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Exploring the Impacts of Social and Technical Aspects of Governance on Smart City Projects

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Highlights

What are the main findings?

- Smart city governance needs to be clearly defined to better understand its impact.
- Smart city governance plays a role on the adoption of smart city projects.
- Governance legitimacy appear to be more relevant for infrastructure projects.

What is the implication of the main finding?

- City managers need to understand local forms of collaboration, power relationships, and interests of groups as they explain smart city developments.
- Successful smart city projects can be embraced as part of a general strategy, but also as focused efforts to solve city problems.

Abstract

Cities across the globe face a variety of social, economic, and environmental challenges, and building smart city systems has become a popular strategy, through a combination of institutional and organizational systems along with technological innovation. However, smart city projects drastically vary in scope and size, from building infrastructure for data gathering to improve policy, to developing more efficient government services, and even covering aspects of sustainable economic development or citizens' quality of life. Applying perspectives from social informatics, we developed and tested two hypotheses using a dataset comprising 99 US cities to answer the following question: What is the impact of technical and social aspects of city governance mechanisms such as regulations, plans, and partnerships on the adoption of smart city projects? We study the adoption of smart city initiatives through the lenses of a comprehensive conceptualization of the smart city that includes the dimensions of government, infrastructure, and society. Our findings suggest that governance arrangements positively correlate with smart city projects in all three dimensions. We found, however, that legitimacy and inclusion aspects for governance may have a stronger impact on Smart Infrastructure projects. Future research is necessary to continue exploring the nuanced interactions between governance and smart city policy.

Keywords: smart city; socio-technical systems; smart city governance; social informatics; smart government; Smart Infrastructure; smart community

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1. Introduction

The global urban population has surged from 751 million in 1950 to 4.2 billion in 2018, accounting for more than half (55%) of the global population, and it is projected that by 2050, 68% of the world's population will be living in cities [1]. Although urban areas expand and contract over time (40% of European cities are shrinking) [2], city managers face important challenges and urban problems, including strain on current infrastructure, limited budgets, traffic jams, air and water pollution, disorganized growth, inefficient healthcare systems, deepening political divisions, outdated or inconsistent technology, the effects of climate change, and managing de-growth [3]. As a response to these challenges, cities are adopting "Smart City" strategies to implement better policy, create stronger communities, and promote development by using modern technologies, policies, and management techniques to improve services [4,5]. Smart city projects often incorporate both state and non-state actors such as citizens, non-profits, or privately owned businesses as a means of addressing urban issues [6,7]. Some examples or types of smart city projects include open data initiatives, online government services, public transportation services, and the use of sensors for the efficient management of parking, lighting, traffic, and other city services. On a general level, smart city projects are concerned with improving the quality of life for citizens as well as their environment [8]. At the very least, smart cities must combine the affordances of information and communication technologies (ICTs) with meeting the needs and services of their community as a whole.

In recent years, and as a response to the major focus on information technologies in the study of smart cities, researchers have paid increased attention to the importance of institutional and governance mechanisms as enablers of innovation, implementation of smart city projects or the overall impact and value creation from these strategies [7,9–15]. Research on smart city governance is rich in case studies that provide qualitative hypotheses on the importance of governance for the success of smart city initiatives [13,16,17]. Nonetheless, the literature is missing research that systematically collects comparable data across cities to produce new empirical insights [10,16]. In this way, the picture is not clear when looking at how the governance structure affects the specific smart city projects' implementation in different cities, and more research is necessary [14,17,18]. In this paper, we contribute to this conversation by answering the following research question: What is the impact of city governance mechanisms such as regulations, plans, and partnerships on the adoption of smart city projects? To answer the question, we develop two hypotheses on the impact of the technical and social aspects of city governance on the adoption of smart city projects and test them using data from 99 cities in the United States. We adopted a definition of governance that involves (1) technical and (2) social aspects of governance [12], and we classified smart city projects using three main categories: (1) building physical infrastructure, (2) improving government programs and services, and (3) increased participation and citizen engagement [4,19].

We contribute to the literature on smart cities in three ways. We propose a conceptual and operational definition of smart city governance that builds on current understanding of socio-technical approaches [20] and smart city governance [12]. Second, we push forward a multidimensional view of the smart city by proposing an operational definition of the smart city based on current conceptual frameworks of smart city approaches. Finally, we use these definitions to explore the impact of governance on the development of smart cities. The rest of this paper is organized into four additional sections. Section 2 includes our review of the current literature on smart cities, as well as our hypotheses. Section 3 includes a description of our methodological approach. In the fourth section, we present the main findings from our exploratory dataset with 100 cities. In the fifth section, we discuss the findings and draw our conclusions.

2. Literature Review

2.1. Understanding the Concept of Smart City

There is no consensus on what it means for a city to be "smart," or even how best to define an urban area or a city, given the different institutional contexts across countries [6,21]. Anthopolous and colleagues [19] show the diversity of conceptualizations of the smart city, ranging from the use of emerging technologies to the extensive use of data for digital transformation of city governments and communities. Existing definitions have emphasized aspects such as technology [22], hard infrastructure management [23], capacity (measured in people, economy, standard of living, environment, mobility, and governance) [24], human capital [6], innovation and quality of life [25,26], governance, economy, mobility, environment, and living [27]. Innovation, technology, environmental requirements, and social development are common themes across definitions [4,19,21]. In some domains, the smart city has become almost a synonym for what Umana [28] calls "best-practice urban planning". In the context of this paper, we adopt the following working definition of the smart city:

> a city which leverages innovative organizational, institutional and governance structures, as well as the infrastructural, technical and data-driven affordances of information and communication technologies and the internet of things to make the city efficient, livable and sustainable.

