

Table 2. Smart city socio-economic readiness framework.

Factors	Definition and Operationalization
Education	Number of universities and research centers Knowledge transfer and knowledge sharing programs
Innovation	Specific policy in place to promote smart city innovation Supporting and encouraging programs for innovative companies (science and technology parks, free zones, etc.)
Awareness	Level of citizens' awareness of the smart city program in their city
	Level of citizens' awareness of the smart city concept and technologies
Perceived usefulness	Level of perceived usefulness of the smart solutions for the city's challenges by citizens
Mentality and values	Citizens' opinion about a smart city Citizens' image of their cities Citizens' different ideas of quality of life

2.4. Political Readiness

An important additional contextual factor affecting smart city readiness is the policy environment, including national policies, legislation, and local governance arrangements. Smith and Stirling (2010),

through highlighting the relation between 'policy institutions and political activities' on the one hand and the transition management processes on the other, stress the importance of political power to decide when and how to make the transition happen [26]. When many actors are involved in a process and their interactions vary across time and policy issues, the process is complex in terms of policy-making and implementation [41]. Smart city programs deal with this complexity, having to cope with different actors who have divergent interests [42–44]. Cairney (2012) believes that power diffusion makes public policy processes and outcomes different.

It is also important to consider governance models that are used in urban transitions. Governance model here refers to all the processes of governing the city, both formal and informal institutions, undertaken by a government or any other actors. Governance includes formal policy instruments, such as laws, rules, municipal ordinances, and territorial policies, and non-institutional mechanisms, such as public–private partnerships, subsidiaries, negotiations, and citizen participation [45]. Governance is not only about what governments do but also about the outcomes of interactions between all actors in the public domain [46,47]. Therefore, there are two characteristics in the political environment that have impact on smart city development: the governance structure, and the interaction between government and other actors (see Table 3). Government also has a role to play in the interaction among actors. In smart cities known as good practice examples, like Dubai or Amsterdam, local government takes the initiative for smart city transition and is responsible for coordinating joint action involving multiple local stakeholders. This includes alignment of visions and expectations, formulation of the smart city vision, and alignment with the overarching policy, regional, and national programs, providing a platform to involve different actors, attracting funds, and eventually implementation of a smart city transition policy. In addition, public leadership is necessary to support establishing a vision for policy making and implementation, while, at the same time, maintaining transparency and building trust among local stakeholders and residents [46,48].

Table 3. Smart city political readiness framework.

Political Context	Definition and Practices
National policy and governance	National leadership
	Government structure, governance arrangements, policy networks
	Rules, laws, legal and regulatory reforms Legitimacy, transparency, and trust
Municipal policy and governance	Local leadership Partnerships with industry, academia, and citizens
	Providing a platform for multi-stakeholder partnership Smart city innovation clusters and networks

3. Research Design and Methods

The analytical framework used is based on the IO model of smart city development [15] and the smart city readiness guide by Smart City Council [2]. We use the framework derived from a qualitative data analysis of scientific papers and existing frameworks for smart cities readiness (Appendix A, Table A1). Our approach applies the IO model and existing related frameworks to develop a framework for technological, socio-economic, and political readiness and uses the theory of urban transitions to understand how technological, social, and political features influence the cities' readiness to become smart [1]. Then, we use the integrated framework on smart city readiness based on Table 1, Table 2, and Table 3 to identify indicators and collect and organize our data. The integrated framework is shown in Table A1. The next step in our research is to apply this framework to the cases of Iranian cities. These cases pertain to four large-scale Iranian cities (with over 500,000 residents each) that have smart city policies in place and have also adopted a smart city brand that is considered credible [3].

The four cities are: Tehran (the capital of Iran), Mashhad (the capital of the Khorasan-e Razavi Province), Isfahan (the capital of the Isfahan Province), and Shiraz (the capital of the Fars Province).

3.1. Data Collection

In order to collect data, we used both desk research and a survey. For assessing technological readiness, both qualitative and quantitative data were collected from the city websites, available statistical datasets, and policy documents, such as masterplans and policy reports. To collect data related to social readiness, we conducted a survey among citizens using a questionnaire. We conducted a survey in 2020 asking for citizens' views on the smart city program in their city (whether respondents are aware of it or not; whether respondents agree with or not; whether respondents find it useful to solve their urban issues or not; to what extent respondents are familiar with smart city technologies, and the perceptions respondents have of a smart city in general, the main issues playing in their city, respondents' perception image of the city; and their assessment of quality of life). We distributed the questionnaire through email and social media (i.e., via WhatsApp and Telegram groups) until we received responses from at least 20 participants in each city. The response rate varied per city: i.e., in Tehran (21/37), Isfahan (23/34), Mashhad (20/52), and Shiraz (20/78). All participants were citizens of one of the four cities and had lived there for at least three years. The sampling method was intended to be random. However, the final sample was biased because an online survey was used. For this reason, respondents are mostly citizens who are familiar with and use the internet, use smart phones, and, in this sense, already have some affiliation with the concept of the smart city. For political readiness, we used qualitative data available on the international index rankings and reports on Iran's governance assessment (Bertelsmann Stiftung's Transformation Index (BTI) 2018), cities' official websites, governmental reports, and policy documents.

3.2. Data Analysis and Theory of Change

To analyze data, we applied the approach of the Theory of Change (ToC), which included a situational analysis as a form of empirical analysis, prior to designing a Theory of Change. Weiss (1995) introduced 'Theory of Change' (ToC) as a theory to clarify how and why a given (policy) intervention initiative works. It was mainly generated to support ex ante evaluation of a given intervention. Connell and Kubisch (1998) argue that there are three main reasons to develop a ToC for interventions: First, by sharpening the planning and implementation; second, by facilitating the measurement and data collection elements of the evaluation process; and third, by reducing problems associated with causal attribution of impact by articulating a roadmap for the change and making an agreement between different stakeholders. The United Nations Children's Fund (UNICEF, p. 3) defines ToC as follows [49]:

'A ToC explains how activities are understood to produce a series of results that contribute to achieving the final intended impacts. It can be developed for any level of intervention–an event, a project, a program, a policy, a strategy or an organization'.

