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Governance logics and government–industry–university collaboration: Comparative evidence from Singapore and Helsinki

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Abstract:
This study examines how distinct governance logics shape government–industry–university (GIU) collaboration in smart city development. Drawing on the Triple Helix Model of Innovation and Collaborative Governance Theory, it compares Singapore's state-oriented innovation framework and Helsinki's networked and participatory governance model. Findings show that Singapore's governance emphasizes strategic alignment, policy coherence, and coordinated implementation across sectors, whereas Helsinki's approach highlights iterative experimentation, stakeholder inclusiveness, and citizen engagement. The comparison demonstrates that GIU collaboration operates differently across governance systems but serves as a common mechanism for aligning diverse institutional resources. The study concludes that effective innovation governance depends on balancing coordination capacity and reflexive adaptability, offering insights for developing hybrid models that integrate coherence with participatory experimentation.

1. Introduction

In recent years, the rapid development of digital technologies and the Fourth Industrial Revolution have significantly influenced how governments, industries, and universities collaborate to promote innovation and sustainable development. The government–industry–university (GIU) collaboration framework—often conceptualized as the "triple helix" of innovation—has become a central mechanism for integrating diverse resources, accelerating knowledge transfer, and enhancing governance capacity (Etzkowitz & Leydesdorff, 2000). Within this framework, cities have emerged as critical arenas where technological innovation and institutional transformation intersect (Selada, 2017).

The concept of the smart city epitomizes this intersection, representing not only the application of data-driven technologies for urban management but also a broader shift toward adaptive and collaborative governance (Kitchin, 2014; Meijer & Bolívar, 2016). Smart city development increasingly depends on the effective alignment of state leadership, market participation, and academic expertise to generate innovative solutions for complex urban challenges.

Among global examples, Singapore and Helsinki have drawn particular attention for their distinctive approaches to GIU collaboration. Singapore's Smart Nation initiative reflects a state-led model anchored in centralized coordination, policy coherence, and national strategic direction (Woo, 2018; Mukherjee & Ho, 2025). In contrast, Helsinki's City as a Testbed initiative exemplifies a networked and experimental

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governance model, facilitated by Forum Virium Helsinki, emphasizing agile piloting, open innovation, and active citizen co-creation (Gemein et al., 2024; Huang & Villari, 2020).

While these two cities differ in institutional settings and governance traditions, both represent distinct pathways toward innovation-driven urban governance. Their models reflect divergent institutional logics—hierarchical integration in Singapore versus distributed experimentation in Helsinki—that shape collaborative processes and innovation outcomes. By comparing these cases, this study examines how distinct governance arrangements influence the configuration and functioning of government–industry–university (GIU) collaboration in the context of smart city development.

2. Conceptual and theoretical framework

2.1 Literature review

As cities respond to complex challenges driven by technological, social, and environmental transformations, government–industry–university (GIU) collaboration has become an important mode of governance. Rather than treating GIU partnerships merely as vehicles for technological innovation, recent scholarship emphasizes their broader institutional role in shaping governance structures, steering capacity, and stakeholder coordination (Jiang et al., 2022; Anttiroiko, 2023).

In the urban governance literature, scholars have suggested two prominent models of government–industry–university (GIU) collaboration. The state-led model, often discussed in the context of East Asian developmental states, typically involves central governments playing a coordinating role in multi-sector partnerships through hierarchical planning, national strategies, and top-down policy instruments (Woods et al., 2025). In contrast, the experimental or networked model tends to emphasize iterative processes and participatory procedures involving diverse urban actors, such as universities and civic organizations, often embedded in urban living labs and experimentation initiatives (Raven et al., 2019).

In the Singaporean context, GIU collaboration operates within a relatively centralized and state-coordinated governance framework. Instead of functioning autonomously, universities and industries are often embedded in national innovation ecosystems through state-led policy frameworks, formalized institutional arrangements, and long-term strategic planning (Loke et al., 2017; Pan, 2016). While this strong governmental steering may enhance coherence and implementation efficiency, it can also pose constraints on bottom-up innovation and limit opportunities for broader public deliberation (Hartley et al., 2018). Universities in Singapore are not simply instrumentalized by the state, but are strategically aligned with national economic and innovation priorities, reflecting a state-centric model of coordinated transformation.