Scholars understand city smartness as a complex socio-technical system encompassing a set of applications on different domains, including technology and platforms, improving and innovating in the development of public policy and management, and building more livable communities [4,5,10,19,22]. Our paper builds on comprehensive frameworks for understanding what makes a city smart [19,25,29]. Specifically, we use the three main dimensions of smart cities proposed by Gil-Garcia and colleagues, namely government, physical environment and society [25]. Fundamental components of the government domain include institutional arrangements (laws, regulations, and policies), city administration and management, and public services. The physical environment domain involves building city technical infrastructure to gather data using many different types of sensors that can be then used to improve the livability of the city by improving public services, the environment, or energy use. The society domain focuses on the development of human capital, engagement and the knowledge economy to improve city development (see Figure 1). In his framework, Anthopoulos [19,29] identified eight interrelated components that constitute the smart city's cyber–physical ecosystem as Smart Infrastructure, Smart Transportation (or smart mobility), Smart Environment, Smart Services, Smart Governance, Smart People, Smart Living, and Smart Economy. As shown in Figure 1, aspects of these components can be mapped into the three dimensions proposed by Gil-Garcia and colleagues [25].

In this way, our conceptualization of the smart city involves an understanding of the smart city as a sociotechnical arrangement that includes (1) building a physical infrastructure for city services (Smart Infrastructure); (2) improving government programs, policy and services (Smart Government); and (3) increased participation, innovation and economic development (Smart Community).

2.2. Understanding Smart City Governance: Research Model and Hypotheses

Our work draws from perspectives in social informatics (SI), popularized by Rob Kling, Howard Rosenbaum, and Steve Sawyer. SI is a transdisciplinary research field with a central argument that every ICT, such as the smart city system, is a socio-technical system composed of not only the technological part (i.e., the artifact), but also people, and the social norms, practices, and rules that surround its implementation. In SI, "socio-technical"

denotes the intertwining and mutual shaping of ICTs and the larger social or organizational context in which they are implemented or embedded [20,30,31]. SI therefore seeks to understand the roles and influences of social forces and practices in shaping the implementation and outcomes of technologies in general and ICT in particular. Consequently, in any research endeavor on ICT, the technological artifact and the human social context (including social forces and social practices) cannot be justifiably decoupled. In this way, the context of the use of ICT directly affects the meanings and functions of ICT, while the design of ICT is linked to social and organizational dynamics [31]. Therefore, information professionals needed to critically analyze "... the roles of elements of power and influence, resources available to and employed by various interests, and the consequences of their personal decisions and of public policy" [32]. SI analyses therefore seek to "... uncover and explain the coupling of technology and social order" [33]. In the case of the smart city, for instance, the social and organizational setting would include, inter alia, the social arrangements or governance structures, the policy frameworks, and the human and financial resources that enable, shape, support, regulate, or govern living conditions in the city.

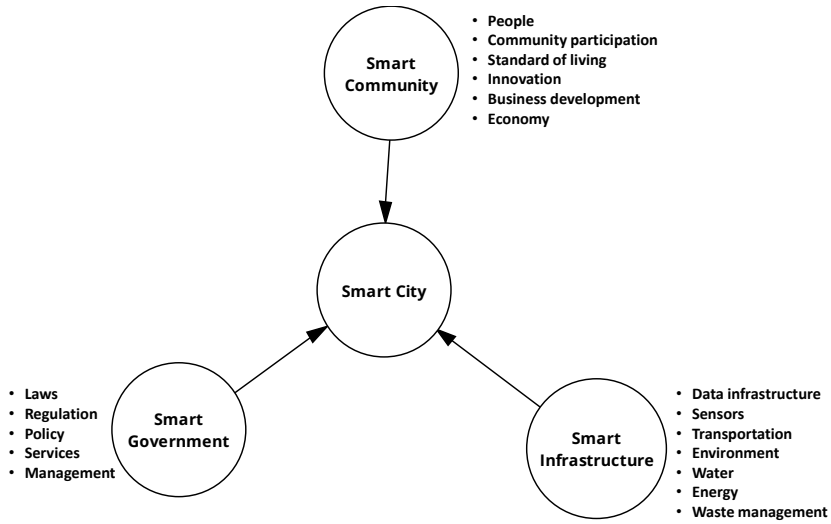

Figure 1. Smart City Dimensions and Components.

There is a gradual acknowledgment in the literature that social arrangements or governance is crucial to the adoption and sustainability of smart city projects [7,11–13,34]. Urban governance is about the processes or social arrangements through which government is organized and delivered in cities, the interrelationships between state agencies and civil society—including citizens, communities, private sector actors, and voluntary organizations. Urban governance is important because it involves questions about who makes the decisions, how the decisions are made, who controls agendas, who enacts and implements policy, what policymaking processes or procedures exist, which interest groups hold the power and resources to influence and shape the policy agenda, as well as how much control the residents and private citizens have over the way the city is governed [35]. In this way, and consistent with the SI perspective, the governance of a city is also a socio-technical concept with two main components: Administrative/technical and legitimacy/inclusion [12]. To the best of our knowledge, there is not yet a formal study of how these structural (i.e., technical) and social aspects (i.e., legitimacy) of governance impact the adoption of smart projects in practice.

The administrative/technical component of city governance encompasses the institutional and human capacities for the exercise of political and administrative authority at all levels of a city's affairs, as well as the designs, goals, and technologies that mediate

the exercise of such institutional and human capacities in service of the city's affairs. The legitimacy/inclusion component, on the other hand, lies in the government's authorized structures of participation but also goes beyond the city government to include other social actors, institutions, and relationships. In the following sections, we develop our perspective on how these aspects of governance influence the adoption of smart city projects (see Figure 2).