Starting with the definition by UNICEF that stresses using the ToC for different levels, we associate the theory of change with smart city policy planning to identify the current situation, the intended situation, and what needs to be done to transform a city into a smart city. According to the UNICEF definition, the ToC deals with the interventions. It makes the theory responsible for addressing three fundamental questions: (1) What are the interventions? (2) What is the current situation in terms of needs and opportunities for future development? And (3), what needs to be done to move from situation 'A' to situation 'B'? [49,50]. In the present study, the object for the ToC is 'the readiness of Iranian cities to become smart', the interventions refers to 'technological resources and capabilities', individuals and society', and 'national and municipal political systems, while 'situation' refers to the plans, projects and actions regarding technological, social, and political readiness to becoming a smart city. The current situation analysis provides insights on available resources, current issues, and problems in need of solutions, as well as contextual conditions. Analysis of the desired situation

clarifies what outcomes the initiative should reach with those interventions and available (or planned) resources in a certain context. The comparison between the current situation analysis and the intended outcomes reveals the gap between situation 'A' and situation 'B', and the challenges and opportunities for the transition from 'A' to 'B'. Generating a ToC -based on the gap analysis considering challenges and opportunities can guide decision-makers on how the gap can be bridged. They may either decide to plan for making necessary resources available and some contextual changes, or to adjust their intended goals.

In order to take the first step of generating a ToC in the present study we need to specify what the situation (both the current situation and the desired future situation) means in our intervention (or initiative), including technological, social, and political readiness. Based on the ToC, we take the following three steps for all four city cases data analysis: Step1: A situational analysis; Step 2: An analysis of the gap between current situation and intended situation, laying bare the challenges and opportunities; and Step 3: Mapping a ToC about how to get from the current situation to the desired situation.

To conduct a situational analysis (step 1), we rely on a qualitative analysis of data organized through the integrated framework for smart city readiness in this study. To perform step 2 (determining the challenges and opportunities), we rely on qualitative data reflecting the cities' visions and goals of smart city development, as well as statements of the officials about their smart city programs. And, finally, based on the analysis, we provide policy recommendations for the change (being ready to transform into a smart city).

4. Iranian Smart City Development: Smart City Readiness

Iran started promoting smart city development in its third Five-Year Plan (2018–2022). It sought to deal with urban problems ahead and looked at new approaches in the development of future cities around the world. It selected five cities (Isfahan, Uremia, Tabriz, Tehran, and Mashhad) for the development of smart cities. Later, the municipalities of Shiraz, Qom, and Kish Free Zone also joined to the national smart city program and adopted a vision to profile themselves as 'smart'. In most cases, expressing the wish to become smart was a reaction to urban problems, such as traffic congestion, air pollution, energy crisis, or ideals for improving the general well-being of citizens. Noori and De Jong (2018) examined the credibility of the Iranian mega cities brands and found that four cities among them had the most credible smart city brands, i.e., Tehran, Mashhad, Isfahan, and Shiraz [6].

Tehran metropolis is the capital of the country. It currently has over 9 million inhabitants and 12 million floating population, making it the largest city in West Asia and the twenty-seventh largest city in the world. It is the political, administrative, and economic center of Iran. Mashhad, the second largest city of Iran (with 3 million inhabitants), is the religious center of Iran, with over 20 million pilgrims and tourists per year (to visit the shrine of a Shia Imam). Its economy is also strongly affected by its hosting of the shrine. Isfahan and Shiraz, respectively, are the third and fourth largest Iranian cities, and they are the cultural centers of Iran with a significant historical heritage that make them attractive destinations for global cultural tourism [6]. In this section, the readiness framework presented in Section 2 is applied to the case of these cities to map their current technological, socio-economic, and political situation in terms of being ready for transition towards a smart city.

4.1. Technological Readiness

Tehran, which is more engaged with urban issues, like traffic and air pollution, and has different urban policy layers, perhaps would be one of the most complex smart city projects in Iran. Although all cities in the mainland operate in a multi-level government context, Tehran, as the political center of the country, has always attracted more attention. This most important city of Iran, with a population of more than 8 million people, accounts for about 11% of the country's total population and ranks 28th among the world's most populous cities [51].

ITU ranks Tehran province 1st in Iran with an IDI value of 7.24 in 2017, while Shiraz (6.25), Isfahan (6.24), and Mashhad (5.35) ranked, respectively, 7th, 8th, and 18th. Most of Iran's datacenters are located in Tehran, to serve the entire country from the capital where the equipment and infrastructure is most advanced. Iran's IoT research center launched 'The Things Network of Tehran' as a global open crowd-sourced IoT data network, which is the first of its kind in the Middle East. An integrated city data portal and application, so-called 'My Tehran', was established in 2018. Citizens of Tehran can access many services through this integrated portal with a citizen account in which city statistical data are openly available and visualized in eighteen categories. Yet, the portal is under development and a limited number of data (and not critical data) was accessible at the time of writing this article.

The ICT organization of Mashhad municipality is planning to launch a city portal, as well. The goal is that citizens can access all the smart applications through a single user account [52]. Isfahan launched the 'Network Real Time Kinematic', which aims to develop an integrated platform for spatial information so-called 'Sima' [53]. Shiraz's financial and economic deputy announced setting up a data center in the city of Shiraz in order to achieve smart features. The goal of the Shiraz Big Data Center is to establish smart city features through which services in terms of smart governance and policies, smart economy, smart living and working environment, smart transportation, and smart citizen can be provided [54].

Iran's Minister of Communications and Information Technology (2015) claimed that the fiber-optic network expansion program in Isfahan that is in progress will in the near future provide appropriate infrastructure for Smart Isfahan [55]. The 2019–2020 plan of Isfahan indicates the focus on expanding the fiber-optic network and data center projects. The Geographical Information System projects based on developing a Geo-data base is also another focus of this one-year plan [56]. Sensors and actuator-equipped infrastructures can enrich big data establishments by providing real-time inputs [2]. According to the ICT Director of Tehran Municipality (2019), importing needed sensors for the smart city program will be expensive due to the rising exchange rate and sanctions, so that promoting domestic production will be a cost-effective solution to provide these sensors and actuators [57]. In Mashhad, the municipal ICT organization has announced it will provision flood alert sensors, air quality sensors, and traffic sensors for the smart city development program [52]. To improve traffic conditions, the ICT Organization has started to produce and operate the 'Traffic Image Analysis System' [58].