Conversely, governance in Helsinki tends to follow a more decentralized and facilitative model. Rather than directing through hierarchical mechanisms, local governments often support open-ended collaboration among universities, start-up companies, and civil society actors. In this context, universities may function not only as research institutions but also as co-designers and experimental agents within living labs and co-creation platforms (Anttila & Jussila, 2018). Such arrangements are indicative of a broader orientation toward adaptive and participatory governance, where legitimacy is shaped by inclusiveness, responsiveness, and iterative engagement, rather than top-down authority (Jiang, 2021).

These contrasting governance models are shaped by distinct histories and political cultures. Singapore's coordinated model reflects enduring features of its developmental state legacy, characterized by strong bureaucratic steering, centralized decision-making, and a long-standing emphasis on technocratic policy planning (Woo, 2018; Zhuang, 2025). By contrast, Helsinki's networked governance is rooted in the Nordic tradition of welfare-state governance, where trust-based networks, civic participation, and local autonomy are central (Anttiroiko, 2023; Shamsuzzoha et al., 2021). This divergence in institutional logic informs not only how GIU collaborations are structured but also how legitimacy, agency, and innovation are conceived in each context.

Recent comparative studies suggest that no governance model is universally superior across all contexts. Instead, increasing attention has been given to hybrid arrangements that seek to integrate the coherence and institutional capacity of state-led systems with the adaptability and inclusiveness characteristic of experimental or bottom-up governance (Dinata et al., 2024). These hybrid forms are considered potentially effective in contexts aiming to reconcile centralized coordination with local-level innovation and participation. Nonetheless, further empirical research is needed to better understand the stability and effectiveness of such models across diverse political and institutional environments.

In conclusion, the literature suggests that GIU collaboration extends beyond being a mere technical or organizational tool; it is a governance process that is intricately shaped by political, institutional, and cultural contexts. Examining its various configurations in cities like Singapore and Helsinki provides useful comparative insights for the development of urban governance models that are more responsive to local environments and capable of adapting to the challenges posed by rapid societal and technological transformations.

2.2 Analytical framework for comparative analysis

The theoretical foundation of this study is based on the Triple Helix Model of Innovation (Etzkowitz & Leydesdorff, 2000). This model conceptualizes innovation as the result of dynamic interactions between government, industry, and universities. Unlike the traditional linear model of knowledge production, in which research, application, and regulation occur in separate institutional domains, the Triple Helix emphasizes the hybridization of roles and the co-evolution of institutions. In this model, governments no longer merely regulate; they act as catalysts and coordinators. Industries transcend market competition to engage in co-creation and experimentation, while universities expand their functions from knowledge producers to innovation intermediaries and policy partners. This hybridization facilitates greater flexibility and responsiveness, enabling innovation through the convergence

of institutional roles.

In parallel, collaborative governance theory (Ansell & Gash, 2008; Emerson & Nabatchi, 2015) provides an analytical lens for understanding how diverse actors coordinate in a shared decision-making process to achieve public goals. This theory outlines four key elements that are crucial for successful collaboration: shared motivation, joint capacity, institutional arrangements, and collaborative dynamics. Shared motivation refers to a sense of mutual trust and commitment among the involved actors. Joint capacity involves the resources and knowledge that enable effective cooperation. Institutional arrangements include the rules and norms that structure interaction, while collaborative dynamics highlight the iterative cycles of dialogue, action, and adaptation. These elements explain how different stakeholders—government, industry, and academia—cooperate to address complex urban challenges, such as those in the context of smart cities.

The integration of the Triple Helix Model and collaborative governance theory offers a comprehensive theoretical foundation for analyzing how innovation ecosystems are governed through multi-actor collaboration. Building on these perspectives, the study develops a comparative framework that contrasts two archetypal models of governance in innovation ecosystems: a state-led model characterized by centralized coordination and strategic planning, and an experimental model shaped by localized initiatives, data-driven platforms, and iterative processes of co-creation.

To enable a systematic comparison between the state-led and experimental governance models, this study adopts three analytical dimensions—collaborative goals, actor roles, and coordination mechanisms. These dimensions emerge from the synthesis of the Triple Helix Model, which emphasizes institutional hybridization and innovation dynamics among government, industry, and universities, and collaborative governance theory, which highlights the procedural and relational conditions necessary for effective multi-actor coordination. Together, these frameworks offer a conceptual basis for examining how different governance logics shape the structure and function of government–industry–university collaboration.