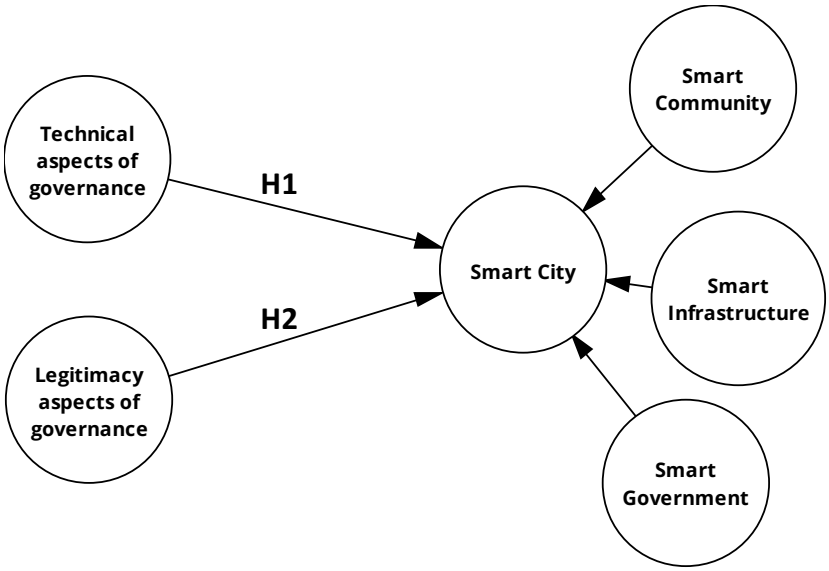

Figure 2. Smart City Dimensions and Components.

2.2.1. Administrative and Technical Aspects of Governance and Their Impact on Smart City Initiatives

The administrative (i.e., institutional and organizational structures) and technical (i.e., technologies used for governance processes) components of urban governance are crucially important for smart city projects. Researchers in social informatics recognize the importance of institutional and organizational structures in the process of technology adoption [36–38]. Orlikowski [38], for example, discusses how technologies are the product of human activity and how human activity is constrained or enabled by organizational and institutional structures. Similarly, Fountain [37] refers to the process of technology adoption within the government organization as a process of technology enactment, where organizational actors decide on specific features of technologies based on constraints and enablers built on their institutional contexts as reflected in laws, regulations, budgets, plans, and policies. This institutional perspective provides a very useful lens for studying technology adoption in government [14,39].

The importance of governance arrangements in technology adoption and implementation is also captured in the recent literature. For instance, in the context of blockchain, some researchers have proposed a conceptual framework that expressly seeks to capture the complex interrelationships and mutual influences between institutional (governance), market, and technical factors underlying the technology [40]. Specifically, by providing the rules regulating the relationship between the stakeholders, governance simultaneously enables trust in the technology and trust among the players or stakeholders who govern the technology. Another study found that the most critical barriers to gainful blockchain implementation are "...organizational and environmental, lack of understanding by top managers, compliance and regulatory requirements, and marketing noise" [41].

For these reasons, both the administrative and the technical components of governance are crucial for the planning, design, adoption, and sustenance of smart city projects. Consequently, we state our first hypothesis as follows:

Hypothesis 1. *Administrative and technical aspects of governance have a positive impact on the development of smart city projects.*

2.2.2. Legitimacy and Inclusion and Their Impact on Smart City Initiatives

The legitimacy and inclusion components of urban governance are also of crucial importance for smart city projects. Considering social components as they modify technology adoption is a key concept of SI [31,42]. *Governance* goes beyond the structure and processes of the government, and it operates under the modus operandi of shared goals, offering a sphere of public debate, partnership, interaction, dialogue, and potential conflict among all stakeholders [43]. Thus, in what has been defined as "Smart Governance" [13], governance shifts from state sponsorship of economic and social projects to the delivery of the same projects through various partnership arrangements, usually involving both governmental and non-governmental actors or organizations. Through these social arrangements, structures, and technologies of legitimacy and inclusion, city stakeholders can participate in the decision-making process in the smart city. One well-documented demonstration of the importance of the legitimacy and inclusion components is the case of open data in cities. Open data enhances civic engagement, reduces public apathy, enhances service delivery, and improves accountability, among other things [44]. These social arrangements, structures, and technologies thus promote engagement and participation by residents and other stakeholders in the life and affairs of the city. Such increased engagement and involvement in decision-making by a broader section of civil society ensures better representation and citizenship, economic competitiveness, privatization, and new forms of public–private partnerships, and ultimately ensures the sustainability and resilience of smart projects in the city [35].

Governing a smart city is about promoting sustainable collaborative networks [45]. In fact, the lack of appropriate governance arrangements may constitute an important obstacle to the effective transformation of cities into being smart [17,46,47]. Three elements related to legitimacy and inclusion, as reported in the literature, include (1) e-governance, (2) engagement by stakeholders, citizens, and communities, and (3) networks, partnerships, and collaboration [25]. Thus, the inclusive governance component encompasses those social arrangements, structures, and relationships that promote participation by residents and other stakeholders in the life and affairs of the city. A supportive ecosystem that encourages citizen participation, nurtures start-ups, and promotes public–private partnerships is a necessity for the realization of the smart city vision of city governance. Consequently, we state our second hypothesis as follows:

Hypothesis 2. *Legitimacy and inclusion have a positive impact on the development of smart city projects.*

3. Materials and Methods

3.1. Rationale

To test our hypotheses and more systematically collect data, we used the *web scraping* method, also referred to as the web harvesting, web extraction, or data scraping method. Web scraping is the process of extracting data in a manual or automated manner from websites. Web scraping has been successfully used in online data collection, especially on social media like Facebook and Twitter [48,49], but also more generally to assess govern-

ment efforts in digital government [50–52]. Web scraping offers several key advantages for this study. First, it enables access to large-scale and diverse data. There is a lack of centralized datasets on the adoption of smart city technologies by governments. Web scraping enables researchers to collect up-to-date and comprehensive information from a broad range of sources such as city websites, official announcements, public procurement records, and news portals [53]. Second, web scraping supports comparative and trend analysis. The ability to compile data from multiple cities enables direct comparison of smart city initiatives, tracks trends in adoption, and identifies patterns at various geographic or administrative levels. Third, web scraping is affordable: it is relatively low-cost, requiring minimal resources beyond the initial development of scraping tools or scripts. Fourth, web scraping addresses data gaps. Since not all agencies or cities publicly publish standardized reports, web scraping helps fill critical data gaps and supports meta-analysis by extracting information embedded in public documents, press releases, and city portals. These benefits make web scraping a powerful and practical methodology for systematically studying how cities implement smart city technologies and how adoption patterns vary [54].

