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A Sequential Model of Dynamic Capabilities in Research Groups and Their Impact on Smart City Development

Un modelo secuencial de capacidades dinámicas en los grupos de investigación y su impacto en el desarrollo de ciudades inteligentes

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ABSTRACT

Objective: The aim of this study was to evaluate the systematic influence of the sensing, learning, integrating, and coordinating dimensions of dynamic capabilities on smart cities. Since dynamic capabilities have been examined mainly from the perspective of improving business performance, their relationship with smart cities has received little attention in the scientific literature.
Design/Methodology: A correlational methodology with a quantitative approach was employed. The study proposed hypotheses about the relationships between the sensing, learning, integration, and coordinating capabilities and their impact on smart cities. These relationships were assessed in 82 research groups in Manizales, Colombia, through a structural equation model estimated using the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique.
Findings: The results indicate that the dynamic capabilities developed by research groups exert a systematic, positive, and significant influence on smart city development. In addition, the constructs analyzed met the criteria for convergent and discriminant validity, and the model demonstrated acceptable predictive power.
Conclusions: Dynamic capabilities are interdependent and evolve through a cumulative process in which research groups identify opportunities, acquire and manage knowledge, integrate this knowledge into strategic decision-making, and coordinate resources to generate innovations with an impact on urban environments. Therefore, the development and implementation of dynamic capabilities within research groups, aligned with public agendas, are essential to strengthen the shift toward smart cities.
Originality: This study extends the analysis of dynamic capabilities within research organizations. Furthermore, it underlines the role of contextual learning and resource orchestration in fostering responsiveness and innovation across urban ecosystems.

Keywords: dynamic capabilities, smart cities, research groups, Partial Least Squares Structural Equation Modeling (PLS-SEM), knowledge integration.

Highlights

- A sequential model of dynamic capabilities for smart cities is developed and applied to research groups in a Latin American city.
- Smart cities development is positively influenced by an organized sequence of sensing, learning, integrating, and coordinating capabilities developed within research groups.
- Supporting research groups in strengthening their dynamic capabilities is essential to promote urban transformation toward smart cities.
- Collaboration between urban managers and research groups that deploy their dynamic capabilities in a coordinated manner constitutes a fundamental management strategy for consolidating smart cities.

RESUMEN

Objetivo: el objetivo de este estudio fue evaluar la influencia sistemática de las dimensiones de detección, aprendizaje, integración y coordinación de las capacidades dinámicas en las ciudades inteligentes. Debido a que las capacidades dinámicas se han estudiado principalmente desde la perspectiva de la mejora del desempeño empresarial, su relación con las ciudades inteligentes ha recibido escasa atención en la literatura científica.
Diseño/Metodología: se adoptó una metodología correlacional con enfoque cuantitativo. Se plantearon hipótesis de las relaciones entre las capacidades de detección, aprendizaje, integración y coordinación, así como su impacto en las ciudades inteligentes. Estas relaciones fueron evaluadas en 82 grupos de investigación de la ciudad de Manizales (Colombia) a través de un modelo de ecuaciones estructurales estimado mediante la técnica modelado de ecuaciones estructurales por mínimos cuadrados parciales (PLS-SEM, por sus siglas en inglés).
Resultados: los hallazgos indican que las capacidades dinámicas desarrolladas por los grupos de investigación ejercen una influencia sistemática, positiva y significativa en el desarrollo de ciudades inteligentes. Asimismo, los constructos analizados cumplieron con los criterios de validez convergente y discriminante, y el modelo mostró un nivel de capacidad predictiva aceptable.
Conclusiones: las capacidades dinámicas son interdependientes y evolucionan mediante un proceso acumulativo donde los grupos de investigación detectan oportunidades, adquieren y gestionan conocimiento, integran dicho conocimiento en la toma de decisiones estratégicas y coordinan recursos para generar innovación con impacto en los entornos urbanos. Por lo tanto, el desarrollo y la aplicación de capacidades dinámicas en los grupos de investigación, alineadas con las agendas públicas, resultan fundamentales para fortalecer la transformación hacia ciudades inteligentes.
Originalidad: este estudio extiende el análisis de las capacidades dinámicas en el contexto de las organizaciones de investigación. Además, subraya el papel del aprendizaje contextual y la orquestación de recursos para fomentar la capacidad de respuesta y la innovación en los ecosistemas urbanos.

Palabras clave: capacidades dinámicas, ciudades inteligentes, grupos de investigación, modelado de ecuaciones estructurales por mínimos cuadrados parciales (PLS-SEM), integración del conocimiento.

Highlights

- Se propone un modelo secuencial de capacidades dinámicas para ciudades inteligentes y se aplica a grupos de investigación de una ciudad latinoamericana.
- El desarrollo de ciudades inteligentes se fortalece a partir de una secuencia articulada de capacidades dinámicas de detección, aprendizaje, integración y coordinación desarrolladas en los grupos de investigación.
- El fortalecimiento de las capacidades dinámicas en los grupos de investigación constituye un elemento esencial para promover procesos de transformación hacia ciudades inteligentes.
- La colaboración entre gestores urbanos y grupos de investigación que desplieguen sus capacidades dinámicas de forma articulada emerge como una estrategia de gestión clave para la consolidación de ciudades inteligentes.

1. INTRODUCTION

The Organizational theories concerning strategic management include the concept of dynamic capabilities as a theory of competitive advantage that influences organizational performance in response to technological and market changes (Gheitarani et al., 2023; Wohlleber et al., 2024). Dynamic capabilities provide opportunities for knowledge exploration and exploitation, continuous updating of ordinary or operational capabilities, and constant interaction with the environment (Babelytė-Labanauskė & Nedzinskas, 2017).

Dynamic capabilities are therefore important instruments for not just projecting performance but also measuring the research, development, and innovation (R&D&I) performance of companies and the impact they have on smart cities (Fredrich et al., 2022). Knowledge as a mediating variable between human capital, learning, creativity, and R&D&I has allowed having a dominant evolutionary perspective of urban development (Sikora-Fernandez, 2017), i.e., cities understood as complex systems, are migrating towards smart and sustainable cities through the intensive use of digital technologies that allow optimizing urban ecosystems (Komninos et al., 2019).

The integration of R&D&I activities is crucial for research organizations and their impact on smart city ecosystems with a clear strategic intent of innovation (Sikora-Fernandez, 2017). They must develop new technologies that take advantage of new business models where the development and transition from a prototype to a real product ready for commercialization is successfully accomplished (Maranzato et al., 2019).

Dynamic capabilities provide a relatively novel perspective from which to approach smart city contexts. Very few studies have linked dynamic capabilities to smart cities (Linde et al., 2021). Gupta et al. (2017) established a research agenda on smart cities, including identifying the type of capabilities that benefit them. According to Guenduez and Mergel (2022), a smart city model should be supported by dynamic capabilities. Additionally, it has been found that the technological transformation of the public sector, which supports smart cities, has resulted from the emergence of dynamic capabilities (De Magalhães Santos, 2023).

Hence, this article evaluates the influence of dynamic capabilities of research groups in Manizales (Colombia) on smart city dimensions. This objective addresses the scarcity of studies examining the factors that foster the development of smart cities in Latin America. In this regard, the present study is novel in proposing that dynamic capabilities function as enabling factors for the advancement of smart cities within Latin American urban contexts, strengthening theory and its applications. To date, there is limited scientific literature exploring this relationship, particularly in the case of Colombia and the broader Latin American region.

After this introduction, the theory of dynamic capabilities is presented and the concept of smart cities as the foundations of research is deepened. Then, the positive sequential influence of four dynamic capacities of research groups on smart cities is proposed and a conceptual model is proposed. Subsequently, the methodology used to evaluate the measurement model and the structural model is explained. The results are then shown and discussed according to the theoretical approaches, identifying the practical implications and suggesting future research. Finally, the conclusions are presented.

2. THEORETICAL FRAMEWORK

Dynamic capabilities

A firm's dynamic capabilities can be defined as its ability to integrate, develop, and reconfigure both internal and external competencies in response to rapidly changing environments (Teece et al., 1997). This refers to the organization's proactive methods to find different and innovative ways to achieve competitive advantage (Helfat et al., 2007). Therefore, the above calls for differentiation between ordinary and dynamic capabilities (Teece, 2023).

A company's ordinary capabilities reflect its current set of operating procedures that it uses to sell its products to the same customers at the same scale (Winter, 2003). This relates to how an organization "makes a living" in the short term and solves problems (Drnevich & Kriauciunas, 2011; Helfat & Winter, 2011; Karna et al., 2016). In contrast, dynamic capabilities enable organizational change through the detection and exploitation of new opportunities or changes in the environment, leading to the reconfiguration of ordinary capabilities by creating, expanding, or modifying their resource base (Faccin et al., 2019).

The interest in dynamic capabilities arises from the intention to change the status quo in the organization through links between strategy, management, entrepreneurship, and leadership, i.e., when the leaders of the organization propose changes and, as a result, the workforce support such changes on a regular basis (Kurtmollaiev, 2020). Dynamic capabilities are classified according to four processes: sensing, learning, integrating, and coordinating capabilities (Ester et al., 2010; Hernández-Linares et al., 2021; Matarazzo et al., 2021; Pavlou & El Sawy, 2011; Schilke et al., 2018; Teece, 2023).