The dimension of collaborative goals addresses the strategic orientation and underlying rationale for multi-actor engagement. In state-led governance models, collaboration is typically oriented toward national objectives such as economic competitiveness, technological advancement, and innovation-driven growth. These goals reflect centralized planning logics, where collaboration serves to align universities and industries with state priorities through top-down coordination. Conversely, in experimental governance settings, collaborative goals tend to be more localized, adaptive, and socially embedded. They prioritize sustainability, social inclusion, and citizen well-being, emphasizing participatory processes and co-creation as central mechanisms for innovation.

The dimension of actor roles concerns how responsibilities are distributed among the key stakeholders—government agencies, industries, and academic institutions. The Triple Helix Model describes how the roles of these actors evolve in response to changing institutional needs. In state-led governance models, the government typically assumes a central coordinating role, exercising authority through policy instruments, strategic planning, and performance targets. Universities and industries, in turn, are aligned with predefined national priorities. By contrast, experimental governance configurations tend to exhibit polycentric structures in which responsibilities are shared across city governments, research organizations, private firms, and sometimes civil society actors.

The dimension of coordination mechanisms addresses the institutional and procedural arrangements through which collaboration is enacted, structured, and sustained. In state-led systems, coordination is largely hierarchical, relying on formalized rules, regulatory frameworks, and long-term strategic planning. From a Triple Helix perspective, such coordination reinforces state-led integration of university and industry efforts under national innovation agendas. In contrast, experimental governance models employ more flexible and iterative coordination processes. These often include urban living labs, pilot projects, open data infrastructures, and digital platforms that facilitate real-time feedback, knowledge exchange, and participatory experimentation. Collaborative governance theory emphasizes such arrangements as enabling continuous learning and adaptive management.

Integrating the three analytical dimensions, this study develops a comparative framework that links institutional logics to collaborative practices. The framework highlights how different governance types—specifically, state-led and experimental models—structure the processes and purposes of government–industry–university (GIU) collaboration. Applied to the cases of Singapore and Helsinki, the framework enables a systematic comparison of how governance structures mediate the dynamics of collaboration across sectors. Through this comparative lens, the study seeks to generate context-sensitive insights into the enabling conditions and potential limitations of different governance approaches.

In this study, three related but distinct governance logics—networked, experimental, and participatory—are employed to describe different modes of coordination. Networked governance emphasizes the structural dimension of coordination, highlighting horizontal linkages, inter-organizational interdependence, and collaborative resource exchange among government, industry, and academia. Experimental governance centers on the procedural and learning dimension, focusing on iterative testing, reflexive adaptation, and policy experimentation under conditions of uncertainty. Participatory governance underscores the normative and institutional dimension, prioritizing inclusiveness, transparency, and co-production of legitimacy through stakeholder engagement in decision-making processes. In practice, they often overlap and reinforce one another: experimental initiatives typically depend on networked coordination and frequently incorporate participatory elements to ensure social legitimacy.

3. Research design and methodology

This study employs a comparative qualitative case study design to examine the mechanisms of government–industry–university (GIU) collaboration under two distinct governance contexts: Singapore's state-led model and

Helsinki's experimental urban governance. A comparative approach is well suited to exploring institutional diversity and identifying patterns of coordination and collaboration across different political and administrative systems. By juxtaposing these analytically contrasting cases, the study seeks to develop a nuanced understanding of how governance logics influence the organization and operation of collaborative innovation within smart city initiatives.

Following a most-different systems design (MDSD) logic, the cases were selected because they differ substantially in political structure, administrative culture, and governance traditions, while sharing a comparable policy orientation toward innovation-driven urban development. This design facilitates analytical generalization and enables reflection on how distinct institutional contexts shape the structures and processes of GIU collaboration.

Despite their differences in political scale and administrative structure—Singapore being a city-state and Helsinki a municipal city within a nation-state—the two cases remain comparable in the context of smart city governance for several reasons. First, both can be regarded as functional innovation ecosystems in which local governments possess a considerable degree of autonomy in designing and implementing digital transformation strategies. Second, each has been positioned as a national or regional demonstration site for smart city policy diffusion, linking urban experimentation to broader processes of governance reform. Third, the cases embody distinct governance logics—centralized coordination in Singapore and distributed experimentation in Helsinki—thereby providing analytically meaningful contrasts for understanding how institutional design conditions collaborative innovation.

