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Technological Entrepreneurship and Startup Ecosystems

Factores que favorecen el emprendimiento tecnológico en ecosistemas urbanos.

Yohania de Armas [a]

Wilfrido De La Rosa-Viloria [b]

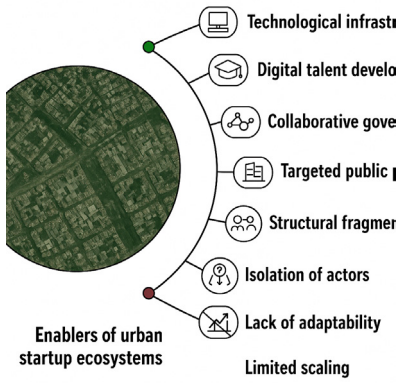
[a] Master's in Intellectual Property, Conecta Iberoamérica, proyecta@conectaiberoamerica.com, Managing Partner and Founder, ORCID 0009-0001-8817-2119, Madrid, Spain.

[b] MBA, Mangus, wdelarosa@mangus.org, Commercial Director, ORCID 0009-0005-0719-6397, Scholar, Madrid, Spain.

HIGHLIGHTS

- Identifies key enablers of technological entrepreneurship within urban startup ecosystems in Latin America.
- Provides a comparative analysis of innovation hubs and their role in scaling technology-based ventures.
- Offers strategic recommendations to strengthen institutional and policy frameworks that support urban tech entrepreneurship

GRAPHICAL ABSTRACT



Wilfrido De La Rosa-Viloria
Corresponding author
Email address: wdelarosa@mangus.org

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ABSTRACT

This study analyzes the structural and enabling factors that support technological entrepreneurship within urban ecosystems, focusing on Latin American cities. Employing a mixed-methods qualitative design, the research integrates a systematic literature review using thematic mapping with a comparative case analysis of three urban contexts: Medellín (Colombia), Santiago de Chile (Chile), and Mexico City (Mexico). Four key enabling dimensions were identified: technological infrastructure, digital talent development, collaborative governance networks, and targeted public policies. Findings reveal that the isolated presence of these factors is insufficient; rather, their systemic articulation is critical for ecosystem consolidation. Medellín stands out for its tripartite governance model and territorial innovation strategy, while Santiago demonstrates progress through public-private funding mechanisms and skill-building initiatives. In contrast, Mexico City exhibits structural fragmentation despite its potential. The study concludes that urban ecosystems for technological entrepreneurship require adaptive institutional frameworks, collaborative governance structures, and outcome-oriented policy instruments to scale impact and ensure long-term sustainability.

Palabras clave:

Ecosistemas de emprendimiento, Emprendimiento tecnológico, Innovación urbana, Políticas públicas, Ciudades inteligentes.

RESUMEN

El presente estudio analiza los factores que estructuran y favorecen el emprendimiento tecnológico en ecosistemas urbanos, con un enfoque centrado en ciudades latinoamericanas. A partir de un diseño metodológico mixto de carácter cualitativo, se combinó una revisión sistemática de literatura con enfoque de mapeo temático y un análisis comparado de tres casos urbanos: Medellín (Colombia), Santiago de Chile (Chile) y Ciudad de México (México). La investigación identificó cuatro dimensiones habilitadoras clave: infraestructura tecnológica, capital humano digital, redes colaborativas de gobernanza y políticas públicas específicas. Los resultados evidencian que la presencia aislada de estos factores no garantiza la consolidación del ecosistema, siendo la articulación sistémica entre ellos el principal determinante del éxito. Medellín se destaca por su modelo de gobernanza tripartita y enfoque territorial, mientras que Santiago avanza con mecanismos público-privados de financiamiento y formación. Ciudad de México, aunque con alto potencial, presenta una estructura fragmentada. El estudio concluye que los ecosistemas urbanos de emprendimiento tecnológico requieren marcos institucionales adaptativos, estructuras de gobernanza colaborativa y políticas públicas orientadas a resultados para escalar su impacto y sostenibilidad.

1. Introduction

Cities have become key nodes in knowledge-based economic development, where technological entrepreneurship plays a central role in digital transformation and innovation. In Latin America, the emergence of tech startups is linked to rapid urbanization, investment in ICT infrastructure, and the growth of collaborative networks connecting academia, industry, and government (González-Pernía et al. 2019; Kantis et al. 2020).

This article aims to identify the factors that strengthen technological entrepreneurship within urban ecosystems through a systematic literature review and a comparative analysis of three representative case studies. The research is oriented toward generating strategic recommendations that support the creation of urban environments conducive to the development of technology-based startups.