Research on smart cities and governance has highlighted the critical role of technological preparedness and integrated governance, showing that their absence creates substantial barriers to innovation in developing contexts (Tan & Taeihagh, 2020). Within this broader debate, Latin American scholarship is beginning to develop its own voice, advancing both conceptual and contextual insights. A bibliometric study of the region’s scientific production between 2007 and 2017 revealed that the most frequent topics relate to urban technologies, digital governance, and geospatial data, suggesting a growing recognition of the institutional role in smart urban design (Fernandes et al., 2019).

In Brazil, studies have further shown that unequal access to and effective use of digital technologies across individuals, groups, and regions limits the impact of smart government on citizens, highlighting tensions between technical capacity, institutional design, and the social demands embedded in governance policies (Leite da Silva et al., 2022). More recently, contributions exploring urban innovation, sustainable strategies, and institutional challenges have begun to expand this conversation in Latin American contexts, pointing to the emergence of a regional perspective on smart city development (Escobar et al., 2024). Taken together, these studies reinforce the need to articulate a Latin American approach in which institutional capacities, digital inequality, and socio-economic conditions are recognized as central to ensuring that strategies of smart governance effectively contribute to the broader project of building inclusive and sustainable smart cities.

Sensing capability

Sensing allows firms to identify trends, market information, and knowledge that have the potential to influence its competitive position (Kump et al., 2019; Makkonen et al., 2014; Teece, 2007, 2014). As a result, sensing detects opportunities and/or threats based on conjectures or hypotheses relating to economic trends, best practices, competitor activities, customer needs, supplier interactions, government regulations, socio-political currents, R&D activities, technological advances, among others (Kump et al., 2019; Teece, 2007). The lack of sensing can limit the absorption of new knowledge and information required in learning new capabilities (Bingham et al., 2015; García Pineda et al., 2023; Hodgkinson & Healey, 2011; Kale & Singh, 2007).

Learning Capability

Zollo and Winter (2002) argue that dynamic capabilities are fundamentally the outcome of organizational learning and the development of established forms of collective activity, through which firms systematically generate and adapt their operational routines to enhance strategic success (Cyfert et al., 2021). Organizational knowledge, developed by learning capabilities, is disseminated in novel ways of doing things, evolving organizational routines or new logics in the functioning of an organization that are difficult to replicate (Hermawati, 2020; Teece, 2009).

Previous research indicates that routines are learned through trial-and-error learning and by selecting and retaining past behaviors (Gavetti & Levinthal, 2000). This view is related to the idea that organizational routines are stored as procedural memory (Cohen & Bacdayan, 1994) and to the image of routine responses as quasi-automatic. Moreover, it is consistent with the traditional view of organizational learning as skill development based on repeated execution of similar tasks (Argote & Miron-Spektor, 2011; Teece, 2016).

Integrating capability

Integrating capability is the ability to capture the value of consolidated actions in the learning capability, with the purpose of developing and exploiting business opportunities and evading threats that match the organization's environment considering its strengths and weaknesses (Karimi-Alaghehband & Rivard, 2020; Kump et al., 2019; Teece, 2014).

Integrating involves bringing together information and knowledge external and internal to the organization, and is closely related to strategic decision making (Kump et al., 2019). This involves improving, combining, and protecting tangible and intangible assets, as well as reorganizing and recombining them to realize the opportunities detected (Karimi-Alaghehband & Rivard, 2020; Yeow et al., 2018). As a result, this capability is associated with the development of new products, processes, services, and business models through the creation of business frameworks and new procedures (Froehlich et al., 2017; Teece, 2009).

Coordinating capability

Coordinating is the ability to enhance, combine, protect, and, when necessary, recombine and reconfigure assets (tangible and intangible) and organizational structures as the organization grows and markets and technologies change, preventing path dependency and inertia (Chien & Tsai, 2012; Liu & Hsu, 2011; Sachitra & Chong, 2018). Therefore, coordinating refers to the implementation of strategic decisions on evolving business models, product, or process innovations through the implementation of new structures and routines (Teece, 2023). When an organization lacks coordination, redundant resources and skills may reduce its flexibility in operation, which is undesirable from the perspective of environmental dynamics (Cyfert et al., 2021; Kump et al., 2019; Maranzato & Salerno, 2018).

Dynamic capabilities in knowledge-based organizations

Although the literature on dynamic capabilities in research organizations is limited, existing studies emphasize their importance despite perceptions of rigidity to change and reliance on infrastructure for R&D&I outcomes (Babelytė-Labanauskė & Nedzinskas, 2017). In scholarly debates, such organizations are often described as knowledge-based entities (Güldenberg & Leitner, 2008), where the transition from basic to applied research, innovation, and research management has become increasingly complex and bureaucratic, requiring shared leadership (Kulakowski & Chronister, 2006). This complexity is reflected in frameworks such as the triple helix, which highlights collaboration among academia, industry, and government for knowledge-driven development (Galvao et al., 2019; Leydesdorff, 2012), positioning inter-institutional cooperation as central to R&D&I agendas (Benner & Sandstrom, 2000) and to the orientation of research toward societal and market needs (Etzkowitz & Leydesdorff, 2000; Philpott et al., 2011).

In this context, research organizations that effectively exploit dynamic capabilities demonstrate improved performance in turbulent environments by integrating diverse stakeholders and adapting to regional demands (Babelytė-Labanauskė & Nedzinskas, 2017). Unlike traditional firms that measure success mainly in financial terms, their performance depends on leadership and governance capacity to reconfigure resources and achieve organizational flexibility. This enables them to balance academic outputs with social and market demands through the commercialization of R&D&I results, while developing core dynamic capabilities in sensing, learning, integration, and coordination (Babelytė-Labanauskė & Nedzinskas, 2017).

Smart cities

The smart city concept is a consequence of the evolution of urban centers from cities as scientific centers, through eco-cities (utilizing renewable energy sources and focusing their efforts on environmental protection), digital (making intensive use of ICT), smart (implementing a knowledge-based economy), to the most advanced form today: a city that employs ICT to increase the interactivity and efficiency of urban infrastructure and its components, and awareness of residents

(Wdowiarz-Bilska, 2012). The smart city uses ICT to optimize the effectiveness of necessary and useful city processes, usually by linking various components and actors in a smart system that collaborates without fail (Su et al., 2011).

Smart city definitions comprise four common elements (Seisdedos, 2016): (1) a holistic or global vision: the smart city is present in all areas of the city and is reflected in its management, which unifies and coordinates urban areas and actors transversally; (2) a means to accomplish certain objectives: the concept of intelligence associated with the city is not an end in itself, but a means to achieve priority objectives for cities, such as: improving public services and the quality of life of citizens; making the local productive sector more competitive and innovative; and generating an environmentally sustainable space for coexistence; (3) technology as a disruptive factor: the key to achieving these objectives is the use of technology that collects large amounts of data, processes it and shares it in real time in the form of relevant information to generate added value; (4) a new model of relationships: based on changes of various kinds: economic (moving to a collaborative economy); social (new forms of citizen participation); and at the municipal level (facilitating the adoption of more agile and transparent urban policies).

The smart city framework is structured around six key dimensions: (1) smart economy emphasizes productivity, flexible labor markets, and innovation-driven industries, particularly through ICT applications in manufacturing and construction, while also addressing challenges in internationalization, infrastructure, and teleworking (Giffinger & Gudrun, 2010); (2) smart people represent the distinctive factor of digital cities, defined by education, skills, and civic collaboration, as well as their ability to connect globally (Azkuna, 2012; Madkour et al., 2015); (3) smart environment involves the adoption of advanced technologies, such as remote sensing and geographic information systems, to mitigate climate change, pollution, and resource management issues (Bokolo et al., 2018); (4) smart governance entails citizen participation, e-government, and e-democracy, supported by innovative technologies that strengthen transparency and service delivery (Giffinger et al., 2007; Marciniak & Owoc, 2013); (5) smart mobility focuses on sustainable, efficient, and safe transport systems through real-time information sharing, renewable energy use, and improved infrastructure (Azkuna, 2012; Giffinger et al., 2007); and (6) smart living covers quality-of-life dimensions such as education, health, housing, security, and tourism, where technologies like MOOCs, e-medical records, surveillance systems, and digital platforms improve accessibility, safety, and cultural development (Azkuna, 2012; Giffinger et al., 2007).

It is important to note that smart cities depend directly on the innovation management strategies implemented by public administrations (Beckers & Mora, 2025). Such management guides R&D initiatives that sustain the technological innovations required for integrated urban solutions (Cambra-Fierro et al., 2024) and involves knowledge absorption from diverse urban actors to foster collaborative innovation (Adjei-Bamfo et al., 2019). In this role, innovation management in the public sector acts as a strategic leader and orchestrator of human capital and resources essential for initiating and advancing smart city projects (Ferraris et al., 2020). However, Ferraris et al. (2020) note the need for public managers to move beyond a preference for stability and embrace risk-taking and proactivity to strengthen innovation processes for smart cities.

From this perspective, smart cities should be approached as open innovation platforms (Mainka et al., 2016), where public innovation management relies on open government principles and the active integration of urban knowledge (Ferraris et al., 2020). This approach enables the use of consolidated methodologies and theories (such as open innovation, sensemaking, technology roadmapping, and innovation intermediation) to provide coherence, flexibility, and legitimacy to smart city projects (Beckers & Mora, 2025). As a result, initiatives are not fragmented into isolated technological solutions but evolve into broader socio-technical processes with economic, social, and environmental impact in smart cities (Ferraris et al., 2020).