Data collection relied primarily on documentary and secondary sources. Official policy documents and strategic plans provide the strategic context for understanding each city's innovation agenda. Institutional and organizational reports, including those from A*STAR, Forum Virium Helsinki (FVH), and the National Research Foundation (NRF), offer insights into operational frameworks and institutional arrangements. In addition, academic and gray literature—comprising peer-reviewed journal articles, working papers, and policy briefs—was reviewed to situate each case within the broader scholarly and policy discourse. Digital and secondary sources such as open data platforms were also analyzed to obtain complementary information on collaborative initiatives and governance practices.

The collected data were analyzed through manual thematic analysis, guided by the three analytical dimensions derived from the theoretical framework: collaborative goals, actor roles, and coordination mechanisms. The analysis proceeded in three stages. First, a within-case analysis was conducted to map the institutional context, governance logic, and collaborative structures of each city. Second, a cross-case comparison was undertaken to identify key differences and commonalities between the two governance models. Finally, a synthetic interpretation integrated findings from both cases, highlighting how different governance configurations shape the patterns and practices of GIU collaboration.

All materials used in this study were drawn from publicly available and institutionally published sources. To enhance analytical credibility, multiple forms of evidence were triangulated, and consistency in interpretation was maintained across both cases. Although the study is qualitative in nature and does not aim for statistical generalization, it provides in-depth insights into institutional variation and collaborative practice. Future research could extend this analysis by incorporating fieldwork or interviews to further explore informal and processual aspects of GIU collaboration.

4. Singapore: A state-led collaboration model anchored in national strategy

As a city-state with limited natural resources, Singapore has consistently viewed technological innovation as essential to overcoming developmental constraints and maintaining its status as a global hub. The government's strategic execution capacity has facilitated the steady advancement of technologies such as autonomous mobility and the Internet of Things (IoT), resulting in an advanced infrastructure network encompassing smart transport, energy grids, water systems, and communication. In the 2025 IMD World Digital Competitiveness Ranking, Singapore placed second globally and ninth in the Smart City Index (Smart Nation Singapore, 2025). The country's smart city agenda reflects an extension of its national strategy into urban governance where the government plays both the role of strategic architect and coordinating authority. This has led to a vertically integrated collaboration structure driven by policy, with clear responsibilities at each level.

4.1 Collaborative goals: Advancing national competitiveness and policy coherence

The core driver of Singapore's smart city development lies in national strategic priorities. The 2006 Intelligent Nation 2015 plan focused on ICT infrastructure and digital inclusion, while the launch of Smart Nation 2025 in 2014—also known as "Smart Nation 1.0"—shifted the focus from infrastructure to a data-driven national system built on the principles of connection, collection, and comprehension. This framework aimed to create an integrated platform for data collection, connectivity, and analytics, enabling anticipatory and personalized public services (Prime Minister's Office Singapore, 2014). In 2024, the government introduced Smart Nation 2.0, with a vision of "creating a thriving digital future for all" underpinned by three key pillars: Trust, Growth, and Community (Ministry of Digital Development and Information Singapore, 2024).

Throughout these stages, Singapore has consistently positioned digital transformation as a key element of its national competitiveness strategy and as a global reference point for digital governance. The goals of GIU collaboration align closely with the implementation of the Smart Nation agenda, reflecting a governance logic that prioritizes efficiency, resilience, and innovation, where collaboration serves the overarching objectives of national adaptability and global positioning.

4.2 Actor roles: Vertically integrated governance and institutional role alignment

Within Singapore's Smart Nation system, the government serves as both the central coordinator and institutional driver. Since 2014, the Smart Nation and Digital Government Office (SNDGO), under the Prime Minister's Office, together with GovTech, has been responsible for digital strategy formulation, standard setting, and the development of public digital infrastructure (Woo, 2018). Key initiatives, such as the National Digital Identity (SingPass), electronic payment systems, the National Sensor Platform, and the Moments of Life (Lee Kuan Yew School of Public Policy, 2018), form the foundation of Singapore's digital governance framework, enabling cross-agency coordination and efficient public service delivery.

