

Understanding the Role of Scaling in Smart City Strategies: Evidence from German Municipalities

Wintana T.Y. Habte , Eberhard Kurz 

Department of IT Management
Justus-Liebig-University Giessen
Giessen, Germany

e-mail: wintana.habte@wirtschaft.uni-giessen.de, e-mail: eberhard.kurz@uni-giessen.de

Abstract—Future cities, or smart cities, aim to use information and communication technologies in ways that improve efficiency across all aspects of urban infrastructure. While an increasing number of smart city projects can be observed, many tend to decline after their piloting phase. In this paper, we seek to identify whether the lack of scaling constitutes a strategic issue. By investigating the central thematic structures within 70 German smart city strategies and employing Structural Topic Modeling (STM), we explore the extent to which thematic priorities vary across municipalities. This topic modeling approach allows us to identify the strategic priorities emphasized by municipalities and to assess the extent to which topics within these strategies can be linked to project success. In a broader sense, we examine whether and how considerations of project scaling are integrated during the strategy development phase. Based on this analysis, it becomes possible to evaluate whether the observed lack of scaling beyond successful pilot projects can be attributed to insufficient long-term planning at the strategic level and, by extension, help to better understand the efficiency of future cities.

Keywords—Smart city strategy; STM; upscaling; project success; future cities.

I. INTRODUCTION

Smart cities are increasingly recognized as vital instruments for future-oriented urban development, particularly in addressing pressing environmental and social challenges. Despite the strategic planning underpinning these initiatives, many smart city projects struggle to scale beyond their initial pilot phase [1].

For the purpose of this paper, long-term success is measured through scaling activities, which may take the form of horizontal scaling, such as expansion or roll-out [2], or vertical scaling in terms of replication [3]. Even when municipalities actively pursue smart city initiatives, often supported by external funding, these projects frequently remain confined to pilot or experimental phases, thereby limiting their broader societal impact. This issue is particularly critical because most smart city initiatives reveal their full potential only over extended periods. The objectives of being safer, more efficient, and greener can only be achieved if cities fully adopt the initiatives [4]. As demonstrated by the Scalable Cities Initiative of the European Commission, across all participating cities of Horizon 2020, energy consumption was reduced by 53% and CO₂ emissions by 88% [5].

Smart city projects, like most complex initiatives, are guided by strategic frameworks. These strategies aim to align stakeholders, coordinate resources, and facilitate the successful

implementation of projects to achieve predefined objectives. However, governments frequently face challenges in planning and executing smart city development [6][7].

This observation raises an important question: Does the limited scalability of smart city projects indicate a strategic shortcoming?

To explore this question, this study analyzes the smart city strategies of municipalities funded by the Federal Office for Building and Regional Planning. The aim is, first, to identify the thematic priorities emphasized in these strategies and, second, to examine which dimensions, particularly those related to scaling and long-term institutionalization, are often overlooked. For this purpose, we extracted 70 strategy documents from the Ministry's publicly available sources, covering projects issued between 2018 and 2024. To systematically categorize and analyze these strategies, we employ Structural Topic Modeling (STM) [8], a probabilistic modeling approach that uncovers latent topics within textual data while incorporating relevant metadata. This method enables a rigorous assessment of both thematic focus and potential gaps in strategic planning for smart city initiatives.

While previous research has investigated smart city strategies focusing on large cities, such as Amsterdam, Barcelona, or New York [9], this study contributes to the discourse by focusing on the topic of scaling across a broad set of German cities. This approach allows us to examine the effects of city-based differences, such as city size, economic stability, and regional context, on strategic success, which so far has not been exhausted. In doing so, the study seeks to clarify whether the lack of scaling constitutes a strategic issue and therefore requires adjustments in the strategic phase of smart city project planning.

Building on existing research, section two of this paper first summarizes important literature and related work. In section three, the applied methodology is outlined, followed by the presentation and discussion of the interim results in the fourth and final section.

II. RELATED WORK

In general, well-designed and effectively executed strategies are believed to enhance competitive advantage, generate economic value, and structure project phases, thereby ensuring both short-term and long-term success [10]. Accordingly, the role and relevance of strategies within organizations have

long been established. However, smart city development in particular faces additional layers of complexity that go beyond the deployment of new technologies and therefore require more systematic and coordinated approaches.