Research hypothesis

Recent scholarship increasingly demonstrates that dynamic capabilities are central to the development of smart cities. Evidence shows that municipalities capable of sensing opportunities, prioritizing initiatives, and reconfiguring resources are more likely to generate public value through projects such as open data and digital services (Chong et al., 2018). Research on dynamic capabilities further indicates that systematically exploring opportunities, integrating resources across organizations, and empowering teams accelerates urban transformation by orchestrating innovation across complex ecosystems (Guenduez & Mergel, 2022). Comparative studies also reveal that cities with more advanced dynamic capabilities are better positioned to sustain innovation outcomes over time, particularly when implementing smart policies and projects at scale (Chen et al., 2024; Guo & Zhong, 2022). In addition, recent contributions confirm that these capabilities can be deliberately cultivated and measured within local governments, thereby enhancing their adaptive capacity to confront challenges such as climate change and mobility, while reinforcing institutional resilience as a foundation for smart city development (Kattel, 2022; Kattel et al., 2025).

Building on this body of research, the present study argues that the systematic interplay of sensing, learning, integrating, and coordinating capabilities represents a fundamental mechanism through which cities advance toward smart models. This perspective provides the rationale for the research hypotheses developed below, which address the systematic influence of dynamic capabilities dimensions on the evolution of smart cities.

Influence of sensing on learning capability

Teece (2007) explains that an adequate business model is a micro-foundation of learning. In the context of research groups, once a new opportunity is detected, groups must create projects and products (business models) to define their development, publication, commercialization, investment strategy and priorities. These definitions require calculated assumptions about competitors' and market segments' behavior based on information and intelligence about the environment. This information is gathered through sensing capabilities. As Liu and Yang (2020) put it, sensing entails gathering and analyzing information to better understand the needs and demands of customers as well as predict the reaction of competitors. Therefore, the goal is to exploit combinations of resources and capabilities based on detected opportunities (Matysiak et al., 2018). Torres et al. (2018) show that by detecting a wide variety of competitive actions, firms can benefit from more opportunities. Therefore, it can be assumed that sensing facilitates learning capabilities. Based on the above, the following hypothesis is formulated:

Hypothesis 1: Sensing capability positively influences learning capability in research groups.

Influence of learning on integrating capability

Learning encompasses a wide range of activities, including not only formal communications, such as planning sessions, regular meetings, training programs, and employee education, but also both internal and external social interactions to share information (Iansiti & Lakhani, 2020; Lee & Klassen, 2008; Vachon & Klassen 2006). Research group staff can use knowledge transfer to seek out and share sustainable concerns. Therefore, researchers use social interaction routines to support the free exchange of knowledge (Alvarez et al., 2010). Hart and Sharma (2004) describe this social interaction process as a center-to-periphery network approach. Lee and Klassen (2008) and Alvarez et al. (2010) show that integration-based knowledge transfer often generates novel perspectives on sustainability and thus enables firms to find creative ways to cooperate with external stakeholders for mutual benefits. Therefore, the following research hypothesis is formulated:

Hypothesis 2: Learning capability positively influences integrating capability in research groups.

Influence of integrating in coordinating capability

Integrating capability implies the firm's ability to assess the value of existing resources and transform them to shape more efficient capabilities (Iansiti & Clark, 1994). In addition, it has to do with understanding how new resources can be used to create stronger competitive advantages. Consequently, derived from this dynamic capability, an organization knows how to implement an innovative business model or strategy (Sanchez & Heene, 1997). Through the initiatives of the research groups, new knowledge is generated that improves the conditions of cities. This implies that groups understand how to apply it, so they have developed a strategy to facilitate city innovation (Iansiti & Clark, 1994). In cities, research groups assist in integrating knowledge that guides and supports the coordination of resources to implement a smart city ecosystem (Helfat & Raubitschek, 2000). Therefore, the following hypothesis is formulated:

Hypothesis 3: Integrating capability positively influences coordinating capability in research groups.

Influence of coordinating capability on smart cities

Coordinating involves orchestrating tasks and activities for the deployment of new capabilities (Teece, 2023). Thus, it facilitates the development of new products and processes in collaboration between multifunctional teams made up of members of different organizations or business units (Helfat et al., 2007). Coordination capability aligns innovation and research efforts with organization objectives (Kelly, 2009). The coordination capability implies that firms use acquired innovations to develop enhanced products, services, and processes for commercialization or deployment (Protogerou et al., 2012). A study by Okhuysen and Bechky (2009) revealed that coordination mechanisms facilitate the transfer of innovations from the R&D stage to the implementation stage (Chang et al. 2012).

Hence, this dynamic capability developed by research groups influences the implementation of smart city dimensions. It is imperative to note that these initiatives are based on innovations such as reconfiguring the operational capacity of the city through information technology systems and infrastructure to support and improve traditional city services in the most efficient manner (Chong et al., 2018). Consequently, coordinating, as a research group capability, supports the creation, adaptation, and renewal of the processes and services that take place in a city. For this reason, a city can become a smart city. Therefore, the following hypothesis is formulated:

Hypothesis 4: Coordinating capability positively influences the smart city construct in research groups.

The theoretical model tested through a system of structural equations is presented in Figure 1. This shows a causal chain of relationships between dynamic competencies and the smart city construct. This sequential model indicates that dynamic capabilities operate as an interconnected and cumulative mechanism through which research groups contribute to smart city development. First, sensing capability enables the identification, interpretation, and anticipation of environmental opportunities, thereby facilitating organizational learning through the acquisition and analysis of strategic information (Liu & Yang, 2020; Matysiak et al., 2018). In turn, learning capability promotes the integration of knowledge by supporting social interaction, knowledge transfer, and collaboration among internal and external stakeholders, which fosters innovative perspectives and collective problem-solving processes (Iansiti & Lakhani, 2020; Lee & Klassen, 2008). Subsequently, integrating capability allows organizations to transform and recombine resources into stronger capabilities that support innovation strategies and the implementation of urban solutions (Iansiti & Clark, 1994; Sanchez & Heene, 1997). Finally, coordinating capability orchestrates activities, resources, and innovation efforts to facilitate the deployment of smart technologies, processes, and services within cities, ultimately affecting in a positive manner the smart city deployment (Chong et al., 2018; Helfat et al., 2007). Collectively, this sequential relationship explains how dynamic capabilities evolve from opportunity recognition to coordinated urban transformation, providing a coherent theoretical foundation for the proposed conceptual model.

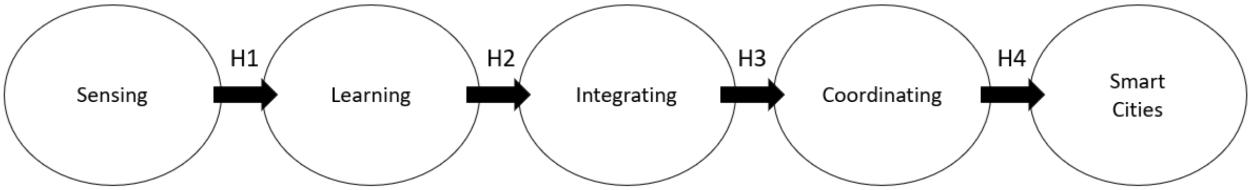

Figure 1. Conceptual model
Figura 1. Modelo conceptual
Source: own elaboration.

3. METHODOLOGY

Context of the study

This study was carried out in research groups in Manizales, Colombia. These groups, through their research, development, and innovation results, have contributed to this city's capacity to improve its services to citizens. They have also taken advantage of information technologies to offer novel services and products to Manizales' citizens. Therefore, the research groups of Manizales have facilitated the consolidation of the Smart City dimensions presented in the theoretical framework of this article. Additionally, these groups have generated many of the Smart City products offered in the city. Since they are research groups constantly creating new knowledge, they have developed dynamic capabilities. Consequently, this research is carried out in research groups, as they have transcended from being eminently academic entities to having a direct impact on market conditions and citizens' welfare (Philpott et al., 2011).

In particular, Manizales was selected as the empirical setting because it is an intermediate city with demonstrated advances in smart city development in Latin America. The city has been ranked by the National Planning Department (DNP) as the most modern in Colombia, leading in key dimensions such as governance, science and technology, and sustainability (DNP, 2023). Beyond this performance, Manizales represents a knowledge-intensive urban context characterized by the presence of highly recognized higher education institutions and a dense concentration of research groups classified within the national science and technology system (Ministerio de Ciencia, Tecnología e Innovación [MinCiencias]), many in top-tier categories (A1 and A), indicating strong capabilities in research, development, and innovation (MinCiencias, n. d.). Its inclusion in the UNESCO Global Network of Learning Cities further reflects an institutional orientation toward knowledge-based development and coordinated governance (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020). These conditions make Manizales an appropriate setting to examine how dynamic capabilities unfold within research groups and translate into smart city development, consistent with prior research on institutional and technological capacities in intermediate urban contexts (Guenduez & Mergel, 2022; Fernandes et al., 2019; Tan & Taeihagh, 2020).

Sample and data collection procedure

There were 82 research groups from the city of Manizales that participated in this study, out of a total of 182. This means that a response rate of 47 % was achieved. The selection of these groups has to do with the fact that they are recognized by the Ministry of Science, Technology, and Innovation of Colombia. They belong to the Universities of the city of Manizales. On the one hand, a survey on dynamic capabilities was conducted using Pavlou and El Sawy (2011) scale. In this scale, specific items are proposed to measure each of the dynamic abilities: 6 for sensing, 4 for learning, 6 for integration, and 5 for coordination. On the other hand, a survey was conducted on the dimensions of Smart Cities, based on scales found in the existing literature (Anthopoulos et al., 2016; Giffinger & Gudrun, 2010; Jnr et al., 2017; Kumar & Dahiya, 2017; Mishra et al., 2017; Tahir & Malek, 2016). This is divided into each of the Smart City's dimensions, so it contains 7 items for Smart economy, 4 for Smart people, 6 for Smart governance, 8 for Smart mobility, 10 for Smart environment, 11 for Smart living, and 13 for Smart city adoption. On both scales, a 7-point Likert type scale was used (7 maximum scale level; 1 minimum scale level). Annex A and Annex B contains surveys.