In this way, we scraped data from multiple websites, including the official websites of the cities in the sample, along with other official websites of cities' departments and local news outlets in each city, looking for data related to smart city projects as well as the technical and legitimacy aspects of city governance. We stored the extracted data in a structured format in an MS Excel spreadsheet and used these data to test research hypotheses using regression analysis.

3.2. Population and Sampling Procedures

Cities in the United States form the population for this study. We drew our sample of 99 cities by selecting the top two cities with the largest population according to the US Census Bureau of Statistics for the year 2021 in each of the 50 states. The sample is not 100 cities because one city, Pearl City, Hawaii, was dropped from the sample because it is still an unincorporated community and census-designated place and has no official website.

It is important to note that our sample includes a wide variation of cities in terms of size, representing cities with diverse demographic trends. Most cities in the sample are experiencing growth, some of them have been steadily growing in the last decade, and others are experiencing a turnaround from declining to growing after the pandemic [55]. The fastest-growing urban areas are located in the south and southwest. The sample of cities in our study includes smaller cities that are not usually included in most smart city research; only 9 of the cities in our sample are larger than 1 million inhabitants, and more than half (55) have less than 300 K inhabitants, including some of the fastest growing cities in the United States (see Appendix A for the population distribution in the sample). We believe that this is one of the strengths of our paper. Urbanization continues to change societal, economic, and environmental dynamics, creating both significant opportunities and notable challenges, such as the rise of urban slums and increased demand for infrastructure and services.

3.3. Key Variables and Data Sources

As described in previous sections of the paper, the *smart city* is a multi-dimensional concept that encompasses government efforts to promote better places to live. We designed our data collection on closely related smart city conceptualizations by Gil-Garcia and colleagues [4] and Anthopoulos [29]. Building on the common interrelated components of the smart city in the two frameworks, we compiled our dataset using the broad themes of *Smart Government*, *Smart Infrastructure*, and *Smart Community*,as three major components of a smart city. For each theme, we defined potential smart city projects as described in any of the selected frameworks (see Table 1). Although an overall measure of a smart

city is the combination of projects in these three areas, the literature acknowledges that cities may emphasize one of them as an element of their strategic approach to becoming smart. In this way, we compiled data separately for each dimension and treated them as independent variables. An aggregation of the three dimensions (using the average) constituted a measure for City Smartness.

Table 1. Components of smart cities found in the initial sample.

Variable	Operationalization	Data Sources
Smart Government	Citizen Communication (i.e., mobile notifications, social media for G2C interactions) Open Government (i.e., open data, open records requests) Digital Services (i.e., permits and licenses, payments, 311 type services) GIS apps and maps Drone Use (i.e., public safety, infrastructure inspection, waste management) Paperless Government	City Websites Local News Websites
Smart Infrastructure	Housing (i.e., energy efficiency and livability) Smart Transportation (i.e., city mass transit, street redesign, e-bikes and scooter projects, autonomous vehicle programs) Sensors (i.e., street lights, water quality, CCTV, parking, traffic, power spikes, natural disaster monitoring, air quality, waste, gunshot detection) Internet Access (i.e., free public WIFI)	City Websites Local News Websites
Smart Community	Quality of Life (i.e., leisure and entertainment, arts and culture) Digital Economy (i.e., technology hub) Smart Public Safety (i.e., new surveillance, AI/ML technologies, predictive policing) Preservation of Landscape (i.e., natural, historical)	City Websites Local News Websites
Technical Aspects of Governance	Dedicated Funding Strategic Plan Including Technology/Data-driven Components Smart City Policy or Plan Collaboration Agreements with Neighbor Cities	City Websites
Control Variables	Form of Government Per-Capita Income Total Population Percentage of residents w/Bachelor degree	City Websites Census Bureau

3.3.1. Dependent Variable: Smart City

A *Smart Government* includes the capacity and programs to promote integration, innovation, evidence-based decision making, citizen-centricity, sustainability, creativity, effectiveness, efficiency, equality, entrepreneurialism, citizen participation, openness, resilience, and technological savviness [4]. In this way, we operationalized Smart Government to include the availability of specific programs and services to facilitate government interactions with their constituents, digital services, government openness, and paperless government. Such programs include citizen communication and open government, digital services, paperless government, drone use in public service, and geographic information service (GIS) resources. Specifically, we included in the Smart Government theme the availability of social media handles for Government-to-Citizen (G2C) interactions; mobile

notifications regarding news, events, and emergencies; GIS apps and maps for residents' use; the availability of programs that use drones in delivering public services in some form; the adoption and practice of a paperless government; and the availability of digital services on the city's official website to enable residents to complete service transactions such as permits and licenses, various forms of bill and fee payments, and 311-type services fully online.

We used *Infrastructure* to denote the fundamental physical, technological, social, and economic systems that support society or a city, and *Smart Infrastructure* to mean infrastructure that also collects and utilizes data and information using sensors, cameras, and connected devices to support decision-making, urban planning, and service delivery in different domains. Accordingly, our breakdown of the theme of Smart Infrastructure includes the availability of specific programs on housing, Smart Transportation, various uses of sensors in public service delivery, and the provision of public internet access (WiFi). Thus, smart housing programs would include housing developments that prioritize not only affordability but also design, energy efficiency, and livability. In this category, we also included various smart public transportation programs, including programs involving the creation of special street lanes or the redesign of some districts to accommodate the mass transit program, the adoption of autonomous or flying transportation systems in the city, and the provision of electric-powered transportation in the form of e-bikes and scooters. Our operationalization of infrastructure also included programs targeting the provision of free public WiFi in designated public spaces in the city, as well as various programs that utilize sensors to maintain, monitor, track or regulate public services and utilities such as smart street lights, water quality, security cameras (CCTV), parking, traffic, power spikes, natural disasters, air quality, waste, and gunshot detection (shotspotters).