While closely related, strategy, governance, and policy fulfill distinct functions and should be analytically differentiated. Policy plays a crucial role in operationalizing strategic goals [11]. In the sustainability literature, Lafferty and Hovden [12] conceptualize policy through vertical and horizontal policy integration. Vertical integration concerns the alignment of goals, budgets, and supervisory mechanisms across governance levels, whereas horizontal integration focuses on long-term strategic coherence, including national action plans and conflict-resolution mechanisms. From a scaling perspective, this linkage is particularly relevant, as policies can facilitate access to funding and institutional support [13]. Strategies may initiate policy development, while policies in turn reinforce strategic objectives.

Within this context, governance is widely recognized as a key instrument embedded within development strategies [14]–[16]. Kardos [15] conceptualizes governance as an iterative process that builds a shared vision through consensus and translates it into concrete objectives. For smart city initiatives, governance models are also critical enablers of upscaling [1]. Mora [17] further argues that governance mechanisms can generate synergies by coordinating and allocating tasks and responsibilities, although these mechanisms may follow different archetypical forms [18].

Therefore, it is evident that strategies alone do not render cities “smart”. Angelidou [11] argues that strategies are a necessary but not sufficient condition, as they must reflect the underlying smart city architecture and local context. Similarly, Letaifa [19] emphasizes that strategies serve to align stakeholders around a coherent vision tailored to local challenges. Given the heterogeneity of cities in terms of social, cultural, and institutional conditions, local adaptation is therefore essential.

Additionally, smart city development can be examined either from an innovation management perspective [17] or from a socio-economic perspective [20]. City examples, such as Amsterdam and Barcelona illustrate that successful smart city initiatives involve a wide range of stakeholders who jointly deploy technologies to address social and environmental challenges while strengthening urban competitiveness [1]. These observations highlight the necessity of strategic frameworks that structure a shared vision and clearly define roles and responsibilities across actors. Building on this, Dai et al. [21] emphasize that strategies must not remain abstract but should explicitly translate smart city visions into concrete and operational action plans.

A closer examination of the literature shows broad agreement that project success depends on the inclusion of multiple strategic elements [22][23]. Earlier research predominantly relied on the “triple constraint” model, which defines success through time and cost adherence [24]. While this model captures short-term performance, it fails to account for long-

term outcomes, such as scalability. To overcome these limitations, Poli and Shenhar [10] propose an expanded framework that incorporates additional dimensions, including strategic focus, competitive advantage, value creation, and business orientation.

Although these frameworks originate from corporate project contexts, their underlying logic is transferable to smart city development. Smart city strategies similarly aim to coordinate multiple projects and actors toward shared objectives [7]. A central component of this coordination is governance, which structures responsibilities and decision-making processes [13][14][16][25]–[27]. However, a structural challenge arises from the fact that strategy formulation and project implementation are often carried out by different actors [21].

To better capture competitiveness and long-term impact, more comprehensive strategic models have been proposed. One prominent example is the SMART framework by Letaifa et al. [19], which integrates Strategy, Multidisciplinary collaboration, Appropriation, Roadmap, and Technology. These components are distributed across macro, meso, and micro levels, ranging from overarching urban strategies and stakeholder coordination to concrete action plans and technological implementation [26].

Complementary insights emerge from software project management, where poorly defined scope is a major determinant of project failure. Ul Hassan et al. [28] address this issue through a Software Project Scope Rating Index (SPSRI) comprising 45 elements, including tools, managing uncertainty, and estimating costs. Adding to that, Mora et al. [29] synthesize key development principles, including moving beyond technology-centric approaches, adopting quadruple-helix collaboration, combining top-down and bottom-up processes, and embedding projects within an integrated strategic framework.

Building on these contributions, Dai et al. [21] distinguish between the strategy level and the project level of smart city development. They argue that while strategy formulation requires flexibility and iterative refinement, project implementation focuses on operationalizing predefined objectives. Their proposed five-stage transformation framework, ranging from goal definition to evaluation, highlights the importance of monitoring and performance assessment mechanisms [17]. At the same time, recent research increasingly calls for citizen-centric strategies to avoid an overreliance on technological solutions, often referred to as “technological solutionism” [17].

