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Smart City Capacities: Extant Knowledge and Future Research for Sustainable Practical Applications

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Abstract: Throughout the smart city literature, there are mentions of capacities, the application of which is claimed to result in the sustainable achievement of objectives. Because of the often desperate need for smart city objectives to be met, we sought to understand which were the capacities and whether the components of these capacities are explained sufficiently for them to be effective in practice. We applied a four-stage methodology commencing with a search of multiple databases for smart city capacity knowledge. We next assembled the evidence from the items identified in that search using a thematic analysis that identified the capacity to exploit technology, innovate, collaborate, and orchestrate. Next, we followed the threads of knowledge, iteratively allocating the knowledge to each of the four capacities to a typology of what, why, and who. The fourth stage was a cross-capacity analysis that generated further refinement and identified important factors. We identified that capacities are not sufficiently explained. In addition to the need for more levels of detail as to practical implementation, we identified significant underdevelopment of the literature as to the impact of institutional complexity and the influence of stakeholders. We propose research directed at increasing the effectiveness of capacities, define the concept of smart city capacities, propose a framework of the components of capacities, and draw on established stakeholder theory to create a stakeholder influence research framework.

Keywords: collaboration; innovation; exploiting technology; orchestration; smart city capacity; smart city; smart city government; institutional complexity; stakeholder influence

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1. Introduction

Many smart city scholars touch on or explain the capacities needed to achieve the quite challenging objectives of a smart city. An example is the work of Meijer and Bolivar [1] who depict a smart city as having the capacity to both attract and mobilize human capital through information and communication technologies (ICT). This is an admirable aspiration but what capacity actually is, and who precisely is to have it are not explained. There is substantial criticism of smart city prescriptions as being formed at high levels of abstraction [2]; vendor hype [3]; or self-congratulatory assertions [4], causing us skepticism as to whether capacities are sufficiently explicated for theorists and practitioners to apply the capacities and achieve sustainable smart city objectives. We reasoned that if our research could assemble the extant knowledge and set paths for future research that addresses the unanswered aspects of the smart city capacities literature, then smart cities would benefit by way of increased sustained achievement of objectives.

With that improvement in the outcomes of the application of smart city capacities firmly in mind, we established and confirmed broad purposes for our research as depicted in Figure 1.

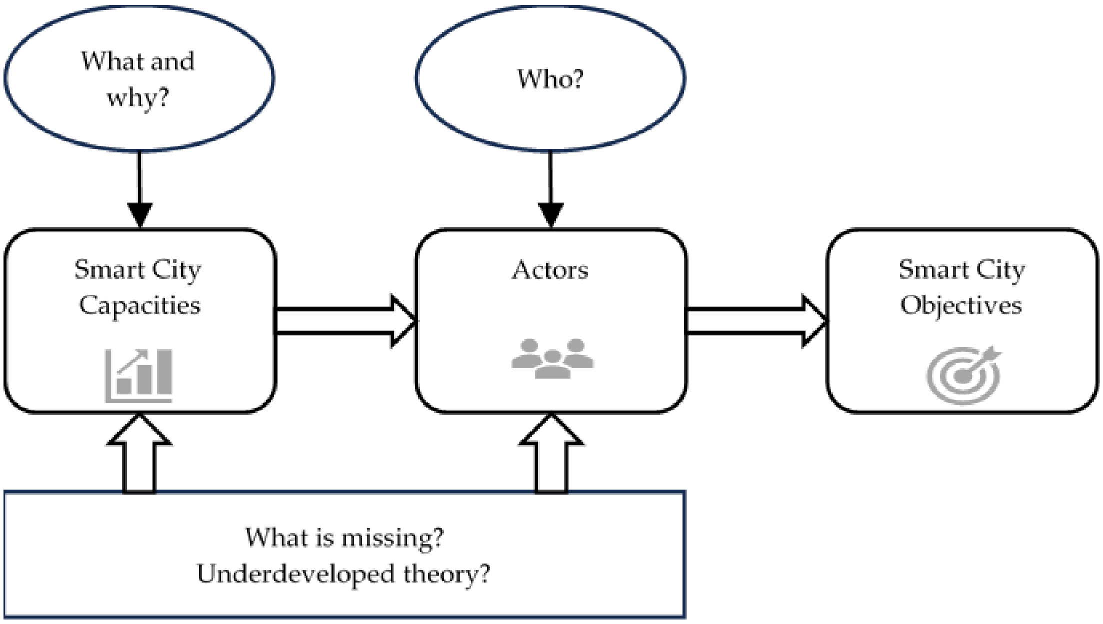

Figure 1. Research purposes—smart city capacities.

Simply put, our research objectives were to develop theoretical conceptualizations as to smart city capacities, identify all important areas where theory is underdeveloped, and, in turn, recommend paths for research that would build the knowledge that is currently missing. The formal questions that guided our research were the following:

1. Which are the capacities required of actors to sustainably achieve smart city objectives and are the components of these capacities explained sufficiently for them to be applied in practice?
2. What future research should take place in order to optimize the sustainable achievement of smart city objectives through the application of capacities?

Our research methodology was comprised of several methods, applied in four sequential stages. The first stage was the application of the database search method that typically underpins a systematic literature review using the terms smart cit and capacit. The second stage was the extraction of evidence from the articles identified in that search. The third stage employed a selective search and iterative, inductive development of themes around nodes for each prominent capacity. The fourth stage was a cross-capacity comparison to further refine themes.

The literature was found to provide a substantial consideration of four dominant capacities, namely capacity to exploit technology, capacity to innovate, capacity to collaborate, and capacity to orchestrate. We identified that capacities are not sufficiently explained. In addition to the need for more levels of detail as to sustained practical implementation, we identified significant underdevelopment of the literature as to the impact of escalating institutional complexity and the influence of stakeholders. Yet, smart city scholarship has progressed from high-level conceptualizations of capacities to recently providing the detail of the capabilities, attributes, and routines that comprise the capacity to innovate [5] and orchestrate [6,7], collectively suggesting a framework of the components of a smart city capacity. To create the smart city knowledge that is missing, we propose paths for research directed at increasing the effectiveness of capacities, define the concept of smart city capacities, propose a framework of the components of capacities, and draw on established stakeholder theory to create a stakeholder influence framework, to provide tools to facilitate that research.

The research we have performed advances smart city theory in that it brings a spotlight to extant scholarship as to the smart city capacities required to achieve smart city objectives and is the first scholarship to assemble the knowledge for each separate capacity. In turn, our research is the first to identify the areas of underdevelopment of the theory and recommend paths for research aimed at remedying that underdevelopment. Our research benefits smart city theorists and practitioners by both presenting the available knowledge and providing tools and paths for research that will assist the sustained achievement of smart city objectives and better address the quite difficult challenges faced by smart cities.

This paper next lays out what the governance, public management, and political sciences literature say about the concept of capacities and establishes a working definition of a capacity for application throughout this research. Then, the approach adopted for this research is explained. Then, the findings as to four dominant smart city capacities are laid out. We then discuss the key implications of the findings, propose several paths for future research, propose a framework of components of smart city capacities, and justify a fit-for-purpose definition of smart city capacity.

