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Understanding the Factors that Affect Smart City and Community Initiatives: Lessons from Local Governments in the United States

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Abstract. With urbanization, cities around the world have experienced increasingly complex issues that are difficult to solve using traditional strategies. So, many local governments have started smart city initiatives in order to address community issues, improve quality of life, achieve sustainable development, and, overall, make their cities smarter. As a multidimensional concept, smart city contains different components. In addition, to successfully implement smart city initiatives, local governments need to take multiple factors into consideration. Based on a survey of local governments in the United States, this article identifies what factors affect smart city and community initiatives. Overall, the analysis shows that the level of economic development, the existence of a smart city office, the availability of local government funding, the skill level of local government staff, adopting a collaborative approach, and citizens' current IT skills all have a significant positive impact on the extent that a local government invests in smart city projects. In addition, city governments invest in significantly more types of smart city projects than villages.

Keywords: Smart City, Local Government, Influential Factors, Governance, Citizen.

1 Introduction

With increasing urbanization, cities have experienced new issues that could be described as wicked or tangled and that are difficult to address using traditional models and strategies [1, 23]. The smart city concept has emerged and been adopted by many local governments as a strategy to look for alternative solutions to better address community issues, improve quality of life, achieve sustainable development, and overall, make cities smarter. In the last two decades, when talking about smart city develop-

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ment, it mainly emphasized the utilization of information and communication technologies (ICTs) to improve city infrastructures and services, and most of the existing definitions then viewed technology as one of the main components of smart cities [2]. More recently, researchers have started to recognize the importance of social aspects in smart cities and advocate to adopt a socio-technical view [3-5]. Currently, even though there is still no consensus on the definition of smart city, it seems that there is an agreement that smart city is a multidimensional and multifaceted concept [3, 6, 21].

Recognizing the different contexts in which smartness development occurs (villages, towns, cities and megacities, etc.) and conceptualizing smartness beyond technology and closely related to people's living in different communities, the discussion of smartness development has not been limited to the urban environment [18, 22], the concept of smart community has been more discussed and was defined by Nam & Pardo [3] as "a community broadly ranging from a small neighborhood to a nation-wide community of common or shared interest, whose members, organizations, and governing institutions are working in partnership to use IT to transform their circumstances in significant ways" [pp. 286].

In addition to research that discusses the characteristics of smart cities and smart communities, more recent studies have focused on how to develop smart cities and communities. For example, Oktaria et al. [7] concluded that services in different aspects, such as transportation, health, safety, education, and housing are all needed in the development of smart cities. Mora and colleagues [8-9], based on an extensive literature review, summarized a set of dichotomies that question whether smart city development should be based on: (1) a technology-led or holistic strategy, (2) a double or quadruple-helix model of collaboration, (3) a top-down or bottom-up approach, and (4) a mono-dimensional or integrated intervention logic. However, there is still a need for empirical studies that focus on the factors that influence smart city development across a wide range of cities and communities. This article contributes to filling this gap by surveying local governments in the United States and analyzing their perspectives on what factors are affecting smart city development in their communities.

This paper is organized into six sections, including the foregoing introduction. Section two presents our review of existing literature, which includes a conceptual model of smart city and community development and presents the hypotheses of this study. Section three briefly describes the research approach used in this paper, including the design and administration of a national survey to local governments across the United States. The section also provides some details about the survey responses and our analysis approach. Section four presents our main results as a regression analysis on the impact of multiple factors on the development of smart cities and communities. Section five discusses some of our main findings and compare them with previous research. Finally, section six presents some concluding remarks and suggests ideas for future research.

2 Factors that Affect Smart City Development

The development of smart cities and communities is affected by multiple success factors and several studies have explored some of those factors of smart city and community development. For example, recognizing the uniqueness of different cities, Harms [10] proposed six critical success factors that can be used when developing a smart city strategy, which go from a clear vision to a city-wide smart strategy. Sujata and colleagues [11] designed a framework of developing smart city initiatives with identify six significant pillars: social, management, economic, legal, technology and sustainability. Myeong and colleagues [12] examined the internal and external determinants of smart cities and their priorities through an analytic hierarchy process analysis, they suggested that citizen participation with multi-communication channels should be included in the process of smart city development. Based on a few of these previous studies [11-12, 14], we are grouping the factors into five categories: 1) external environment; 2) organization; 3) governance; 4) technology; and 5) citizen. In addition, to strengthen our model, we are also considering literature on the development of e-government at the local level [13-15, 17]. Figure 1 shows the conceptual model that guides our study.