Taken together, the reviewed frameworks converge on two central questions: how strategies should be developed and which components they should include. Strategically, development follows a continuous cycle of definition, implementation, and evaluation (Figure 1). Substantively, effective strategies integrate vision, action planning, resource identification, governance structures, and financial considerations. This understanding aligns with Winden and Van den Buus’s scaling framework [2], which emphasizes economies of scale, knowledge transfer, supportive policy environments, and return on investment, including financial sustainability [27]. Consequently, smart city strategies



Figure 1. Strategy Development Cycle.

must articulate a locally grounded vision [30], specify implementation pathways, mobilize institutional and societal resources, and clearly assign responsibilities to enable long-term scaling.

III. METHODS

As previously outlined, this study employs STM to analyze a corpus of 70 smart city strategies. Roberts et al. [8] describe STM as a probabilistic mixed-membership model that builds upon Latent Dirichlet Allocation (LDA). Its primary objective is the semi-automatic identification of latent thematic structures within large collections of text documents.

STM assumes that each document is composed of a mixture of multiple topics and that each topic is characterized by a multinomial probability distribution over words. Within the generative process, each word in a document is assigned to a topic based on response-specific topic distributions. In contrast to classical LDA, STM allows topics to be correlated and enables the inclusion of covariates. This extension makes STM particularly suitable for analyzing strategic documents, as it allows the examination of how thematic emphases vary systematically across different contextual characteristics. In addition to identifying the dominant thematic structures within the strategies, the analysis specifically investigates the role of scaling in smart city strategies. By examining whether and how scaling-related aspects appear in the strategic phase, the study aims to assess whether the limited scaling of smart city projects beyond successful pilot phases may be linked to insufficient long-term strategic planning. This, in turn, provides insights into whether it would be beneficial to establish scaling as a distinct and explicit strategic focus within municipal smart city initiatives. The analysis follows the standard workflow for estimating a STM. First, a preprocessing phase is conducted to prepare the textual data for modeling. This is followed by the selection of relevant covariates, the specification of the model through the determination of an appropriate number of topics (K), and the final estimation of the STM. Text preprocessing includes common steps in topic modeling and text mining, such as the removal of stop words. Concerning stemming and

lemmatization, special consideration is required due to the German language of the strategy documents. While stemming is relatively straightforward in English because of regular conjugation patterns, German morphology and compound nouns significantly increase complexity. To avoid semantic distortion, aggressive stemming and lemmatization are therefore not applied. Text segmentation, which is necessary for languages without explicit word boundaries, is not required in this case. Furthermore, compound splitting is not performed, as German compound words often carry specific semantic meanings that could be altered through decomposition.

The optimal number of topics was determined using a combination of held-out likelihood, residuals, and semantic coherence, which are commonly used diagnostic measures in topic modeling. Based on these criteria, a final model with $K = 8$ topics was selected. Following the approach proposed by Lucas et al. [31], several document-level covariates were incorporated into the model. These include city size, region, population, and federal state GDP, all of which are relevant to the research question. The secondary data was collected from Statista and Federal Statistical Office of Germany (Destatis) [32][33]. Since the study aims to investigate potential regional and structural differences in thematic priorities across municipalities, the chosen covariates describe key socio-economic and geographic characteristics of the cities.

Topic Identification and Labeling Initially, a model with ten topics was estimated based on diagnostic comparisons. However, a closer qualitative inspection of the most representative words and documents revealed substantial thematic overlap between some topics. Consequently, closely related topics were merged, resulting in a final set of eight distinct and interpretable topics:

- Cooperation and Collaboration
- Sustainable Urban Development
- Economy and Scalability
- Data Infrastructure
- Urban Development Strategy
- Traffic Management and Tourism
- Mobility Concepts
- Efficient Urban Infrastructure Design

These topics form the basis for the subsequent analysis of thematic priorities and scaling considerations within German smart city strategies.