Technological entrepreneurship has become a strategic vector for urban economic development in the 21st century, particularly within the context of digital transformation, reconfigured value chains, and the acceleration of open innovation processes. Cities, as dense spaces of knowledge, resources, and interconnected actors, are increasingly functioning as hubs of entrepreneurial ecosystems capable of generating new productive dynamics driven by emerging technologies (Audretsch & Belitski 2021; Spigel 2017).

In this context, technological entrepreneurship ecosystems operate as complex and adaptive systems involving institutional actors, companies, universities, social networks, technological infrastructure, and regulatory frameworks (Stam & Spigel 2017). Their effectiveness depends not only on the presence of these elements but also on the quality of their articulation, the flow of inter-institutional collaboration, and their ability to respond to evolving urban opportunities (Carayannis et al. 2010; Isenberg 2011).

Latin America has witnessed the rise of urban ecosystems for tech startups, characterized by heterogeneous configurations, partial institutional advances, and fragmented efforts toward territorial integration (Kantis 2020). Despite this diversity, cities such as Medellín, Santiago de Chile, and Mexico City have emerged as regional benchmarks, albeit with different trajectories and outcomes. This raises a critical question for both theory and practice: What structural and systemic factors promote the sustainable development of technological entrepreneurship in Latin American urban ecosystems?

This article addresses this question through a methodological design that combines a systematic literature review based on thematic mapping and a comparative qualitative analysis of three urban case studies. The objective is to identify, contrast, and explain the enabling

factors—technological infrastructure, human capital, collaborative networks, and public policy—that shape the conditions for the emergence and consolidation of technological entrepreneurship ecosystems in Latin American cities.

The proposed approach not only seeks to contribute theoretically to the understanding of the phenomenon but also to provide empirical evidence and strategic recommendations for decision-makers, urban planners, and innovation policy designers. Through this research, we aim to advance the development of replicable models of territorial governance geared toward sustainable urban innovation through technology.

2. Literature Review

2.1 Technological Entrepreneurship Ecosystems

Entrepreneurship ecosystems are complex systems of interaction among actors, institutions, and resources that enable the creation and scaling of new ventures (Isenberg 2011). In the context of technological entrepreneurship, these ecosystems require specific conditions such as access to technology, venture capital, and digital talent (Spigel 2017; Audretsch & Belitski 2021).

Technological entrepreneurship ecosystems represent dynamic environments in which various actors, institutions, and resources interact to facilitate the emergence and growth of technology-based enterprises. These ecosystems are fundamental to urban economic development and innovation, as they provide the necessary infrastructure and support for entrepreneurs to transform innovative ideas into sustainable businesses.

Table 1. Systematization of Experiences in Technological Entrepreneurship

Author(s)	Year	Main Contribution
Isenberg	2011	Introduced the ecosystem framework for entrepreneurship with a systemic perspective.
Spigel, B. .	2017	Highlighted the role of cultural and social contexts in shaping entrepreneurial ecosystems.
Audretsch & Belitski	2021	Examined universities as key enablers of regional entrepreneurial ecosystems.
Stam, E.	2015	Proposed a framework to measure the quality and performance of ecosystems.
Carayannis & Campbell	2010	Developed the triple, quadruple, and quintuple helix models of innovation.
González-Pernía et al.	2019	Investigated innovation-driven entrepreneurship in urban contexts.
Kantis, Federico & Ibarra	2020	Analyzed ecosystem dynamics and new generations of entrepreneurs in Latin America.
Crespo & Vázquez	2018	Explored the Medellín case as a model of collaborative innovation governance.
Stam & Spigel	2017	Studied the structure and evolution of entrepreneurial ecosystems.
Florida, R.	2014	Emphasized the role of the creative class and urban density in driving innovation.

Source: Author's own elaboration, 2024

The literature emphasizes that technological entrepreneurship ecosystems depend not only on the presence of firms and entrepreneurs, but also on a network of institutions and resources that include universities, public policy frameworks, an entrepreneurial culture, and access to financing. Isenberg. (2011) stresses the importance of a systemic approach, while Spigel. (2017) highlights the influence of cultural and social factors. Audretsch, & Belitski. (2021) examine the catalytic role of universities in regional entrepreneurship. Stam. (2015) proposes metrics to assess ecosystem quality, and Carayannis, & Campbell. (2010) introduce innovation models based on multi-helix interactions.

Understanding the structure and dynamics of technological entrepreneurship ecosystems is essential to identifying the factors that enhance startup growth in urban contexts. The interaction among actors, institutions, and resources creates a favorable environment for innovation and the development of sustainable technology-based ventures.

2.2 Enabling Factors in Urban Contexts

Various studies agree that successful cities in the domain of tech startups are characterized by a critical mass of universities, mentorship networks, angel investors, and proactive public policies (Stam 2015; Carayannis & Campbell 2010). Urban density enables economies of agglomeration and fosters open innovation (Florida 2014).