2. Concept of Capacities

The capacity of a society and its government in the context of a United Nations development program is defined by Fukuda-Parr, Lopes, and Malik (p. 8) [8] as '. . . the ability to perform functions, solve problems and set and achieve objectives'. More recently, Cingolani [9] identified seven categories of powers held by governments, defining the transformative/industrializing capacity as the ability of the government to intervene in production systems and shape the economy. Lodge and Weigrich [10] advocate for governments to have an overarching problem-solving capacity.

Explanation of how these capacities manifest in practice and who is to have the capacities is commenced by Lodge and Weigrich [10] who depict state and non-state organizations as actors involved at transnational, national, and local levels. Howlett [11] divides government policy capacity into analytical, review, formulation, and implementation capacities and Head [12] explains government policy analytical capacity as provided by individual professionals who bring competencies.

Few articles touch on the capacities of local governments or municipalities. Local government management capacity is conceptualized by Andrews and Boyne [13] as comprised of the five systems identified by Ingraham [14], namely, capital management, financial management, human resource management, information technology management, and leadership. Leadership capacity in local government is defined by Andrews and Brewer [15] as comprised of understanding of the complex relationships between social capital, management capacity, and performance.

The organizing capacity required of metropolitan local government regions seeking to achieve sustainable development is comprised of administrative organization, strategic networks, leadership, vision and strategy, spatial-economic conditions, political support, and societal support [16]. Importantly, organizational capacity is not ascribed to a single local government, nor to only local government. In the instance of administrative organizational capacity, cooperation and collaborative capacity are envisaged [16] as also being collectively possessed by other actors, public and private, because metropolitan cities are aggregations of multiple municipalities, other companies, and charitable organizations. The organizational capacity of a city is defined [16] as the ability to enlist all actors to generate new ideas and develop and implement policy directed to needs.

Working Definition of Capacity

The smart city literature does not define capacities. Drawing on the knowledge set out above, we established the following definition of smart city capacities, which we applied throughout evidence gathering and the analysis processes:

Smart city capacities are the abilities of city government and other actors across the city to act and achieve smart city objectives.

This definition relies on the definition of the capacity of governments and societies established by Fukuda-Parr and Lopes [8] and takes up the perspective that other actors, including the city as a whole, may have a capacity [16]. Because the role of this definition was to cast a wide net in the evidence gathering processes, we did not constrict the scope to only actions that were proactive or interventional or transformative, notwithstanding the literature as to capacities of governments having presented such a theme.

3. Research Approach

Because our research objectives are the development of theoretical conceptualizations as to smart city capacities and the identification of paths for research aimed at filling gaps in theory, a sequence of several separate methods was required to move from the current quite dispersed fragments of knowledge to a comprehensive understanding of extant theory and its areas of underdevelopment. Our methods commenced with the application of the database search method that typically underpins a systematic literature review, through a stage of extracting evidence from the articles identified in that search, to a further selective search and assembly of evidence around nodes taking an iterative and inductive approach. The final stage was analysis by cross-capacity comparison.

3.1. Literature Review Search

The first research method was the application of the PRISMA database search method [17] that typically underpins a systematic literature review to the smart city literature. ProQuest, EBSCO, Web of Science (Core Collection), Scopus, and Google Scholar databases were queried.

The searches applied the terms 'smart cit*' AND 'capacit*' to the abstracts and, where possible, the full text of articles published in English, Portuguese, and Spanish from 1999 to 2022. The 1999 parameter was applied because the smart city scholars Gil-Garcia, Pardo, and Nam [18] and Meijer and Bolívar [1] report smart city items being published from 1999. The searches were further focused by including only articles that had attracted more than two citations because those citations demonstrate support from the community of researchers as having merit as a source of knowledge. The search parameters applied in each database and the results of each search are set out in Table 1. The full listing of articles identified in each search can be found at the Harvard Dataverse data repository [19].

Table 1. Literature search parameters and results by database.

Database	ProQuest	EBSCO	Web of Science	Scopus	Google Scholar
Search string	"Smart cit*" AND capacit*	"Smart cit*" AND capacit*	"Smart cit*" AND capacit*	"Smart cit*" AND capacit*	"Smart city" AND capacity
Search field	Abstract	Not specified	Abstract	Abstract	-
Date range	1999–2024	1999–2024	1999–2024	1999–2024	1999–2024
Languages	English Portuguese Spanish	English Portuguese Spanish	English Portuguese Spanish	English Portuguese Spanish	English Portuguese Spanish
Limit to	Peer reviewed	Peer reviewed	-	-	-
Source type	Scholarly Journals	Academic Journals	-	-	-
Document type	Article	Article	Article	Article	Search articles
Minimum citations	-	-	>2	>2	-
Search results	363	211	367	479	100 (limited)

In addition to the search parameters specified, certain research area criteria were applied to the Web of Science search: computer science, engineering, telecommunications, environmental science, communication, energy fuels, geography, business economics, public administration, transportation, urban studies, social studies, sociology, water resources, architecture, and area studies. Similarly, the following specific subject areas were applied as inclusion criteria to the Scopus database search: computer science, social sciences, energy, environmental science, business management and accounting, and multi-disciplinary.

A total of 1520 articles were exported from the respective databases and uploaded to the Rayyan© collaborative review platform. Duplicates amounting to 627 were identified and removed leaving 893 unique records. Two researchers independently reviewed these articles against the inclusion and exclusion criteria. To be included, articles had to portray any form of actor as having or requiring the ability to act and achieve a smart city objective. There were three exclusion criteria: (1) unrelated meaning or context—the expressed concept of ‘capacity’ was displayed only in an unrelated meaning or context, as in the case where capacity was used to describe the volume of an inanimate object, (2) different word—the search term capacit* yielded a result such as a capacitor or capacitance and not capacity or capacities, and (3) insufficient evidence—the mention was superficial and not explained further. Where the researchers initially disagreed about inclusion in the final dataset, a discussion was held and consensus was reached.

At the conclusion of this process, a total of 54 items remained for close analysis.

3.2. Analysis of The Literature Search Items

The method of the analysis was chosen to best answer Research Question 1. “Which are the capacities required of actors to sustainably achieve smart city objectives, and are the components of these capacities explained sufficiently for them to be applied in practice?’

Core to that answer is the identification of the capacities and the assembly of the knowledge and building of theory around each capacity that was identified. We employed the qualitative research method of inductively developing the knowledge because the knowledge was fragmented and dispersed. The inductive approach to data analysis is appropriate for conceptual research such as developing typologies as it involves the stepwise observation of each item of data, developing plausible explanations for observed phenomena along the way, and then modifying the explanation when unexplained data are encountered. It is iterative in the sense that the evolving explanation must be retested from the start of the dataset each time it is modified [20]. We extracted evidence from articles identified in the literature search and assembled that around a tree node for each capacity. Some evidence is related to more than one capacity. The branches of each tree node were the categories for data, ‘What’, ‘Why’, and ‘Who’, which presented as a suitable typology [21] for the inductive building of theory.

The data contained in each tree branch were critically examined by at least two researchers and iterative adjustments and reallocations were used to identify the themes across the articles from the literature search.

The data were drawn from a total of 28 items.

3.3. Evidence and Analysis from Citations

Having established that base of knowledge of each of the capacities, we then followed forward and backward citations from the articles in each node for the purposes of clarification and uncovering further knowledge regarding the theme or issue. In most instances, the thread of knowledge extended beyond the cited articles to additional articles identified by further citation following or by researchers or responses from subject matter experts who were consulted. This stage of the identification and analysis of the literature is described as a selective literature review by Yin [22], who recommends its use to identify the nuances of the existing knowledge as to an aspect of a theory so that future research can be best planned.