The National Research Foundation (NRF) manages the national research and innovation system under the Research, Innovation and Enterprise (RIE) framework (National Research Foundation Singapore, 2025). It aligns research investments with national priorities and funds programs like the Corporate Laboratory initiative, which encourages collaboration between universities, research institutes, and industries to address strategic challenges (National Research Foundation Singapore, 2025). Through such arrangements, the government ensures systemic coherence and mobilizes resources to achieve the objectives of the Smart Nation initiative.

Universities and research institutes are the intellectual and human capital backbone of this system. Institutions like the National University of Singapore (NUS) have aligned their research strengths in areas such as data science, AI, and cybersecurity with national digital agendas. Programs such as Campus as a Living Lab allow universities to transform their campuses into experimental platforms for testing solutions in sustainable energy, transportation, and urban management. Supported by NRF funding, universities collaborate with public agencies and industries to translate research into practical solutions for sustainable urban and industrial development (National Research Foundation Singapore, 2025). As the Smart Nation 2.0 Report (2024) highlights, enrollment in information and digital technology programs grew by 40% between 2017 and 2023 (Ministry of Digital Development and Information Singapore, 2024), underscoring the critical role of universities in digital talent cultivation.

Enterprises are central to the technological realization and market-driven growth of Singapore's Smart Nation ecosystem. Government policy encourages firms to collaborate with academic and public institutions to commercialize research into practical digital solutions. For example, the Sembcorp-NTU Joint Laboratory, with an investment of SGD 61 million, focuses on digitalization and green technologies for urban sustainability (Nanyang Technological University, 2018). Telecommunications and technology firms, such as Singtel and ST Engineering, actively participate in national IoT, AI, and smart transport projects, driving the digital transformation of public services (Singtel, 2023; Agency for Science, Technology and Research Singapore, 2019). These partnerships position firms not only as suppliers but as key actors in accelerating technology transfer, industrial upgrading, and economic diversification.

4.3 Coordination mechanisms: Government-led networks and hierarchical integration

The hallmark of Singapore's GIU collaboration is a multi-layered innovation system anchored in robust governmental leadership. The state is responsible for high-level planning, institutional design, and resource coordination, while universities and enterprises operate within a shared strategic framework. The SNDGO and GovTech serve as central coordinating bodies, steering national projects, developing common data infrastructures, and overseeing policy implementation. This integrated approach systematically links research and innovation to national objectives, ensuring a smooth transition from knowledge production to societal application.

Collaboration within this system follows a dynamic interaction between top-down planning and bottom-up response. The government sets strategic priorities and defines public service needs, guiding research direction and technological application. Universities contribute fundamental research, policy analysis, and talent development, while enterprises focus on applied innovation and commercialization. Their interaction is facilitated by cross-agency coordination, competitive research funding, and shared digital platforms such as Data.gov.sg and the API Exchange. These infrastructures enable efficient knowledge exchange and data interoperability, fostering a cohesive innovation ecosystem that integrates research, governance, and market development.

In summary, Singapore's model demonstrates how a state-led governance structure can integrate public, private, and academic capacities into a highly coordinated system of collaborative innovation. The model prioritizes coordination, efficiency, and strategic alignment, reflecting a national philosophy of adaptive governance and long-term capacity building.

5. Helsinki: A networked and experimental collaboration model centered on urban co-creation

As a leading example of "smart governance" in the Nordic region, Helsinki has long regarded smart city development as key to promoting urban sustainability and public innovation. Unlike centralized, national-level planning, Helsinki's smart city strategy is driven by local government leadership and supported through collaboration among diverse social actors within an open governance framework. Through innovation funds, experimental zones, open data policies, and cross-sector collaborative networks, Helsinki has established an open innovation model centered around the concept of "the city as a living lab". In this model, the government acts both as the "institutional provider" and "experiment facilitator", integrating universities and enterprises into a citywide co-creation network. Helsinki ranks eighth globally in the Smart City Index and leads the European Union in digital economy development, with citizens ranking first worldwide in digital skills (Helsinki Smart Region, 2025).

5.1 Collaborative goals: Promoting citizen well-being and sustainable urban innovation

Helsinki's smart city strategy is driven by a citizen-centered digital vision. In 2002, the city government established the Innovation Fund to provide early-stage funding for digital and social innovation projects, focusing on solutions for public services, urban environments, and social inclusion. This fund aimed to pilot the application of emerging technologies in public governance and social services (City of Helsinki, 2022). In 2013, Helsinki introduced the Smart Kalasatama project, which envisioned giving residents "one hour more a day" through smart transportation, energy management, and co-creation initiatives aimed at improving urban efficiency and quality of life (Forum Virium Helsinki, 2021).