Urban contexts offer unique conditions that can either facilitate or hinder the development of technological entrepreneurship ecosystems. Key factors such as technological infrastructure, human capital, public policy, entrepreneurial culture, and collaborative networks play critical roles in consolidating these ecosystems.

Table 2. Systematization of Experiences in Urban Enabling Factors

Author(s)	Year	Main Contribution
Stam, E.	2015	Emphasized the influence of urban institutions and local governance in entrepreneurial success.
Carayannis & Campbell	2010	Highlighted the role of multi-actor interaction (university–industry–government) in urban contexts.
Florida, R.	2014	Analyzed the impact of urban density and the creative class on innovation ecosystems.
Spigel, B.	2017	Identified urban universities as drivers of digital talent and innovation infrastructure.
Audretsch & Belitski	2021	Studied how proximity to academic institutions fosters regional entrepreneurship.
Kantis, Federico & Ibarra	2020	Linked institutional policy frameworks to ecosystem development in urban settings.
González-Pernía et al.	2019	Explored how institutional quality and access to finance concentrate in cities.
Crespo & Vázquez	2018	Demonstrated how urban innovation planning can drive sustainable ecosystem growth.
Rueda & Orduz	2021	Examined urban inclusion policies as enablers of broader ecosystem participation.
Angelelli & Prats	2019	Analyzed the role of innovation hubs in connecting urban talent, technology, and capital.

Source: Author's own elaboration, 2024

The literature indicates that urban contexts offer a concentration of resources and actors that can be leveraged for the development of technological entrepreneurship ecosystems. Stam (2015) and Carayannis, & Campbell. (2010) emphasize the importance of university–industry–government interactions in urban environments. Florida. (2014) highlights the role of urban density and the creative class in fostering innovation. Spigel. (2017) and Audretsch, & Belitski. (2021) further assert that urban universities are not only centers of knowledge but also catalysts for the emergence of new tech-based ventures by providing talent and support infrastructure. Studies by Kantis et al. (2020) and González-Pernía et al. (2019) underscore the relevance of institutional environments, public policy, and financing flows—all of which are highly concentrated in urban areas. Finally, Crespo & Vázquez (2018) demonstrate how urban planning geared toward innovation can sustainably scale entrepreneurial ecosystems.

Understanding the enabling factors within urban settings allows for the identification of structural elements that drive technological entrepreneurship in cities. When effectively managed, these factors contribute to the strengthening of resilient urban ecosystems—aligned with this article's central research question: Which elements support the development of technological entrepreneurship in urban ecosystems?

2.3 Latin American Experiences

Research conducted in Medellín, Santiago de Chile, and Mexico City highlights that the most robust ecosystems are those where shared governance exists among the public, private, and academic sectors (Kantis et al. 2020; IDB, 2022). Nonetheless, persistent challenges remain in areas such as infrastructure, scalability, and international connectivity (Crespo & Vázquez 2018).

Latin America has emerged as a dynamic region for technological entrepreneurship, particularly in urban settings. Cities such as Medellín, Santiago de Chile, and Mexico City have positioned themselves as regional innovation hubs for startup development. This section reviews empirical studies on Latin American experiences and their contribution to the understanding of urban tech-based ecosystems.

Table 3. Systematization of Experiences in Latin American Contexts

Author(s)	Year	Main Contribution
Kantis & Federico	2020	Mapped ecosystem dynamics in Latin America, identifying the importance of institutional coordination.
Banco Interamericano de Desarrollo (BID)	2022	Highlighted the role of public policy and support networks in the emergence of urban startup ecosystems.
Crespo & Vázquez	2018	Analyzed Medellín as a successful case of sustained investment in innovation infrastructure.
Rueda & Orduz	2021	Examined Medellín's innovation ecosystem as a social inclusion platform.

Angelelli & Prats	2019	Studied urban innovation hubs in Santiago and Buenos Aires as connectors of talent, tech, and finance.
Guerrero, Urbano & Herrera	2019	Investigated the impact of universities in Latin American ecosystems and their entrepreneurial role.
Amorós & Cristi	2011	Compared entrepreneurial activity rates across Latin American cities.
Lafuente, Vaillant & Serarols-Tarrés	2007	Explored institutional conditions and their influence on urban entrepreneurship.
Contreras & López	2020	Evaluated the influence of accelerators and coworking spaces in Mexico City.
ECLAC	2022	Proposed inclusive innovation policy recommendations for urban ecosystems in the region.