IV. RESULTS

Based on our review of the literature, we examined whether key elements, such as co-creation, business models, scaling, and funding are addressed in the analyzed strategies. The results show that all strategies at least acknowledge the importance of involving citizens in project development and implementation. Scaling is mentioned in 41 strategies, business models are described in ten, and future funding is addressed in 37 strategies. However, most strategies outline the importance of funding and the need for scaling mechanisms but do not elaborate. We first provide an overview of the relative frequency of each topic across the analyzed documents. As

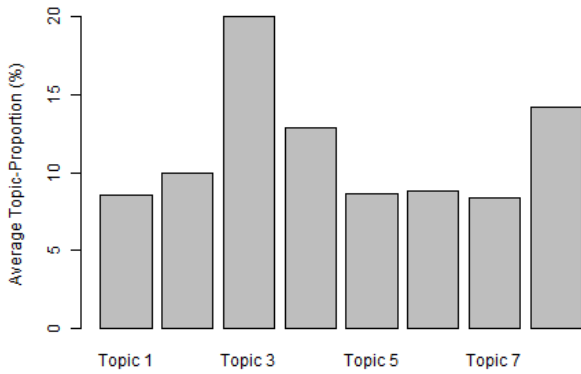


Figure 2. Average Topic-Proportion.

illustrated in Figure 2, Topic 3 (“Economy and Scalability”) emerges as the most prominent theme, with an average share of 20% across all documents. This is followed by Topic 8 (“Efficient Urban Infrastructure Design”), with an average prevalence of 14.21%, and Topic 4 (“Data Infrastructure”), accounting for 12.85%. Overall, these three topics dominate the content of the smart city strategies examined in this study.

The results from the STM show that population size has a clearly non-linear influence on the thematic focus of municipal smart city strategies. While Topic 1 is largely independent of city size, Topics 2 (Sustainable Urban Development), 3 (Economy and Scalability), and 4 (Data Infrastructure) become significantly more important as population size increases. Topic 4 occurs almost exclusively in larger cities, indicating a greater concentration of complex strategic content in urban centers. While Topic 7 (Mobility Concepts) occurs largely independently of population size, Topics 5 (Urban Development Strategy), 6 (Traffic Management and Tourism), and 8 (“Efficient Urban Infrastructure Design”) show differentiated, non-linear correlations. Topic 6 is particularly prevalent in medium-sized cities, whereas Topic 5 and Topic 8 occur more frequently in smaller municipalities. This highlights the importance of considering municipal size classes in a differentiated manner when analyzing thematic priorities.

V. DISCUSSION

As discussed in the related work section, we have summarized the key insights from the literature into a framework that we used to evaluate the strategies beyond the initial STM. This was done to better understand the insights derived from the STM. The literature underlines the need for a clear vision, governance models clarifying responsibilities, the resources needed to realize these goals, and a clear action plan describing each step within the transformation process toward a future city. Nevertheless, these components are relatively general and not focused on the final stage of most smart city initiatives, the scaling phase.

This phase can be divided into two types, similarly to what Lafferty and Hovden [12] proposed for policy integration. Either a project is scaled horizontally, meaning, for example, that it is rolled out on a larger scale, or it is scaled vertically,

meaning that the project is replicated elsewhere. Therefore, it is important to address scaling already in the strategy phase.

Winden and Van den Buus [2] argue that not all projects are meant to be scaled. In some cases, the main objective is to test a technology and its usefulness. This applies mostly in smaller cities or cities with little technological advancement. However, even if a project is not intended for future use, the findings need to be documented and preserved, either as a blueprint for other cities or for future projects. In order to do so, it is necessary to determine within the strategy not only what the objectives are, but also how the project results are supposed to be documented and preserved for future use. While most of the 70 strategies have a clear vision for what they want to achieve, there is little mention of how to preserve the insights.

Further, many municipalities face the challenge of funding and financing their initiatives after the initial funding runs dry. Many researchers underline the importance of creating and improving projects together with stakeholders from all parts of society, not only for long-term user satisfaction. Public-private partnerships are not only promising for developing useful tools, but can also be a way to share costs and serve as a foundation for business models [34]. While most strategies emphasize the need for scaling, especially smaller cities often do not elaborate on how they intend to achieve this within the context of their local environment. This may be because smaller cities primarily focus on testing whether the initiative actually generates incremental value. They do, however, mention a broad list of stakeholders with whom they plan to work together.