The success of the Kalasatama model cemented the concept of the "City as a Testbed", viewing urban space as an open environment for innovation. This idea has since expanded to other districts, such as Pasila, Mellunkylä, Malmi, and Malminkartano-Kannelmäki, forming a citywide testing network (Forum Virium Helsinki, 2021). Through the Testbed Helsinki platform, Helsinki integrates innovations in edtech, smart mobility, built environment, circular economy, and health & wellbeing into a collaborative urban innovation system (City of Helsinki, 2021). In the city's 2021–2025 strategy, Helsinki aims to become "the most functional city in the world", with a vision focused on sustainable growth, innovation, and digital transformation. The ultimate goal of the collaboration among government, industry, academia, and society is to achieve balance across economic, social, and ecological dimensions, enhancing inclusion and citizen welfare through digital and open innovation (City of Helsinki, 2021).

5.2 Actor roles: Multi-level networks and distributed collaborative responsibilities

Helsinki's smart city governance relies on a multi-layered network where the government plays a central coordinating role. The Forum Virium Helsinki (FVH) serves as the innovation hub, linking universities, businesses, and citizen communities in an innovation network. The city government acts as the strategic leader and resource integrator, playing a crucial role in promoting innovation ecosystems, attracting investment, and coordinating the implementation of innovation projects. Through the Innovation Fund, the government supports pilot projects that enhance the city's knowledge base and business infrastructure. These projects, funded in collaboration with city departments, universities, enterprises, and associations, must align with Helsinki's urban strategy, with at least one government agency involved in each initiative (City of Helsinki, 2022). Open data policies provide shared resources for businesses and research institutions, ensuring the sustainability of innovation experiments (Forum Virium Helsinki, 2025).

Forum Virium Helsinki (FVH), a city-owned innovation company, serves as the implementation platform for urban innovation. It acts as both the initiator and coordinator of projects, providing a "living lab" for testing digital innovations and fostering public-private collaborations. FVH connects the government's strategic goals with urban experimentation, integrating academic research, business innovation, and citizen feedback into a cohesive collaboration mechanism. This approach ensures that smart city innovations move beyond design and enter the application and testing phases. Since its inception in 2006, FVH has led numerous smart city projects that test transportation, energy, and service innovations in real urban environments, offering testing platforms for businesses and policy validation data for the government.

Universities and research institutions in Helsinki are shifting from traditional "knowledge providers" to institutional participants in collaborative governance. The role of universities is central in knowledge production and policy support for urban decision-making. The Helsinki Institute of Urban and Regional Studies (Urbaria) focuses on interdisciplinary issues such as people, places, and politics, aiming to translate academic research into evidence-based urban governance recommendations (University of Helsinki, 2025). The institute, through research briefs and policy reports, serves as a key knowledge source for municipal research collaboration and policy development. Helsinki also widely employs the "living lab" model, embedding academic research in real-world urban settings. Universities such as Aalto University, the University of Helsinki, and the VTT Technical Research Centre of Finland collaborate with FVH and the city government to build research and testing platforms for advancing cutting-edge urban applications (City of Helsinki, 2024).

In Helsinki's smart city ecosystem, enterprises and citizen communities are deeply involved in urban governance through open innovation mechanisms. The Testbed Helsinki platform, established by the city government, provides a real urban environment for testing new technologies and services, facilitating collaboration between startups and government departments (City of Helsinki, 2025). Simultaneously, citizens are regarded as co-creators in smart city projects, participating in design, feedback, and testing phases to co-shape the social value of technological applications. In the Smart Kalasatama project, over 200 stakeholders—including residents, businesses, municipal officials, and researchers—collaborated in joint experiments, cultivating a "user-to-co-creator" innovation culture (Fiksu Kalasatama, 2015).