The survey on dynamic capabilities was sent to the research or development directors of the groups. In addition, the survey on smart city was sent to the administrative or general directors of these same organizations. This decision has to do with the fact that research and development directors know the process of developing novel products and services from the perspective of dynamic capabilities. On the other hand, the administrative and general directors know the application of these within Manizales. By doing so, we can avoid bias in the study between dynamic capabilities and smart cities. Finally, the surveys were sent through the Surveymonkey platform, which allowed tracking progress towards completion of both surveys. Telephone reinforcement was used to motivate the completion of the surveys, obtained between July and September 2022.

Data analysis technique

This study used Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) technique for data analysis. It is appropriate to assess relationships that are new theoretical developments, such as those proposed in this study's hypotheses, using PLS-SEM (Hair et al., 2014). Additionally, PLS-SEM can be used to evaluate complex theoretical models involving multiple variables, as shown in Figure 1 (Hair Jr. et al., 2017). PLS-SEM involves two analysis processes (Hair et al., 2014). The first step involves evaluating the measurement model. Specifically, this aims to determine if the measures used in the study reach convergent and discriminant validity (Hair Jr. et al., 2017). The second process involves evaluating the structural model, which evaluates the relationships that are indicated in the research hypotheses (Hair et al., 2014).

4. RESULTS

Measurement model evaluation

As a first step, the literature on PLS-SEM recommends that the evaluation of the measurement model used should be performed on all the constructs involved in the relationships (Hair et al., 2014). Several constructs were integrated into the measurement model: Sensing, Learning, Integrating, Coordinating, Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environmental, Smart Living, and Smart City Adoption. This measurement model achieved convergent validity according to Table 1.

In the first instance, with respect to the construct items, all obtained standardized loadings that, for the most part, were greater than 0.6. This is necessary according to the PLS-SEM literature, as it indicates that the convergent validity values of the items used in the surveys theoretically represent each construct (Hair et al., 2014). Secondly, measurement constructs all exceeded the 0.7 threshold required for Cronbach's Alpha and Composite Reliability indicators. Finally, the Average Variance Extracted (AVE) reached values above 0.5, in each construct, which is recommended by the PLS-SEM literature (Hair et al., 2014).

Table 1. Convergent validity results

Tabla 1. Resultados de validez convergente

Construct	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Sensing	0,85	0,89	0,63
Learning	0,77	0,85	0,59
Integrating	0,92	0,93	0,71
Coordinating	0,84	0,89	0,68
Smart Economy	0,87	0,91	0,67
Smart People	0,81	0,89	0,73
Smart Governance	0,77	0,87	0,69
Smart Mobility	0,83	0,88	0,66
Smart Environmental	0,82	0,88	0,67
Smart Living	0,90	0,92	0,63
Smart City Adoption	0,91	0,93	0,66

Note: The items of all constructs reached standardized loadings greater than 0.6 and were significant, which contributes to the convergent validity of the constructs.

Source: Ringle et al. (2022).

In addition, the measurement model achieved discriminant validity, measured through the Heterotrait-Monotrait Ratio of Correlations (HTMT) indicator. The literature on PLS-SEM warns that this indicator, which is established between pairs of variables, should be less than 0.9 (Henseler et al., 2015). Table 2 shows that this indicator did not exceed the HTMT threshold. This implies that measurement constructs are different. According to the results of convergent and discriminant validity, the measurement model successfully reflects the theoretical model from which the questionnaires were derived for each construct.

Table 2. Discriminant validity results (HTMT)

Tabla 2. Resultados de la validez discriminante (HTMT)

Construct	1	2	3	4	5	6	7	8	8	10
Sensing										
Learning	0,71									
Integrating	0,82	0,85								
Coordinating	0,87	0,76	0,67							
Smart Economy	0,21	0,44	0,27	0,28						
Smart People	0,23	0,45	0,56	0,37	0,39					
Smart Governance	0,43	0,34	0,33	0,36	0,52	0,67				
Smart Mobility	0,33	0,35	0,22	0,21	0,69	0,81	0,58			
Smart Environmental	0,41	0,45	0,56	0,67	0,72	0,77	0,89	0,79		
Smart Living	0,24	0,27	0,28	0,31	0,73	0,67	0,59	0,73	0,65	
Smart City Adoption	0,33	0,40	0,52	0,35	0,78	0,70	0,83	0,81	0,76	0,88

Source: Ringle et al. (2022).

In this research "Smart Cities" was treated as a construct of a second order reflective-formative nature, as it is integrated by seven variables: Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environmental, Smart Living and Smart City Adoption. To evaluate this model, the two-stage process recommended by the PLS-SEM literature (Hair et al., 2014) was applied. From this, the VIF indicators and weights of each construct were calculated. The VIF must be less than 5 and the weights must be significant (Hair Jr. et al., 2019). When both conditions occur (Hair et al., 2014), this signals that the reflective-formative construct is the appropriate construct to measure the main variable. These results were appropriate for "Smart Cities' sub-constructs". All seven constructs are relevant to measuring the latter variable (see Table 3).

Table 3. Evaluation of the reflective-formative construct

Tabla 3. Evaluación del constructo reflexivo-formativo

Second-order construct	First-order construct	VIF	First-order construct weight on second-order construct
Smart Cities	Smart Economy	0,32	0,133*
	Smart People	0,43	0,106*
	Smart Governance	0,35	0,107*
	Smart Mobility	0,37	0,141*
	Smart Environmental	0,37	0,170*
	Smart Living	0,39	0,243*
	Smart City Adoption	0,19	0,100*

Note: *Weights were significant at 99 %.

Source: Ringle et al. (2022).

Structural model assessment

According to the PLS-SEM literature (Hair et al., 2014), the structural model was evaluated. This procedure involves hypotheses evaluation. First, it was demonstrated that the dynamic capability "Sensing" positively influences the dynamic ability "Learning" (β=0.64; T-value=3.45). Second, this dynamic capability positively influences the dynamic ability "Integrating" (β=0.56; T-value=4.52). Third, this dynamic capability positively influences the dynamic capability "Coordinating" (β=0.70; T-value=2.67). Finally, this dynamic capability positively impacts "Smart Cities" (β=0.41; T-value=4.77). All these relationships were significant, supporting the four research hypotheses. Table 4 present these results.

Finally, the predictive power of the identified relationships was evaluated within the sample, through the R2 indicator. This value, when it exceeds the threshold of 0.1 in the dependent variables, indicates that the results have significant predictive power (Hair et al., 2014). This occurred in the four dependent variables established in the model (Learning, Integrating, Coordinating, and Smart Cities).

Table 4. Hypothesis testing results

Tabla 4. Resultados de la comprobación de hipótesis

	Direct effect		
Relationship	**Path Coefficient**	**T-Value**	**Result**
Sensing → Learning	0,64	3,45	H1 supported
Learning → Integrating	0,56	4,52	H2 supported
Integrating → Coordinating	0,70	2,67	H3 supported
Coordinating → Smart cities	0,41	4,67	H4 supported

Learning R2: 0,41
Integrating R2: 0,31
Coordinating R2: 0,49
Smart cities R2: 0,17

* Significance of 99 % for t-values exceeding the threshold of 2.5.

Source: Ringle et al. (2022).

5. DISCUSSION

This research introduces an original analytical perspective by empirically examining the sequential interaction of dynamic capabilities within the context of urban processes associated with smart cities. While prior theoretical frameworks have outlined the relevance of such capabilities, empirical evidence on their interconnected progression in research-driven environments remains scarce (Matarazzo et al., 2021; Schilke et al., 2018).

The confirmation of the first hypothesis demonstrates that research groups actively monitor their external environments to identify emerging needs and opportunities. This environmental sensing strengthens their learning capabilities by enabling the assimilation of novel routines, behaviors, and knowledge structures (Kump et al., 2019; Teece, 2007, 2014). Thus, opportunity recognition serves as a foundation for developing learning capabilities, a necessary characteristic of dynamic capabilities (Hermawati, 2020; Liu & Yang, 2020; Matysiak et al., 2018; Teece, 2016).

According to the confirmation of the second hypothesis, learning capabilities have a positive influence on integration capabilities. This result reinforces existing arguments regarding the dynamic nature of organizational knowledge bases, particularly in research institutions (Cyfert et al., 2021). As groups accumulate knowledge, they engage in practices that encourage collective sense-making and knowledge-sharing to support decision-making processes (Kelly, 2009; Kump et al., 2019). These findings are consistent with the view that integrating dispersed knowledge is crucial for leveraging identified opportunities (Karimi-Alaghehband & Rivard, 2020; Teece, 2007; Yeow et al., 2018).