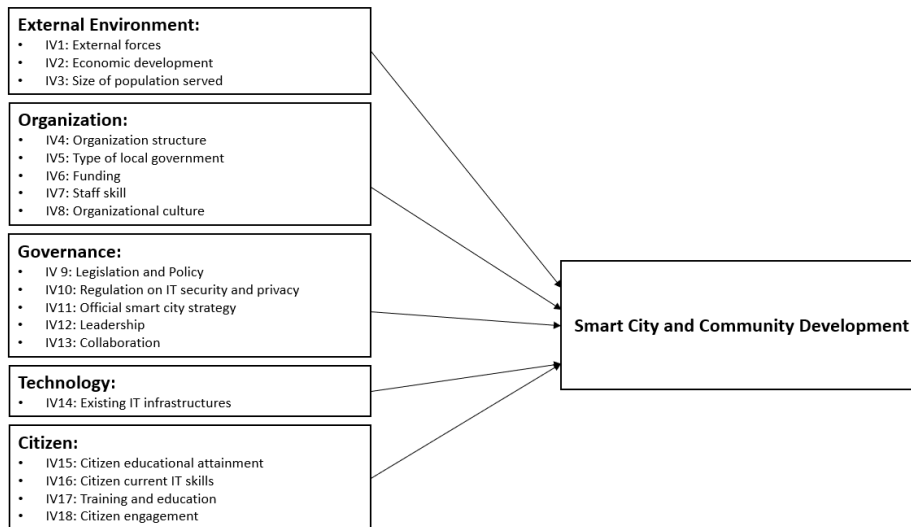


Fig. 1. Factors affecting smart city and community development

External Environment. With the urbanization, cities and communities are facing great challenges in solving complex and diverse urban problems [12]. In the meantime, government are also facing increasing and changing demands from the citizens [13], both external pressures force the government to change its traditional working methods and start to adopt smart city approach to address community issues and better serve the citizens [1, 12, 23]. Previous research also mentioned that the diversity in cities and

communities, especially the level of economic development (usually refers to the citizen median household income [14]), greatly impacts the opportunities for developing and implementing new government initiatives, in this case, the implementation of the smart city initiatives [1, 14-15]. Communities that are in disadvantage of economic development, may be more eager to start smart city development but may face more challenges in doing so due to limited resources compared to the communities who are rich in funding and resources. The size of population served by the local government is another factor that was mentioned to have an impact on adopting IT innovation [14]. Based on this, we hypothesize that:

H1. Pressures to solve complex problems and increasing demands from citizens positively influence the development of smart cities and communities.

H2. A higher level of economic development positively influences the development of smart cities and communities.

H3. The size of the population served by a local government influences the development of smart cities and communities.

Organization. Local government is the main actor that leads the smart city and community development. The diversity of local governments in different cities and communities is found to have an influence in smart city and community development. The diversity mainly shows in the organization structure, the types of local governments, funding, staff skills, and organization culture. First, creating a dedicated and high-power smart city office helps form and lead collaborative efforts among different stakeholders in developing smart cities and communities [16]. Type of local government refers to whether the local government is in a county, a city, a town, a village, etc. It is a factor that was found to have an impact on adopting IT innovation [14, 22], which could be seen as related to smart city initiatives. Funding is an important and necessary financial resource that supports smart city and community development. The availability of funding on smart city development influences the available options and possibilities in implementing smart city initiatives [14-15, 17]. Project leaders and team members with strong technical skills and expertise were identify as important factors in adopting IT innovation [16-17]. Organization culture that is in favor of innovation is also mentioned as a facilitator in government innovation [15]. Based on this, we hypothesize that:

H4. The existence of a smart city office within the local government positively influences the development of smart cities and communities.

H5. The type of local government influences the development of smart cities and communities.

H6. The availability of local government funding positively influences the development of smart cities and communities.

H7. A higher skill level of local government staff positively influences the development of smart cities and communities.

H8. An innovative organization culture in a local government positively influences the development of smart cities and communities.

