SMART CITY INITIATIVES AND ECONOMIC GROWTH IN INDIA: AN EMPIRICAL ANALYSIS

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Abstract:
In developing countries, cities are vying with each other to improve their infrastructure to attract business activities and become more efficient, effective, and sustainable. Against this backdrop, the 'Smart City Mission' is one of the flagship Indian government initiatives started in 2015. In order to provide people with a high-quality living, smart cities are the latest urban conceptions. It is the idea of combining different technologies to create sustainable and intelligent practices. However, the quantitative assessment of this initiative on urbanization in India is very limited. In this study, we assess the impact of smart city projects on urbanization, which is measured by city population size and city gross domestic product. The results show that the mission has a mixed effect on urbanization. Though it increases the size of the city's population, it does not promote city income. Therefore, implementing a smart city mission has to be done in the hinterland area along with the core area of a city. Finally, it discusses the challenges faced and their potential solutions. The results suggest several policies for making urbanization a success and making India a developed country.

Key words: Smart City Mission, infrastructure, economic growth, development

JEL Classification: C10, I31, R11

Citation
Khan A., Tripathi S., Chandiramani J., 2024. "Smart city initiatives and economic growth in india: an empirical analysis", Sustainable Regional Development Scientific Journal, Vol. I, (2): Special Issue, pp. 52-67

1. Introduction

Rapid urbanization in developing countries is straining traditional governance models. Cities grapple with issues like resource scarcity, traffic congestion, and crime. Sinha (2018) predicted a massive population shift in India, with an estimated 200 million people migrating from rural to urban areas over the next 15 years. This influx is nearly equivalent to the combined populations of France, Germany, and the United Kingdom. In response to this significant change, the Indian government is committed to improving the quality of life in its cities through various urban development initiatives (Nair, 2017).

To address these challenges, the concept of "smart cities" has emerged. The idea of "smart cities" emerged in the 1990s, focusing on how information and communication technologies could improve city infrastructure and networks. This widespread use of technology allows cities to enhance essential services related to safety, healthcare, governance, and service delivery (as discussed in Hernández-Muñoz et al., 2011 and Pereira et al., 2018).

In 2015, India's new federal government launched the Smart Cities Mission (SCM) by focusing on urban renewal and creating 100 sustainable smart cities. This ambitious program aims to improve governance and infrastructure in Indian cities. Notably, the SCM avoids a rigid definition of "smart city," allowing each city to define its own approach to smart solutions. Smart cities leverage technology and best practices in urban planning to drive economic growth, improve quality of life, and promote sustainable and inclusive development. It often involves public-private partnerships and utilize digital tools to deliver essential services to residents. Ideally, a smart city is a model of advanced infrastructure, efficient transportation networks, and a thriving economy, all achieved in an environmentally sustainable way. Additionally, it highlights the key components – environmental, economic, and social – that are addressed through the integration of sustainable and intelligent technologies. Essentially, a smart city is a place that leverages these technologies in a knowledgeable, practical, and innovative way to improve the quality of life for its residents. In essence, a "smart city" leverages science and technology, especially information and communication tools (ICT) like artificial intelligence and the Internet of Things, to drive urban development. With the use of the accepted ICT, city dwellers able to build an interconnected network with a variety of service providers, enabling all systems and services to operate in an intelligent and clever manner while still being comfortable for the residents (Kumar et al., 2018).

While there's no single agreed-upon definition of a "smart city," many experts around the world are working to understand the concept. A common thread across these perspectives is the central role of technology in creating a smart city.

In the context to importance of Indian smart cities, Save (2021) explored the concept of smart cities as a means to enhance the quality of life for urban residents. The study discussed how various smart technologies are integrated to create a more comfortable and efficient living environment. Madakam and Ramaswamy (2015) emphasized six key dimensions for smart cities: smart economy, mobility, environment, people, living, and governance. The authors also recognized the importance of "smart city enablers," tools that can significantly improve these aspects. Datta and Sharma (2017) conducted a study in New Delhi examining the architecture, protocols, security considerations, and smart city applications of the Internet of Things (IoT).