Building upon this logic, the third hypothesis was also supported, substantiating the idea that integrative capacities enable more effective coordination among research teams. By aligning and mobilizing internal resources, groups are better positioned to implement innovations or adjust operational procedures (Helfat & Raubitschek, 2000; Teece, 2023). Coordinated action depends not only on access to resources but on a shared understanding of how knowledge translates into strategic response. Furthermore, support for the fourth hypothesis confirms that coordination capabilities, encompassing the structuring and deployment of new competencies, are vital for enacting strategic decisions and enabling innovation pathways in urban development (Chien & Tsai, 2012; Chong et al., 2018; Liu & Hsu, 2011; Sachitra & Chong, 2018).

These results are consistent with, and extend, previous research that highlights the central role of dynamic capabilities in the development of smart cities. The dynamic capabilities framework, understood through the processes of sensing, learning, integrating and coordinating, shows that cities capable of recognizing opportunities, prioritizing initiatives and reorganizing resources are more effective in creating public value through projects such as open data systems and digital services (Chong et al., 2018). In a similar direction, studies on dynamic capabilities reveal that the ability to explore opportunities, to connect resources across organizations and to empower teams contributes to accelerating urban transformations by orchestrating innovation in diverse ecosystems (Guenduez & Mergel, 2022).

Beyond these specific mechanisms, research has shown more broadly that cities which cultivate dynamic capabilities are better positioned to sustain innovation, adapt to changing environments and align diverse stakeholders around coherent strategies. Comparative evidence demonstrates that when dynamic capabilities are developed systematically, cities achieve more consistent and long-lasting results in implementing smart initiatives, underlining the importance of coordination and institutional flexibility (Chen et al., 2024; Guo & Zhong, 2022). Furthermore, recent studies confirm that these capabilities can be deliberately built and measured in local governments, providing administrations with the resilience required to respond effectively to pressing urban challenges such as climate change, mobility and social inclusion (Kattel, 2022; Kattel et al., 2025).

Altogether, these perspectives, combined with the evidence presented here, suggest that the evolution of smart cities cannot be reduced to the implementation of new technologies alone. What truly drives their formation is the systematic interaction of sensing, learning, integrating and coordinating capabilities. When these capabilities operate together, they allow cities to transform resources, align diverse stakeholders and implement coherent solutions that balance technological innovation with social, economic and environmental objectives. This study contributes to this body of knowledge by showing that the convergence of dynamic capabilities provides the institutional and organizational basis required for the sustainable advancement of smart cities.

In practical terms, the findings of this study offer significant implications for urban managers, academic leaders, and public policy makers. The identification of a causal relationship between the dynamic capabilities of research groups and the consolidation of smart city dimensions indicates that the success of urban innovation relies on the effective management of knowledge, resources, and collaborative networks. Within the logic of the triple and quadruple helix, research groups are not only producers of knowledge but also mediators that connect universities, industry, governments, and civil society, thereby facilitating the circulation of ideas and the joint development of solutions. Their ability to anticipate technological trends, combine interdisciplinary expertise, and adapt institutional arrangements is essential for aligning academic research with the demands of society and urban contexts. When governments and institutions provide sustained support through adequate funding, regulatory frameworks, and inclusive policies, these capacities are translated into concrete applications in domains such as mobility, digital governance, environmental sustainability, and citizen participation. In this process, urban managers and policy makers acquire a strategic role as coordinators who transform fragmented efforts into integrated governance models capable of addressing Latin America's socio-economic inequalities, institutional constraints, and cultural diversity, thereby fostering the development of smart cities that are innovative, inclusive, and resilient.

The study has several limitations. Its scope was limited to research groups located in Manizales, Colombia, which may constrain the generalizability of the findings. Additionally, the cross-sectional design prevents causal conclusions. Research group leaders' responses may also introduce subjective bias. Nevertheless, the use of structural equation modeling ensured the robustness of the findings by validating both convergent and discriminant measurement properties.

Future studies could explore how dynamic capabilities shape academic teams' research productivity and innovation outcomes. Understand how scholarly outputs contribute to specific smart city projects remains relevant. Moreover, it is critical to analyze the role of additional actors like government agencies, commercial sectors, NGOs, and civil society, and their interactions with research entities in advancing smart urban ecosystems.

6. CONCLUSIONS

This study advances the understanding of dynamic capabilities by evidencing their sequential structure and collective impact when oriented toward urban innovation processes. The empirical model demonstrates that sensing capabilities initiate a chain reaction, enhancing learning, which then supports integration, ultimately leading to effective coordination. This sequence significantly influences the smart city dimension, challenging the conventional view of capabilities as simultaneous and isolated functions.

By emphasizing the interdependence of these four capabilities, the findings offer a process-based explanation for how research groups contribute strategically to urban development. Such a progression suggests that dynamic capabilities evolve through accumulative refinement rather than isolated deployment, especially in knowledge-intensive environments.

The results imply that leaders within research organizations must synchronize their strategies for sensing, learning, integrating, and coordinating. The empirical framework proposed here allows for the design of practical pathways to strengthen institutional capacities aligned with urban impact. It also underscores the role of contextual learning and resource orchestration in fostering responsiveness and innovation within city ecosystems.

Strategic information management, facilitated by organizational learning, equips research teams to act decisively and creatively in response to urban challenges. Aligning these capabilities with public policy and institutional priorities can bridge the gap between academic expertise and urban transformation agendas. Therefore, systematically strengthening dynamic capabilities is essential for transforming research entities into catalysts for sustainable and intelligent city change.

CONFLICTS OF INTEREST

The authors declare no financial, professional, or personal conflicts of interest that could have inappropriately influenced the results or interpretations presented in this study.

AUTHOR CONTRIBUTIONS

All authors contributed significantly to the development of this article, including its design, conceptual framework, methodology, data analysis, and manuscript writing and revision the final version of the manuscript.

REFERENCES

Adjei-Bamfo, P., Maloreh-Nyamekye, T., & Ahenkan, A. (2019). The role of e-government in sustainable public procurement in developing countries: A systematic literature review. *Resources, Conservation and Recycling, 142*, 189-203. https://doi.org/10.1016/j.resconrec.2018.12.001

Alvarez, G., Pilbeam, C., & Wilding, R. (2010). Nestlé Nespresso AAA sustainable quality program: an investigation into the governance dynamics in a multi-stakeholder supply chain network. *Supply Chain Management, 15*(2), 165-182. https://doi.org/10.1108/13598541011028769

Anthopoulos, L., Janssen, M., & Weerakkody, V. (2016). A Unified Smart City Model (USCM) for Smart City Conceptualization and Benchmarking. *International Journal of Electronic Government Research*, *12*(2), 77-93. https://doi.org/10.4018/IJEGR.2016040105

Argote, L., & Miron-Spektor, E. (2011). Organizational Learning: From Experience to Knowledge. *Organization Science, 22*(5), 1123-1137. https://doi.org/10.1287/orsc.1100.0621

Azkuna, I. (2012). *Smart Cities Study: International study on the situation of ICT, innovation and Knowledge in cities*. The Committee of Digital and Knowledge-based Cities of UCLG – Mayor of Bilbao. https://www.uclg-cisdp.org/sites/default/files/smartcitiesstudy_en.pdf

Babelytė-Labanauskė, K., & Nedzinskas, S. (2017). Dynamic capabilities and their impact on research organizations' R&D and innovation performance. *Journal of Modelling in Management, 12*(4), 603-630. https://doi.org/10.1108/JM2-05-2015-0025

Beckers, D., & Mora, L. (2025). Overcoming the Smart City Governance Challenge: an Innovation Management Perspective. *Journal of Urban Technology, 32*(2), 85-106. https://doi.org/10.1080/10630732.2025.2461983

Benner, M., & Sandström, U. (2000). Institutionalizing the triple helix: research funding and norms in the academic system. *Research Policy, 29*(2), 291-301. https://doi.org/10.1016/S0048-7333(99)00067-0

Bingham, C. B., Heimeriks, K. H., Schijven, M., & Gates, S. (2015). Concurrent learning: How firms develop multiple dynamic capabilities in parallel. *Strategic Management Journal, 36*(12), 1802-1825. https://doi.org/10.1002/smj.2347

Bokolo, A. J., Majid, M. A., & Romli, A. (2018). *A trivial approach for achieving Smart City: a way forward towards a sustainable society*. 2018 21st Saudi Computer Society National Computer Conference (NCC), Riyadh, Saudi Arabia, 2018. IEEE. https://doi.org/10.1109/NCG.2018.8592999

Cambra-Fierro, J. J., López-Pérez, M. E., Melero-Polo, I., Pérez, L., & Tejada-Tejada, M. (2024). Smart innovations for sustainable cities: Insights from a public-private innovation ecosystem. *Corporate Social Responsibility and Environmental Management, 31*(3), 1654-1666. https://doi.org/10.1002/csr.2660

Chang, Y. C., Chang, H. T., Chi, H. R., Chen, M. H., & L. L. Deng. (2012). How Do Established Firms Improve Radical Innovation Performance? The Organizational Capabilities View. *Technovation 32*(7), 441-451. https://doi.org/10.1016/j.technovation.2012.03.001

Chen, S., Zhang, X., Wang, W., Liang, Y., He, W., & Tan, Z. (2024). The Effect of Smart City Policies on City Innovation — A Quasi-Natural Experiment from the Smart City Pilot Cities in China. *Sustainability, 16*(18), art. 8007. https://doi.org/10.3390/su16188007

Chien, S. Y., & Tsai, C. H. (2012). Dynamic capability, knowledge, learning, and firm performance. *Journal of Organizational Change Management, 25*(3), 434-444. https://doi.org/10.1108/09534811211228148