5.3 Coordination mechanisms: Experimental governance through the "City-as-a-Testbed" ecosystem

Helsinki's smart city coordination mechanisms are defined by its experimental governance approach, where the city serves as an open platform for continuous testing and co-creation (Lazarevic et al., 2024). Through open data, cross-departmental collaboration, and citizen participation, Helsinki achieves an iterative alignment of policy-making, technological innovation, and social experimentation. The "City as a Testbed" concept transforms urban public spaces into real-world environments for testing technologies and social innovations. The Testbed Helsinki platform, coordinated by the City Executive Office's Economic Development Department, serves as the key mechanism for this approach, collaborating with

Table 1. Comparative analysis of GIU collaboration mechanisms in Singapore and Helsinki.

Comparison Dimensions	Singapore	Helsinki
Governance Model	State-led, Centralized	Local, Networked
Governance Logic	Strategy-driven, Top-down	Demand-driven, Bottom-up
Strategic Goals	National competitiveness and public governance efficiency	Social inclusion and sustainable innovation
Core Institutions	SNDGO / GovTech	City of Helsinki / FVH
Actor Roles	Government-led, with academic and industry involvement	Government-guided, with innovation agencies coordinating multi-stakeholder co-creation
Collaboration Structure	Vertical integration	Networked collaboration
Key Mechanisms	National strategy, centralized resources	Testbed experiments, agile piloting

municipal departments and businesses across the Helsinki City Group. FVH plays a central role in coordinating testing and co-creation activities, utilizing platforms like the Helsinki Region Infoshare (HRI) to provide open public data that facilitates cross-sector collaboration.

The platform focuses on five key areas: educational technology, smart mobility, the built environment, circular economy, and health and wellbeing (City of Helsinki, 2021). It offers data, space, and policy support to enterprises and universities, enabling innovation projects to rapidly iterate in real urban environments. Helsinki's agile piloting innovation mechanism, characterized by short pilot cycles (≤ 6 months), accelerates the testing of new services and technologies (Smart Kalasatama, 2015). Since 2013, FVH has implemented more than 50 agile pilot projects. These thematic piloting rounds have ranged from climate positive solutions to education, mobility and wellbeing, making it a model of experimental governance that has been adopted and promoted by other cities globally (Spilling & Rinne, 2020).

The innovation system, supported by a multi-layered network of government strategy, public institutions, academic research, and citizen co-creation, operates through FVH as a cross-domain intermediary. Through projects such as Helsinki Innovation Districts, the city has expanded its model to new districts such as Mellunkylä and Malmi, creating a dynamic network of experimentation, diffusion, and re-experimentation.

6. Comparative analysis of governance models and collaboration mechanisms

Following the distinction between hierarchical and networked governance proposed by Meijer & Bolívar (2016), Singapore and Helsinki exemplify two archetypal forms of government–industry–university (GIU) collaboration. Table 1 presents a comparative analysis of their collaboration mechanisms, summarizing the key differences in governance models, logics, and strategic orientations. Singapore reflects a state-led, centralized approach driven by national strategy, characterized by top-down coordination and a vertically integrated structure. In contrast, Helsinki operates through a networked, experimental governance model, with an emphasis on local autonomy, social collaboration, and horizontal coordination. Both models are institutionally embedded but reflect different governance priorities and strategic orientations: national competitiveness in Singapore and social innovation in Helsinki.

Singapore's governance model operates through a technocratic and top-down logic, as critical analyses of the Smart Nation initiative have shown (Ho, 2017). The government acts as a central orchestrator within the Smart Nation architecture, coordinating policy design, technological development, and cross-ministerial data integration to strengthen national competitiveness (Chong, 2021; Lim, 2019). In contrast, Helsinki adopts a participatory and experimental governance model supported by public sector facilitation, emphasizing citizen engagement and co-creation (Anttiroiko, 2016). Through the City as a Testbed framework, enterprises, universities, research institutions, and residents collaborate within publicly supported innovation platforms, co-developing solutions for sustainable urban transformation and fostering a collaborative environment for innovation.

Institutional arrangements further reveal distinct configurations of collaboration. Singapore exemplifies a centralized and policy-driven governance model, where the SNDGO defines strategic priorities and GovTech operationalizes digital transformation initiatives. Collaboration with universities and enterprises occurs within government-defined frameworks, primarily to provide research and technical expertise for national projects. Although participatory mechanisms exist, citizen engagement remains largely consultative rather than co-creative (Woo, 2018). Conversely, Helsinki represents a distributed, multi-actor governance ecosystem characterized by shared responsibility and iterative experimentation. The City of Helsinki provides strategic oversight, while FVH facilitates coordination among public agencies, private firms, universities, and residents. This networked arrangement fosters open data sharing, agile piloting, and iterative learning through co-creation spaces such as the Testbed Helsinki platform.