The evidence identified in this stage of the research process was iteratively integrated into the nodes and, in turn, the themes emerging within the nodes were refined. This selective process identified 58 items, in addition to the 28 items that were utilized from the list obtained by way of the database literature review.

The analysis proceeded to the fourth stage, a cross-capacity comparison of results that provided further insights and adjustment of knowledge within each node.

The overall research methodology proved highly effective in progressing the research objectives. The methods magnified the distinction made by each author as to the actor to which the capacity is attributed, for example, the city as a whole as distinct from the city government or another entity. Furthermore, not starting with an existing framework of capacities allowed thematic analysis to reveal the emerging capacity of orchestration and allowed the research to move beyond the organization as a unit of analysis to fully recognize the city as a whole or eco-system as an alternate unit of analysis.

The results for each node of analysis are reported in the following Section 4 entitled capacities of the smart city.

4. Capacities of the Smart City

Models of the smart city present a problematic mix of the normative and the ideological [23], city objectives, aspirations, and capacities. For example, Giffinger et al. [24] establish six high-level characteristics, namely smart economy, smart people, smart governance, smart mobility, smart environment, and smart living, which are supported by 31 factors that mix capacities with attributes. For example, a smart economy is supported by innovation, entrepreneurship, trademarks, productivity, labor flexibility, and market integration [24]. Other scholars [1,18] attribute capacities to the city as a whole or to the city government [25].

The challenges then are to separate out 'the what' (the particular capacity), the 'why' (the reasons the capacity is needed), and 'the who' (the actors who are said to require the capacity).

The most prominent capacities are the capacity to exploit technology, the capacity to innovate, the capacity to collaborate, and the capacity to orchestrate ecosystems. Those capacities are reported in the sequence from which they emerged in the literature.

4.1. Capacity to Exploit Technology

The early emphasis upon ICT capacity is demonstrated by Hollands' [23] depiction of the smart city leveraging its collective intelligence by connecting the physical, information technology, and social and business infrastructures through ICTs. Scholars [1,26,27], after conducting quite separate reviews of the smart city literature, and industry publications [26] have concluded that ICTs are the foundation of all sustainable smart city solutions.

We first assemble the evidence as to what is intended by the concept of capacity to exploit technology. Secondly, we report why the capacity to exploit technology is advocated. Then, we separate out the actors depicted as requiring the capacity to exploit technology.

4.1.1. What—Exploiting Technology

The smart city is depicted as an interconnected 'system of systems' [26]. These are described as ubiquitous and virtual, utilizing sensors and wireless technologies to provide real-time information and perform decision making [26–29]. Conceptualizations of systems evolved into streams of big data flowing between physical objects and a universe of actors [30,31], often by way of the IoT [32]. The data are analyzed through analytics and artificial intelligence [33]. The literature has progressively moved from offering the application of ICTs alone [29] to depicting ICT as integrated with the organizational, institutional, political, economic, and social dimensions of the city [27]. The integration is said to engender a high capacity for learning and innovation [28,34]. However, Nam and Pardo [26] and Gil-Garcia, Zhang, and Puron-Cid [27] caution that achieving previously not achieved intensities of information integration and knowledge sharing will require profound levels of applied technology.

Embedding of ICT infrastructure alone does not make a city smart [23]. Rather, ICT, human and social capital, and economic policy must be combined to leverage growth and manage development [35]. A contrary perspective is provided by European smart city practitioners who, when surveyed by Bolivar and Meijer [36], identified five aspects of change to the city government organization as being more important than the use of technology, per se. Yet, Nam and Pardo [26] observe that the tenet that up-to-date technologies are a necessary condition for achieving sustained smart city objectives has not been overturned.

More recently, difficulties in actually exploiting technology in a smart city have been highlighted. Municipal governments in Denmark were not able to achieve intended inter-organizational integration of data because the required data were locked up within private and public organizations, which persisted in developing systems that could not be integrated with those of the municipal governments [37]. Similarly, European smart city governments attempting to apply a big data approach to carbon emission reduction were obstructed by siloed data storage and continued development of independent applications by the complex multiplicity of institutions in energy systems [38].

4.1.2. Why—Reasons to Exploit Technology

Exploitation of technology was initially prescribed as a remedy for the wicked economic, environmental, and quality of life problems faced by cities [26] or to achieve efficiency and economic performance [29,38].

Such citywide development by way of networked ICT infrastructures enables the creativity of both the population and knowledge institutions [1,23], yet these and other stakeholders exercise a significant influence upon the exploitation of technology. For example, the technological competence of the population and their acceptance of technological advances, strongly influence the technology chosen and the success of its implementation [39]. Similarly, governments of all levels, by their own capacity to exploit new technologies and willingness (or otherwise) to provide funding, strongly influence the adoption of technology in a smart city [40].

4.1.3. Who—Actors Who Exploit Technology

Gil-Garcia, Zhang, and Puron-Cid [27] alert us to the need for research as to the roles and capacities of actors beyond city government in making a city a smart city.

City as a Whole

There is a distinct thread of conceptualizations of the city as a whole: it is a territory [41], comprised of integrated systems all requiring the city, distinct from city government, with capabilities in respect of ICT, new smart business processes, and smart technology [25].

How the city as a whole might acquires the capacity to innovate in technology is suggested by Caragliu and Nijkamp [42] to be absorptive capacity whereby the territory's accumulated knowledge is continually harnessed to decode new knowledge and successfully apply that new knowledge.

City Government

City government is said to exploit ICTs either for administrative purposes including delivery of municipal services or for wider smart city purposes.

City administration purposes

City government is said to need sophisticated forms of technology [4,39] to adopt a big-data approach [32] and use AI-based chatbots [43] to improve city services.

The intended change to city administration or services may be incremental [1,44] or, more often, transformational change [1]. Transformational technological change to city government processes [1] may be either innovation in decision-making processes within a single system [45] or across the whole city administration requiring medium to high levels of transformation of ICT systems and restructuring of the internal organization [46], resulting in a digital transformation [47].

City managers must have competency in the technology itself and also a political understanding of technology [1]. Scholars have adopted the concept of information technology savviness on the part of city government as an essential dimension of the smart city [27], which is explained by Scholl and Alawadhi [46] as knowledge and competencies, one of which is competence in contracting in ICT services in an environment of vendor hegemony.

The success of digital transformations in Milan, Barcelona, and Munich is attributed to each city government having organizational capabilities, most importantly, management and collaboration [7,48].

Smart city purposes

The conceptualization of the smart city as a territory involves interoperable technical and social networks of actors who collaborate with each other. The city government nurtures the inter-organizational information integration [27]. Overall, the city government must have the competence to promote the uptake of technology by actors across the city [39].

A city government is to initiate and lead initiatives and projects that are not related to city administration [25] but which both provide supporting infrastructure for business activity and growth and stimulate new forms of service and entrepreneurship [39].

4.2. Capacity to Innovate

Innovation is extensively presented as a high-level generalized conceptualization of strategy to achieve smart city objectives. Because in the public management context innovation has often been conflated with the concept of improvement [49], we sought a precise definition of innovation to guide data interrogation. We assessed the evidence against Gieske et al.'s (p. 478) [50] definition of innovation in the broad public sector, namely '... implementation of a new—technical, organisational, policy, service or other—concept that changes and improves the functioning and outcomes...'.