Chong, M., Habib, A., Evangelopoulos, N., & Park, H. W. (2018). Dynamic capabilities of a smart city: An innovative approach to discovering urban problems and solutions. *Government Information Quarterly, 35*(4), 682-692. https://doi.org/10.1016/j.giq.2018.07.005

Cohen, M. D., & Bacdayan, P. (1994). Organizational Routines are Stored as Procedural Memory: Evidence from a Laboratory Study. *Organization Science, 5*(4), 554-568. https://doi.org/10.1287/orsc.5.4.554

Cyfert, S., Chwiłkowska-Kubala, A., Szumowski, W., & Miśkiewicz, R. (2021). The process of developing dynamic capabilities: The conceptualization attempt and the results of empirical studies. *PLoS One, 16*(4), art. e0249724. https://doi.org/10.1371/journal.pone.0249724

De Magalhães Santos, L. G. (2023). Dynamic Capabilities and Digital Transformation in Public Sector: Evidence from Brazilian Case Study. In I. Lindgren, C. Csáki, E. Kalampokis, M. Janssen, G. Viale Pereira, S. Virkar, E. Tambouris & A. Zuiderwijk (eds.), *International Conference on Electronic Government* (pp. 365-380). Springer Nature Switzerland. https://doi.org/0.1007/978-3-031-41138-023

Departamento Nacional de Planeación [DNP]. (2023). *Índice de Ciudades Modernas 2023*. Observatorio del Sistema de Ciudades - Gobierno de Colombia. https://osc.dnp.gov.co/resources/icm/Documento-tecnico-ICM-2023.pdf

Drnevich, P. L., & Kriauciunas, A. P. (2011). Clarifying the conditions and limits of the contributions of ordinary and dynamic capabilities to relative firm performance. *Strategic Management Journal, 32*(3), 254-279. https://doi.org/10.1002/smj.882

Escobar, A., Luna, J., & Caraballo, A. (2024). Innovating smart cities in Latin America: Addressing regional urban challenges and opportunities. *Journal of Infrastructure, Policy and Development, 8*(13), art. 8378. https://doi.org/10.24294/jipd8378

Ester, R. M., Assimakopoulos, D., von Zedtwitz, M., & Yu, X. (2010). Global R&D organization and the development of dynamic capabilities: Literature review and case study of a Chinese high-tech firm. *Journal of Knowledge-based Innovation in China, 2*(1), 25-45. https://doi.org/10.1108/17561411011031972

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy, 29*(2), 109-123. https://doi.org/10.1016/S0048-7333(99)00055-4

Faccin, K., Balestrin, A., Volkmer Martins, B., & Bitencourt, C. C. (2019). Knowledge-based dynamic capabilities: A joint R&D project in the French semiconductor industry. *Journal of Knowledge Management, 23*(3), 439-465. https://doi.org/10.1108/JKM-04-2018-0233

Fernandes, R. A. S., Queiroz, A. O., Lourenço Wilmers, J. T. A. V., & Hoffmann, W. A. M. (2019). Urban governance in Latin America: Bibliometrics applied to the context of smart cities. *Transinformação, 31*, art. e190014. https://doi.org/10.1590/2318-0889201931e190014

Ferraris, A., Santoro, G., & Pellicelli, A. C. (2020). "Openness" of public governments in smart cities: removing the barriers for innovation and entrepreneurship. *International Entrepreneurship and Management Journal, 16*(4), 1259-1280. https://doi.org/10.1007/s11365-020-00651-4

Fredrich, V., Gudergan, S., & Bouncken, R. B. (2022). Dynamic Capabilities, Internationalization and Growth of Small-and Medium-Sized Enterprises: The Roles of Research and Development Intensity and Collaborative Intensity. *Management International Review, 62*(4), 611-642. https://doi.org/10.1007/s11575-022-00480-3

Froehlich, C., Bitencourt, C. C., & Bossle, M. B. (2017). The use of dynamic capabilities to boost innovation in a Brazilian Chemical Company. *Revista de Administração, 52*(4), 479-491. https://doi.org/10.1016/j.rausp.2017.08.007

Galvao, A., Mascarenhas, C., Marques, C., Ferreira, J., & Ratten, V. (2019). Triple helix and its evolution: a systematic literature review. *Journal of Science and Technology Policy Management, 10*(3), 812-833. https://doi.org/10.1108/JSTPM-10-2018-0103

García Pineda, V., Rojas Arias, J. P., Macías Urrego, J. A., & Rodríguez Correa, P. A. (2023). Identificación de capacidades de innovación en contextos universitarios virtuales: una aproximación desde una institución universitaria privada. *Revista CEA, 9*(21), art. e2678. https://doi.org/10.22430/24223182.2678

Gavetti, G., & Levinthal, D. (2000). Looking Forward and Looking Backward: Cognitive and Experiential Search. *Administrative Science Quarterly, 45*(1), 113-137. https://doi.org/10.2307/2666981

Gheitarani, F., Nawaser, K., Hanifah, H., & Vafaei-Zadeh, A. (2023). Human-behavioural micro-foundations of dynamic capabilities: a systematic review of the last two decades of research. *International Journal of Management and Decision Making, 22*(1), 1-26. https://doi.org/10.1504/IJMDM.2023.127685

Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: an effective instrument for the positioning of the cities? *ACE: Architecture, City and Environment, 4*(12), 7-26. https://doi.org/10.5821/ace.v4i12.2483

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., & Meijers, E. (2007). *Smart Cities–Ranking of European Medium-Sized Cities*. Centre of Regional Science (SRF), Vienna University of Technology. https://www.smart-cities.eu/download/smart_cities_final_report.pdf

Guenduez, A. A., & Mergel, I. (2022). The role of dynamic managerial capabilities and organizational readiness in smart city transformation. *Cities, 129*, art. 103791. https://doi.org/10.1016/j.cities.2022.103791

Güldenberg, S., & Leitner, K.-H. (2008). *Strategy Processes in Research and Development Organisations: Why Knowledge Management is still more isolated than integrated* [paper]. 3th International Conference on Organizational Learning, Knowledge and Capabilities (OLKC), Copenhagen, Denmark. https://warwick.ac.uk/fac/soc/wbs/conf/olkc/archive/olkc3/papers/contribution157.pdf

Guo, Q., & Zhong, J. (2022). The effect of urban innovation performance of smart city construction policies: Evaluate by using a multiple period difference-in-differences model. *Technological Forecasting and Social Change, 184*(4), art. 122003. https://doi.org/10.1016/j.techfore.2022.122003

Gupta, A., Panagiotopoulos, P., & Bowen, F. (2017). Towards a capabilities approach to smart city management. In M. Janssen, K. Axelsson, O. Glassey, B. Klievink, R. Krimmer, I. Lindgren, P. Parycek, H. J. Scholl & D. Trutnev (eds.), *Electronic Government: 16th IFIP WG 8.5 International Conference, EGOV 2017*, *St. Petersburg, Russia, September 4-7, 2017, Proceedings* (pp. 25-35). Springer International Publishing. https://doi.org/10.1007/978-3-319-64677-0_3

Hair Jr., J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate Data Analysis* (8th ed.). Pearson.

Hair Jr., J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Sage Publications.

Hair Jr., J. F., Matthews, L. M., Matthews, R. L., & Sarstedt, M. (2017). PLS-SEM or CB-SEM: updated guidelines on which method to use. *International Journal of Multivariate Data Analysis, 1*(2), 107-123. https://doi.org/10.1504/IJMDA.2017.087624

Hart, S. L., & Sharma, S. (2004). Engaging fringe stakeholder for competitive imagination. *IEEE Engineering Management Review, 32*(3), 28-28. https://doi.org/10.1109/EMR.2004.25105

Helfat, C. E., & Raubitschek, R. S. (2000). Product sequencing: co-evolution of knowledge, capabilities and products. Strategic *Management Journal, 21*(10-11), 961-979. https://doi.org/10.1002/1097-0266(200010/11)21:10/11<961::AID-SMJ132>3.0.CO;2-E

Helfat, C. E., & Winter, S. G. (2011). Untangling Dynamic and Operational Capabilities: Strategy for the (N)ever-Changing World. *Strategic Management Journal, 32*(11), 1243-1250. https://doi.org/10.1002/smj.955

Helfat, C. E., Finkelstein, S., Mitchell, W., Peteraf, M., Singh, H., Teece, D., & Winter, S. G. (2007). *Dynamic Capabilities: Understanding Strategic Change in Organizations*. John Wiley & Sons.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115-135. https://doi.org/10.1007/s11747-014-0403-8

Hermawati, A. (2020). The implementation of dynamic capabilities for SMEs in creating innovation. *Journal of Workplace Learning, 32*(3), 199-216. https://doi.org/10.1108/JWL-06-2019-0077

Hernández-Linares, R., Kellermanns, F. W., & López-Fernández, M. C. (2021). Dynamic capabilities and SME performance: The moderating effect of market orientation. *Journal of Small Business Management, 59*(1), 162-195. https://doi.org/10.1111/jsbm.12474

Hodgkinson, G. P., & Healey, M. P. (2011). Psychological foundations of dynamic capabilities: reflexion and reflection in strategic management. *Strategic Management Journal, 32*(13), 1500-1516. https://doi.org/10.1002/smj.964

Iansiti, M., & Clark, K. B. (1994). Integration and Dynamic Capability: Evidence from Product Development in Automobiles and Mainframe Computers. *Industrial and Corporate Change, 3*(3), 557-605. https://doi.org/10.1093/icc/3.3.557