Governance. Governance is defined as “regimes of laws, administrative rules, judicial rulings, and practices that constrain, prescribe, and enable government activity, where such activity is broadly defined as the production and delivery of publicly supported goods and services.” (p. 235) [1]. Among previous studies, legislation and policy, official strategy, leadership, and collaboration are the most mentioned factors related to governance that will influence the development of smart city and community. To smooth the implementation of smart city initiatives, it is important to remove legal and regulatory barriers and establish up-to-date legal framework and supportive policies to guide the practice of smartness development [1, 13-15, 17]. The adoption of ICTs in smart city development provides opportunities for innovation, but could also raise people’s concerns about privacy and information security. The availability of appropriate regulations and policies could help alleviate this problem [1, 15, 17]. The existence of an official strategy provides a clear vision that helps maintain the direction of smart city development and specific plans on how cities use their resources to achieve their goals of smart city development [10, 13, 15, 17]. The presence of formal and informal leadership is important for good governance and the top management support is important for government innovation [1, 14]. Supportive leadership in leading smart city development is related to good ICT knowledge and great social skills [12-13, 16-17, 22]. Collaboration among different stakeholders is important to smart city development. Adopting a participative approach that encourages co-creation and co-development could be seen as key to the success of smart city initiatives [13, 15-16]. Based on this, we hypothesize that:

H9. The existence of supportive legislation and policy positively influences the development of smart cities and communities.

H10. The existence of regulations and policies that protect information privacy and security positively influences the development of smart cities and communities.

H11. The existence of an official smart city strategy positively influences the development of smart cities and communities.

H12. Supportive leadership in a local government positively influences the development of smart cities and communities.

H13. A collaborative approach positively influences the development of smart cities and communities.

Technology. The development of ICTs is the foundation of smart city development. Using ICTs to address urban problem is the major task in development smart cities and communities. The existence of a reliable ICT infrastructure makes it easier to successfully implement innovative initiatives, because it provides supports to further developing existing systems and services [1, 12, 15]. Based on this, we hypothesize that:

H14. The existence of a reliable ICT infrastructure positively influences the development of smart cities and communities.

Citizen. In addition to beneficiaries of smart city development, citizens should also be seen as important actors in the design of those initiatives [19-20]. Citizen’s educational

attainment and IT skills are often mentioned as factors that influence citizen's acceptance and adoption of government innovative services. In the context of smart city development, these two factors may also affect citizen's abilities to participate in the development of smart cities and communities [14-15, 17, 23]. Training and education are also important strategies to improve citizens' readiness in understanding and participating in developing smart cities and communities [15, 18]. Increased citizen participation could also be seen as essential to enhance democracy, since citizens are able to express their needs and opinions for smart city initiatives to truly address community needs [1, 12]. Based on this, we hypothesize that:

H15. A higher citizen educational attainment positively influences the development of smart cities and communities.

H16. A higher level of citizen IT skills positively influences the development of smart cities and communities.

H17. The availability of training and education opportunities for citizens positively influences the development of smart cities and communities.

H18. Citizen engagement positively influences the development of smart cities and communities.

3 Research Approach

3.1 Survey Design

For testing these hypotheses, a survey was designed and distributed to local government leaders and IT professionals across the United States, since these are the type of actors that are often involved in the development of smart cities and communities. The survey was sent through a SurveyMonkey email invitation from September to October, 2020. Reminders were sent to non-responders on a weekly basis, and follow-up phone calls were conducted with 10% of the sample randomly. Later, we also shared the survey link with local government associations across the United States and asked them to share the survey link with their local government members on our behalf (from November to December, 2020). In total, we received 167 responses. Before we distributed the survey, we conducted two pretests and one pilot test with 5% of the sample (N=243) to assess and adjust the survey instrument and administration process.

The questions included in the survey were based on the model presented in Fig. 1. Among the independent variables, some were measured using scaled-response questions (Likert scale 1-10). The value of external forces is the average score of its two indicators, namely urban problem and citizen demand. Funding (availability) was measured by the extent of adequate funds for smart city development. Staff skill was measured by the level of skills and knowledge of the local government staff that support smart city development. Organization culture was measured by how much it supports innovation. Legislation and policy was measured as the average score of the availability of formal, clear, up-to-date laws and specific policies. Regulation on IT security and privacy was measured as the average score of protective regulation on IT security and privacy. Leadership was measured as the average score of leaders' ICTs knowledge, how much he/she was respected within the local governments, and the existence of

informal leaders. Collaboration was measured as the average score of internal collaboration among local government departments, and external collaboration between the local government and other community stakeholders. Existing IT infrastructure was measured as the availability of reliable and integrated technology infrastructures. Citizen current IT skills was measured by the level of citizens' digital literacy and skills. Training and education was measured as the availability of training opportunities for citizens to improve their digital skills. Citizen engagement were measured using the extent that citizen participate in designing and implementing smart city initiatives.