We first assemble the evidence as to smart city innovation. Secondly, we report why innovation is advocated. Then, we separate out the actors who are said to need the capacity to innovate.

4.2.1. What—Innovation

Early pieces of smart city literature conceptualize innovation at a high level. For example, Giffinger et al. [24] describe the economy of a smart city as characterized by a spirit of innovation. Hollands [23] pairs capacity for learning with innovation. Nam and Pardo [26] conceptualize innovation as extending beyond technology to management and policy.

More recently, Timeus and Gasco [5] used theory and case study evidence to form an innovation capacity framework for public organizations comprised of four capabilities, namely idea generation, knowledge management, innovation-focused human resource strategy, and intense use of technology. In turn, for each capability, Timeus and Gasco [5] specify questions that must be addressed to successfully operationalize that capability. For example, for the knowledge management capability, the questions go to whether there are systems for acquiring and utilizing knowledge and whether there are feedback and learning systems in place.

4.2.2. Why—Reasons to Innovate

Innovation is prescribed to address the increasingly problematical large-scale technical, physical, and societal challenges of smart cities [18].

The extent of digital innovation across a comprehensive range of domains of 70 smart cities, for example, natural resources and energy, transport and mobility, and government, was found to be most influenced by the city's economic development and urban structural variables [51].

4.2.3. Who—Actors Who Innovate

City as a Whole

Innovation at a territorial or industry level is explained as engendered and accelerated by an ever-increasing spiral of innovation outcomes generated by a collaboration ecosystem formed between knowledge institutions, industry, and government [52]. Smart city scholars offer a double-helix model to depict the innovation collaboration between two actors [53,54] such as the city government and an information-technology industry. Others offer the quadruple-helix model, which builds on the triple-helix model by adding citizens [55,56].

Innovation and other factors are depicted as leading to the intelligence or smartness of a territory, typically a region or a city [28,41,57,58]. In turn, the combined intellectual capacities of the population, institutions, and material infrastructures of the whole city are depicted as an innovation ecosystem that presents spatial intelligence [41]. The territory or city as a whole is characterized as having an absorptive capacity [42,59] for innovation knowledge. Absorptive capacity is where a commercial firm recognizes the value of new information and applies that knowledge to the benefit of the firm [60]. Abreu et al. [61] explored the impact of the firm-level absorptive capacity on regional variations in innovation performance. European regions with lower absorptive capacity experienced knowledge spillovers toward surrounding areas, hampering the region's capability to exploit both their locally produced new knowledge and knowledge originating externally [62].

City Government

The evidence was of capacity to innovate for administrative purposes or delivery of municipal services and for wider smart city purposes.

City administration purposes

A city government's capacity to innovate is presented as an essential element of the smart city model [1], which provides an enabling environment [26] through which the city government becomes smarter by continuously incorporating new and improved ways to achieve the objectives of its operations [27].

However, Meijer and Bolivar [1] observe that because innovation in the internal organization of city governments requires a high level of transformation, it is very difficult. Increased outsourcing of technology-based innovations and reliance on knowledge intermediaries such as universities and consulting firms are exacerbating existing deficiencies in the technological and policy capabilities of city governments to effect innovations [63,64]. Examples of smart city innovations that achieved specified objectives are the City of Philadelphia reforms of workflow and technology into a consolidated single channel for multiple non-emergency contact systems [65] and the Rio de Janeiro city government's consolidation of separate emergency service call centers into a single operations center through managerial, policy, and technological innovations [66].

Beyond the framework of capabilities established by Timeus and Gasco [5], there is a limited explanation of the components of a capacity to innovate on the part of city government.

Smart city purposes

City governments, indeed, all levels of government, are perceived to be enablers of the innovation achieved by smart city industry and investment companies and other collaborative arrangements [28,41,53].

Such enabling of innovation by city government may be achieved by way of the direct involvement of the city government through joint project initiatives [1] or through joint governance with for-profit and third-sector organizations of programs of smart city initiatives such as the Amsterdam Smart City program [54,67].

In addition, city government is required to influence the city as a whole to align with anticipated innovation. Specifically, political actors such as the city's council, the city mayor, and the overall city government must have the competence to influence change to policies to shape institutional and societal readiness for the innovation inherent in future smart city initiatives [25].

Actors Other Than City Government

Private-for-profit companies are depicted as the principal producers and beneficiaries of smart city innovation processes, with other actors being from the technology transfer and funding sectors, whilst governments and knowledge institutions are enablers of the company's innovation [28,41,57].

Knowledge institutions are key actors in models of smart city innovation based on the triple helix model of innovation [53]. Further variations to that model take up the ecosystem analogy in explaining the contribution of knowledge institutions to innovation in the smart city [55,68]. Integral to the concept of knowledge institutions is the creative class, comprised of scientists, entrepreneurs, artists, venture capitalists, and other talented people [41,57]). Caragliu, Del Bo, and Nijkamp [35] expand the creative class to encompass the wider group, human capital. In short, the smart city literature positions human capital and creative culture as important elements of innovative cities [18].

4.3. Capacity to Collaborate

Collaboration is increasingly offered as a solution to the wicked problems faced by smart cities [1,18,69–71].

We first assemble the evidence as to the capacity to collaborate. Secondly, we report why collaboration is advocated. Then, we separate the actors who are said to need the capacity to collaborate.

4.3.1. What—Collaboration

Authentic collaboration is characterized by Keast, Brown, and Mandell [72] as a long-term relationship; having a shared purpose; often requiring a new entity, new systems, and new rules; parties being highly interdependent; and resources being contributed and shared.

Smart city collaboration literature was found [71] to mostly apply to Keast, Brown, and Mandell's [72] model of collaboration when using the terminology of collaboration, with only a small number of assertions of collaboration actually being informing, consulting, or cooperating.

Harrison et al. [73] warn of some smart city collaboration being 'empty scaffolding', resulting in more attention to collaboration than to actually making things work.

4.3.2. Why—Reasons to Collaborate

Collaboration is portrayed as instrumental in implementing policies and achieving reform objectives [73], particularly where transformation of values, systems, and practices is required [1] because the problems are wicked [74] in that they cannot be solved easily, nor by usual approaches, and require sharing and integration of information across boundaries [27].

Collaboration in smart cities is portrayed as different from business as usual. For example, in the smart cities Bristol and Milton Keynes, collaboration and inclusion were found to be necessary to mobilize collective learning so that city physical infrastructures transformed into integrated organizational infrastructures [75]. Similarly, in the smart cities Milan and Barcelona, successful initiatives included those where companies were fully collaborating with the government when taking up the traditional city government roles of being in charge of project funding and implementation [7].

Collaboration in the smart city context is difficult and time-consuming. Information shared between organizations encounters geographical, organizational, jurisdictional, program, and knowledge borders [27,76]. There are conflicting values and cultures of actors and stakeholders [27]. Organizational transformation is often required [1]. The objectives of the Data for London initiative of the Greater London Authority to identify carbon emission-related environmental impacts that were not met because of the overwhelming complexity of institutions and stakeholders. The actors and stakeholders involved were the Greater London Authority and its Borough councils, knowledge institutions, regulatory and standards bodies, data needs specifiers, and systems providers such as utilities and ITC vendors, direct users of the data infrastructure, data enrichers, data integrators, and data consumers [38]. The actors failed to agree on the data to be collected and its forms [38].