Iansiti, M., & Lakhani, K. R. (2020). *Competing in the Age of AI: Strategy and Leadership When Algorithms and Networks Run the World*. Harvard Business Press. https://www.hbs.edu/faculty/Pages/item.aspx?num=56633

Jnr, B. A., Majid, M. A., & Romli, A. (2017). Sustainable Adoption and Implementation in Collaborative Enterprise: A Systematic Literature Review. *Journal of Theoretical & Applied Information Technology, 95*(9), 1875-1915. https://www.researchgate.net/publication/314947566_Sustainable_Adoption_and_Implementation_in_Collaborative_Enterprise_A_Systematic_Literature_Review

Kale, P., & Singh, H. (2007). Building firm capabilities through learning: the role of the alliance learning process in alliance capability and firm-level alliance success. *Strategic Management Journal, 28*(10), 981-1000. https://doi.org/10.1002/smj.616

Karimi-Alaghehband, F., & Rivard, S. (2020). IT outsourcing success: A dynamic capability-based model. *The Journal of Strategic Information Systems, 29*(1), art. 101599. https://doi.org/10.1016/j.jsis.2020.101599

Karna, A., Richter, A., & Riesenkampff, E. (2016). Revisiting the role of the environment in the capabilities–financial performance relationship: A meta-analysis. *Strategic Management Journal, 37*(6), 1154-1173. https://doi.org/10.1002/smj.2379

Kattel, R. (2022). *Dynamic capabilities of the public sector: Towards a new synthesis* [paper]. Discussion Paper, No. 267. Institute for Applied Economic Research (IPEA). https://doi.org/10.38116/dp267

Kattel, R., Mazzucato, M., Baafi, K., Fernandez-Monge, F., Goulden, A., Gronchi, I., Kalema, N., & Puttick, R. (2025). *Dynamic capabilities for transformative change in city governments* [paper]. Working Paper IIPP WP 2025-03. UCL Institute for Innovation and Public Purpose. https://discovery.ucl.ac.uk/id/eprint/10210996/1/Kattel_dynamic_capabilities_for_transformative_change_in_city_governments.pdf

Kelly, D. (2009). Adaptation and Organizational Connectedness in Corporate Radical Innovation Programs. *Journal of Product Innovation Management, 26*(5), 487-501. https://doi.org/10.1111/j.1540-5885.2009.00676.x

Komninos, N., Kakderi, C., Panori, A., & Tsarchopoulos, P. (2019). Smart City Planning from an Evolutionary Perspective. *Journal of Urban Technology, 26*(2), 3-20. https://doi.org/10.1080/10630732.2018.1485368

Kulakowski, E. C., & Chronister, L. U. (2006). *Research Administration and Management*. Jones & Bartlett Publishers.

Kumar, T. V., & Dahiya, B. (2017). Smart Economy in Smart Cities. In T. M. V. Kumar (ed.), *Smart Economy in Smart Cities* (pp. 3-76). Springer. https://doi.org/10.1007/978-981-10-1610-3_1

Kump, B., Engelmann, A., Kessler, A., & Schweiger, C. (2019). Toward a dynamic capabilities scale: measuring organizational sensing, seizing, and transforming capacities. *Industrial and Corporate Change, 28*(5), 1149-1172. https://doi.org/10.1093/icc/dty054

Kurtmollaiev, S. (2020). Dynamic Capabilities and Where to Find Them. *Journal of Management Inquiry, 29*(1), 3-16. https://doi.org/10.1177/1056492617730126

Lee, S., & Klassen, R. D. (2008). Drivers and Enablers that Foster Environmental Management Capabilities in Small- and Medium-Sized Suppliers in Supply Chains. *Production and Operations Management, 17*(6), 573-592. https://doi.org/10.3401/poms.1080.0063

Leite da Silva, A. S., Teixeira, A. A., & Ramos Cavalcanti, T. C. (2021). The Digital Divide and the Smart Digital Governance in Brazil: Tensions between the skills of multiple policy areas and the needs of society. In E. Loukis & M. A. Macadar (eds.), *Proceedings of the 14th International Conference on Theory and Practice of Electronic Governance* (pp. 129-135). Association for Computing Machinery.

Leydesdorff, L. (2012). *The Knowledge-Based Economy and the Triple Helix Model.* https://www.leydesdorff.net/arist09/arist09.pdf

Linde, L., Sjödin, D., Parida, V., & Wincent, J. (2021). Dynamic capabilities for ecosystem orchestration A capability-based framework for smart city innovation initiatives. *Technological Forecasting and Social Change, 166*, art. 120614. https://doi.org/10.1016/j.techfore.2021.120614

Liu, H. M., & Yang, H. F. (2020). Network resource meets organizational agility. *Management Decision, 58*(1), 58-75. https://doi.org/10.1108/MD-10-2017-1061

Liu, H. Y., & Hsu, C. W. (2011). Antecedents and consequences of corporate diversification: A dynamic capabilities perspective. *Management Decision, 49*(9), 1510-1534. https://doi.org/10.1108/00251741111173961

Madkour, M., Benhaddou, D., Khalil, N., Burriello, M., & Cline Jr., R. E. (2015). *Living Campus: Towards a Context-Aware Energy Efficient Campus Using Weighted Case Based Reasoning* [paper]. Workshops at the Twenty-Ninth AAAI Conference on Artificial Intelligence. https://cdn.aaai.org/ocs/ws/ws0126/10191-46031-1-PB.pdf

Mainka, A., Castelnovo, W., Miettinen, V., Bech-Petersen, S., Hartmann, S., & Stock, W. G. (2016). Open innovation in smart cities: Civic participation and co-creation of public services. *Proceedings of the Association for Information Science and Technology, 53*(1), 1-5. https://doi.org/10.1002/pra2.2016.14505301006

Makkonen, H., Pohjola, M., Olkkonen, R., & Koponen, A. (2014). Dynamic capabilities and firm performance in a financial crisis. *Journal of Business Research, 67*(1), 2707-2719. https://doi.org/10.1016/j.jbusres.2013.03.020

Maranzato, F. P., & Salerno, M. S. (2018). Integration between research and development: A dynamic capabilities perspective. *Revista de Administração de Empresas, 58*(5), 460-474. https://doi.org/10.1590/S0034-759020180503

Maranzato, F. P., Salerno, M., Gomes, L. A. V., Barbosa, A. P. F. P. L., & Brasil, V. C. (2019). *Mechanisms for the integration between Research and Development: a literature review* [paper]. R&D Management Conference 2019. https://www.researchgate.net/publication/334263568_Mechanisms_for_the_integration_between_Research_and_Development_a_literature_review

Marciniak, K., & Owoc, M. L. (2013). Usability of Knowledge Grid in Smart City Concepts. In S. Hammoudi, L. Maciaszek, J. Cordeiro & J. Dietz (eds.), *Proceedings of the 15th International Conference on Enterprise Information Systems - Volume 3: ICEIS* (pp. 341-346). ICEIS. https://doi.org/10.5220/0004453903410346

Matarazzo, M., Penco, L., Profumo, G., & Quaglia, R. (2021). Digital transformation and customer value creation in Made in Italy SMEs: A dynamic capabilities perspective. *Journal of Business Research, 123*, 642-656. https://doi.org/10.1016/j.jbusres.2020.10.033

Matysiak, L., Rugman, A.M., & Bausch, A. (2018). Dynamic Capabilities of Multinational Enterprises: the Dominant Logics Behind Sensing, Seizing, and Transforming Matter! *Management International Review, 58*(2), 225-250. https://doi.org/10.1007/s11575-017-0337-8

Ministerio de Ciencia, Tecnología e Innovación [MinCiencias]. (n. d.). *Resultados de la convocatoria nacional para el reconocimiento y medición de grupos de investigación, desarrollo tecnológico o de innovación*. Gobierno de Colombia. https://minciencias.gov.co/resultados-convocatorias-reconocimiento-y-medicion-grupos-investigacion

Mishra, A. P., Sen, A., & Kumar, A. (2017). Exploring Potentials and Challenges in Making Smart Cities in India: A Case Study of Allahabad City, Uttar Pradesh. In P. Sharma & S. Rajput (eds.), *Sustainable Smart Cities in India* (pp. 123-142). Springer. https://doi.org/10.1007/978-3-319-47145-7_8

Okhuysen, G. A., & Bechky, B. A. (2009). Coordination in Organizations: An Integrative Perspective. *The Academy of Management Annals, 3*(1), 463-502. https://doi.org/10.1080/19416520903047533

Pavlou, P. A., & El Sawy, O. A. (2011). Understanding the Elusive Black Box of Dynamic Capabilities. *Decision Sciences, 42*(1), 239-273. https://doi.org/10.1111/j.1540-5915.2010.00287.x

Philpott, K., Dooley, L., O'Reilly, C., & Lupton, G. (2011). The entrepreneurial university: Examining the underlying academic tensions. *Technovation, 31*(4), 161-170. https://doi.org/10.1016/j.technovation.2010.12.003

Protogerou, A., Caloghirou, Y., & Lioukas, S. (2012). Dynamic Capabilities and Their Indirect Impact on Firm Performance. *Industrial and Corporate Change, 21*(3), 615-647. https://doi.org/10.1093/icc/dtr049

Ringle, C. M., Wende, S., & Becker, J. M. (2022). *SmartPLS 4*. https://www.smartpls.com

Sachitra, V., & Chong, S. C. (2018). Resources, capabilities and competitive advantage of minor export crops farms in Sri Lanka: An empirical investigation. *Competitiveness Review, 28*(5), 478-502. https://doi.org/10.1108/CR-01-2017-0004

Sanchez, R., & Heene, A. (1997). Competence-based strategic management: concepts and issues for theory, research and practice. In A. Heene & R. Sanchez (eds), *Competence-based Strategic Management* (pp. 3-42). John Wiley and Sons.