Some variables were measured using open-ended questions, such as the size of population served by the community, the percentage of funding that the local government has dedicated to smart city development, and the type of the local government. Some were measured using multiple-choice questions. For example, we were asking whether they have a smart city office that supports the smartness development in their community, and whether they have an official smart city strategy that guides their smartness development. Economic development and citizen educational attainment were variables measured using secondary data from the Census.¹ The dependent variable smart city and community development was measured by the total amount of types of smart city projects that the local government has invested in.

3.2 Sample and Methods

For the 167 responses that we received, we used the multiple imputation technique to address missing data in scale-response and open-ended questions. In the end, 143 responses were used in our descriptive analysis and 98 responses were used in the regression analysis. Among the local governments that participated in our survey, about half of the local governments are cities. One third of them has an annual budget that is between 5 to 10 million dollars. About 20% of the respondents are town managers. About 40% of them have less than five year of experience in their current position. In this study, we first conducted descriptive analysis on the variables included in the model, then a multiple regression was conducted to test which factor has a significant impact on the development of smart cities and communities.

4 Results

Table 1 shows the descriptive analysis of the factors and dependent variable that we included in this study. We can see that among the samples in our study, the average number of the types of smart city projects that the local government has invested is still quite limited (less than 4). Less than 17% of the local governments have a smart city department that supports their smartness development, and less than 12% of them have an official smart city strategy to guide their smartness development. About the influential factors, protective regulations and policies on IT security and privacy exist in most of the local governments, and citizens' participating in designing and implementing

¹ Source: US Census Bureau 2015-2019 American Community Survey 5-Year Estimates

smart city/community initiatives is the least mentioned by local governments.

Table 1. Descriptive statistic of independent and dependent variables

Variables	Mean/Percentage	Sd. dev.
DV: Smart city projects (0-10)	3.682	2.059
IV1: External forces	6.082	1.980
IV2: Economic development	61131.694	26592.384
IV3: Size of population served	43438.174	80712.729
IV4: Organization structure	Yes: 16.8% No: 83.2%	
IV5: Type of local government (Dummy variables)	County: 12.6% Township: 2.1% Town: 19.6% Borough: 3.5% Village: 13.3%	
IV6.1: Adequate funding	3.874	2.468
IV6.2: Percentage of funding (0-100)	4.481	6.413
IV7: Staff skill	4.907	2.418
IV8: Organizational culture	5.412	2.351
IV9: Legislation and Policy	3.535	2.041
IV10: Regulation on IT security and privacy	6.493	2.061
IV11: Official smart city strategy	Yes: 11.8% No: 88.2%	
IV12: Leadership	4.772	2.140
IV13: Collaboration	6.168	2.147
IV14: Existing IT infrastructure	6.036	2.527
IV15: Citizen educational attainment (0-1)	.880	.070
IV16: Citizen current IT skills	5.094	2.012
IV17: Training and education	4.767	2.259
IV18: Citizen engagement	3.482	2.268

Before hypothesis testing, all the assumptions were checked, including linear relationship between independent variables and the dependent variable, independence of errors, multicollinearity, normality, and homoscedasticity of the errors. Table 2 summarizes the results of the multiple regression.

We can see that in this model, 42.4% of the variance in the local governments' investment in smart city projects can be explained by all these factors included in the model, once adjusting for the number of variables included. Looking at the impact of each individual factor, the result shows that economic development ($\beta=.403$, $p=.005$), organization structure ($\beta=.186$, $p=.068$), staff skills ($\beta=.355$, $p=.023$), percentage of funding ($\beta=.204$, $p=.031$), collaboration ($\beta=.210$, $p=.081$) and citizen current IT skills

($\beta=.301$, $p=.017$) all have a significant positive impact on the extent that local governments invest in smart city projects. And compared to city governments, villages have significant less investment in smart city projects ($\beta=-.260$, $p=.012$). Overall, hypotheses 2, 4, 5, 6, 7, 13 and 16 are supported by the data from this study.