Pardo, Gil-Garcia, and Luna-Reyes [76] warn that achieving collaboration across governance systems not only takes time and resources, but also legislative and executive support.

4.3.3. Who—Actors Who Collaborate

Many categories of actors are said to need the capacity to collaborate [1,18,71] to enable virtually every smart city strategy, specifically strategies based on technology and innovation [1].

We now report the evidence as to the capacity to collaborate with each category of actor.

City as a Whole

Smart city society is attributed the capacity to collaborate as a component of the smartness of the whole city, in addition to smartness attributed to the city government [18]. Scholars depict the city as attracting and mobilizing human capital in collaborations [1], as comprised collaborative governance networks [77,78] and as an ecosystem where actors and stakeholders collaborate to produce innovation [78].

Similarly, the ecosystems captured in the triple-helix model of innovation [52] and double-helix model [54] are characterized by way of helix imagery as having a strong capacity to engender collaboration.

City Government

Mills, Izadgoshasb, and Pudney [71] identified three distinct bodies of smart city collaboration knowledge, namely collaboration between the city government and external actors, collaboration internal to the city administration, and city government engendering collaboration between other city actors.

External collaboration between the city government and other organizations such as companies, other governments, and not-for-profits has been positioned in theoretical and empirical research [79–81] as highly important and sometimes essential to success when addressing smart city challenges. The most frequently occurring model has city government establishing collaborative relationships across geographical or jurisdictional boundaries to achieve smart city objectives [76,79,82].

Internal collaboration between departments of a city administration is considered essential to remedying the persistent siloed approach that has obstructed the implementation of smart governance and smart city initiatives [79,82]. Managers in four North American smart cities advised that interdepartmental collaboration and cooperation had been essential for the success of smart city initiatives [83]. In contrast, Pierce and Andersson [84] reported smart city administrators from mid-sized European smart cities as nominating collaboration as their dominant challenge and that 11 of the 12 informants specified the absence of internal cooperation as frustrating project objectives. Candidate innovation project partners in the Amsterdam Smart City scheme were found to be apprehensive of the internal dysfunction of city governments and to have stipulated internal reform as a condition of participation in projects [67].

Collaboration, not involving city government directly, between other actors in the city [18], is conceptualized as requiring the city government to facilitate networks and develop a collaborative ecosystem [78]. The approach where city government coordinates the efforts of the collaborating actors toward the smart city objective is characterized as a bottom-up process [77].

Actors Other Than City Government

The extent of consideration of the role of actors other than city government in collaborations in the smart city literature is limited. Some explore the role of citizens in Urban Living Labs (ULLs), which are authentic collaborations [7,81,85]. Individual citizens are portrayed as highly influential actors in a number of models of smart city collaboration directed at resolving wicked problems [73] and achieving environmental, social, and economic benefits [55,86–89] but these conceptualizations are high-level and generalized.

Non-government organizations dominate the Amsterdam Smart City/Amsterdam Economic Board where private, governmental, and not-for-profit organizations have collaborated since 2007 in an ongoing scheme of mostly successful innovation projects [67,71,77,90].

4.4. Capacity to Orchestrate Eco-Systems

Ecosystem conceptualizations are prominent in the smart city literature [6,34,67,78,90,91]. Recently, scholars have presented models of the purposeful alignment of the many elements of an ecosystem, that is, ecosystem orchestration.

We first assemble the evidence as to the concept of smart city orchestration. Secondly, we report why orchestration is advocated. Then, we separate out the actors who are said to need the capacity to orchestrate.

4.4.1. What—Orchestration

The depictions of ICT-based systems underpinning most smart city conceptualizations [18,25,27,29,92] have been overtaken by a focus on socio-technical systems [1,93]. Subsequently, the nature of the conceptualizations has been evolving into a complex interplay of systems and relationships of a part of, or the whole of, the city [6,67,78,90] designated an ecosystem. Emerging with the eco-system model is the concept of smart city initiatives being successful through the orchestration of interactions between stakeholders and actors.

The ecosystem is depicted as a territory possessing a combination of intellectual capacities to learn, problem-solve, and innovate [28] as well as effective institutions and smart technologies [1]. Alternately, the ecosystem can be perceived through a structural lens, focused on a single sector, activity, or service comprised of multiple interacting multilaterally interdependent actors who need to interact in partnership to achieve the shared objective [94,95], such as a public service [96,97]. An example of both perspectives is the activities of the Amsterdam Smart City/Amsterdam Economic Board, which van Winden et al. [67] conceptualizes as an innovation ecosystem comprised of collaborating actors nested within the larger Amsterdam ecosystem.

The capacity required in that collaboration-centered model of the ecosystem to engender and promote innovation has been explored by Reypens, Lievens, and Blazevic [95] in a network context and by Linde et al. [6] in a smart city innovation project context. Linde et al. [6] sought to understand the capabilities required to be effective in the typically quite dynamic smart city innovation project ecosystems. Applying the lens of dynamic capabilities to the strategic management of ecosystems, Linde et al. [6] explored the challenges experienced by actors in case study smart city and sustainability projects, finding the major challenge to be the orchestration of diverse actors and stakeholders who had no experience of one another but who were highly dependent upon one another. Reypens, Lievens, and Blazevic [95] had established that intra- and inter-network orchestration entailed three categories of orchestration practices, namely connecting practices that make stakeholder connections visible, facilitating practices that promote stakeholder harmony, and governance practices that establish an efficient network system.

Orchestration is affected by a central actor, an organization, which addresses opportunities and threats and mobilizes ecosystem efforts around opportunities by reconfiguring resources [6]. Linde et al. [6] are adamant that for a smart city innovation ecosystem to succeed, it must have an orchestrator and that orchestration must be viewed as dynamic activities of a non-static non-structural position. Gasco-Hernandez et al. [7] explain that in practice, the orchestrator should lead the determination and configuration of roles, allocate the roles within the partner actors, be motivated to provide more efficient services, encourage the use of data and information technologies, and facilitate value co-creation between all ecosystem actors. The orchestrator has the capacity to dominate or, alternately, to govern through collaboration, switching between approaches as required [98].

Linde et al. [6] took the available scholarship as to factors that impact the capability of the orchestrator organization, gathered data from archives and through interviews of customers, municipalities, suppliers, and orchestrator organizations from four smart city digital innovation ecosystems, and formed three distinct themes of actions, processes, and routines utilized by successful orchestrator organizations, based upon the three capabilities, namely sensing, seizing, and reconfiguring.

To explain the features of this framework, we have created an extract from the full framework by focusing on the ecosystem seizing capability, which we set out in Figure 2.