The literature review encompasses various studies on the SCM in India, focusing on different aspects such as infrastructure, sustainability, technology, and governance. Lende, and Ambadkar (2024) suggest to create a citizen-friendly urban environment using technology, highlighting a sustainable financing model leveraging public-private partnerships. Aijaz (2021) evaluated the mission's progress, identifying key administrative and financial challenges. Thimmavajjala (2023) emphasized the need for practical technical interventions and assessed the mission's overall benefits and shortcomings. Agrawal and Kumar (2022) discussed the technological and financial alternatives provided by smart city projects. Hoque and Prakash (2023) focused on the challenges and current status of smart cities, stressing the importance of digital services. Kumar and Dahiya (2017) analyzed the impact of smart city elements on urban economies. Ravi et al. (2021) advocated for customized solutions tailored to local needs. Agrawal and Doshi (2016) discussed enhancing urban living standards through smart solutions. Quan and Solheim (2023) reviewed the role of public-private partnerships in smart cities. Vaishampayan et al. (2020) highlighted the need for better stakeholder communication with the SCM. Arora (2018) stressed the importance of a developed financial system for smart city development. Murugaiah et al. (2018) compared the SCM with the Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

scheme, emphasizing sustainability. Finally, Ahmed and Ali (2020) analyzed the plans and policies of the SCM, showcasing its impact and the role of collective creativity in urban development. Appendix Table A1 presents the detailed review of literature.

However, the availability and quality of data on smart city initiatives and economic growth in India are limited. This makes it difficult to accurately measure the impact of smart city initiatives on economic growth. Many of the benefits of smart city initiatives may take time to materialize. This makes it challenging to capture the long-term effects of smart city initiatives on economic growth. The impact of smart city initiatives may vary across different types of cities and different sectors of the economy. This heterogeneity needs to be accounted for in empirical analyses.

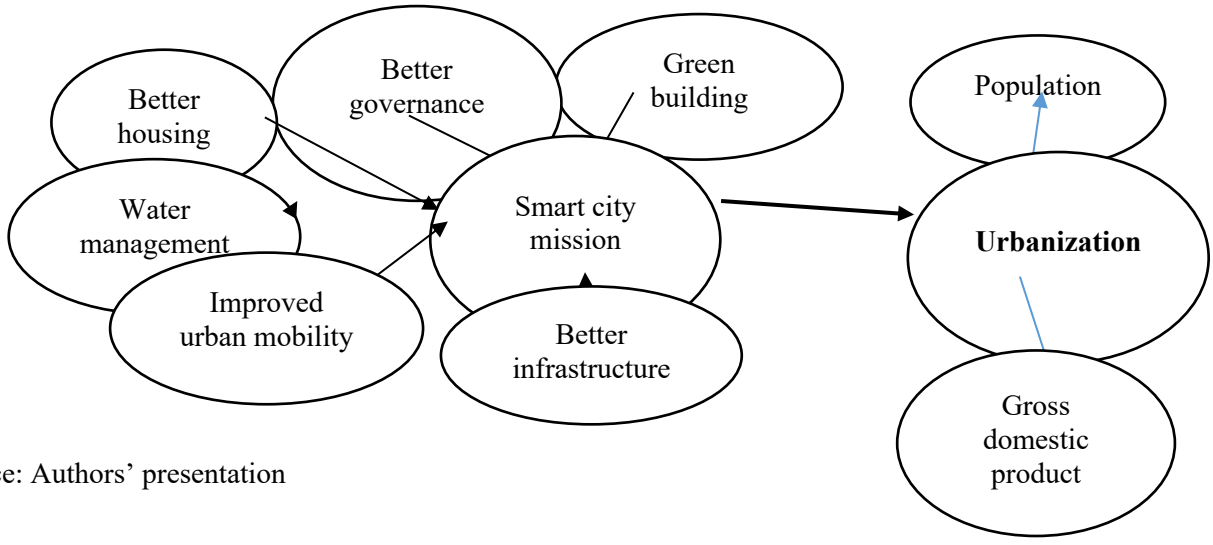
Against this backdrop, we assess the extent to which smart city initiatives contribute to economic growth in India via escalating urbanization. And what Policies need to be recommended to promote smart city initiatives that contribute to economic growth in India. The study performs econometric analysis to explore how factors like infrastructure development, number of implemented projects, population demographics, and a city's Gross Domestic District Product (GDDP) influence economic growth under the Smart City initiatives. In essence, the research investigates whether these factors play a significant role in driving India's economic expansion through smart city development.

The paper is organized as follows. Following section explains the conceptual framework of the study. Section 3 presents the data and methodology. Section 3 and 4 discuss the main empirical results and discussion. Finally, section 5 highlighted main conclusions and policy suggestions.