Four main data centers are based in Tehran (Supreme Council of Cyberspace, ICT research institute, Iranian Institute of Information Science and Technology, and Iran's IoT Academy) and one in Mashhad (IT and Cyberspace Research Center). In 2017, Iran's Supreme Council of Cyberspace established IoT laws and regulations for the whole country, which were approved and authorized by Iran's Leader [59]. In terms of establishing a cyber security platform, Tehran has a cyber security research institute, and Mashhad's and Isfahan's master plans indicate specific budget allocation for cyber security projects.

4.2. Socio-Economical Readiness

In examining whether a given society has a suitable platform for developing a smart city, the educational status is a first indicator. There are 119 universities and academic centers in the city of Tehran, and 24% of its population is high educated. There were 1,382,515 students enrolled in Tehran universities in 2018, with 149,544 professors and faculty members. These figures for Isfahan are 67 universities and academic centers, with 140,374 enrolled students in 2018. These numbers for Shiraz and Mashhad are at 25 and 30, respectively, for universities and academic centers [60].

One of the main knowledges and experience sharing programs around smart cities was founded in 2008 following the proposal of Tehran Municipality to the Asian Parliamentary Assembly (APA), Asian Mayors Forum (AMF): the Asian Smart Cities Committee. The Tehran Urban Innovation Center (TUIC) was founded in 2017, aiming to present new urban solutions influenced by the smart city discourse. TUIC's innovation model is based on the network innovation approach, striving to build a

foothold in the international network of knowledge generation and idea sharing in the field of urban innovation [61].

Isfahan Urban Creativity and Innovation Center was also established in 2017 as a bridge between the citizens' ideas and the municipality [62]. In 2018, the Urban Innovation Center in Mashhad was put into operation to establish a link between urban management and emerging technologies [63]. The City Council of Mashhad and Mashhad municipality have raised the issue of establishing an urban innovation center to achieve the 20-year vision of city as a knowledge and smart city [64]. According to the ICT Director of Isfahan Municipality (2017), Isfahan has adopted the international standards and indicators as its smart city model, issued by the Smart City World Council and the International Organization for Standardization (ISO 37120) [65]. The head of the Center for Strategic Technologies Development of the Scientific Deputy stated that the Shiraz Innovation Factory will be launched in 2020. Ghaderifar (2020) mentions that the innovation factory is a campaign for start-ups aimed to support ideas and train human resources and specialists to create knowledge-based companies and innovative solutions [66].

There are eight science and technology parks and incubators around Tehran to support innovative companies and startups by providing benefits to businesses based in the parks. These are based on: tax exemption, annual performance exemption, exemption of duty payments, commercial interests and export duties, and foreign exchange transactions, like free economic zones [67]. All science and technology parks in Iran are allowed to offer these advantages. In Mashhad, there is a science and technology park, and there are eleven incubators. Isfahan has three science and technology parks and 10 incubators, and Shiraz has one and five, respectively, science and technology parks, and incubators [68].

The results from this four-city survey show that the level of citizen awareness of the smart city program in their cities are almost similar, and citizens mainly have heard about it but have not received enough information. They also have an average level of awareness of the of the smart city concept and technologies. The level of perceived usefulness of the smart solutions for the city's challenges by citizens (of all four cases) is significantly higher for traffic, pollution and environmental issues. However, in Isfahan, the usefulness of smart solutions for housing issues was also mentioned. In terms of citizens' opinion about a smart city, our preliminary results from a pilot survey indicate that, in Tehran and Mashhad, the most frequent statements by the survey respondents are related to 'green' and 'surveillance' city; in Isfahan, are linked to 'surveillance' and 'happy' city 'surrounded by technology'; and, in Shiraz, are associated with a 'safe' and 'green' city. Regarding the image of the respondents from Tehran of their city, the most frequent images are intertwined with a 'polluted city', 'over-crowded', and 'expensive', but still an 'alive' city. The images that appear most frequently by the respondents of Mashhad minds regarding their city are linked to a 'crowded' and 'polluted' city with deficiencies in public transportation. In Isfahan, in addition to crowds and pollution, the respondents have the image of a 'beautiful' and 'historical' city 'with a lot of potential'. The most frequent images of the city expressed by the respondents of Shiraz are 'happy' and 'beautiful' city. Regarding citizens' different ideas of quality of life, the most frequent statements in Tehran by the respondents are: 'safety', 'prosperity', 'happiness', 'peace', and 'citizen's (human) rights'; in Mashhad, they are: prosperity', and 'happiness'; in Isfahan, they are: 'health', 'safety', and 'happiness'; and in Shiraz, they are: 'safety', 'prosperity', and 'happiness'. However, these statements are not based on a large sample from among citizens but, given the internal variation, they still represent the opinions, images, and ideas of a relatively random group of citizens such that it can at least serve as a first approximation in this exploratory study.

4.3. Political Readiness

In terms of political readiness assessment, the BTI report in 2018, on the governance index, such as political participation; rule of law; stability of democratic institutions; socioeconomic development; economic transition; private property, ranks Iran 115th out of 129 nations (Figure 1) [69]. The report (p. 4) states that:

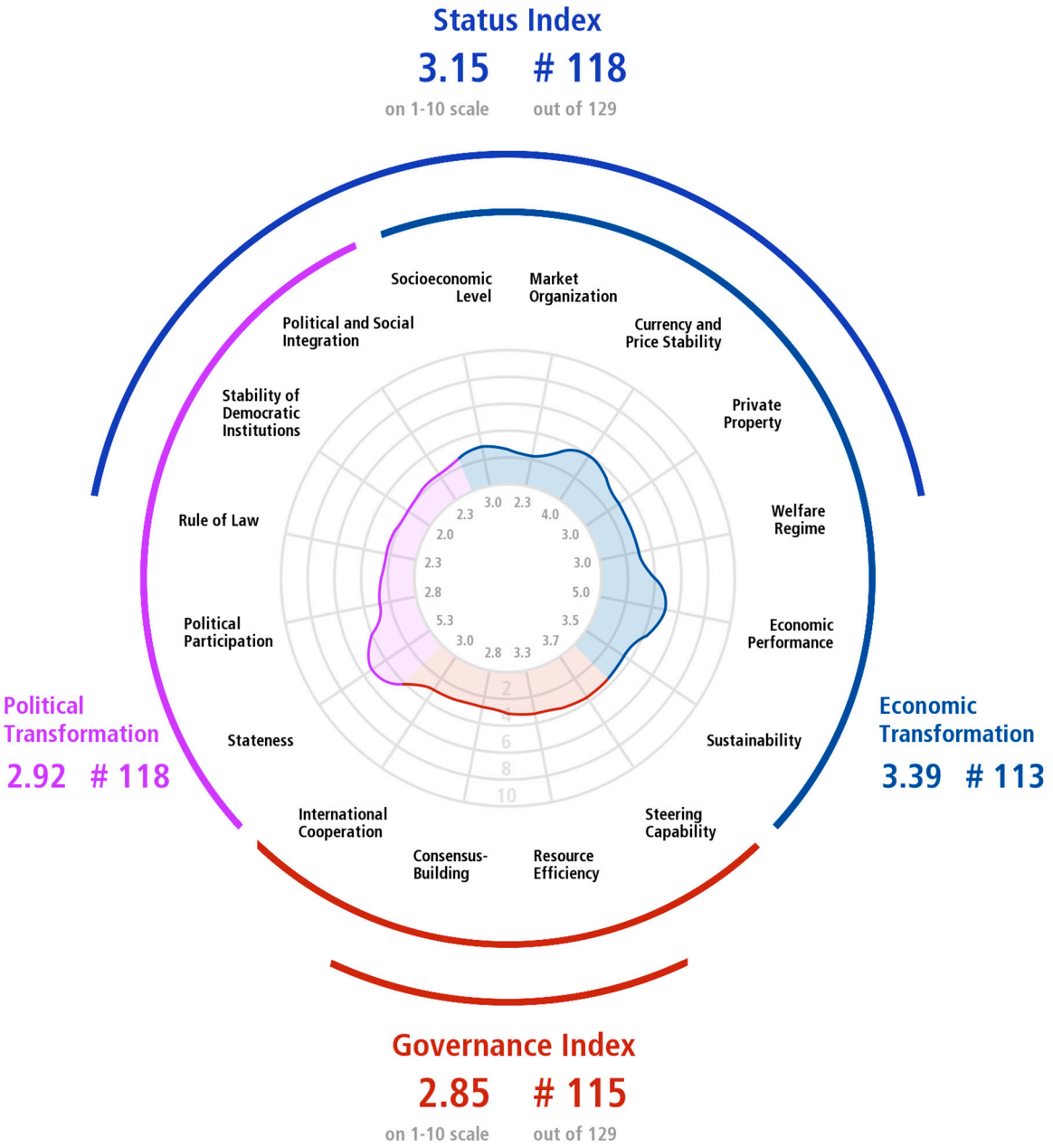

Figure 1. Bertelsmann Stiftung's Transformation Index (BTI) 2018 Iran Country Report [69].

'Ideological and religious dogmas are basic principles of politics and the economy in Iran, often preventing the implementation of professional strategic plans, projects and expertise. The leadership style and the entire ideological-religious foundation of the Islamic Republic are the major constraints.'

Iran has a multi-level governance structure, governing cities through a centralized approach. Each city has a city council of which candidates should be examined by a central council overseeing the elections, and people will elect members of the city council from among them. Each city has a municipality and its own municipal laws and regulations that have to be aligned with the upstream policy documents under the overarching Islamic law (Shariah). One of the main trustees of the smart city program in the Iranian cities is the ICT Organization of Municipality. It is responsible for directing and supervising the activities of the municipality and all its affiliated organizations in the field of information and communication technology. Another highlight in the BTI report (2018) is its emphasis on the lack of transparency of the political system in their financing and administrative structures,

which play a crucial role in smart city governance. A poll conducted by the state-run Iran Students Polling Agency (ISPA) in 2019 confirmed that only 15 percent of the citizens of Tehran were satisfied with the government [70]. Moreover, in 2020, only 26 percent of Tehran's citizens participated in the parliamentary election. Political analysts believe that, based on recent events (such as suppression of public protests in November 2019 and the Ukrainian plane crash in Iran), the level of public trust in government institutions has declined even further [71–73]. The results of the survey presented in this study, on the other hand, indicate that all respondents emphasize the importance of citizen participation in urban decision-making. Appendix A (Table A1) summarizes the results and empirical observations from the four Iranian smart cities in addressing the research questions.

5. Iranian Smart City Development: Vision and Expectations

According to the analysis of about one million scientific articles, the topics around smart city concepts, such as 'sustainability', 'information technology', 'quality of life', 'environment', 'data mining', 'knowledge management', and 'entrepreneurship', are among the top 20 research topics in Iran over the last 10 years [74]. These themes are derived from academic channels. But what do urban managers and policy makers aim for? Tehran has clearly mentioned the 'smart' program in its third Five-Year Plan (2019–2023) [75]. In both strategic documents of Isfahan 2021 and Isfahan 2026, the smart city program is referred to in the vision, goals, and missions [76]. The Five-Year Plan (2017–2021) of Mashhad Municipality has been compiled as the fourth operational plan, in which smartening is clearly one of the goals mentioned, in line with the 2026 vision document of Mashhad city [77]. Shiraz's third Five-Year Plan stresses smartening of urban management, in particular by having an electronic municipality, i.e., making digital public service delivery facilities available [78]. Iran's Minister of ICT, during the third Smart Cities Conference (Tehran, 2019), emphasized the duty of the government to provide infrastructures for smart city projects and noted that '. . . *the activities carried out in the field of the smart city over the past year show that we have moved beyond the infrastructure layer, and this year we need to focus on developing inter-sectoral collaboration'* [79]. There is a strong emphasis on preparing the infrastructures for smart cities in which the Ministry of ICT will be involved, and it also requires the involvement of other ministries. He added '. . . *apart from the above-mentioned investors, also universities, knowledge-based companies, Internet companies and mobile operators must be active in this sector to ensure smart city development'* [79].