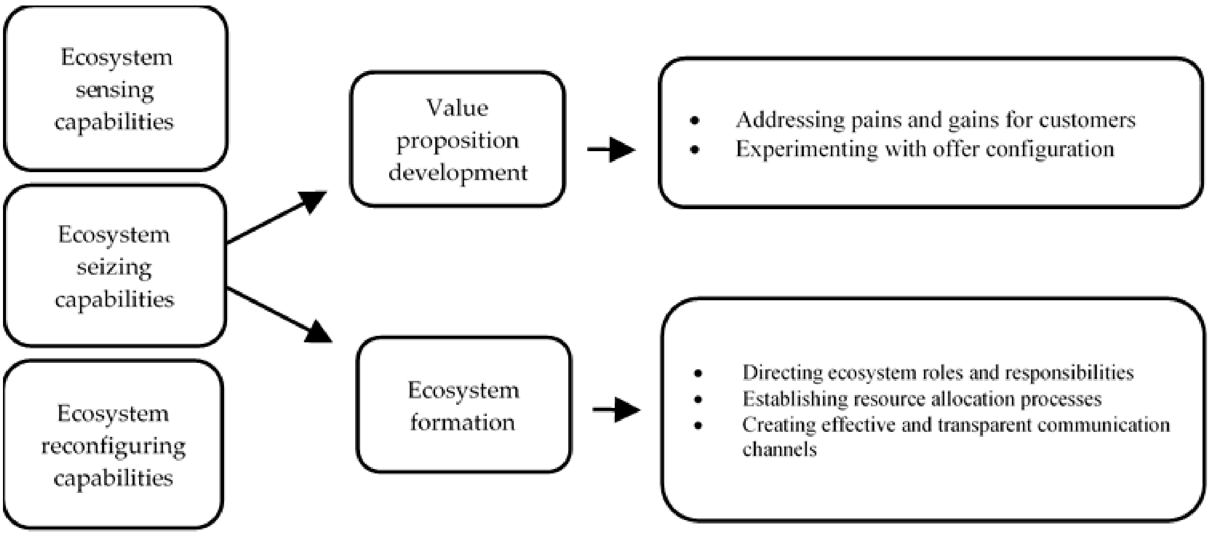

Figure 2. Linde et al.'s [6] ecosystem orchestration capabilities*. * Adapted from Linde et al. [6], demonstrating the concept of a capacity, its capabilities, and practices by providing the detail of the ecosystem seizing capability.

A notable feature of Linde et al.'s [6] framework is that they propose, for the use of theorists and practitioners, some 13 sub-routines or processes that an ecosystem orchestrator should practice if demonstrating the three capabilities.

4.4.2. Why—Reasons to Orchestrate

The literature presents two distinct threads of reasons as to why there should be an orchestration of the smart city innovation ecosystem. The first is the achievement of the objectives of the innovation project or initiative. The second is the benefit to the orchestrator organization.

The link between having an orchestrator and the achievement of the objectives of the innovation initiative [94] was confirmed in three of Linde et al.'s [6] four case studies. Informants from both provider and customer partners stressed the need for a leading actor to both set the ecosystem's agenda and direct ecosystem roles and responsibilities. Linde et al. [6] concluded that the ecosystem orchestrator organization must have each of the sensing, seizing, and reconfiguring capabilities to be considered to have an orchestration capacity.

4.4.3. Who—Actors Who Orchestrate

An orchestrator of a smart city innovation ecosystem is typically the central organization that has taken the decision that set the ecosystem objectives, such as to provide green energy to a territory, and becomes the focus of all partners in the innovation ecosystem.

Whilst the ecosystem literature [94] and the smart city innovation ecosystem literature [6] focus on the concept of actors, the term is used to encompass stakeholders, for example, consumers with pre-eminence given to the orchestrator.

An example of an orchestrator is the Greater London Authority (GLA), which led the data ecosystem across London city authorities according to the precepts of openness, diffusion, and shared vision [98]. Openness involved being open in technological and organizational aspects that allowed stakeholders to realize and replicate the city's data ecosystem. Diffusion seeded advanced data skills and built trust in the data ecosystem through learning and knowledge mobility. Shared vision is a mature orchestration stage that established central coordination structures, facilitated by the GLA.

In the instance of the London city government's data eco-system, the role of the orchestrator and the number of orchestrators changed as initiatives moved through the project phases [99]. In the initial foundational global aggregation phase, a single orchestrator invited other stakeholders, encouraging their participation and self-organization. Next, in the configured aggregation phase, there were multiple orchestrators with data capabilities development happening through a dialectical process. In the final maturity phase, control returned to an individual orchestrator who orchestrated the process toward a collective goal.

A further variation on the model of multiple orchestrators is found in the example of the Amsterdam Smart City (ASC)/Amsterdam Economic Board (AEB) where two private companies orchestrated simultaneously but with municipal governments participating. ASC emerged in 2007 as a formal collaboration between the energy network operator Liander, Amsterdam Innovation Motor (AIM), and the Municipality of Amsterdam [71]. These founding organizations were joined by KPN, a Dutch telecommunications provider in 2009 with AIM later becoming the Amsterdam Economic Board, which is the dominant partner in the ASC collaboration to the extent that the AEB and ASC are now mostly not distinguished in the internet sites of the entities. The leadership role in orchestrating the evolution of ASC has been taken by private sector companies and not the city government. The evidence is that these non-government orchestration arrangements were established because of perceptions and experiences of dysfunction between city government departments and consequential apprehension that innovation initiatives would be jeopardized by greater involvement of the city administration [67,81].

5. Discussion

Because of the claims that certain capacities lead to sustained achievement of smart objectives, our research sought to answer the following questions:

1. Which are the capacities required of actors to sustainably achieve smart city objectives and are the components of these capacities explained sufficiently for them to be applied in practice?
2. What future research should take place in order to optimize the sustained achievement of smart city objectives through the application of capacities?

Whilst there is evidence that the application of the four most prominent capacities, namely exploiting technology, innovation, collaboration, and orchestration, leads to success in achieving the smart city objectives, we found the overall body of smart cities capacities literature to be problematic in that the knowledge is not sufficiently developed to be useful to theorists and practitioners seeking to examine the implementation of the capacities in practice. We discuss the major areas of underdevelopment: firstly, knowledge as to the components of each capacity; then, institutional complexity; and thirdly, the influences of stakeholders on the application of capacities by actors. Finally, the concept of smart city capacity is defined to guide future research.

5.1. Components of a Capacity

We sought evidence as to whether the components of each capacity are explained sufficiently to inform the actor operationalizing the capacity. Scholars [1,2,28] warn that the smart city literature presents prescriptions notable for their high level of abstraction. We found that the extant literature does not provide sufficient knowledge for those seeking to create and apply the capacity in their organization or ecosystem. Yet, company CEOs or city mayors seeking to create capacities must be equipped with overarching theory and detail of the many practical steps that must be taken to operationalize the capacity.

Recently scholars have begun to drill down within a capacity to explicate the capabilities or dimensions that comprise a capacity. For example, public organization innovation capacity is explained as comprised of four capabilities, each of which is provided with a set of questions that must be addressed if the organization is to successfully operationalize that capability [5]. Similarly, the capacity of smart city governments to orchestrate digital transformations has four dimensions, each of which has four or five attributes [7]. Reaching down to a third level, Linde et al. [6] explained 13 routines or processes, each of which supports one of the three capabilities. These descending hierarchical models are effective in providing an ever more detailed explanation of what has to be conducted to achieve the capacity in a sustainable form. Such a logical approach to presenting knowledge is likely to resonate with mayors and CEOs seeking to implement smart city capacities. For that reason, we bring together the extant literature on the structure of components depicted in Figure 3.