2. Conceptual framework

Figure 1 presents the conceptual framework of the study. Smart City Mission (SCM) accelerates urban growth by providing smart solutions to urban problems, such as urban sprawl, and enhances the quality of life for urban residents (Kumar et al., 2021). The SCM adopts a triple-zero framework: zero fossil-fuel energy use, zero waste, and zero emissions. A liveable city provides residents with a high quality of life, including access to on-time and efficient services, green spaces, clean air, and a healthy environment (Javidroozi et al., 2023). The SCM provides Smart water management systems, incorporating IoT and ICT technologies; these systems enable efficient water distribution, real-time monitoring of water quality, and effective wastewater treatment, thus ensuring a sustainable water supply for urban populations. This approach also helps mitigate water scarcity and promote sustainable urban development (Bajpai & Biberman, 2021). Implementing intelligent traffic management systems, which is part of the SCM, aims to enhance urban mobility in Indian cities. It upgrades the public transportation system and promotes non-motorized transport. Therefore, the SCM has increased urban mobility by reducing traffic contestation, lowering pollution levels, and improving overall urban connectivity (Gupta, 2022). The SCM contribute to economic growth by integrating Information and Communication Technologies (ICT) to improve the quality of life, efficiency of urban operations, and services that multiply the economy by establishing innovation clusters, creating jobs, attracting investments, and boosting productivity (Kumar et al., 2017).

Figure 1: Impact of Smart City Mission on urbanization



Source: Authors' presentation

Additionally, the SCM is associated with infrastructural developments by focusing on improvements in public amenities, healthcare, and education facilities. Therefore, it has transformed urban landscapes, making cities more liveable and resilient to future challenges. Figure 1 shows that the SCM is associated with better governance, housing, water management, urban mobility, green building, and the availability of better infrastructure. Therefore, the SCM promotes urbanization by attracting more people from rural areas and creates agglomeration economics that generates economic growth.

3. Data and Methodology

3.1 *Data*

The study leverages existing data sources to analyze the economic impact of India's Smart City Mission. Information was compiled from government entities like the Ministry of Housing and Urban Affairs, along with Census data, newspapers, journals, and books. Table 1 presents the data sources of all variables used for the analysis. The data are available for the year 2021-22. However, out of 100 smart cities, we could collect data for only 36 cities. Table 2 presents the cities those are consider for the study and the name of the states where they belong to. Table 2 shows that 36 cities belong to 10 states and union territories (UTs) in India.

Table 1: Data sources

Variable	Sources
Population	Census 2011 (Projected Population)
Gross District Domestic Product	Economic Survey Reports of each State
Number of Pan city projects	Standing Committee on Housing and Urban Affairs- 21st Report (2023-24)
Total cost of Pan city projects	Standing Committee on Housing and Urban Affairs- 21st Report (2023-24)
Density (density)	Census 2011
Completed Projects	Open Government Data (OGD) Platform India
Completed projects Amount	Open Government Data (OGD) Platform India
Total number of smart city projects relating to core infrastructure cost	Open Government Data (OGD) Platform India
Total number of smart city projects relating to core infrastructure elements	Open Government Data (OGD) Platform India
Number of area based development Projects	Standing Committee on Housing and Urban Affairs- 21st Report (2023-24)
Total cost of area based development projects	Standing Committee on Housing and Urban Affairs- 21st Report (2023-24)

Source: Authors' calculation

Table 2: Name of the cities considered for the study

State	City	State	City
Uttar Pradesh	Agra, Aligarh, Bareilly, Jhansi, Kanpur, Lucknow, Moradabad, Prayagraj, Saharanpur, Varanasi	Andhra Pradesh	Amaravati, Kakinada, Tirupati, Vishakhapatnam
Delhi	New Delhi	Himachal Pradesh	Shimla
Karnataka	Belagavi, Bengaluru,Davanagere, Hubbali-Dharwad, Mangaluru, Shivamogga, Tumakuru	Maharashtra	Aurangabad, Pune, Solapur, Thane, Nagpur, Nashik, Kalyan-Dombivali
Jammu and Kashmir	Jammu	Kerala	Kochi, Thiruvananthapuram
West Bengal	New Town, Kolkata	Telangana	Karimnagar, Warangal

Source: Authors' compilation

2.2 Methodology

Our econometric model to investigate the impact of smart city mission on urbanization takes the following representation:

$$URB = \beta_0 + \beta_1 \sum_{i=1}^{9} X_i + \varepsilon URB = \beta_0 + \beta_1 \sum_{i=1}^{9} X_i + \varepsilon \quad \text{---------- (1)}$$

where URB is the urbanization is measured by city population size and city GDP. $X_i X_i$ is the set of independent variables that includes; number of pan city projects, cost of pan city project, number of completed projects, completed project amount, smart city projects relating to core infrastructure cost, smart city projects relating to core infrastructure elements, number of area based development (ABD) projects, total cost of ABD projects, and city population density. Appendix Table 2 presents the variable definitions.