Source: Author's own elaboration, 2024

The reviewed studies indicate that the success of technological entrepreneurship in Latin American urban environments largely depends on the degree of articulation among ecosystem stakeholders. Kantis & Federico. (2020) and the Inter-American Development Bank (IDB, 2022) demonstrate that cities with the most developed entrepreneurial ecosystems are those that implement active public policies, have robust institutional frameworks, and provide access to support networks such as incubators and accelerators. The case of Medellín (Crespo & Vázquez 2018; Rueda & Orduz 2021) exemplifies how sustained investment in infrastructure, education, and inter-institutional collaboration can transform a traditional city into a regional innovation hub. Likewise, Angelelli & Prats (2019) emphasize the importance of urban innovation hubs as connectors of talent, technology, and financing.

The analysis of Latin American experiences reveals that the coherent implementation of public policy, combined with the activation of key ecosystem actors, is critical to strengthening technological entrepreneurship in cities. This empirical evidence directly addresses the article's central research question and supports the need to adapt successful models to emerging urban contexts.

Synthesis of the Timeline Graphic (Key Authors and Contributions)

The timeline illustrates key theoretical contributions made between 2007 and 2022 regarding technological entrepreneurship and urban ecosystems. A progressive evolution in focus is observed, beginning with studies on institutional conditions (Lafuente et al. 2007) and innovation models (Carayannis & Campbell 2010), progressing to structural proposals such as the concept of entrepreneurial ecosystems (Isenberg 2011) and their assessment frameworks (Stam 2015), and culminating in empirical analyses centered on Latin America (Kantis & Federico 2020; IDB, 2022).

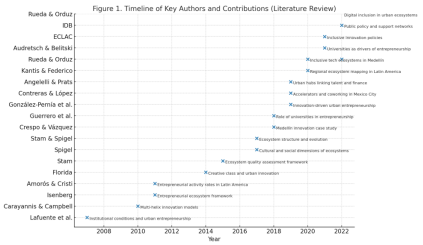


Grafico 1. Timeline de autores y sus contribuciones clave (Revisión de la literatura)

Fuente: elaboración propia, 2024

Since 2018, a more applied and context-specific approach has become evident, with case studies in Medellín, Santiago de Chile, and Mexico City that incorporate governance structures, collaborative networks, social inclusion, and sustainability. This visual resource illustrates the evolution of key contributions to the literature on technological entrepreneurship and urban ecosystems from 2007 to 2022. The timeline highlights a shift from global theoretical frameworks toward regionally grounded perspectives, enriching the understanding of enabling factors for entrepreneurship in Latin American cities.

This chronological journey reinforces the structure of the literature review and is closely aligned with the other components of the article. First, it provides theoretical context for the comparative case study analysis developed in the methodology (Section 3), by highlighting relevant models and variables. Second, the findings presented in the results (Section 4) revisit previously identified factors—such as infrastructure, talent, and public policy—confirming their relevance and applicability in specific urban contexts. Finally, in the discussion and conclusions (Sections 5 and 6), this bibliographic synthesis strengthens the strategic recommendations by integrating a historical, empirical, and context-sensitive perspective on the development of urban technological entrepreneurship ecosystems in Latin America.

3. Methodology

This study adopts an exploratory–interpretative approach grounded in qualitative techniques aimed at identifying, contrasting, and

understanding the factors that enable technological entrepreneurship in urban ecosystems. The research integrates two complementary methodological components: a systematic literature review based on knowledge mapping, and an analysis of emergent qualitative correlations, developed through thematic coding and relational matrices.

Systematic Literature Review Using Knowledge Mapping: The review was conducted between October 2024 and February 2025, using databases such as Scopus, Web of Science, and ScienceDirect (Elsevier Open Access). A flexible and progressive search strategy was employed, based on the Thematic Mapping by Clusters method proposed by Cobo et al. (2011), which enables the visualization of conceptual connections among articles, authors, and keywords.

Search Strategy:

- Keywords: *technological entrepreneurship, startup ecosystems, urban innovation, Latin America, innovation policy*.
- Filters: Open access, peer-reviewed articles published between 2007 and 2023, in English or Spanish.
- Inclusion criteria: Studies focused on cities as units of analysis, with empirical evidence or theoretical modeling.
- Exclusion criteria: Articles focusing exclusively on rural entrepreneurship or non-technological contexts.

Analytical Stages:

- Thematic coding: Articles were reviewed in depth and coded according to five dimensions—*infrastructure, talent, networks, culture,* and *public policy*.
- Conceptual clustering: Articles were grouped based on similarities in their theoretical frameworks using bibliometric tools (VOSviewer and Bibliometrix in R).
- Convergence mapping: A map was generated identifying central, emerging, and peripheral themes, enabling the prioritization of key enabling factors in the literature.

This approach allowed the identification of consensus patterns, knowledge gaps, and emerging perspectives on urban entrepreneurship ecosystems, with particular emphasis on the Latin American context.

Analysis of Emergent Qualitative Correlations: The second methodological component consisted of an analysis of qualitative correlations among enabling factors, based on documentary case studies in three selected cities: Medellín (Colombia), Santiago de Chile (Chile), and Mexico City (Mexico). The technique combined adapted Grounded Theory with a cross-case pattern matching approach (Yin, 2014; Strauss & Corbin, 1998).