Vice President of Science and Technology, Sattari, during the third Tehran Smart Conference (2019), pointed out the necessity of Tehran's smartness. He stated that: *'The smart City is a new operating system that will be installed on Tehran hardware and will change the city's usage; all the cities around the world are moving in this direction and Tehran must take important steps in this regard to achieve the intended goals'* [80]. A deputy of the Technology and Innovation department at the Ministry of Communications during the recent Smart Cities Panel in Tehran (2019) stated that '. . . *we need a shared discourse to create smart cities'* [81]. Hashemi, head of the Tehran City Council during the third Smart Tehran Conference and Exhibition (2019), emphasized that data aggregation and management, open data platform, and big data establishment are Tehran's most important challenges in the path towards becoming smart [82]. Hanachi (2018), Tehran's Mayor, believes that Smart Tehran can make a profound difference in the lives of its citizens through the development of technological infrastructure and technological advances [83]. Regarding the current situation in Tehran, he reported that: *'In September 2017, in a poll conducted by Tehran municipality, citizens introduced the two problems of air pollution and traffic as the main problems of the city'*. In response to the question of what his plans to combat air pollution were, he said '*Reducing the share of private cars on the roads and developing the public transportation system are our main goals*'. It is mentioned in the Tehran Smart program that '. . . *the smart city approach does not just mean hiring urban information and communication technology (ICT) infrastructure, but six dimensions of smart economy, smart mobility, smart environment, smart infrastructure, smart governance and smart living will be noticed at the same time*' [84]. The Tehran Mayor emphasizes that the supreme leader advised him to use experts in the city administration and preserve the cultural identity of Tehran [85].

Mashhad puts its main focus on smart citizens. The Mashhad smart city portal marks as its slogan 'Smart City, Smart Citizen'. Currently, Mashhad profiles itself as 'Mashhad; smart city, city of hope and life' [86]. Managing Director of ICT Organization in Mashhad Municipality (2019) in the annual report of 2018 states that in 2018, we witnessed positive developments towards the smart city, which mostly related to smart applications and services for citizens. He also stresses smart mobility goals '*. . . the issue of traffic is still at the top of urban issues and is one of the most important concerns of citizens*' [58]. According to the city council announcement, the city of Mashhad also follows smart economic objectives, including the development of regional-global competition and access to business opportunities.

Isfahan, with its historical, cultural, and tourist attractions, has a distinctive look to be smart, sets its goal for smart citizen services, smart traffic and tourism, and smart buildings. Isfahan Municipality's Deputy Minister of Transportation and Traffic announced that Isfahan's smart traffic infrastructures were put into operation at a cost of more than 402 billion Rials [87]. Nonetheless, the most important project currently is the integrated spatial information system. In Isfahan municipality, a headquarters was established for the smart city under the direct supervision of the Mayor of Isfahan, whose task it is to implement a comprehensive plan for the smart city with the cooperation of the city council research center [88]. The director of Isfahan Municipality's ICT Organization (2017) points out: "*Our movement is based on a 5-year plan, which is proposed as Isfahan's 1400 vision program and as the municipality's ICT representative*." According to this plan, it intends to achieve the indicators of the smart city in the next three years. But certainly, what is planned in the 'Isfahan 1400' is still not what it takes to reach the ideal smart city. Arbabshirani also mentioned that, comparing Isfahan with Tehran and Mashhad, it is clear that the former two were ahead of Isfahan in this field. However, it is hopeful that, by using their positive and negative experiences, trial and error in the Isfahan's Smart program can be reduced [88]. Recently, a member of Isfahan's City Council (2019) stated: '*Since 2016, Isfahan has established its smart city program but unfortunately, despite the great emphasis of this council, the smart city project in Isfahan is not going well and at present, Isfahan is not in a good position compared to Tehran, Mashhad, and Shiraz in terms of smart city indicators*' [89].

'In Shiraz, we have tried to define our goals for the realization of the smart city based on both scientific definitions, and the situation and problems of our city, in order to draw a better future for the city', stated the managing director of Shiraz's ICT organization. He stressed that citizen welfare enabled by information technology was the highest goal of Shiraz's smart city program, which was based on the sub-goals of having clean air, a smart economy, smart transportation, preserving gardens, and greenery of the city. He believed the lack of integrated urban management was the biggest hurdle in the pathway toward developing the smart city and pointed to the scattered policies and activities of various organizations, such as healthcare and telecommunications, noting that the municipality has a pivotal role to play as coordinator and facilitator [90]. The head of the Smart and Information Technology Commission of Shiraz City Council (2020) emphasized the smart economy as one of the main goals of Shiraz's Smart city program. She declared that, in order to achieve a smart economy, eliminating unnecessary regulations and facilitating administrative affairs for the private sector were important issues requiring serious implementation [91].

Table 4 provides an overview of the current situation (A) based on the evidence and observations presented in Section 4, as well as the expectations and goals of the Iranian smart cities (situation B) to reveal the challenges and opportunities for a transition from 'A' to 'B'.

Table 4. Challenges and opportunities of Iranian cities for transition towards the smart city.

RQs	Empirical Evidence and Observations (Current Situation 'A')	Expectations and Goals (Future Situation 'B')	Challenges & Opportunities to a Transition From 'A' to 'B'
To what extent are Iranian cities ready for becoming smart?	Existence of big data establishment is considering in all four cities, Limited availability of sensors and actuator equipped devices, Notable improvements in terms of ICT Development Index (IDI) in 2017, IoT laws and regulations establishment for the whole country, Existence of data visualization platforms in Tehran and Mashhad, Establishing a cyber security framework is considering.		**Challenges**: Insufficient infrastructures, Unavailability of some emerging technologies, Restrictions on buying and transferring technologies due to the sanctions and raising exchange rate. **Opportunities**: Focusing on knowledge transfer instead of technology transfer, fostering innovation and supporting start-ups, focusing on the creativity-based solutions instead of high-tech solutions through citizen participation.
To what extent are Iranian cities socio-economically ready for becoming smart?	Proper status in knowledge generation, Organizing smart city conferences and events, Existence of urban innovation centers in all four cities, Existence of science and technology parks and incubators in all four case, Low level of citizens' awareness of the smart city program in all four cases, Perceived usefulness of the smart solutions for traffic and pollution issues by citizens, Citizens' image of their cities are not commonly positive.	**General goals and expectations**: 'Sustainability, Higher quality of life Reducing air pollution and congestion, **Individual goals and expectations**: Tehran; smart economy, smart mobility, smart environment, smart infrastructure, smart governance and smart living. Isfahan: smart citizen services, smart traffic and tourism, and smart building. Mashhad; smart citizens, smart economy, changing the image of Mashhad into a city of hope and life. Shiraz; having clean air, smart economy, smart transportation, preserving gardens and greenery of the city.	**Challenges**: Poor citizen participation due to lack of trust and low level of awareness, commercialization of creative solutions, scaling-up the innovations. **Opportunities**: Increasing knowledge and innovation capacity, Expanding the positive view of citizens towards the smart city by solving traffic and pollution problems and then attracting the participation of citizen.
To what extent are Iranian cities politically ready for becoming smart?	Having a rigid and narrow vision due to the ideological and religious dogmas, Multi-Level Governance structure with a centralized approach, Lack of integrated urban management system The low level of citizens' sovereignty, The low level of Citizens' trust in the government, Lack of an integrated partnership platform,		**Challenges**: Lack of a common language for the smart city, Lack of a clear vision and roadmap for the smart city development, scattered policies and institutions, Gaining the trust of citizens. **Opportunities**: Utilization of open data policies and data sharing to gain the trust of citizens, making reforms in government structures to achieve smart government, considering the smart city as a common ground to improve international communication and foreign relations.