As smart city mission is intended to promote and facilitate urbanization in India, we expect all these variable have a positive effect on the urbanization. For example, density fosters energy-efficient building and transportation, increases productivity and innovation, enhances access to goods and services, shortens normal travel distances, and permits greater sharing of limited urban assets. Hence, density has a positive effect on the urbanization (Duranton and Puga, 2020). As the data is available for one year, we are using cross sectional econometrics model using Ordinary Least Square (OLS) technique.

4. Empirical results

Table 3 shows that the coefficient of variation (CV) of number of smart city projects relating to core infrastructure cost and total cost of ABD projects are relatively low, indicating a moderately symmetrical distribution. Conversely, city population size, city GDP, and number of Pan city projects have a higher CV, suggesting a wider range of values across the observations. Table 4 shows the correlation of the variables. The positive correlation is obtained for city population size with number of pan city projects, density, and completed projects. However, other variables show a negative correlation with city population size. Number of Pan city projects and density has a positive relationship with city GDP.

Table 3: Descriptive statistics

	Mean	Standard Deviation	Minimum	Maximum	CV
Total population (population)	2088306	2913318	103000	1.43E+07	139.51
Gddp (gddp)	100366.8	136305.2	3641	652649	135.81
Number of Pan city projects (pan_city_pro)	35.83333	29.69223	6	131	82.86
Total cost of Pan city projects (cost_pan)	911.2222	677.4302	71	2624	74.34
Density (density)	9733.912	6949.41	474.14	31594	71.39
Completed Projects (complete_proj)	70.33333	49.96913	10	216	71.05
Completed projects amount (crores) (complete_p_a)	1275.559	729.7973	376.85	3272.97	57.21
Total number of smart city projects relating to core infrastructure cost (project_infras)	1435.701	624.4069	417.87	2769.89	43.49
Total number of smart city projects relating to core infrastructure elements (infras_ele)	62.63889	43.43478	8	194	69.34
No. of ABD Projects (adb)	57.58333	34.66029	5	150	60.19
Total cost of ABD projects (adb_cost)	1048.806	499.6504	377	2786	47.64

Note: The estimation is based on 36 observations. Source: Authors' estimation

Table 4: Correlation coefficients of the variables

	population	gddp	pan_city_pro	cost_pan	density	complete_proj	complete_p_a	project_infras	infras_ele	adb	adb_cost
population	1.00										
gddp	0.79	1.00									
pan_city_pro	0.16	0.10	1.00								
cost_pan	-0.16	-0.08	0.28	1.00							
density	0.29	0.01	-0.04	-0.30	1.00						
complete_proj	0.06	-0.11	0.86	0.20	0.06	1.00					
complete_p_a	-0.07	-0.19	0.10	0.56	-0.09	0.35	1.00				
project_infras	-0.26	-0.20	0.14	0.75	-0.11	0.23	0.67	1.00			
infras_ele	-0.09	-0.17	0.78	0.03	-0.03	0.80	0.08	0.18	1.00		
adb	-0.11	-0.34	0.54	-0.10	0.15	0.77	0.15	0.06	0.81	1.00	
adb_cost	-0.12	-0.17	-0.16	-0.23	0.19	0.15	0.45	0.25	0.04	0.33	1.00

Note: See Table 3 for variable definitions. The correlation coefficients are based on 36 observations

Table 5 shows the results of estimated price regression models. We estimate parsimonious regression models as they fit the data well while utilising a small number of independent variables. Parsimonious regressions are used to obtain accurate results with minimal variables, allowing for easier interpretation and less overfitting, thereby identifying relevant variables influencing urbanization in India. We use robust standard errors to solve heteroskedasticity problem. Lower values of Variance inflation factor (VIF), indicates our regression results free of multicollinearity problem. As the dependent variables are in logarithmic form, the regression models are log-linear model. The R^2 values lies between 0.42 to 0.56, indicates better goodness of fit of the regressions.

Regression models 1 and 2 consider log of city population size as the dependent variables. The results show that total cost incurred under Pan city projects, city GDP, density, completed projects, and completed projects amount have a positive and statistically significant effect on the city population size. For instance, one-unit increase in completed project amount leads to increase in city population size by 0.9 percent. However, higher number of Pan city projects have a negative effect on city population size. Regression models 3-5 consider log of city GDP as the dependent variable. The results show that density and number of ABD projects has a negative effect on the city GDP. However, higher population size has a positive and statistically significant effect on the log of city GDP. Other variables related to smart city mission have no statistically significant effect on the city GDP.