Procedure:

- Data collection: Relevant secondary sources were compiled (e.g., government plans, public policy reports, technical documents from multilateral agencies, academic papers, and reports from accelerators and universities).
- Open and axial coding: Emerging categories associated with enabling factors (infrastructure, policy, culture, etc.) were coded for each city.
- Cross-relational matrix: A comparative matrix was constructed to identify qualitative correlations among the factors in each case, assessing their co-occurrence, intensity, and perceived impact.
- Relational analysis: Using qualitative analysis software (Atlas.ti 23), the relationships among categories were visualized, generating a network map of nodes and links that revealed convergent and divergent patterns across the cities.

Rigor Criteria:

- Triangulation of sources (academic, institutional, sectoral).
- Category validation through peer cross-checking.
- Theoretical saturation reached with at least five sources per city.

The integration of thematic mapping and qualitative correlation analysis enabled a systemic and context-sensitive approach to the phenomenon under study. The first method provided a consolidated and updated theoretical foundation, while the second allowed for the interpretation of urban realities in Latin America through the convergence of contextual factors. As such, the methodology effectively addresses the core research question by connecting theory and practice, global models and local experiences, through an inductive, flexible, and interdisciplinary lens.

4. Results

The findings of this study reveal the systemic interaction of factors that enable technological entrepreneurship in Latin American urban environments, based on two primary sources of evidence: (i) emerging thematic clusters identified through the systematized literature review, and (ii) qualitative correlations derived from the case studies of Medellín, Santiago de Chile, and Mexico City. The results are presented below by key dimensions, each supported by coding matrices and qualitative relational analysis.

4.1 Technological Infrastructure and Urban Connectivity

Methodological stage applied: a) Systematic review: identification of the "Smart Infrastructure" and "Urban Tech Hubs" thematic clusters. b) Comparative cases: documentary analysis and co-occurrence matrix of relational data.

Table 4. Comparison of Key Dimensions by City

Dimension	Medellín	Santiago de Chile	Mexico City
Technological Infrastructure	Ruta N: public, innovation-oriented infrastructure	Decentralized tech districts supported by municipal governments	Numerous private coworking spaces, but lack systemic integration
Human Capital Development	Dual training programs linking universities and the tech sector	Bootcamps with strong job placement in tech industries	Broad educational offer, but poorly aligned with ecosystem demands
Collaborative Networks	Tripartite governance: university–industry–government collaboration	Public-private hybrid networks driven by national funding agencies	Fragmented ecosystem with weak institutional coordination
Public Policy and Support Tools	Innovation-focused urban policy as a pillar of territorial development	CORFO funding, early-stage startup incentives	General public policies lacking specific focus on tech entrepreneurship

Source: Author's own elaboration, 2024.

Based on the findings derived from the systematic literature review and the qualitative correlation analysis, a comparative table was constructed to synthesize how the main dimensions of technological entrepreneurship manifest in three Latin American cities. The dimensions considered include infrastructure, human capital, collaborative networks, and public policies.

The table illustrates that **Medellín** leads in infrastructure, governance, and innovation policy, driven by initiatives such as *Ruta N*. **Santiago de Chile** stands out for its funding instruments and its alignment with the private sector through bootcamps and accelerators. In contrast, **Mexico City** exhibits dispersed initiatives and weaker inter-actor coordination, which limits the consolidation of its ecosystem.

Key Findings (Dimension: Technological Infrastructure and Urban Connectivity):

- In Medellín, the presence of *Ruta N* as a publicly funded innovation hub has facilitated the emergence of technology-based startups by providing open access to infrastructure and services.
- Santiago de Chile has developed decentralized technology districts, such as *Santiago Innova*, supported by municipal innovation policies and incentives.
- Mexico City presents a mixed model with a high density of private coworking spaces but lacks territorial integration or coordinated infrastructure strategy.

There is a strong correlation between the availability of urban infrastructure dedicated to innovation and the consolidation of business networks and attraction of external investment—particularly when such infrastructure is aligned with fiscal incentives or usage subsidies.

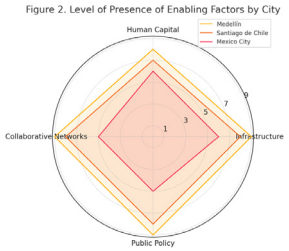


Figure 2. Level of Presence of Enabling Factors by City

Source: Author's own elaboration, 2024.