Table 2. Results of the Regression Analysis: Smart City Development

	Unstandardized Coefficients		Standardized Coefficients	
	B	Std. error	Beta	Sig.
(Constant)	4.061	2.693		.136
IV1: External forces	.040	.094	.039	.669
IV2: Economic development	3.120E-5	.000	.403	.005***
IV3: Size of population served	5.126E-7	.000	.020	.857
IV4: Organization structure	1.005	.543	.186	.068*
County	.420	.557	.072	.453
Township	-1.951	1.304	-.135	.139
Town	-.364	.546	-.064	.507
Borough	-1.198	1.268	-.083	.348
Village	-1.519	.587	-.260	.012**
IV6.1: Adequate funding	-.205	.150	-.246	.175
IV6.2: Percentage of funding	.066	.030	.204	.031**
IV7: Staff skill	.303	.130	.355	.023**
IV8: Organizational culture	-.015	.128	-.017	.906
IV9: Legislation and Policy	-.181	.156	-.179	.251
IV10: Regulation on IT security and privacy	-.198	.125	-.198	.117
IV11: Official smart city strategy	-.551	.626	-.085	.382
IV12: Leadership	-.067	.219	-.070	.760
IV13: Collaboration	.201	.114	.210	.081*
IV14: Existing IT infrastructure	-.008	.086	-.010	.924
IV15: Citizen educational attainment	-5.658	3.491	-.192	.109
IV16: Citizen current IT skills	.308	.126	.301	.017**
IV17: Training and education	.051	.098	.056	.607
IV18: Citizen engagement	.266	.171	.294	.124
R ² : .560				
Adjusted R ² : .424				

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 Discussion

This quantitative study was conducted to investigate what factors have a significant impact on the development of smart cities and communities. Based on the results of

multiple regression, the level of economic development, the existence of a smart city office, the availability of local government funding, the skill level of local government staff, adopting a collaborative approach, and citizens' current IT skills all show significant positive impact on the extent that a local government invests in smart city projects. And there is a significant difference between city governments' investment in smart city projects and village governments' investment. Consistent with previous research [15], the level of the economic development, as one of the elements in the domain of external environment, is proven to have a significant positive impact on the development of smart cities and communities. Communities with high level of economic development usually have funding and resources, which help them develop the necessary infrastructure and capabilities, especially IT-related, to support the development of smart cities and communities.

Our results are also consistent with previous research that argue that the different capabilities and resources of local governments lead to different performance in terms of the development of smart cities and communities [14-17]. In our study of local governments, having a dedicated smart city office, more funding dedicated to smart city development, and staff with higher skills all prove to have a significant positive impact on the development of smart cities and communities. Villages seem to invest in significant fewer smart city projects than city governments, which may be due to a lack of financial and human resources or the fact that they have different needs in their communities. Collaboration among different stakeholders, as one of the most mentioned governance factors by previous research [10-13, 15-16], has a significant (although at the 0.10 level) positive impact on the development of smart cities and communities. A holistic collaborative approach in developing smart cities and communities could help mobilize multidisciplinary resources to better address issues and make a community smarter.

Citizens are not only final users, but also participants in smart cities [19-20]. Their IT skills show a significant positive impact on the development of smart cities and communities. This finding is consistent with previous research that emphasized the importance of citizens' IT skills which not only affect citizens' awareness of the smart city concept, but also their abilities to participate in developing smart cities and communities and to use smart city programs and services [14-15, 18, 23]. It is somewhat unexpected that none of the variables related to the governance category, with the exception of collaboration, has a significant impact on the development of smart cities and communities in our study. For instance, several previous studies have stated that supportive legislation and regulation, the existence of an official smart city strategy, and supportive leadership are all factors that will benefit the development of smart cities and communities [10, 12, 14-17]. However, from these variables only collaboration was statistically significant in our study.

6 Conclusion

Local governments have adopted smart city strategies to face a variety of challenges in

their communities. Previous research has identified factors related to external environment, organization, governance, technology and citizens as all having an impact on the development of smart cities and communities. This study shows that the level of economic development, the existence of a smart city office, the availability of local government funding, the skill level of local government staff, adopting a collaborative approach, and citizens' current IT skills all have a significant positive impact on the extent to which a local government invests in smart city projects. In addition, city governments invest in significantly more smart city projects than villages.

The findings are based on a national survey to local governments across the United States. However, at least in part due to the COVID-19 situation, we had a very low response rate. Therefore, the results should be further tested in different context and attempting to have a higher response rate. In addition, future studies should be conducted to refine the constructs in the model and re-test the influence of these factors with samples from different countries or different levels of government in the United States. Finally, in-depth case studies should be also conducted to better understand how and why these factors influence the implementation of smart city initiatives in different cities and communities around the world.

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