Table 5: Impact of smart city mission on urbanization

	Dependent variable				
	Log of city population size		*Log of city GDP*		
VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5
Number of Pan city projects		-0.0196**			0.00464
		(0.00723)			(0.00596)
Total cost of Pan city projects		0.000396**			0.000147
		(0.000156)			(0.000207)
City GDP	4.58e-06***	5.11e-06***			
	(6.34e-07)	(8.58e-07)			
Density	6.65e-05**	6.49e-05***	-4.55e-05***	-4.40e-05**	-3.09e-05*
	(2.59e-05)	(2.08e-05)	(1.54e-05)	(1.72e-05)	(1.80e-05)
Completed Projects	-0.00271	0.00901*		-0.00583	
	(0.00281)	(0.00471)		(0.00363)	
Completed projects amount	0.000502***			3.16e-05	
	(0.000145)			(0.000234)	
Population			2.34e-07***	2.33e-07***	2.01e-07***
			(2.42e-08)	(2.54e-08)	(3.72e-08)
Total number of smart city projects relating to core infrastructure cost			0.000339		
			(0.000212)		
Total number of smart city projects relating to core infrastructure cost			-0.00979***		
			(0.00330)		
No. of ABD Projects					-0.0174***
					(0.00577)
Total cost of ABD projects					0.000452
					(0.000368)
Constant	12.43***	12.55***	10.98***	11.21***	11.01***
	(0.421)	(0.411)	(0.403)	(0.412)	(0.447)
Mean VIF	1.10	2.69	1.10	1.13	1.64
Observations	36	36	36	36	36
R-squared	0.571	0.563	0.509	0.416	0.559

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

5. Discussion

The results show that smart city mission has a mixed effect on the urbanization. Various projects related to smart city mission increases population but does not increases city GDP. The focus of smart city projects such increase in infrastructure elements is mainly devoted to core area of the cities than the hinterland area. It suggests that India's big cities are at capacity. Here, we have two main options: either we need to invest in the core area of cities again, or we may invest in the hinterland attached to a city. Given the limited amount of infrastructure investment available in India, we propose that it is preferable to invest in the outskirts rather than the centre of large cities since there are various benefits related to agglomeration economies and the relative cost of investment is significantly lower. The primary factors lowering operational expenses in the hinterland area are the large supply of land and the low wage rate. As a result, there are more potential rewards for investment than in a city's central area (Tripathi and Mitra, 2022). Therefore, to achieve higher benefits of smart city mission the location of investment in a city is very important.

Smart city mission is also facing major implementation problems. Convergence projects involving multiple agencies and external implementation face delays due to a lack of a unified monitoring system. Implementation speed varies greatly across cities, with many experiencing slow progress. A lack of clear governance structures and monitoring capacity within Special Purpose Vehicles (SPVs) hinders smooth operation. The number of completed projects falls short of the planned targets, indicating weak execution capabilities. Less emphasis is placed on core infrastructure projects compared to other initiatives. Smart city initiatives may have short-term negative economic impacts due to upfront costs before long-term benefits emerge. Restricted availability and quality of data on smart city projects and economic growth make it difficult to accurately assess the economic impact.

The standing Committee on housing and urban affairs believes smart city mission lacks adequate funding. Therefore, more fundraising efforts are needed, especially from-state and local governments. In light of this, the Committee suggested that-the-Central-Government should support-state-governments and-cities-that are in urgent-need-of-organisational-restructuring, personnel-training-and-capacity building-on-strategic-governance-and-financing-systems, and other support in order to fully realise a city's economic potential through creative finance mechanisms like-municipal-bonds-with ULB-credit-ratings, -pooled-financing-mechanisms, tax-increment-financing-(TIF).

One key concept behind the Smart Cities Mission is combining resources from various government programs. This approach aims to reduce overall project expenses, develop solutions that work seamlessly together, enhance environmental sustainability, and deliver maximum benefits to citizens. However, delays have noticed these "Convergence Projects" due to two main reasons: Involving agencies other than the Smart City Mission itself for execution and a lack of clarity regarding the role of Special Purpose Vehicles (SPVs) in implementing these projects.

