

# Adaptive Regional Innovation Systems: Addressing Latin America's Challenges

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## Abstract

This study offers an in-depth exploration of Regional Innovation Systems (RIS), emphasizing their operationalization within the context of regional development. Grounded in neo-Schumpeterian theory, the analysis extends beyond mere definition and characteristic identification, focusing instead on actionable strategies to foster innovative development. By examining the interplay between various actors such as enterprises, educational institutions, research bodies, and government agencies, the study reveals how these entities form cooperative networks that are vital for innovation. The research highlights the unique behavioral, cultural, and structural nuances that give rise to diverse RIS patterns, particularly in regions with distinct socio-economic challenges. The findings underscore the critical role of state entities in catalyzing regional development by mediating interactions, facilitating political articulation, and nurturing innovation initiatives. The study advocates for policies that prioritize interaction, cooperation, and learning processes, coupled with the strategic formation of joint initiatives and resource allocation to bolster regional innovation capabilities.

**Keywords:** Regional innovation system; Adaptive Regional Innovation Systems; Innovation Policy Development; Public-Private Innovation Collaboration; Strategic Regional Partnerships

Submitted: May 22, 2023/ Approved: December 14, 2023

## 1. Introduction

The exploration of innovation systems is fundamental to our understanding of the drivers behind regional economic development and technological progress. Central to this exploration is the concept of Regional Innovation Systems (RIS), which have become pivotal in the discourse on fostering growth within specific spatial dimensions. These systems are particularly relevant within the diverse and complex context of Latin America, where they provide a realistic framework for analyzing the innovation capacity of countries and regions.

Engaging with the broader discourse on innovation systems, this study aims to delineate their meaning, components, and the interplay of various actors involved, grounded in the neo-Schumpeterian literature. This approach highlights the interactive nature of knowledge production and the importance of institutional and cultural factors in shaping innovation processes. In Latin America, these factors become even more pronounced as the localized habits, values, cultures, and institutional structures blend with historical economic formations to uniquely influence the innovation dynamics of regions, as asserted by Asheim et al. (2019).

In these spatial contexts, where the agents' values, habits, culture, and other behavioral aspects intertwine with historical processes of economic formation, the study aims to offer a refined analysis of innovation systems. It will do so by focusing on the specificities of technological infrastructure and innovation policies within certain geographic areas, as highlighted by Garcia (2021).

This paper sets out with the objective to examine how RIS are conceptualized and operationalized within the Latin American context, and proposes ways to enhance their efficacy amidst the financial and institutional challenges unique to the region. It will explore how these regional systems can be cultivated and optimized, proposing a nuanced framework that integrates theoretical constructs with the practical realities of fostering innovation in a region marked by disparities and local nuances.

## 2. Unpacking Innovation Systems: Key Actors and Methodologies

Freeman (1995), Lundvall et al. (2002; 2009), and Freeman and Soete (2008) credit Friedrich List, who recorded in his work *The national system of the political economy*, published in 1841, the seminal ideas that created the NIS approach, arguing that he, despite not using such terminology, anticipated many aspects of contemporary debates on this topic. In this sense, said authors highlight the importance List gave to intellectual capital and the linking of production to formal institutions of science and education. He also recognized the interdependence of importing foreign technologies with local technical development and emphasized the role of the State in coordinating and implementing policies for the development of industry and the economy.

Lundvall (1992) points out that List highlighted the government's responsibility regarding the education and training of personnel, as well as the creation of an infrastructure to support industrial development. Thus, it appears that List is a vital and inspirational force for current research on SNI (Elan, 1997). Following this analytical

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perspective, Freeman (1987) is identified as the first to use the expression “National Innovation System”, with the publication of his work *Technology Policy and Economic Performance: Lessons from Japan* (Lundvall, 1992; 2007). Freeman emphasizes the abilities of different nations to exploit the process of innovation and technology diffusion for their benefit, highlighting which policies could contribute in this regard. It is in this sense that the term SNI is used to bring together the factors that, within each nation, could be used to explain the differences in innovative processes (Fagerberg; Sapprasert, 2011).

Also cited as a reference for this approach among the works of Lundvall (1992), *National Systems of Innovation: towards a theory of innovation and interactive learning*, and Nelson’s (1993) *National Innovation Systems: a comparative analysis* stand out. The former raises a theoretical discussion about NIS, highlighting, among other aspects, the importance of learning and interaction in the innovation process; and the latter, of a more empirical nature, presents case studies of NIS from 15 different countries, drawing a comparison between national realities (Edquist, 2005; 2013).

Thus, it appears that the literature on NIS starts to emerge from the second half of the 1980s, with important contributions in the early 1990s, gradually growing in the 2000s (Lundvall et al., 2009). Fagerberg and Sapprasert (2011), using bibliometric evidence, argue that the literature on NIS has been contributing to the integration of scientific, technological, research, and innovation policies, which are normally approached separately, contributing to the performance of countries and regions.