VI. CONCLUSION AND FUTURE WORK

This research aims to identify the thematic priorities emphasized in the smart city strategies of 70 German municipalities. By conducting STM, we examine which dimensions are most dominant, whether there are city-wide differences, and which aspects may relate to scaling. In conclusion, the analysis shows that while the topic of scaling is addressed in most strategies, it often remains at a rather superficial level. The study identified that “Economy and Scalability”, “Efficient Urban Infrastructure Design”, and “Data Infrastructure” are the dominant themes across the analyzed strategies. When further examining these themes, the results indicate that topics such as “Sustainable Urban Development”, “Economy and Scalability”, and “Data Infrastructure” occur more frequently in cities with larger populations.

However, the explanatory power of these findings is limited, as all examined cities are still in their pilot phase. As a result, it is not yet possible to determine whether the outlined strategies will lead to a successful transformation into smart cities or enable effective scaling processes. Expanding the dataset to include additional strategy documents could further improve the robustness and generalizability of the results. In the long term, this research aims to address its shortcomings and provide a foundation for stakeholders to develop more comprehensive strategies that support the transition from pilot projects to sustainable, scalable smart city solutions.

REFERENCES

- [1] T. Kuyper, "Smart city strategy & upscaling: Comparing barcelona and amsterdam," *Barcelona: Universitat Pompeu Fabra Barcelona School of Management*, 2016.
- [2] W. Van Winden and D. Van den Buuse, "Smart city pilot projects: Exploring the dimensions and conditions of scaling up," *Journal of Urban Technology*, vol. 24, no. 4, pp. 51–72, 2017.
- [3] J. Rabe *et al.*, "Scaling smart city solutions: A roadmap for municipalities," 2024.
- [4] L. Bettencourt and G. West, "A unified theory of urban living," *Nature*, vol. 467, no. 7318, pp. 912–913, 2010.
- [5] European Commission, "Scalable cities," 2024, [Online]. Available: <https://smart-cities-marketplace.ec.europa.eu/scalable-cities> (visited on 01/22/2026).
- [6] J. H. Lee, M. G. Hancock, and M.-C. Hu, "Towards an effective framework for building smart cities: Lessons from seoul and san francisco," *Technological Forecasting and Social Change*, vol. 89, pp. 80–99, 2014.
- [7] D. Beckers and L. Mora, "Overcoming the smart city governance challenge: An innovation management perspective," *Journal of Urban Technology*, vol. 32, no. 2, pp. 85–106, 2025.
- [8] M. E. Roberts *et al.*, "Structural topic models for open-ended survey responses," *American journal of political science*, vol. 58, no. 4, pp. 1064–1082, 2014.
- [9] N. Walravens, "Mobile business and the smart city: Developing a business model framework to include public design parameters for mobile city services," *Journal of theoretical and applied electronic commerce research*, vol. 7, no. 3, pp. 121–135, 2012.
- [10] M. Poli and A. J. Shenhar, "Project strategy: The key to project success," in *PICMET'03: Portland International Conference on Management of Engineering and Technology Technology Management for Reshaping the World*, IEEE, 2003, pp. 231–235.
- [11] M. Angelidou, "The role of smart city characteristics in the plans of fifteen cities," *Journal of Urban Technology*, vol. 24, no. 4, pp. 3–28, 2017.
- [12] W. Lafferty and E. Hovden, "Environmental policy integration: Towards an analytical framework," *Environmental politics*, vol. 12, no. 3, pp. 1–22, 2003.
- [13] N. Micozzi and T. Yigitcanlar, "Understanding smart city policy: Insights from the strategy documents of 52 local governments," *Sustainability*, vol. 14, no. 16, p. 10 164, 2022.
- [14] A. Meijer and M. P. R. Bolívar, "Governing the smart city: A review of the literature on smart urban governance," *International review of administrative sciences*, vol. 82, no. 2, pp. 392–408, 2016.
- [15] M. Kardos, "The reflection of good governance in sustainable development strategies," *Procedia-Social and Behavioral Sciences*, vol. 58, pp. 1166–1173, 2012.