The figure presents a comparative visualization of the level of presence (on a scale from 1 to 10) of key enabling factors for technological entrepreneurship in Medellín, Santiago de Chile, and Mexico City. This representation synthesizes the relative intensity of each dimension across the cases analyzed. Medellín consistently reaches the highest scores across almost all dimensions, particularly excelling in technological infrastructure and public policy. Santiago de Chile exhibits a balanced configuration, with notable strengths in human capital development and collaborative networks. In contrast, Mexico City reflects a lower overall intensity across all factors, highlighting

the need for more targeted policies and stronger coordination mechanisms among ecosystem actors.

Urban technological infrastructure is a structural enabler of entrepreneurship, and its effectiveness relies not only on its existence but also on its accessibility and integration within institutional synergies.

All three cities have made significant progress in terms of connectivity and technological access, although coverage and systemic integration vary. Medellín stands out for its publicly funded innovation network (Ruta N), Santiago maintains a decentralized ecosystem with municipal support, and Mexico City has a high density of private incubators but lacks systemic coordination.

4.2 Development of Human Capital and Digital Talent

Methodological stage applied: a) Systematic review: Identification of the "Tech Talent Development" and "Digital Education in Cities" thematic clusters. b) Qualitative coding: Recurrent mention of training programs connecting universities and startups.

Table 5. Technological Infrastructure and Urban Connectivity

City	Key Features
Medellín	Presence of *Ruta N*, a public innovation hub that provides open-access infrastructure and services.
Santiago de Chile	Development of decentralized tech districts (e.g., *Santiago Innova*) supported by municipal governments.
Mexico City	High density of private coworking and incubator spaces, but with limited territorial and strategic integration.

Source: Author's own elaboration, 2024.

This table shows how physical and digital spaces supporting innovation are structured in each city. Medellín stands out for its robust institutional environment, such as *Ruta N*, a public-access hub that fosters the creation of startups. Santiago de Chile implements a more decentralized model supported by local governments. In contrast, Mexico City offers a wide range of private coworking spaces, but lacks a systemic integration strategy.

Key Findings (Dimension: Human Capital and Digital Talent):

- Medellín integrates dual education programs between universities (EAFIT, UPB) and ICT clusters.
- Santiago has strengthened bootcamp initiatives, such as *Desafío Latam*, with a strong connection to tech-sector employability.
- Mexico City offers a wide educational supply, but it is fragmented and lacks direct links to entrepreneurial hubs.

Digital talent correlates directly with the scalability potential of startups. Cities that align their training programs with ecosystem demands exhibit higher startup consolidation rates.

The development of urban tech talent is a key driving factor, especially when it is embedded within a city strategy that integrates education, technology, and employability.

The quality of local universities and the strength of ICT and digital skills training programs directly impact startup generation. Medellín has successfully built linkages between universities and businesses, while Santiago has a strong presence of private bootcamps (Crespo & Vázquez 2018).

4.3 Collaborative Networks and Ecosystem Governance

Methodological stage applied: a) Systematic review: identification of the "Collaborative Networks" and "Entrepreneurial Governance" thematic clusters. b) Qualitative coding in Atlas.ti focusing on institutional relationships and ecosystem nodes.

Table 6. Collaborative Networks and Ecosystem Governance

City	Collaborative Networks and Governance
Medellín	Tripartite governance model: university–industry–government collaboration
Santiago de Chile	Hybrid public–private network with strong state leadership
Mexico City	Fragmented ecosystem with no clear coordination nodes

Source: Author's own elaboration, 2024.

This table outlines how key ecosystem actors interact in each city. Medellín stands out for its tripartite governance model involving universities, businesses, and government institutions. Santiago de Chile features a hybrid network where the state leads coordination efforts alongside private sector stakeholders. In contrast, Mexico City presents a weak and fragmented network with limited strategic cohesion.

Key Findings (Networks and Ecosystem Governance):

- Medellín demonstrates shared governance among public, private, and academic sectors, sustained through long-term alliances.
- Santiago is characterized by hybrid networks fueled by state funding and active participation from private accelerators.
- Mexico City shows a fragmented collaboration network with overlapping and uncoordinated efforts across institutions.

The density of collaborative networks correlates with the diversity of funding sources and the speed of startup project maturation.

A systemic governance model, with structured information flows and effective collaboration among actors, significantly enhances the evolution of urban entrepreneurial ecosystems. In Medellín and Santiago, public–private platforms such as *Startup Chile* and *CEmprende* enable the alignment of resources. In Mexico City, the network remains more dispersed, hindering the emergence of a cohesive ecosystem identity.

4.4 Public Policies and Support Instruments

Methodological stage applied: a) Systematic review: thematic clusters "Innovation Policy" and "Urban Development Strategy". b) Documentary analysis: review of local government plans, IDB, and ECLAC reports.

Table 7. Public Policies and Support Instruments

City	Public Policies and Support Instruments
Medellín	Urban policy centered on innovation as a pillar of territorial development
Santiago de Chile	CORFO fund, incentives, and programs for early-stage startups
Mexico City	General policies with no specific focus on tech entrepreneurship

Source: Author's own elaboration, 2024.