The challenges regarding technological readiness, however, are related to insufficient infrastructures and unavailability of cutting-edge technologies, but, at a macro level, these are intertwined with Iran's diplomatic status in the world. The issues of economic sanctions and exchange rates have reduced Iran's ability, both economically and in terms of trade, to transfer technology. Meanwhile, focusing on knowledge transfer instead of technology transfer to foster innovation, supporting start-ups, and focusing on the creativity-based solutions instead of high-tech solutions may present opportunities that can boost core competencies for Iran's smart city program. Generating knowledge and innovative ideas is not sufficient, however. Commercialization of creative solutions and scaling-up innovations are key to success in developing smart solutions [92]. Providing a platform for multi-stakeholder partnerships, citizen involvement, and partnership with academia have a critical role in reaching these goals [37]. Our analysis indicates that poor citizen participation is due to low trust and awareness levels. As several officials state, the main concern among citizens in these four cities relates to pollution and traffic congestion. The likelihood of changing the citizens' view in favor of the smart city is thus connected with it solving traffic and pollution problems and may evoke an increase in participation.

The most significant difficulty in getting ready for becoming smart in Iran is associated with the political context. Iran's rigid political ideology and administrative structure do not meet the standards for governing a smart city. Lack of a common language for the smart city, lack of a clear vision and roadmap for the smart city development, scattered policies and urban administration systems, and low levels of citizen trust are Iran's main challenges ahead to be politically ready for any transition towards the smart city. Utilization of open data policies and data sharing, making reforms in government structures to achieve smart government, are sine qua non's to gain momentum for it. Smart Governance and developing Smart Government applications can be considered as alternative possibilities to raise the level of citizen satisfaction. Nonetheless, in our opinion, they should still consider that when the government uses smart solutions and applications for practical issues perceived as smart city optimization of various goods and services, the likelihood of everybody using it, too, will increase. But, we fathom that as soon as it is more about strategic and high-level aspects of policy, trust will be missing among many, and its acceptance is bound to remain lower. In short, it will probably work for non-politically sensitive topics. As soon as people get the impression that this is tied up with promoting the interests of the ruling class, they may reject it.

In consequence, our ToC identifies technological, socio-economic, and political interventions, as well as output, outcomes, and impact in order to become smart (Figure 2).

In terms of technological resources, developing the infrastructures for smart mobility is crucial because of the main urban issues that they face traffic congestion and air pollution. Developing capabilities in cybersecurity, for which Iran already has fine knowledge capacities, can be considered an asset in trading knowledge transfer for technology transfer.

In the national political context, mapping a holistic vision for smart city development programs is essential. This requires support from both leaders and citizens. At the same time, reforms in international relations and diplomacy are crucial role to acquire necessary technologies and make exchange and global harmonization possible. In the municipal context, changes from segregated urban management systems to more integrated ones based on decentralization and meritocracy are a must.

Last, but not least, making individuals and society at large ready to become smart makes raising awareness a key consideration. Iran may consider to, if technology transfer proves out of reach, promote knowledge transfer and innovation as its main drivers in smart city programs.