Schilke, O., Hu, S., & Helfat, C. E. (2018). Quo Vadis, Dynamic Capabilities? A Content-Analytic Review of the Current State of Knowledge and Recommendations for Future Research. *Academy of Management Annals, 12*(1), 390-439. https://doi.org/10.5465/annals.2016.0014

Seisdedos, G. (2016). Hoja de ruta para crear ciudades inteligentes. *Harvard Deusto Business Review*, (255), 32-44. https://www.harvard-deusto.com/hoja-de-ruta-para-crear-ciudades-inteligentes

Sikora-Fernández, D. (2017). Factores de desarrollo de las ciudades inteligentes. *Revista Universitaria de Geografía, 26*(1), 135-152. https://www.redalyc.org/articulo.oa?id=383252125007

Su, K., Li, J., & Fu, H. (2011). Smart City and the applications. In *2011 International Conference on Electronics, Communications and Control (ICECC), Ningbo, China, 2011* (pp. 1028-1031). IEEE. https://doi.org/10.1109/ICECC.2011.6066743

Tahir, Z., & Malek, J. A. (2016). Main criteria in the development of smart cities determined using analytical method. *Planning Malaysia Journal, 14*(5). https://doi.org/10.21837/pmjournal.v14.i5.179

Tan, S. Y., & Taeihagh, A. (2020). Smart City Governance in Developing Countries: A Systematic Literature Review. *Sustainability, 12*(3), art. 899. https://doi.org/10.3390/su12030899

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal, 28*(13), 1319-1350. https://doi.org/10.1002/smj.640

Teece, D. J. (2009). *Dynamic Capabilities and Strategic Management: Organizing for Innovation and Growth*. Oxford University Press on Demand.

Teece, D. J. (2014). The Foundations of Enterprise Performance: Dynamic and Ordinary Capabilities in an (Economic) Theory of Firms. *Academy of Management Perspectives, 28*(4), 328-352. https://doi.org/10.5465/amp.2013.0116

Teece, D. J. (2016). Dynamic capabilities and entrepreneurial management in large organizations: Toward a theory of the (entrepreneurial) firm. *European Economic Review, 86*, 202-216. https://doi.org/10.1016/j.euroecorev.2015.11.006

Teece, D. J. (2023). The Evolution of the Dynamic Capabilities Framework. In R. Adams, D. Grichnik, A. Pundziene, C. Volkmann (eds.), *Artificiality and Sustainability in Entrepreneurship: Exploring the Unforeseen, and Paving the Way to a Sustainable Future* (pp. 113-129). Springer International Publishing. https://doi.org/10.1007/978-3-031-11371-0_6

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509-533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Torres, R., Sidorova, A., & Jones, M. C. (2018). Enabling firm performance through business intelligence and analytics: a dynamic capabilities perspective. *Information & Management, 55*(7), 822-839. https://doi.org/10.1016/j.im.2018.03.010

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2020). *UNESCO Global Network of Learning Cities*. https://www.uil.unesco.org/en/learning-cities

Vachon, S., & Klassen, R. D. (2006). Extending green practices across the supply chain; The impact of upstream and downstream integration. *International Journal of Operations & Production Management, 26*(7), 795-820. https://doi.org/10.1108/01443570610672248

Wdowiarz-Bilska, M. (2012). Od miasta naukowego do smart city. *Czasopismo Techniczne. Architektura, 109*(1-A/2), 305-314. https://repozytorium.biblos.pk.edu.pl/redo/resources/31126/file/suwFiles/WdowiarzBilskaM_MiastaNaukowego.pdf

Winter, S. G. (2003). Understanding dynamic capabilities. *Strategic Management Journal, 24*(10), 991-995. https://doi.org/10.1002/smj.318

Annexes

Annex A. Questionnaire items on dynamic capabilities
Anexo A. Preguntas del cuestionario sobre capacidades dinámicas

Dynamic capability	Items
Sensing capability	SC1 - Frequency of monitoring calls for research projects.
	SC2 - Level of use of technological and systematic tools in the group's production.
	SC3 - Regularity in searching for information.
	SC4 - Frequency of carrying out technological surveillance and updating of knowledge in its strategic core of expertise.
	SC5 - Frequency of monitoring changes in the social and technological environment.
	SC6 - Weekly hourly intensity for the generation of ideas and new design capabilities.
Integration capability	IC1 - Level of participation of group members to contribute their individual knowledge to the projects.
	IC 2 - Level of understanding of the members regarding their tasks and responsibilities.
	IC 3 - Level of identification of skills within the group.
	IC 4 - Level of ability to cultivate unique and valuable talent to share and store it in group knowledge silos.
	IC 5 - Level of inter-relationship in the group.
	IC 6 - Level of connection between group members.
Coordinating capability	CC1 - Balance between the repertoire of capabilities, general and specialized competencies that the members of the group possess.
	CC2 - Level of production of the group in the face of changes in the sociotechnical and cultural environment.
	CC3 - Surveillance capacity regarding the knowledge gap.
	CC4 - Degree of identification of technological markets in the sociocultural and technical environment of the city.
	CC5 - Level of monitoring of the group regarding the technological trajectory followed by innovations in products, processes and business models.
Learning capability	CA1 - Ability to contrast currents of knowledge, to combine capabilities and deploy competencies.
	CA2 - Number of effective routines to identify, evaluate and incorporate new information and knowledge into the core strategic competencies.
	CA3 - Frequency of transformation of existing knowledge and information into new knowledge.
	CA4 - Level of effectiveness of the transformation of existing knowledge and information into new products and processes.

Annex B. Questionnaire items on Smart City

Anexo B. Preguntas del cuestionario sobre la Ciudad Inteligente

Smart City Dimensions	Items
Smart Economy	SE1-Deployment of ICT use in businesses.
	SE2-Design strategies for the economic development of the city.
	SE3-Retaining and attracting talent and promoting creativity.
	SE4-Provide support for entrepreneurship.
	SE5-Development of business spaces and collaborations.
	SE6-Provide international promotion strategy for the city.
	SE7-Provision of tax payment system.
Smart People	SP1-Presence of a university in the city.
	SP2-Plans for ICT use and digital development in classrooms.
	SP3-Collaboration between companies and knowledge centres.
	SP4-Plan for research, development and innovation.
Smart Governance	SG1-Promoting ICT and innovation and online public services.
	SG2-Provide website availability for governance.
	SG3-Offers strategic plans to promote e-government.
	SG4-Administrative staff uses internet connected computers.
	SG5-Transparent governance and citizen participation.
	SG6-Implements e-democracy and electronic voting.
	SG7-Provison of birth and death registration.
Smart Mobility	SM1-Provision of international accessibility.
	SM2-Availability of innovative and safe transport systems.
	SM3-Traffic management and parking system.
	SM4-Availability of bicycle tracks and unobstructed footpaths.
	SM5-Deploy deal with ISPs to offer connectivity of ICT infrastructure.
	SM6-Provides Internet usage and broadband coverage.
	SM7-Provides mobile phone usage and mobile Internet.
	SM8-Provision of public internet access and Wi-Fi hotspots in cities.
Smart Environment	SEN1-Attractivity of natural conditions.
	SEN 2-Supports pollution reduction.
	SEN 3-Provides environmental protection.
	SEN 4-Provision of sewerage and waste water treatment.
	SEN 5-Adherence to the green practices and recycling of solid waste.
	SEN 6-Promotes sustainable resource management.
	SEN 7-Using ICT to improve public safety.
	SEN 8-Initiatives for the digitization of heritage assets.
	SEN 9-Disaster prediction and early warning response system.
	SEN 10-Provision of fire stations disaster alarm system.

Smart City Dimensions	Items
Smart Living	SL1-Promotes utilization of ICT uses in homes.
	SL2-Promotes electronic health (e-health) policies.
	SL3-Provides on-line medical services.
	SL4-Provision of emergency response facilities such as ambulances, emergency and healthcare facilities.
	SL5-Offers remote home control or alarm systems for patients.
	SL6-Development of digital inclusion programme for groups at risk of exclusion.
	SL7-Guarantees individual safety and provides better housing quality.
	SL8-Promotes touristic attractivity and uphold social cohesion.
	SL9-Provision of 24/7 electric supply.
	SL10-Provision of 24/7 water supply.
	SL11-Provision of metering and online payment facility.
Smart City Adoption	SCR1- My city is actively involved for efficient functioning, management of city's sustainable development for more liveable.
	SCR2-My city highly values creativity and welcomes new ideas.
	SCR3- My city offers its citizens diverse economic opportunities.
	SCR4- My city focuses on the mobility of people, and not only that of vehicles.
	SCR5- My city advocates walkability and cycling.
	SCR6- My city conserves and preserves the ecological system in the city region.
	SCR7- My city efficiently and effectively manages its natural resource base.
	SCR8- My city focuses on water conservation and minimizes the unnecessary consumption of water.
	SCR9- My city has and continually upgrades its urban resilience to the impacts of climate change.
	SCR10- My city can create a low carbon environment with focus on energy efficiency, renewable energy.
	SCR11- My city has open and accessible public spaces.
	SCR12- My city has public services and amenities.
	SCR13- My city deploys e-governance for the benefit of all its residents.