This table outlines governmental actions aimed at promoting innovation and entrepreneurship. Medellín has adopted clearly defined policies with a strong territorial focus. Santiago de Chile channels support through mechanisms such as the *CORFO fund*. In contrast, Mexico City applies more general policies, lacking a specific orientation toward technological entrepreneurship, which limits their effectiveness.

Key Findings (Policies and Support Instruments):

- Medellín has implemented public policies centered on innovation as a core axis of territorial development.
- Santiago aligns *CORFO* funding with incentives for early-stage startups.
- Mexico City applies general development policies with no clear technological focus or evaluative monitoring.

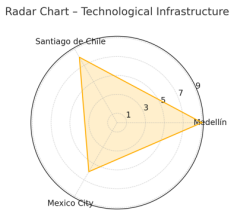
Ecosystems with targeted, well-funded public policies and strong local governance tend to exhibit greater sustainability and replicability of startup ventures.

The design of public policy adapted to urban and technological dynamics is a determining factor in building effective and equitable entrepreneurial environments.

5. Discussion

The findings reveal that there is no single formula for success in urban startup ecosystems; however, common enabling conditions do emerge. Digital infrastructure, talent development, and collaborative governance are critical elements. The analysis shows that models characterized by high interaction density and a systemic approach tend to be more resilient and scalable (Stam & Spigel 2017). Moreover, long-term public policies that promote investment in innovation and sustainable development have a multiplying effect.

The results presented provide insight into how enabling factors are expressed and interconnected in the context of technological entrepreneurship in Latin American urban environments. The discussion integrates the empirical evidence from Section 4 with the theoretical contributions of Section 2, following the four key dimensions identified in the study.



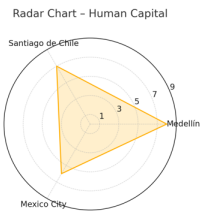


Figure 3. Summary of Enabling Factor Presence by City,

Source: Author's own elaboration, 2024.

The analysis of enabling factors for technological entrepreneurship in urban ecosystems reveals distinct patterns across Medellín, Santiago de Chile, and Mexico City, which are illustrated through the radar charts developed for each dimension.

Medellín stands out as the most robust and balanced ecosystem, achieving the highest scores in infrastructure (9/10), collaborative governance (9/10), and public policy (9/10), while maintaining a strong performance in talent development (8/10). Its success is the result of a coherent strategy that integrates public investment, territorial planning, and tripartite governance, establishing a favorable environment for the emergence and sustainability of tech-based startups.

Santiago de Chile, in turn, demonstrates a solid yet slightly more fragmented configuration. It consistently scores between 7 and 8 across dimensions, with particular strengths in human capital due to effective bootcamp-to-employment pipelines and in support policies via institutions such as CORFO. However, its decentralized infrastructure and lower institutionalization of collaborative networks constrain its potential for systemic articulation.

In contrast, Mexico City shows an emerging ecosystem with structural challenges. Its scores range from 5 to 6, especially low in governance and policy dimensions, where a lack of coordination and thematic focus hampers ecosystem consolidation. While it boasts a broad educational offering and numerous coworking spaces, these remain disconnected from a unified urban innovation strategy, thereby limiting their overall impact.

Taken together, the charts demonstrate that the optimal profile for a successful urban tech ecosystem involves a combination of specific policies, coordinated infrastructure, skilled talent, and collaborative governance. Medellín exemplifies this ideal, followed by Santiago with a more mixed approach, whereas Mexico City presents substantial opportunities for improvement, particularly in terms of systemic integration.

The literature consistently emphasizes the importance of physical and digital infrastructure as foundational components of entrepreneurial ecosystems (Spigel 2017; Stam 2015). This study confirms such claims: Medellín excels with its consolidated public infrastructure (Ruta N), Santiago offers emerging tech districts supported by local institutions, and Mexico City, despite having numerous private innovation spaces, lacks an integrated strategic network.

This confirms that infrastructure cannot be considered in isolation; rather, it must be integrated with public policies and collaborative networks to effectively support the growth and sustainability of technological ventures (Florida 2014; Kantis et al. 2020).

Authors such as Audretsch & Belitski (2021) and González-Pernía et al. (2019) assert that digital talent is a direct enabler of innovative entrepreneurship. Our results validate this assertion, particularly through the comparative lens of Medellín's dual-training model, Santiago's market-aligned bootcamps, and the disconnect between education and ecosystem needs in Mexico City.

Medellín demonstrates how a university–business–government alliance can turn education into a competitiveness driver. Santiago leverages the dynamism of private bootcamps to meet labor market needs. Mexico City, by contrast, shows that broad educational coverage is insufficient without alignment to ecosystem demands.