We used *Smart Community* in the sense of a city or community that has specific programs for leveraging digital methods and technologies of data collection to improve the quality of life of the citizenry and create new solutions to known and future challenges like urbanization, natural, historical, cultural, and environmental preservation and sustainability. Accordingly, we operationalized Smart Community in terms of programs that target the improvement of the quality of life, participation in the digital economy, smart public safety, and the preservation of the natural and historical landscape of the city. Quality-of-life programs would include those involving leisure and entertainment and arts and culture. Society also includes programs aimed at participation in the digital economy, including the city being named explicitly as a technology hub as host to a large number of technology companies, and/or has programs that involve some form of smart public safety, including the adoption of new surveillance, AI/ML technologies, and predictive policing. In this category, we also included programs targeting the preservation of the environmental (i.e., natural and historical) landscape of the city.

3.3.2. Independent Variable: City Governance

We followed the same approach to define operationally the *Technical and Legitimacy* aspects of governance, again using the literature to select main elements to be considered [12]. *City governance* considered the capacity, programs, policy framework, and efforts towards leveraging the affordances of technical and legitimacy resources and procedures to support city programs/projects, ensure citizen participation in decision-making, and involve various partnerships for efficient public service delivery. Accordingly, based on publicly available data on the official websites of cities and state departments within the city, we operationalized the *Technical Aspects of City Governance* in terms of formally funding the smart city strategy through the city budget, the availability of formal policy documents and plans to promote a smart city program or other technology or data-related strategy

and formal agreements to collaborate with neighbor cities in the promotion of better and more livable communities.

On the other hand, *Legitimacy Aspects of Governance* included efforts to promote citizen engagement and participation as well as partnership with private and nonprofit stakeholders. More specifically, citizen participation includes specific programs or arrangements aimed at promoting citizen engagement, such as the availability of a formal citizen participation plan, having advisory boards and committees, having an e-government or smart city committee, and having civil society (i.e., organization) engagement with the city's decision-making process. Public–private partnerships, on the other hand, involve activities and efforts of the city government to engage with private organizations in public service delivery as well as strategic planning efforts.

3.3.3. Control Variables

Finally, we also included in the analysis city data as control variables. We chose to include measures of size and wealth, such as population and income, as well as other structural variables that may have an influence on the effectiveness of the projects, such as the educational level of city inhabitants and the city's form of government (i.e., mayor-council, council-manager, etc.). These control variables are also more generally correlated with the resources available to city governments to start smart city initiatives.

3.4. Data Collection Procedures

The data collection process took approximately four months, from January to April 2023. The research team, involving 5 members, met every other week during this time period. The operationalization of the variables resulted from a combination of deductive and inductive processes. The team started with major topics in each variable and worked together to find the specific projects and results available within the sample. Team members iteratively discussed different aspects of smart cities and governance as they explored the initial websites. Team members took notes of websites that included evidence of the element observed and recoded cities in response to team discussions and data definitions. We found the final set of data elements to be included in the analysis after collecting data for the first 20 cities.

We coded the data manually, populating the rows by inserting a "1" where the variable was present in the city and "0" otherwise (i.e., having or not having a smart city strategy, an open data program, or an online 311-like program). We chose the multiple binary indicator format and equal weights for simplicity since there is not yet a generally accepted theory to support any weight system. In fact, a recent paper reviewing existing smart city rankings found that there is no universally accepted index to assess city smartness [56]. Given this situation, assuming equal weights seems to be an appropriate and transparent simplification. Advantages of equal weight indexes are highlighted by the Cities in Motion team [57], and it is widely used in the creation of indexes [52].

Thus, the values of each of the independent and dependent variables included in the study were calculated by calculating the percentage of 1's in each variable. In this way, the range of possible values for each independent and dependent variable is 0 to 100, where 0 represents the complete absence of any element included in the variable and 100 represents a city that incorporates all aspects of the variable. Finally, using data from the cities' websites and from the US Census Bureau, we incorporated into the data set main control variables, including forms of government implemented in the city, and other city variables, per capita income, the population of the city, and human capital, reflected in the percentage of residents with a bachelor's degree or higher.

To ensure high-quality, reproducible data extraction and data validation, we took the following steps during the coding process. (1) We refined our data definitions collectively by coding in pairs an initial sample of the cities, establishing testable rules for each field and data type in the data spreadsheet. (2) We documented team discussions and decisions on coding to allow data reproducibly, allowing the scraping process to be repeated under the same conditions and yield the same output, given the website has not changed. (3) The research team manually inspected the final sample data first in turns and then collectively for accuracy and completeness, cleaning the dataset by filling in missing values through further web scrapping. (4) The authors of the paper independently audited the coded data and then jointly reviewed the final data to ensure consistency and integrity of the dataset.

4. Results

In this section, we introduce the results of the quantitative analysis that we conducted. We begin with the descriptive statistics of main variables and proceed to show bi-variate correlations among them. The section finishes with the introduction of four regression models that explore the relationships between governance and smart city project adoption within the cities in the sample.

Table 2 includes descriptive statistics of all variables in the study. The cities in the sample have an average population of about 526 thousand people. Nonetheless, there is great variation among cities, with the smallest having just above 20 thousand people (South Burlington, VT), and the largest having about 8.8 million inhabitants (New York City, NY). Full population distribution is included in Appendix A. Average per capita income in the sample is just above USD 34 thousand, which is slightly larger than the national average (USD 31 K). Finally, cities in the sample also have a level of educational attainment above the national average, with 37% of their population holding a bachelor degree.

Table 2. Descriptive statistics of the main constructs and control variables.

Variable	n	Mean	Std Dev	Minimum	Maximum
Smart Government	99	75.66	21.29	0	100
Smart Infrastructure	99	50	24.53	0	93.75
Smart Community	99	80.2	25.15	0	100
Smart City	99	68.59	20.83	20	97.92
Technical Aspects of Governance	99	51.77	33.17	0	100
Legitimacy Aspects of Governance	99	64.65	23.03	0	100
Mayor-Council form of government	99	0.58	0.5	0	1
Council-Manager form of government	99	0.24	0.43	0	1
Other forms of government	99	0.18	0.39	0	1
Per-Capita Income	99	34,250	7802	19,569	63,610
Total Population	99	525,985	1,017,781	20,292	8,804,190
Percentage of residents w/Bachelor degree	99	0.37	0.11	0.15	0.64

All dependent variables are on a scale of 0–100 and represent the percentage of smart city projects that we found in each category. The results suggest that Smart Community projects are the most widely adopted among the cities in the sample, followed by projects to improve government services and administration through digitization. The least common type of projects among cities in the sample involved infrastructure projects, which are also the type of project with the largest variance, suggesting more variation in the adoption of these types of projects. Levels of adoption of smart city projects are high among cities in the sample. The smart city variable represents the average of the three major categories of projects.