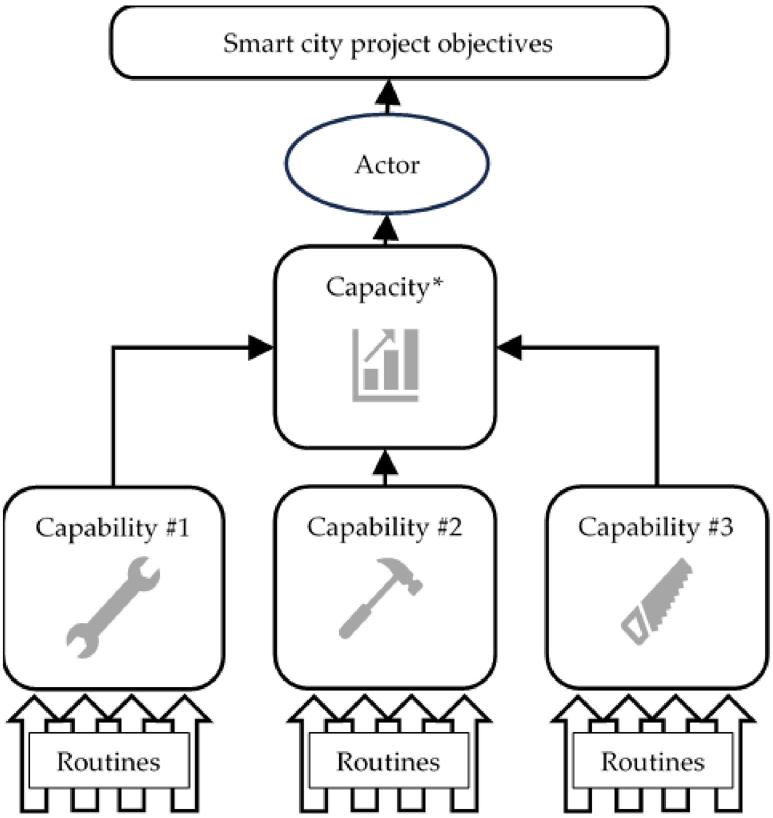

Figure 3. Proposed smart city capacity components framework. * Smart City Capacities: exploit technology; innovate; collaborate, and orchestrate.

Importantly, we have not attempted to position the competencies of individuals in the proposed smart city capacities framework. This is because the literature to date does not proceed down past the attributes of role-based categories. For example, Meijer and Bolivar [1] stipulate that city managers must have a political understanding of technology but no explanation of the criteria that explain such understanding is provided. We suggest that further development of additional levels of knowledge in the hierarchy of the proposed framework follows upon foundational research as to capacities and their capabilities and routines.

The foundational research should be the development of a comprehensive knowledge of the components of each of the four identified capacities through methods that draw evidence from smart city case studies and apply knowledge from the literature of other disciplines. Specifically, research questions might be the following: what are the capabilities and supporting routines that comprise the XYZ smart city capacity? In what ways do the competencies of individuals and contractors contribute to the model of a smart city capacity?

5.2. Institutional Complexity

Smart city scholarship commenced in the late 1990s context of worldwide public sector reform, which applied principles such as marketization, contracting out, and privatization to local government and other levels of government [100]. Creeping fragmentation of the activities of governments and an ever-increasing number of entities involved in the provision of any given public service [101,102] resulted. An example of the negative impact of institutional complexity and the inherent divergence of interests of the many, many actors and stakeholders, on initiative objectives, is reported by [38] with respect to carbon emission data for four European smart cities. The smart city literature is notable for its prescription of collaboration to remedy cross-jurisdictional and interorganizational problems [71] but other than the recent reporting of the success of orchestration in achieving collaboration [6,98,99], the smart city literature has not proposed remedies that facilitate the application of smart city capacities in the context of institutional complexity.

A starting point for research as to the impact of institutional complexity on the application of capacities is the ecosystem lens because of the suitability of the eco-system model for unpacking the multi-lateral, multi-actor, and multi-stakeholder relationships [6,34,67,78,91]. Similarly, the capacity development literature [103] might be productively applied to address the issues emanating from the institutional complexity of a system or eco-system.

Focusing on collaboration capacity, a foundational research question is the following: in what ways can effective collaboration within the ecosystem of a smart city service that is characterized by institutional complexity be achieved?

Focusing on orchestration capacity, in particular, the findings of Gupta et al. [98,99] that orchestration of a smart city project can alternate between strategies of collaboration or domination, as best suited to the stage of the smart city project, then the research question might be the following: in what ways can the ecosystem of a smart city service system project characterized by institutional complexity be orchestrated for the purpose of achieving project objectives?

5.3. Stakeholder Influences

A key element of ecosystem conceptualizations is the stakeholders who most commonly exert influence on city government through regulation, collaboration, agenda-setting, controlling, and legitimating [104]. Stakeholders are characterized as adopting an influence strategy to achieve their objective [105]. The smart city literature conceptualizes stakeholders such as citizens, service users, and residents at a high level but gives little attention to the much more nuanced questions surrounding the influence of each of these stakeholders. For example, Kitchen [39] observes that the technical competence of the population and their acceptance of technological advances influences decisions as to the level of technology and the way in which it is exploited. Governments are subjected to strong influence from global corporations to make developments and purchases favorable to those corporations [39]. Somewhat differently, stakeholders have been found to positively influence smart city initiatives during the implementation stage [6,7].

These examples consider influence at two entirely different times. One is at the stage when an initiative is decided and the other is during the implementation stage. Making this distinction in smart cities capacities scholarship is essential to theory having meaning in practice and is a long-established element of stakeholder theory. For example, Aaltonen and Kujala [106] proved a framework of project lifecycle stages, namely the investment preparation phase, the execution phase, and the operations phase, to be highly useful in the analysis of the evolving dynamics and salience [107] of the many stakeholders during a project.

A further opportunity to build capacities and knowledge through the application of established stakeholder theory is the practice of differentiating between primary stakeholders, the organizations that either have a contractual relationship with the project or government entities who have legal authority over the project, and secondary stakeholders who have no contractual bond or legal authority but can influence the project [106,108]. Stakeholders who are assessed as not having influence are a third category.

The application of these three categories and the framework of project phases in future research into the influence of stakeholders upon capacities is depicted in Figure 4. Application of that framework would facilitate foundational analysis for research that is more fine-grained and targeted to the development of greater knowledge as to the influence of a specific category of stakeholders on all capacities at each stage of a smart city initiative. At this relatively early stage of capacities research, the initial concentration on primary stakeholders is likely to establish a base of knowledge that will facilitate the exploration of the influences of secondary stakeholders on the decisions of actors and primary stakeholders. Alternatively, the research might target the influence of all stakeholders in one or all phases of a project. However, foundational research should answer the following questions:

1. In what ways do primary stakeholders influence decisions as to the application (or not) of each smart city capacity at each phase of an initiative?
2. In what ways does each category of project stakeholder influence the achievement of the objectives of a project?