- [16] M. Azzari, C. Garau, P. Nesi, M. Paolucci, and P. Zamperlin, "Smart city governance strategies to better move towards a smart urbanism," in *International Conference on Computational Science and Its Applications*, Springer, 2018, pp. 639–653.
- [17] L. Mora, P. Gerli, L. Ardito, and A. M. Petruzzelli, "Smart city governance from an innovation management perspective: Theoretical framing, review of current practices, and future research agenda," *Technovation*, vol. 123, p. 102 717, 2023.
- [18] R. W. S. Ruhlandt, "The governance of smart cities: A systematic literature review," *Cities*, vol. 81, pp. 1–23, 2018.
- [19] S. B. Letaifa, "How to strategize smart cities: Revealing the smart model," *Journal of business research*, vol. 68, no. 7, pp. 1414–1419, 2015.
- [20] S. Brorström, D. Argento, G. Grossi, A. Thomasson, and R. Almqvist, "Translating sustainable and smart city strategies into performance measurement systems," *Public Money & Management*, vol. 38, no. 3, pp. 193–202, 2018.
- [21] Y. Dai, S. Hasanefendic, and B. Bossink, "A systematic literature review of the smart city transformation process: The role and interaction of stakeholders and technology," *Sustainable Cities and Society*, vol. 101, p. 105 112, 2024.
- [22] R. Joslin and R. Müller, "The relationship between project governance and project success," *International journal of project management*, vol. 34, no. 4, pp. 613–626, 2016.
- [23] R. Müller and K. Jugdev, "Critical success factors in projects: Pinto, slevin, and prescott—the elucidation of project success," *International journal of managing projects in business*, vol. 5, no. 4, pp. 757–775, 2012.
- [24] A. J. Shenhar, D. Dvir, O. Levy, and A. C. Maltz, "Project success: A multidimensional strategic concept," *Long range planning*, vol. 34, no. 6, pp. 699–725, 2001.
- [25] G. M. Rueda, M.-C. Therrien, and J. Préval, "Smart cities governance: Governance models for sustainable smart cities," *Preprints.org*, 2024.
- [26] W. Castelnovo, G. Misuraca, and A. Savoldelli, "Smart cities governance: The need for a holistic approach to assessing urban participatory policy making," *Social Science Computer Review*, vol. 34, no. 6, pp. 724–739, 2016.
- [27] Z. A. Kaiser, "Smart governance for smart cities and nations," *Journal of Economy and Technology*, vol. 2, pp. 216–234, 2024.
- [28] I. ul Hassan, N. Ahmad, and B. Zuhaira, "Calculating completeness of software project scope definition," *Information and software technology*, vol. 94, pp. 208–233, 2018.
- [29] L. Mora, M. Deakin, and A. Reid, "Strategic principles for smart city development: A multiple case study analysis of european best practices," *Technological Forecasting and Social Change*, vol. 142, pp. 70–97, 2019.
- [30] P. Mupfumira, M. Mutingi, and M. Sony, "Smart city frameworks swot analysis: A systematic literature review," *Frontiers in Sustainable Cities*, vol. 6, p. 1 449 983, 2024.
- [31] C. Lucas *et al.*, "Computer-assisted text analysis for comparative politics," *Political Analysis*, vol. 23, no. 2, pp. 254–277, 2015.
- [32] Statista, "Gross domestic product (GDP) in Germany by federal states in 2024," Accessed on 27 January 2026; Data source: Statistical Offices of the Federation and the Federal States (Working Group on National Accounts of the Federal States), 2025, [Online]. Available: <https://de.statista.com/statistik/daten/studie/36889/umfrage/bruttoinlandsprodukt-nach-bundeslaendern/> (visited on 01/27/2026).
- [33] Federal Statistical Office (Destatis), "Population by nationality and federal states – non-german population as of 31 december 2023," Accessed on 27 January 2026; Results of the population update based on the 2011 census, 2024, [Online]. Available: <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/Tabellen/bevoelkerung-nichtdeutsch-laender.html> (visited on 01/27/2026).
- [34] R. Wolniak, B. Gajdzik, M. Grebski, R. Danel, and W. W. Grebski, "Business models used in smart cities—theoretical approach with examples of smart cities," *Smart Cities*, vol. 7, no. 4, pp. 1626–1669, 2024.