In terms of the main independent variable, governance, cities in the sample showed more development in the aspects of governance oriented to build legitimacy—stakeholder involvement—compared to the technical aspects of governance such as formal instruments and dedicated budgets. There is also a larger variance in the use of technical instruments of governance among cities in the sample. The majority of cities in the sample have a mayor–council form of government (58%), followed by council–manager (24%), and other hybrid forms of government are the least common (18%).

Table 3 shows the bi-variate correlations among all variables in the study. The dependent variables are correlated among themselves, suggesting that cities include all different types of projects as components of their smart city strategies. Data shows that there is also a significant correlation between both aspects of governance, also suggesting that cities pay attention to both aspects of governance in their strategies. Finally, correlations show that larger cities tend to have the most developed smart city strategies, particularly in the area of Smart Infrastructure.

Table 3. Bi-variate correlations among main variables in the study.

	S Gov	S Inf	S Com	S City	Technical	Legitimacy	P/Cap I	Pop	Res Bachelor
Smart Gov	1	0.663 ***	0.619 ***	0.850 ***	0.535 ***	0.534 ***	−0.08	0.286 **	−0.108
Smart Infrastructure		1	0.697 ***	0.898 ***	0.660 ***	0.693 ***	0.108	0.446 ***	0.05
Smart Community			1	0.888 ***	0.538 ***	0.516 ***	0.082	0.239 *	0.01
Smart City				1	0.657 ***	0.662 ***	0.049	0.369 ***	−0.014
Technical					1	0.555 ***	0.004	0.399 ***	0
Legitimacy						1	−0.04	0.380 ***	−0.055
Per Capita Income							1	0.116	0.805 ***
Population								1	0.002
Res. w/Bachelor									1

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Finally, Table 4 shows the regression analysis for the four dependent variables. We are including in the table the standardized coefficients for all variables (Betas). Given that variables show important correlations among them, we performed analysis to assess if the models had problems of multicollinearity. Our analysis suggested that multicollinearity is not an issue across models. Tables including multicollinearity analyses as well as more complete regression results are included in Appendix B. Results suggest that both technical and legitimacy components of governance play a role in the adoption of smart city projects across all dimensions explored in our research. Although both aspects of governance have about the same importance when thinking about Smart Government projects (citizen services), technical aspects appear to be more important for the adoption of Smart Community projects, and legitimacy aspects appear to be more important for Smart Infrastructure adoption. Again, in the aggregate of all smart city projects, both aspects of governance tend to have similar impact on adoption. Results also suggest that council–manager forms of government tend to have less smart city projects across all dimensions when compared to mayor–council forms of government among cities in the sample. However, the difference is only statistically significant for Smart Community projects and for the aggregate of smart city projects. It is important to note that other control variables appear not to have any significant impact on smart city projects on any dimension, with the only potential exception of per capita income in the case of Smart Community projects.

Table 4. Regression results for the 4 dependent variables.

Ind. Variable	Smart Government	Smart Infrastructure	Smart Community	Smart City
Technical	0.35 ***	0.36 ***	0.39 ***	0.42 ***
Legitimacy	0.33 **	0.45 ***	0.32 ***	0.42 ***
Council-Manager	−0.05	−0.1	−0.23 **	−0.15 *
Other Governance	0	−0.06	−0.08	−0.06
Per Capita Income	0.01	0.17	0.26 +	0.18
Population	0.02	0.11	−0.08	0.02
Res. w/Bachelor	−0.1	−0.07	−0.21	−0.15
R Square	0.38	0.63	0.42	0.59

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

5. Discussion and Conclusions

In this paper, we conducted an empirical analysis of a sample of 99 cities in the United States to answer the research question: What is the impact of city governance mechanisms such as regulations, plans, and partnerships on the adoption of smart city projects? To answer the question, we posed two hypotheses based on a socio-technical view of governance of smart cities [12]; a perspective that conceptualizes governance as a combination of formal plans, policies, agreements and funding mechanisms, combined with activities and programs to improve acceptance and legitimacy of the projects. In addition, we build on current conceptual approaches to the smart city to develop an operational definition of the smart city based on three main dimensions included in these frameworks [4,10,19]. Specifically, in light of our hypotheses, this later idea takes two forms: (1) the administrative and technical aspects of governance have a positive impact on the development of smart city projects, and (2) legitimacy and inclusion have a positive impact on the development of smart city projects. These results are preliminary, and our conclusions for causality are limited by having a cross-sectional sample that prevents us from using more advanced methods of causal inference and makes it difficult to explore reverse causality.

The research that we report in this paper contributes to the smart city literature in three important ways. First, we provide an operational definition of city governance. Second, we develop an operational definition of smart city, and finally, we find empirical evidence that suggests the potential value of conceiving governance as a socio-technical phenomenon. In addition, we also explore the relationship between both concepts. We developed two hypotheses on the impact of the technical and social aspects of city governance on the adoption of smart city projects and test them using data from 99 cities in the United States. We adopted a definition of governance that involves (1) technical and (2) social aspects of governance (e.g., [12]), and we classified smart city projects using three main categories: (1) building physical infrastructure, (2) improving government programs and services, and (3) increased participation and citizen engagement [4,19]. In this section we discuss our main findings, and we will also situate our findings within the larger social context in which smart city projects are implemented.