The committee recommends that the Ministry establish a strong coordination mechanism across its various schemes whenever convergence is planned. This system, ideally managed at the District Collector level, would ensure smooth and unified monitoring. This will promote successful convergence, preventing duplication of efforts and wasted resources.

The committee acknowledges the limitations of the public sector in solely driving urban infrastructure growth. They recommend a multi-pronged approach where all levels of government actively engage and attract private companies. This public-private partnership (PPP) strategy offers a dual benefit. Private firms not only bring in additional funding but also introduce cutting-edge technologies, fostering innovation in infrastructure development. To maximize these advantages, the committee suggests the government analyze why some cities haven't adopted PPP models. By identifying the roadblocks and implementing corrective measures, all cities can leverage the potential of private sector involvement for a more robust and technologically advanced infrastructure.

6. Conclusion and policy implications

The Smart City Mission in India holds immense importance for the country's future. It aims to transform cities into hubs of innovation and sustainability, improving the quality of life for residents. By focusing on areas like infrastructure, sanitation, and technology, these smart cities can attract businesses and investment, leading to economic growth. Additionally, the mission prioritizes environmental concerns, promoting sustainable practices that benefit both citizens and the environment. Overall, the Smart City Mission has the potential to create a more prosperous, liveable, and future-proof urban landscape for India.

In order to understand how the Smart City Mission initiatives, impact the urbanization in India, a thorough evaluation was conducted. Urbanization is measured by city population size and city GDP. We use data by sourcing from various government offices, such as Census 2011, Economic Survey Reports of each State, Standing Committee on Housing and Urban Affairs- 21st Report (2023-24), Open Government Data (OGD) Platform India, Ministry of Urban and Housing Affairs for the year of 2021-22. The econometric model OLS (Ordinary Least Squares) has been performed for analysing the factors contributing to the economic growth of India through smart city mission initiatives.

The results show that smart city mission related various factors such as cost incurred under Pan city projects, completed projects, and completed projects amount all have positive effect on the city population size. However, number of ABD projects have negative effects on city GDP. The results suggest that smart city initiatives can contribute to economic growth in India, but there are caveats. There seems to be a positive correlation between city GDP and population size, and to a lesser extent, the total amount of money spent on smart city initiatives. However, the negative coefficient for total project costs suggests that spending needs to be efficient to maximize the positive impact.

The results are very important. Urban policymakers in India can develop better strategies to promote smart city projects that specifically contribute to and accelerate economic growth across India via smart city initiative.

First of all, the implementation of Smart city projects is important to extend in hinterland area near a big city than only in the core area of the city. It will facilitate to expand and extend the saturation points of a city. And the benefits of agglomeration economies can be achieved at its maximum.

The Smart Cities Mission has delivered a range of successful smart project initiatives across participating cities and towns. These completed projects demonstrably improve the social and economic well-being of residents, particularly those from marginalized communities. However, the report also highlights uneven progress among cities, with some lagging behind in implementation. While the COVID-19 pandemic undoubtedly played a role in these delays, the study identifies additional administrative and financial hurdles that require attention.

To enhance transparency and accountability, civil society organizations should establish a nationwide network connecting all Smart Cities. This network could then utilize tools like public report cards to independently assess the performance of each city's Special Purpose Vehicle (SPV). By conducting such evaluations, the network could generate unbiased efficiency rankings of the SPVs, providing valuable insights into the strengths and weaknesses of each Smart City program. This information would be crucial for promoting best practices and ensuring that all cities are effectively leveraging the Smart Cities Mission.

Integrated Command and Control Centres (ICCC) can be transformed into powerful hubs for managing various critical city services. This expansion would encompass healthcare, public safety, waste collection, traffic flow, disaster response, and e-governance initiatives. Consistent funding is essential to support these efforts. Additionally, continuous technological advancements should be integrated to ensure seamless coordination across these services.

Furthermore, an assessment should be conducted to determine the optimal number of ICCCs needed within each city. This would pave the way for the creation of a state-level ICCC, functioning as a central platform to connect and unify all city-based ICCCs. This comprehensive network would establish a unified e-governance platform for the entire state.

To quicken progress under the Smart Cities Mission (SCM), it's crucial to identify and analyze the reasons behind delays. A comprehensive plan should be formulated to bolster the capabilities of ULBs in smaller cities that are not fully benefiting from the initiative. This will ensure timely completion of SCM projects and optimize the Mission's impact.

The study has few limitations. First, once the data is available, consideration of panel data model to capture common and individual’s characteristics is essential. Data also has to provide for all smart cities so that a robust regression results are obtained. These issues are topic for future research.