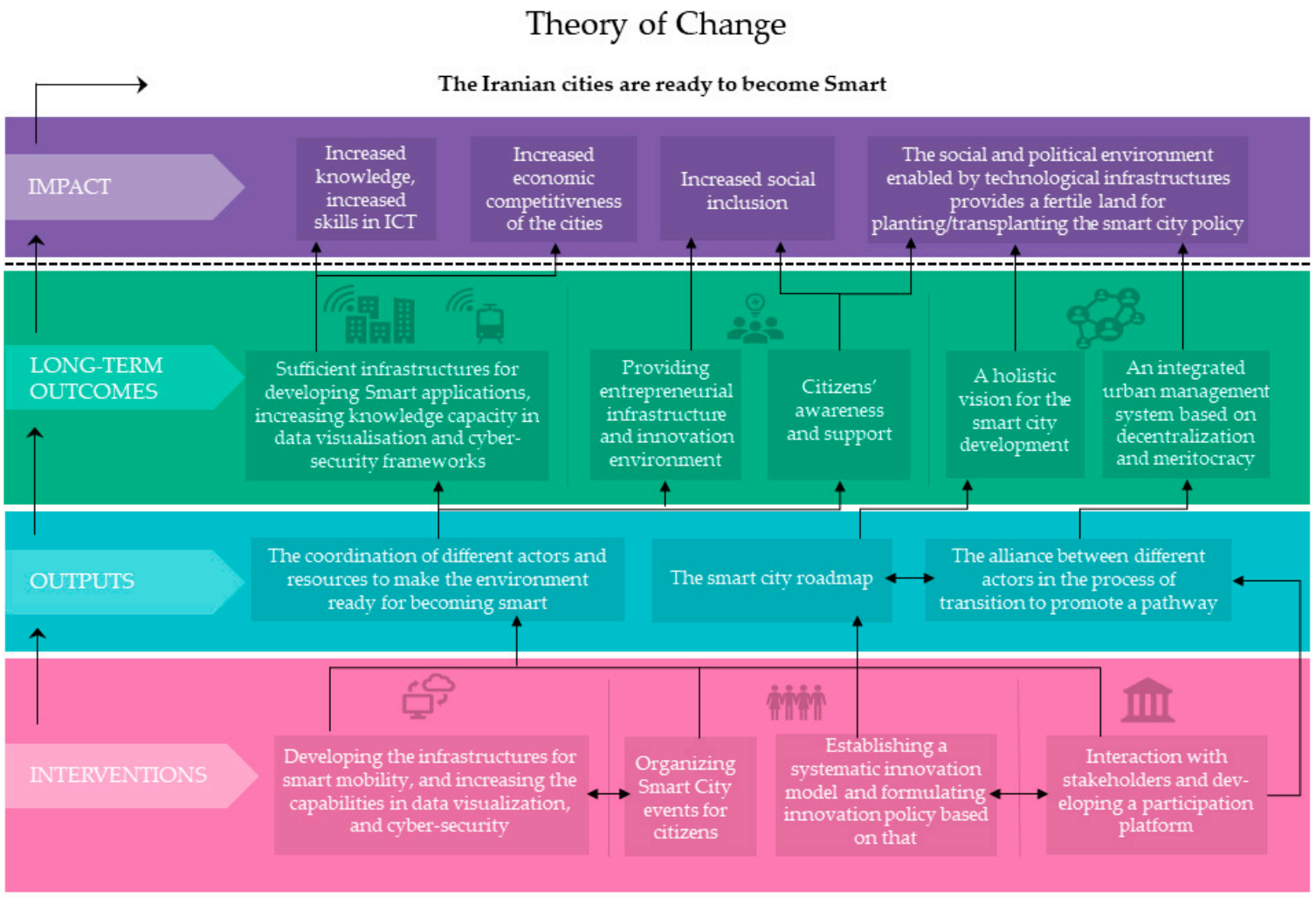

Figure 2. The infographic Theory of Change (ToC) for the readiness of Iranian cities to become smart (developed by the authors).

6. Conclusions

Through a descriptive-analytical approach, the present study sought to address the following questions: How to determine whether cities are ready for a transition into Smart Cities? What does an indicator system measuring smart city readiness look like? To what extent do Iranian cities meet the minimum requirements to become smart?

The academic merit of the present study was to develop a framework for cities' readiness to move toward a smart city through an in-depth study of the existing literature, and by measuring it in four large Iranian cities, to reveal the challenges and opportunities ahead for them to become smart. We developed a Theory of Change (ToC) for the transition Iranian cities should go through.

The results of our analysis show that for several reasons the urban governance model is the most important factor and key bottleneck for Iranian smart city readiness, making them miss vital opportunities. First, Iran shows significant advances in ICT development, but, for proceeding on that road, it needs to overcome the negative consequences of international sanctions. Big data availability and competencies in cybersecurity are Iran's strengths in ICT infrastructures required for smart city development. Second, as many studies stress the importance of citizen participation in transitions towards a smart city, Iran needs its citizens' trust and support to be socially ready. Our survey reveals that one of the most frequent ideas among citizens' conception of quality of life is connected to 'safety'. Lastly, fundamentalist religious considerations affect openness in policy-making negatively and lead to societal polarization. Rejection of political and religious opponents in governance bodies make the development of a common language and getting citizens on board difficult. Organizing citizen awareness programs, government openness, and adopting a bottom-up approach instead of imposing restrictions can be seen as potential solutions for increasing civic trust and participation. However, to enable a bottom-up approach for developing smart cities, Iran basically first needs reforms in its governance structure. Starting smart city experiments, like urban living labs, virtual forums and meeting hubs, etc., also encourage citizens to participate in the smart city development process.

Tehran, Mashhad, Isfahan, and Shiraz have planned to become smart, but it seems that their plans are neither comprehensive nor sufficiently systematic. They seem to satisfy neither policy-makers nor engineers. Iran requires policy and planning based on knowledge regarding the effects of information technologies on urban structures. Compared to good practices of smart cities elsewhere (e.g., Amsterdam, Barcelona, and Dubai), the Iranian cities need to provide a clear horizon and systematic plans through taking into account the variety of different aspects involved in any smart city program [66]. Poorahmad et al. (2018), who conducted a study on the necessities and requirements of Tehran to become smart, believe that many of the urban issues in Tehran reside in the way the city is governed and the attitude of its urban managers. They argue that the centralized and authoritarian planning style of the city administration is increasingly linked to the tastes and wishes of city managers. In their view, the formulation and implementation of integrated policies, legislation, and aligned vision have a significant role to play in Tehran's smart city initiative [93]. Kazemian and Mirabedini (2011) stress the need for an integrated urban management system and state that Tehran, with more than a hundred years of systematic urban management, due to the regime's centralized approach, still lacks sufficient autonomy in its decision-making process [94]. Similarly, Isfahan and Shiraz have no clear vision for their smart city programs. They, too, require an integrated urban management system, alongside the development of smart infrastructures [95]. Zarabi et al. (2019) mention the inequality in infrastructure development in different neighborhoods of Isfahan [96]. The same holds true for other Iranian large cities, particularly Tehran. Unequal access to urban services in poor and wealthy neighborhoods is another characteristic of large Iranian cities which constitutes an obstacle to becoming a smart city. Mashhad, in comparison, has adopted a more systematic approach. But none of the four cities use a comprehensive roadmap for developing their smart city. The leadership style and chain of command in Iran present another challenge ahead in promoting systematic urban management. This challenge is more severe in Mashhad, which has conservative local rulers in place with extreme religious perspectives.

The present study adds a few significant insights to the existing frameworks for smart city readiness in the academic body of knowledge. They contribute knowledge on how cities that are just getting started can be prepared for their transition and start the smart city development process. An important limitation in our work is that the cultural factors affecting social readiness were not included for lack of measurability. Future research may cover the these and other relevant factors to make the framework even more encompassing. As follow-up research, we suggest an in-depth empirical investigation on how cities just starting up smart city programs can learn from the good practices elsewhere. They can localize experiences, which can help them to use these instrumentally as a means to reach their proclaimed smart city goals.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Iranian smart cities' readiness assessment.