The collaborative mechanisms in these cities reflect distinct innovation dynamics. In Singapore, government–industry–university collaboration adopts a centrally coordinated, outcome-oriented governance approach that emphasizes efficiency and measurable performance (Venkat et al., 2014; Lee Kuan Yew School of Public Policy, 2018). Centralized data platforms, unified and interoperable infras-

tructures, and integrated service delivery systems reflect the state's pivotal role in orchestrating digital transformation across government agencies. By contrast, Helsinki adopts a more iterative and exploratory approach based on a "test–feedback–diffusion" process, where pilot initiatives serve as learning laboratories for scaling innovation (Forum Virium Helsinki, 2021; Sayún, 2020). The Smart Kalasatama district illustrates how small-scale experiments evolve into institutionalized practices through reflexive governance and collaborative co-creation.

Conclusion and discussion

This study explored how distinct governance logics shape the configuration and functioning of government–industry–university (GIU) collaboration in smart city development. Drawing upon the Triple Helix Model of Innovation and collaborative governance theory, it compared Singapore and Helsinki as analytically contrasting cases that broadly represent state-led and networked models of innovation governance. The comparative perspective illuminates how innovation ecosystems are embedded within broader political–institutional contexts, thereby generating distinct patterns of coordination, legitimacy, and collective learning.

The findings reveal that the organization of GIU collaboration is shaped by historically grounded governance capacities and institutional legacies. Rather than a simple dichotomy between hierarchy and participation, Singapore and Helsinki exemplify alternative pathways of multi-actor coordination. Singapore's centralized model demonstrates how policy coherence and hierarchical alignment can sustain strategic coordination, translating national priorities into innovation agendas. By contrast, Helsinki's networked configuration highlights the value of iterative experimentation and cross-sectoral interaction in embedding innovation within local contexts and enhancing social legitimacy.

By integrating the Triple Helix framework with collaborative governance theory, this study advances understanding of how institutional design interacts with processual dynamics in innovation ecosystems. Earlier studies emphasized the co-evolution among universities, industries, and governments as structural foundations of innovation (Etzkowitz & Leydesdorff, 2000), whereas recent research has increasingly highlighted the governance foundations of coordination—showing that coherence, cross-actor alignment, and the effectiveness of policy mixes depend on the institutional arrangements and interaction processes through which coordination is enacted (Flanagan et al., 2011; Rogge & Reichardt, 2016).

The comparative analysis suggests that effective innovation governance depends on balancing structural coherence and process adaptability. Strong coordination mechanisms enhance implementation capacity, but excessive centralization may suppress feedback and adaptive learning (Ansell & Gash, 2008; Emerson et al., 2012). Conversely, participatory and experimental arrangements foster creativity and legitimacy but may risk fragmentation and weak integration (Sørensen & Torfing, 2011; Kuhlmann & Rip, 2018).

By situating the Triple Helix within the broader framework of collaborative governance, this study bridges the gap between structural coordination and relational collaboration. It further refines the conceptual link between governance logic and collaborative outcomes, showing that distinct combinations of motivation, institutional arrangements, and interaction dynamics can yield functionally equivalent yet contextually specific innovation systems. This theoretical pluralism highlights the importance of contextual sensitivity when applying governance models across political systems. Ultimately, innovation governance emerges as a dynamic capability that enables collective learning and adaptability within complex socio-technical environments.

The comparative analysis of Singapore and Helsinki indicates that the governance of smart city innovation is not adequately captured by a universal model or fixed institutional design. Rather, it unfolds as a context-dependent process in which coherence and adaptability are continually negotiated in response to political, social, and technological contingencies. Sustainable innovation, therefore, relies less on specific policy instruments than on the institutional capacity for coordination and collective learning across organizational and sectoral boundaries. Conceiving innovation governance as a form of collective intelligence—rooted in both strategic alignment and reflexive experimentation—underscores its dual function as a stabilizing framework and a generative mechanism. In this sense, the central challenge for contemporary urban governance lies in maintaining this delicate balance, enabling cities to evolve as adaptive and learning systems within increasingly complex innovation ecosystems.

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Conflict of interest

The author declares no conflict of interest.

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