5.1. A Sociotechnical Approach to Smart City Governance

The literature suggests that governance arrangements can have effects on the adoption of technologies in institutions. Many have written on governance in smart cities, but our paper is the first formal attempt to define and operationalize governance in the context of smart cities. Our work serves to address that gap by (1) differentiating between technical/administrative aspects of governance and (2) legitimacy/inclusion components of governance, as well as (3) moving the focus from the use of technologies to incorporate and

account for other components (elements) of governance, including formal plans, policies, and budgets, as well as efforts to promote citizen and stakeholder involvement in city planning and collaboration in areas such as service delivery. Our results suggest that cities in the sample are more developed in the dimension of governance that involves legitimacy and inclusion compared to their development in the dimension of governance that involves the technical and administrative aspects. This result may not be surprising given the long tradition of the "Town Hall" as a space to collectively develop policy in many local governments (e.g., [58]). However, the finding is consistent with the main principles of social informatics that stress the importance of the social system in the way that communities and organizations interpret and make decisions related to technologies [31,32]. In this way, understanding the interests, forms of collaboration, power relationships, and interests of groups involved in policy design and smart city projects has important potential to explain smart city developments.

In this research, we considered the city's form of government as a control variable that interacts with the social and technical aspects of smart city governance. An interesting finding from our study is that when it comes to the effect of the form of government on the adoption of smart projects, the council–manager form of government seems to be less effective in the development of smart city projects when compared to the mayor–council form of government, especially in the area of Smart Community. This finding is a departure from previous thought on the subject that tended to elevate the council–manager form as more representative (participatory) and therefore more functional (effective) for decision-making in the city [59]. A potential explanation may reside in the fact that the effectiveness of the council–manager form of country is more closely related to the operations of city services, and efficiency in management, which may or may not be directly correlated to our smart city dimensions. Further exploration of this relationship is necessary.

In addition to the reflection on the meaning of Smart Governance, our second contribution relates to a multidimensional conceptualization of smart city. Building on current smart city frameworks developed in the areas of digital government and information systems [10,19,25], our findings highlight the potential value of conceptualizing the smart city as the convergence of the three dimensions of government, physical environment, and society. This view of the smart city is also socio-technical in nature, as it suggests that more sustainable and livable communities need to incorporate in their strategies not only the use of technology but also projects that involve the improvement of citizen's quality of life [11,13,34]. In fact, our results suggest that cities in the sample, instead of focusing on a single dimension, include in their strategy a combination of all three dimensions (see Table 2).

5.2. Impacts of Governance on Smart City Initiatives

Our results suggest that effective governance frameworks provide the necessary foundation for coordinating and implementing diverse stakeholders' interests and efforts, including those of local governments, private sector entities, community organizations, and citizens. Previous research suggests that by engaging citizens and stakeholders in the decision-making process, governance structures ensure that smart city projects are relevant and responsive to local needs and priorities (e.g., [45]), thereby increasing their acceptance and adoption across communities. Our research is in line with these previous findings, providing additional empirical support for hypotheses and assumptions produced by case studies and conceptual frameworks.

Our findings also show a potential relationship between administrative and technical aspects of governance and the development of smart city projects, which is consistent with research that acknowledges the importance of institutional and organizational structures

in the process of technology adoption (e.g., [36,37]). From a theoretical standpoint, our findings are also aligned to other common SI findings, particularly that the design, implementation and uses of ICTs have reciprocal relationships with the larger social context but particularly benefiting those in a position of power [20,30,31,38,60], given that the only control variable that appear to have an impact on the development of smart city projects is Per Capita Income. This finding calls for additional reflection on who is benefiting from smart city projects, and further exploration is necessary. Future research needs to include additional contextual variables to better understand this phenomenon, broadband coverage, or fiscal capacity.

The statistical association between governance and smart project adoption has several **practical implications** for cities. First, the adoption and sustainability of smart initiatives is closely related to the social context or characteristics of the cities themselves. These contextual realities of a city can include anything from pressing public needs (like traffic control, air and water quality, susceptibility to natural disasters, epileptic or inefficient service delivery, and representation and citizenship) to high budget and intellectual capital, rapid urbanization, economic competitiveness, etc. This means that policy, planning, design and implementation of smart initiatives and the smart city model must always consider the social embeddedness of the initiatives in the peculiar realities of the city served. In addition, our research suggests that both technical and legitimacy aspects of governance may positively influence the development of smart city initiatives. In this way, effort in the preparation of formal policy and planning, as well as involving stakeholders in the process has the potential to pay-off with better and more impactful projects.

Second, the awareness of this insight will boost strategic project planning and execution, as practitioners will be better able to tailor smart initiatives to local institutional realities, citizen needs, and societal contexts through a participatory, context-aware predeployment assessment, instead of an ineffective one-size-fits-all approach [61]. Again, a structured decision-making framework ensures that projects are contextually appropriate and fit for legitimate purposes [62]. Third, this association highlights the potential for enhanced stakeholder engagement and inclusive collaboration where citizens, businesses, and other stakeholders are involved in smart project design and use. For example, practical experience shows higher adoption rates when users are engaged through participative approaches—such as double, triple, and quadruple helix models that include academia, industry, government, and civil society [61]. At the same time, strengthening governance mechanisms enhances transparency and accountability, building public trust and facilitating smoother adoption of smart solutions [63].

Fourth, the association between governance and results also highlights the importance of policy, regulation, and best practice adoption. Policy alignment, cooperation between local, national, and regional governments, and adequate resourcing enable cities to effectively implement and sustain smart solutions. Also, policy alignment reduces legal and operational (inefficiency or project failure) risks and harmonizes best practices. Fifth, this finding highlights the importance of capacity building and knowledge sharing. For example, technical and managerial training ensures staff can assess, procure, and maintain Smart Infrastructure effectively. Moreover, implementing knowledge-sharing mechanisms such as benchmarking and participation in global alliances helps cities learn from each other's project outcomes and governance models.

Sixth, this finding highlights the potential for sustainability and citizen-centric outcomes. Governance structures that are well-designed strengthen the sustainability and resilience of smart projects, ensuring that they are adaptable to evolving societal needs and technological advances. Similarly, focusing on human needs through placing citizens

at the center is more likely to yield solutions that are both technically robust and socially accepted, improving quality of life and public value delivered by smart investments.