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Appendix Table A1: Review of literature

Author(s)	Main Objective	Variables Used	Source of Data	Methodology	Conclusion
Aijaz (2021)	This report evaluates the first five years of the Mission, and draws lessons from its successes and failures. It discusses the physical and financial status of the projects taken up so far, and identifies the most crucial challenges—administrative, financial, and technology-related—that impede progress.	Infrastructure and services, Area-based development	Ministry of Housing and Urban Affairs (MoHUA), "Vision".	Descriptive Statistics	The completed projects are providing social and economic benefits, especially to the marginalised sections of the populations of these cities. However, the study also shows that several cities are lagging in project implementation. No doubt the COVID-19 pandemic has impeded progress, but there are also various administrative and financial reasons for the underperformance.
Thimmavajjala (2023)	This report evaluates the progress of the mission and draws lessons found over last 8 years	Infrastructure, sustainable environment, Special economic zones	Ministry of Housing and Urban Affairs, March 2023 ITDP (The Institute for Transportation and Development Policy) 18th Report of Standing Committee on Housing and Urban Affairs (2022-23)	Descriptive Statistics	Smart solutions are fine but who is benefiting from it should also be assessed. Technical interventions have to be practical as well. There should be an assessment made if the powers of a Smart City SPV to implement are overlapping those of the local municipal body
Agrawal and Kumar (2022)	to strengthen the urban infrastructure through the application of technology and smart solutions.	Special-Purpose Vehicles (SPVs), ABD (area-based development), economic infrastructure	The report by the Planning Commission of India in its 12th and last Plan (2012-17) Ministry of Housing and Urban Affairs (MoHUA) 15th Finance Commission for the years 2021-26	Distributive Statistics	Multidisciplinary projects such as Smart Cities Urban projects may not necessarily have the only solution, but they do have a technologically and financially sounder alternative for providing a method for a way of life suitable to the city.

Hoque and Prakash (2023)	1. To examine the current status and performance of smart cities in India. 2. To find out the challenges of implementing of smart city in India.	Infrastructure, Mobility, Sustainable Development, Technology	Ministry of Housing and Urban Affairs (MoHUA)	Descriptive Statistics	smart city development is more concerned with making progress as concerned with the smart indicators and providing digital and smart services to the urban dwellers rather than rating the city.
Kumar and Dahiya (2017)	To examine what constitutes smart city commerce services, transportation, and communication, and how they impact on smart city economy.	economic growth, Urbanization	IBEF [India Brand Equity Foundation] and Aranca (2013), PWC [PriceWaterHouse Coopers Private limited] (2015) Statista	Descriptive Statistics	The development of conventional urban economy relied on public sector-led planning, design, investment, implementation, and monitoring of development process.
Agrawal and Doshi (2016)	to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions.	Infrastructure, sustainable environment, economic growth	Census 2011, Ministry of Urban Development Government of India, Smart city Guidelines, 2015, Pune Smart City – Making It a Reality 2015, Pune Muncipal Corporation.	Descriptive Statistics	With a vibrant cultural heritage, a strong human capital and strong business environment as key strengths, Pune aspires to become one of the most livable cities in India by making its infrastructure world class & future proof, and by transforming its neighborhoods on key dimensions of livability like mixed use, open spaces and sustainable energy usage.
Aijaz and Hoelscher (2015)	To improve economic and physical infrastructure of urban settlements having populations of up to 500,000, so that these would be in a position to generate economic growth and control the problem of migration to larger cities.	Infrastructure, SPV (Special Purpose Vehicle)	Ministry of Housing and Urban Poverty Alleviation, Annual Report 1999-2000; Planning Commission, Eleventh Five Year Plan 2007-12; Ministry of Urban Development, Smart Cities Mission	Descriptive Statistics	Previous city improvement efforts under centrally sponsored schemes, such as Mega City and JNNURM, have been helpful to some extent in various ways. The new Mission offers the State and the local government institutions yet another opportunity to think creatively and work towards the betterment of their cities.