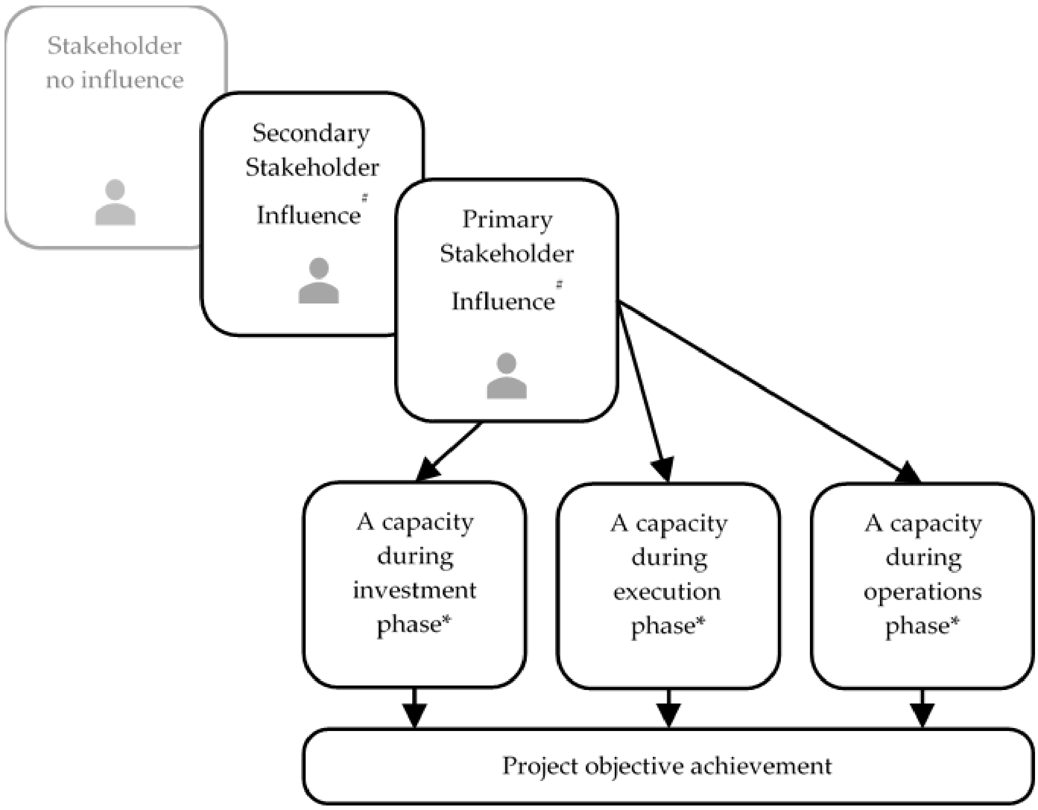

Figure 4. Research framework—stakeholder influence on smart city capacities. * Aaltonen and Kujala [106], # Eesley and Lenox [108].

5.4. *Defining the Concept of Smart City Capacities*

The concept of smart city capacities is impacted by the continually evolving conceptualizations of actors, the intertwining of capacities, and a number of other characteristics. We now lay out those impacting characteristics and justify a definition of capacities that will assist future research.

5.4.1. Evolving Conceptualizations of Actors

The literature attributes each capacity to territories, such as cities as a whole [28,42,57], industry sectors, and ecosystems of an initiative or territory [52–55], private companies, knowledge institutions, third-sector organizations, and city governments [1] and their elected officials [27] and managers [46].

This existing wide spread of categories of actors to whom a capacity is attributed and the more fine-grained separation out of broad categories such as city government into elected officials and city managers suggests that the entities to which a capacity is attributed are not a static listing of actors. Indeed, the concept of an eco-system is open to an ever-evolving range of models of collective efforts, allowing the attribution of a capacity to any form.

Accordingly, the scope of the concept of actor must be open to further conceptualizations.

5.4.2. Interdependence of Capacities

Despite our primary research method being to iteratively separate evidence into nodes that formed the four capacities, we found that by working backward chronologically, the more recently reported capacities, namely collaboration and orchestration, are presented as assisting those established earlier, namely capacity to exploit technology and capacity to innovate. We wondered whether there is a causal link, an interdependence.

The evidence is that no one capacity is dependent upon another. To the contrary, exploiting technology is not always dependent upon innovation, collaboration, or orchestration and innovation is not dependent upon collaboration. Similarly, orchestration is not dependent upon collaboration with there being evidence of the orchestrator choosing unilateral action instead of collaboration [6,98,99]. Yet, much of the literature proposes or reports the capacities as intertwined and operating to support the effective operationalization of other capacities. The intertwining of capacities is not a characteristic that defines a smart city capacity.

5.4.3. Definition of Smart City Capacity

This discussion of those characteristics indicates the need to recast the tentative working definition that we applied in our data-gathering methods, namely

> *Smart city capacities are the abilities of city government and other actors across the city to solve problems and set and achieve objectives.*

We now discuss the implications for a fit for purpose definition of smart city capacity of the evolving conceptualization of actors and other characteristics.

Firstly, our specifying city government and using the term 'other actors' had privileged city government over all other actors. Yet, the reality presented by the literature is one of many more actors conceptualized as having capacities to achieve smart city objectives. We propose a definition that is fully open to all actors and which does not specify city governments nor attempt to list actors.

Secondly, and similarly, we propose that a definition should not list existing capacities because the evidence is that smart city capacities have emerged progressively and, recently, requiring a definition that assists the capture of additional capacities in future research.

Thirdly, as laid out in Figure 3, our research identified that capacities are conceptualized as comprised of capabilities specific to each capacity and that possession of these capabilities in combination is an essential characteristic that defines the capacity. We insert that component in the definition below.

Fourthly, our working definition followed the perspective of Fukuda-Parr and Lopes [8] that the capacities of governments are generally about addressing problems. Whilst a significant body of the smart cities literature depicts capacities as addressing wicked problems and achieving transformation [1,7], more recent scholarship is reporting capacities as not only supporting successful initiatives [6] but also success in the ongoing operations phase [7]. Thus, a definition should also be open to the possibility of smart city capacities also being applied to effect incremental change and ongoing operations.

Bringing those characteristics together, for the purpose of guiding future research, we offer the following definition of smart city capacity:

A Smart city capacity is a combination of specific capabilities that enable a smart city actor to achieve the intended smart city objective.

6. Conclusions

We commenced this research intrigued by claims of smart city capacities that could resolve previously unresolved and emerging wicked problems. We quickly realized that the capacities are authentic, yet the knowledge as to the components of those capacities and how they can be applied to achieve smart city objectives is very underdeveloped.

Our research approach of bringing together the loose threads of extant smart city capacities knowledge and forming substantial bodies of knowledge as to what, why, and who of each of the four prominent capacities proved apposite to the research objective of understanding what these smart city capacities are and, in turn, identifying and justifying an agenda of research directed at increasing knowledge of capacities to optimize the sustained achievement of smart city objectives. Our defining the concept of smart city capacity based on the knowledge from the four identified capacities has led to a research tool that sets the concept of smart city capacity without closing off the possibility of further emerging conceptualizations of capacities, actors, and the components of existing and yet to be identified capacities.

Yet our research approach has an inherent limitation. Our research is founded on the prescriptions of the extant literature. We had a view of the possibility of the literature, for whatever reason, not yet identifying an important capacity. Our method of iteratively following the thread of the literature is blind to the possibility of there being another capacity that is required, or helpful, for smart city actors achieving objectives. We have reasoned that research regarding smart city capacities is in its infancy and that the widely sourced research to date has reported the reality as perceived, in many instances informed by empirical evidence. We feel that this limitation of our research methodology can be addressed by empirical research; we have recommended applying methods that seek evidence of informants as to what they perceive to be the required capacities.

The future research, which we have identified and justified, is necessary for the sustained achievement of smart city objectives through the application of smart city capacities. The research goes down paths characterized as components of smart city capacities, collaboration in the context of institutional complexity, and stakeholder influence. We have provided research questions to guide the journey down each path.

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