	Operationalization	**Qualitative Analysis**			
		Tehran	**Isfahan**	**Mashhad**	**Shiraz**
Technological readiness assessent	Big data establishment	My Tehran' portal	Isfahan Integrated spatial portal	Mashhad' portal	N/A
	Sensors and actuator equipped devices, CCTVs, and cameras	Air quality sensors, traffic, and monitoring Cameras	Traffic and monitoring Cameras	Flood alert sensors, air quality sensors, and traffic sensors	Traffic and monitoring Cameras
	ICT Development Index (IDI)	7.24 (in 2017)	6.24 (in 2017)	5.35 (in 2017)	6.25 (in 2017)
	Data science centers	Supreme Council of Cyberspace, ICT research institute, Iranian Institute of Information Science and Technology, Iran's IoT Academy	N/A	IT and Cyberspace research center	Shiraz Data Center

Table A1. *Cont.*

	Operationalization	Qualitative Analysis			
		Tehran	**Isfahan**	**Mashhad**	**Shiraz**
Technological readiness assessent	Data visualization platforms	IT, Judicial Affairs, Energy, Education, Financial and Commercial, Healthcare, Demography, Transportation and traffic, Social services, Buildings and housing, Environment, Industry, Landscape and urban services, Culture and religion, Agriculture, forestry and fisheries, Economy, Tourism	An integrated platform for spatial information	Mobile Mashhad Apps; Transportation and traffic, Business, Environment, Payment and Transactions, Waste management	N/A
	Data Laws	IoT laws and regulation issued by Supreme Council of Cyberspace (in 2017)	IoT laws and regulation issued by Supreme Council of Cyberspace (in 2017)	IoT laws and regulation issued by Supreme Council of Cyberspace (in 2017)	IoT laws and regulation issued by Supreme Council of Cyberspace (in 2017)
	Establishing a cyber security framework	Cyber security research institute	Budget allocation for cyber security projects	Budget allocation for cyber security projects	N/A

Table A1. *Cont.*

	Operationalization	Qualitative Analysis			
		Tehran	**Isfahan**	**Mashhad**	**Shiraz**
Social Readiness assesment	Number of universities and research centers	119 (in 2019)	67 (in 2019)	30 (in 2019)	25 (in 2019)
	Knowledge transfer and knowledge sharing programs	Asian Smart Cities Committee of Asian Mayors Forum	Joint cooperation between the Technical and Vocational University and the ICT Organization of Isfahan Municipality	Mashhad SmartExpo	Shiraz Smart City Exhibition and Urban Investment Opportunities
	Specific policy in place to promote smart city innovation	Tehran Urban Innovation Center (TUIC)	Isfahan Urban Creativity and Innovation Center	Mashhad Urban Innovation Center	Launching Shiraz Innovation Factory
	Supporting and encouraging programs for innovative companies (Science and technology parks, free zones, etc.)	8 Science &Technology Parks around Tehran, The National Festival of 'From Science to Practice' to support innovative companies with commercialization approach	13 Science and Technology parks and incubators	A Science and Technology parks and 11 incubators	6 Science and Technology parks and incubators
	The level of citizens' awareness of the smart city program in their city	Citizens have heard about it but have no information of the program	Citizens have heard about it but have no information of the program	Citizens have heard about it but have no information of the program	Citizens have heard about it but have no information of the program

Table A1. *Cont.*

	Operationalization	Qualitative Analysis			
		Tehran	**Isfahan**	**Mashhad**	**Shiraz**
Social Readiness assesment	The level of citizens' awareness of the smart city concept and technologies	Average level of awareness	Average level of awareness	Average level of awareness	Average level of awareness
	The level of perceived usefulness of the smart solutions for the city's challenges by citizens	The high level of citizens perceived usefulness is for pollution and traffic	The high level of citizens perceived usefulness is for pollution, traffic, and housing issues	The high level of citizens perceived usefulness is for pollution and traffic	The high level of citizens perceived usefulness is for pollution and traffic
	Citizens' opinion about a smart city	Most frequent statements are related to 'green' and 'surveillance' city	Most frequent statements are related to 'surveillance' and 'happy' city 'surrounded by technology'	Most frequent statements are related to 'green' and 'surveillance' city	Most frequent statements are related to 'safe' and 'green' city
	Citizens' image of their cities	Most frequent images are 'polluted city', 'busy', 'expensive', and 'alive' city	Most frequent images are 'crowded', 'polluted', 'beautiful', 'historical' city 'with a lot of potentials'	Most frequent images are 'crowded', 'polluted' city with deficiencies in public transportation	Most frequent images are 'happy' and 'beautiful' city
	Citizens' different ideas of quality of life	Most frequent ideas are related to 'safety', 'prosperity', 'happiness', 'peace', and 'citizens (human) rights '	Most frequent ideas are related to 'health', 'safety', and 'happiness'	Most frequent ideas are related to 'prosperity' and 'happiness'	Most frequent ideas are related to 'safety', 'prosperity' and 'happiness'

Table A1. *Cont.*

	Operationalization	**Qualitative Analysis**			
		Tehran	**Isfahan**	**Mashhad**	**Shiraz**
Political Readiness assessment	Leadership vision/support for smart city program	Ideological and religious dogmas	Ideological and religious dogmas	Ideological and religious dogmas	Ideological and religious dogmas
	Government structure, governance arrangements, policy networks	Multi-Level Governance, Centralized approach	Multi-Level Governance, Centralized approach	Multi-Level Governance, Centralized approach, the power of Astan-e-Qods, and the conservative ruler of Mashhad (the Friday Prayer leader)	Multi-Level Governance, Centralized approach
	Rules, laws, legal and regulatory reforms	Existing municipal laws and regulations, upstream policy documents, Islamic law (Shariah)	Existing municipal laws and regulations, upstream policy documents, Islamic law (Shariah)	Existing municipal laws and regulations, upstream policy documents, Islamic law (Shariah), the Rules by the Friday Prayer leader	Existing municipal laws and regulations, upstream policy documents, Islamic law (Shariah)

Table A1. *Cont.*

	Operationalization	**Qualitative Analysis**			
		Tehran	**Isfahan**	**Mashhad**	**Shiraz**
Political Readiness assessment	Policies, policy instruments	Policies of the different levels of national, regional and municipal, are under consideration	Policies of the different levels of national, regional and municipal, are under consideration	Policies of the different levels of national, regional and municipal, and Astan-e-Qods are under consideration	Policies of the different levels of national, regional and municipal, are under consideration
	Legitimacy, tranparency and trust	Extreme religious considerations, low level of transparency and trust	Extreme religious considerations, low level of transparency and trust	Super-extreme religious considerations, low level of transparency and trust	Extreme religious considerations, low level of transparency and trust
	Partnerships with industry, academia, and citizens	Lack of an integrated partnership platform	Lack of an integrated partnership platform	Lack of an integrated partnership platform	Lack of an integrated partnership platform
	Providing a platform for multi-stakeholder partnership	Lack of an integrated partnership platform	Lack of an integrated partnership platform	Lack of an integrated partnership platform	Lack of an integrated partnership platform

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