Thus, by recognizing the significant statistical association between governance and smart project adoption, policymakers and practitioners can prioritize governance reforms and capacity building as critical enablers for successful, sustainable smart city initiatives.

5.3. Limitations and Future Research

This exploratory research, like any other research effort, is not free of limitations. The main limitations may include sample size, data quality as well as a focus on the United States. Regarding sample size, 99 cities is still a relatively small sample, and future research may explore the interactions between governance and smart city projects with additional cases and in different contexts, including the Global South. Regarding data quality, even though the team was rigorous in the process of web scraping and we were careful in having auditing mechanisms included in the process, we could have missed some projects in those cases where websites did not have the most up-to–date information. Moreover, we are only using the aggregation of binary values scrapped from web pages. Future research may include data from additional data sources or use different data gathering methods such as surveys.

Importantly, while we define our independent variables and use a number of control variables, we also recognize the possibility of reverse causality in smart city adoption, which can only be studied with longitudinal data. As mentioned before, additional control variables also need to be included in future research, including a city's political culture and ideology (i.e., local governance norms whether participatory or technocratic governance style), form of government (i.e., whether democracy or authoritarianism), state-level mandates and incentives, industrial and economic policy [64], broadband coverage, regional dummies, and fiscal capacity. Nevertheless, evidence suggests that well-resourced and innovative cities tend to implement smart city projects, which raises concerns about attributing the effects of these projects solely to their adoption rather than to prior city-level conditions [65,66].

Our research framework and results also suggest that probably more nuanced explanations of the impacts of Smart Governance on smart city projects are necessary. In this way, future research may also involve the use of network analysis to better understand the structure of the collaboration and power among key actors in the development of smart city policy and projects. Also, future research may further explore the interactions of city forms of government (i.e., mayor–council) with smart city programs and approaches. These findings can be applied to many more cities as a way to understand how trends in smart initiatives adoption grow and change over time, and how that trajectory relates to the interactions between technology deployment and the social context.

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Appendix A. Sample Distribution by City Population

Table A1. Sample Distribution by City Population.

Interval (In Thousands)	Frequency
[0, 100 K)	18
[100 K, 200 K)	21
[200 K, 300 K)	16
[300 K, 400 K)	9
[400 K, 500 K)	8
[500 K, 600 K)	5
[600 K, 700 K)	7
[700 K, 800 K)	2
[800 K, 900 K)	2
[900 K, 1000 K)	2
[1000 K, . . .)	9

Appendix B. Regression Tables with Confidence Intervals and Multicollinearity Assessment

Table A2. Regression Results for Smart Government Including 95% Confidence Intervals for B and Multicollinearity Statistics.

Variable	B	Std. Error	Beta	Lower Bound	Upper Bound	Tolerance	VIF
Technical	0.22	0.07	0.35	0.09	0.36	0.63	1.59
Legitimacy	0.3	0.09	0.33	0.12	0.49	0.65	1.53
Council-Manager	−2.55	4.31	−0.05	−11.12	6.01	0.9	1.11
Other	−0.23	4.86	0	−9.88	9.42	0.87	1.14
Per Capita Income	2.27×10^{-5}	0	0.01	0	0	0.33	3.02
Population	3.75×10^{-7}	2.00×10^{-6}	0.02	-3.60×10^{-6}	4.35×10^{-6}	0.75	1.34
Res. w/Bachelor	−20.7	28.24	−0.1	−76.79	35.4	0.33	2.99

Table A3. Regression Results for Smart Infrastructure Including 95% Confidence Intervals for B and Milticollinearity Statistics.

Variable	B	Std. Error	Beta	Lower Bound	Upper Bound	Tolerance	VIF
Technical	0.27	0.06	0.36	0.15	0.39	0.63	1.59
Legitimacy	0.48	0.08	0.45	0.32	0.65	0.65	1.53
Council–Manager	−5.76	3.84	−0.1	−13.4	1.87	0.9	1.11
Other Governance	−4.1	4.33	−0.06	−12.7	4.5	0.87	1.14
Per Capita Income	0	0	0.17	0	0	0.33	3.02
Population	2.65×10^{-6}	1.78×10^{-6}	0.11	-8.90×10^{-7}	6.19×10^{-6}	0.75	1.34
Res. w/Bachelor	−15.68	25.16	−0.07	−65.66	34.29	0.33	2.99

Table A4. Regression Results for Smart Community Including 95% Confidence Intervals for B and Multicollinearity Statistics.

Variable	B	Std. Error	Beta	Lower Bound	Upper Bound	Tolerance	VIF
Technical	0.3	0.08	0.39	0.15	0.45	0.63	1.59
Legitimacy	0.35	0.11	0.32	0.14	0.57	0.65	1.53
Council–Manager	−13.65	4.9	−0.23	−23.38	−3.93	0.9	1.11
Other Governance	−5.03	5.52	−0.08	−15.98	5.93	0.87	1.14
Per Capita Income	0	0	0.26	-5.71×10^{-5}	0	0.33	3.02
Population	-1.93×10^{-6}	2.27×10^{-6}	−0.08	-6.45×10^{-6}	2.58×10^{-6}	0.75	1.34
Res. w/Bachelor	−48.77	32.07	−0.21	−112.48	14.93	0.33	2.99

Table A5. Regression Results for Smart City Including 95% Confidence Intervals for B and Multicollinearity Statistics.

Variable	B	Std. Error	Beta	Lower Bound	Upper Bound	Tolerance	VIF
Technical	0.26	0.05	0.42	0.16	0.37	0.63	1.59
Legitimacy	0.38	0.08	0.42	0.23	0.53	0.65	1.53
Council–Manager	−7.48	3.42	−0.15	−14.28	−0.69	0.9	1.11
Other Governance	−3.15	3.85	−0.06	−10.8	4.51	0.87	1.14
Per Capita Income	0	0	0.18	0	0	0.33	3.02
Population	3.66×10^{-7}	1.59×10^{-6}	0.02	-2.78×10^{-6}	3.52×10^{-6}	0.75	1.34
Res. w/Bachelor	−29.41	22.4	−0.15	−73.91	15.08	0.33	2.99

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