Ecosystem governance emerges as a key differentiator in the development of tech entrepreneurship (Carayannis & Campbell 2010; Isenberg 2011). Medellín exemplifies tripartite governance, enabling joint decision-making and strategic ecosystem direction. Santiago reflects an active yet informal network, whereas Mexico City exhibits fragmentation and institutional duplication.

This dimension is crucial as it determines resource flows, coordination capacity, and responsiveness to emerging challenges. An ecosystem with interconnected nodes and a shared vision fosters open innovation and resilience, as proposed by Spigel. (2017).

The literature is clear that public policies focused on innovation act as catalysts for technological entrepreneurship (Kantis & Federico 2020; IDB, 2022). Our results indicate that Medellín and Santiago have built coherent institutional frameworks with targeted funding, incentives, and monitoring systems. Mexico City, by contrast, operates under generalist policies that do not specifically address the needs of the tech ecosystem.

In line with ECLAC (2022), the conclusion is that cities with targeted and evaluable policies are more likely to consolidate their ecosystems. Urban policy design should therefore include support instruments linked to infrastructure, talent, and networks.

In summary, the comparative analysis confirms that urban technological entrepreneurship does not depend on a single factor, but rather on a systemic combination of enabling conditions: integrated infrastructure, relevant talent development, strong collaborative networks, and outcome-oriented public policies. Medellín represents a mature ecosystem that has effectively aligned these elements. Santiago is in the process of consolidation, with sectoral strengths and active public leadership. Mexico City remains a potential-rich ecosystem in need of greater institutional and strategic integration.

Therefore, in response to the article's central research question—What factors foster technological entrepreneurship in urban ecosystems?—we conclude that the key lies in the interaction between actors, resources, and governance instruments, enabling the scaling of successful experiences and the construction of inclusive, sustainable urban development models.

6. Conclusions

The findings of this research make it possible to identify common patterns and substantial differences among the urban technological entrepreneurship ecosystems analyzed. Based on the methodological approach applied, comparative evidence was obtained to support a set of conclusions aimed at understanding the structural factors that shape and strengthen these ecosystems in Latin American contexts. The conclusions presented below integrate empirical results with the theoretical contributions reviewed, offering a structured and substantiated perspective on the phenomenon.

Technological entrepreneurship in urban environments relies on the systemic articulation of enabling factors. The evidence collected demonstrates that the isolated presence of infrastructure, talent, or funding is not sufficient; what truly matters is how these elements are integrated through collaborative networks and coherent, sustained public policies.

Medellín stands out as a consolidated urban ecosystem, where territorial public policies, publicly funded innovation infrastructure (Ruta N), relevant educational programs, and shared governance among universities, companies, and government converge. This articulation explains its high performance across all analyzed dimensions.

Santiago de Chile presents a hybrid model that is still maturing, with notable progress in talent development and public funding (via CORFO), although it faces challenges related to the decentralization and institutionalization of collaborative networks. Its ecosystem is dynamic but still requires reinforcement through a more strategic city-wide vision.

Mexico City reflects a fragmented ecosystem with multiple disconnected initiatives. Despite offering a dense supply of coworking spaces and academic training, the absence of specific policies and governance structures limits the consolidation of a favorable environment for technological startups.

Collaborative governance emerges as the most decisive factor for scaling urban technological entrepreneurship ecosystems. Cities with participatory models and structured networks demonstrate greater resilience, innovation capacity, and talent attraction.

Public policy is also crucial to catalyze tech entrepreneurship, provided it is targeted, evaluative, and aligned with urban development strategies. The successful experiences of Medellín and Santiago highlight this, while Mexico City's case illustrates the cost of diffuse or generic public action.

The four-dimensional analysis model—infrastructure, talent, networks, and policy—proves useful for diagnosing and comparing ecosystems in a structured and replicable manner, enabling the generation of specific recommendations for each city.

In conclusion, strengthening technological entrepreneurship in Latin American cities requires moving from isolated interventions to strategic planning that integrates actors, resources, and future-oriented visions, thereby promoting smart, sustainable, and innovative territories.

These conclusions not only provide evidence for comparative analysis of urban innovation ecosystems but also offer relevant inputs for public policy design, institutional strategies, and entrepreneurship training programs. By demonstrating that the development of these ecosystems depends on the effective articulation of infrastructure, talent, governance, and policy, this study establishes a solid foundation for future research that seeks to deepen understanding of territorial dynamics, social impact, and replicable models of sustainable urban development through innovation.

Credit authorship contribution statement

This article was developed through the equal collaboration of all authors. Contributions included the conceptualization of the study, methodological design, literature review, results analysis, manuscript drafting, and critical content review. All authors approved the final version of the article and are jointly responsible for its content.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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