			Statement and Guidelines, 2015.		
Quan and Solheim (2023)	This study examines (1) the current state of empirical research on PPP in smart cities, and (2) assesses emerging themes of interest for smart city research and practice.	Public-private partnerships,Urban development,Cross-sector collaboration	In 2007 inaugural IEEE-IES (Institute of Electrical and Electronics Engineers- Industrial Electronics Society) digital EcoSystems and technologies conference, Social Science Computer Review, Journal of Strategy and Management,	This study reviews, critiques, and synthesizes representative literature on PPP in smart cities through an integrative literature review	In this paper, they conducted an in-depth empirical evidence synthesis to enhance our understanding of PPP in smart cities, which was distilled into four cross-cutting themes encompassing the fragmented and varied body of literature on the topic.
Praharaj et al. (2018)	this research critically assesses the ability of Indian cities to transform their traditional bureaucratic governments into a more accountable collaborative governance.	SPV (Special Purpose Vehicle), E-Governance,	The Ministry of Urban Development, Government of India. 13th Finance Commission (2010–2015)	Descriptive Statistics	This study finds that emerging smart cities governance in India encourages institutional compartmentalism due to poor convergence and integration mechanism among interventions, which fails to realise the added value offered by coordination of resources and from the joint efforts of agencies
Vaishampayan et al. (2020)	(a) to evaluate the adequacy of measures taken; and (b) application of project stakeholder management theory in enhancing the citizen engagement process.	socio-economic and political variables, Area Based Development	Census 2011, Project Management Institute (PMBOK Guide), 6th Edition	Descriptive Statistics	Literature shows that a key reason for lack of participation is poor communication and collaboration amongst various project stakeholders.
Arora (2018)	This study aims to fill in the gap in the current literature on smart cities and examines existing financial sector development of selected smart cities in the Indian context	Infrastructure, economic growth.	Journal of Urban Technology, Indian Journal of Public Administration, Swedish Institute for Financial Research, IMF Working Paper, WP/15/22,	Assign weights (denoted by αj for dimension j to each dimension). compute the financial services index (FSI) for	A policy implication drawing from this research is that for a ‘smart city’ to develop the government should pay attention not only to adequate availability of water supply, electricity, IT facilities, governance and environment, but also should consider a developed financial system which provides access to

			Journal of International Affairs	each smart city as follows. $FSI = \sum_{j=1}^{J} \alpha_j D_j$	financial services and facilitates investment in health, education and businesses and strengthening human capital.
Murugaiah et al. (2018)	1.To understand and compare Smart cities Mission and AMRUT scheme. 2.To analyze the Sustainability component in the Smart cities Mission and AMRUT scheme.	Sustainability, Economy, Environment & Society	Government of Karnataka Report 2015, The Ministry of Urban Development, Journal of the Knowledge Economy,	Descriptive Statistics	There is need for further research to work out the parameters, definitions and guidelines for the development of new cities on green field developments. More and more sustainable development projects to be included as add on components in the schemes.
Ahmed and Ali (2020)	This research tracks the smart city mission that was launched by the Indian government along with the plans and policies put forth by the authorities.	Housing, IT connectivity, Governance, Education	IEEE (Institute of Electrical and Electronics Engineer) International Conference on Technologies for Smart-City Energy Security and Power, smartcities.gov.in	Document Analysis, Qualitative Content Analysis	The study demonstrates significant effects from an Indian standpoint for a fundamental perception of the smart city framework and for identifying the role of collective creativity in promoting smart city progress and healthier development activities.

Source: Authors' compilation

Appendix Table 2: Variable definitions

Variable	Definition
Population	The total number of people living in a given urban area, typically measured within the geographical boundaries of a city or district.
Gross District Domestic Product	Proxy of Gross Domestic Product (GDP)
Number of Pan city projects	The count of projects implemented across the entire city to improve urban infrastructure and services using smart technologies, such as intelligent traffic management systems or city-wide Wi-Fi.
Total cost of Pan city projects	The aggregated financial investment required to execute all pan-city projects within a smart city initiative.
Density (density)	The number of people living per unit area of land, typically measured in persons per square kilometer or mile, indicating how crowded or sparse the urban area is.
Completed Projects	The total number of smart city projects that have been fully implemented and are operational.
Completed projects Amount	The total financial expenditure on all completed smart city projects, reflecting the investment made to achieve the planned developments.
Total number of smart city projects relating to core infrastructure cost	The count of smart city projects specifically focused on core urban infrastructure, such as water supply, sewage systems, and energy grids, including their associated costs.
Total number of smart city projects relating to core infrastructure elements	The count of individual projects aimed at enhancing specific elements of core urban infrastructure, such as transportation networks, waste management, and public safety.
Number of area based development Projects	The count of projects targeting specific areas within the city for redevelopment or improvement, aiming to transform these areas into better-planned and serviced human settlements.
Total cost of area based development projects	The aggregated financial investment required to complete all area-based development projects, encompassing the redevelopment and retrofitting of specific urban zones.

Source: Authors' compilations