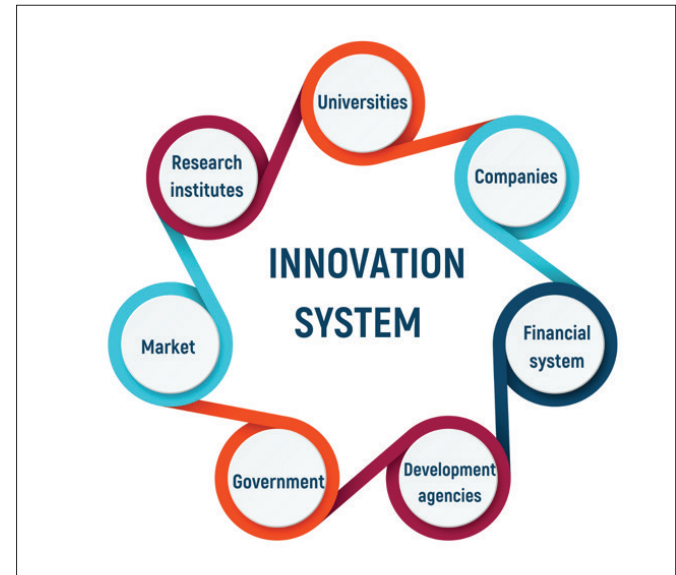
For Niosi et al. (1992), an NIS constitutes an interaction process, involving private and public companies, universities, and government agencies to create conditions for the development of science and technology within the territorial border of a country. Lundvall (1992, p. 89) in turn points out that an NIS expresses “The elements and relationships that interact in the production, dissemination, and use of new and economically useful knowledge and are located within or rooted in the borders of a State- nation”.

Still, in the understanding of Lundvall (1992), national economies differ in terms of the structure of their production system and terms of the institutional framework. While also combined with issues such as experience, language, and culture, they generate national specificities in the internal organization of companies, intercompany relationships, the role of the public sector, the role of the financial system in promoting innovations, and the intensity and organization of research and development (R&D) activities.

In this sense, an innovation system constitutes a network of institutions from the public and private sectors whose activities focus on interaction, creation, alteration, importation, and diffusion of new technologies. This network includes universities, research institutes, R&D centers, government development and financing agencies, public and private companies, business associations, non-governmental organizations, users, and clients in the market, among others, as shown in Figure 1. An innovative system consists of a set of actors focused on

technical training, stimulating innovation—product, process, organizational, etc.—intending to drive the economy towards growth.

**Figure 1:** Network of Actors within the Innovation System



Source: Prepared by the authors

The actors that make up an NIS, as well as the relationships that form within it, depend on the characteristics of each country, such as the size and degree of development, as well as the specific role of the main protagonists in the innovation process (companies, public and private research bodies, and other public institutions) as well as the forms, quality, and intensity of their interactions. It is observed that these actors are influenced by several factors specific to the country, such as the financial system and government structure, legal and regulatory frameworks, level of education and qualification, degree of labor mobility, labor relations, labor practices, business management, among others (OECD, 1999).

Studies on the innovation system incorporate, over time, new analytical scopes with a neo-Schumpeterian basis. However, an important and distinct landmark, in terms of analytical perspective is found in the studies carried out at the beginning of the ‘90s, considered of restricted scope, treated by Nelson (1993), and with the broad vision of Lundvall (2002). On the other hand, new analytical elements have been raised, such as, for example, incorporating more theory in the scope of the concept to provide greater analytical support, as observed by Edquist (2005), or even incorporating the vision of analyzing systems innovation from the perspective of the industrial organization expressed in global value chains (Pietrobelli and Rabelotti, 2009; 2011).

The comparative study carried out by Nelson (1993) on the innovation system considers the restricted perspective of the determinants of innovation, which is since the results show that the innovative processes come from the relationship between the structure of science and technology (S&T), the policies adopted, and the innovative performance

of companies in each country. This conclusion is supported by the greater attention and support that the technological infrastructure, which promotes R&D activities, traditionally receives. In this sense, the attention is given and the guaranteed resources support functions that enable the exercise of better conditions for the promotion and dissemination of knowledge and, consequently, promote innovations (Nelson and Rosemberg, 1993).

Lundvall (2002), in turn, points out—based on the experiences of innovative systems in the Nordic countries—that the success achieved in the industrial structure, in innovative capacity, and in sustaining competitiveness results from learning mechanisms that are not intensive in scientific knowledge. The interactions between producers-suppliers-users generate far-reaching innovative capacity, established from different forms of learning. From this perspective, innovative capacity extends beyond formal internal learning structures such as *learning by searching* or even manifestations such as *learning-by-using* and *learning-by-interacting*. In this sense, requirements such as culture, values, behavior, loyalty, trust, and power rooted in each national space contribute to the establishment of pro-innovation, dynamic, and interactive relationships.

An approach to the innovation system that has been growing lately refers to the incorporation of the new form of the industrial organization expressed by global value chains within the framework of the institutional structure, which promotes innovation. An important requirement is to understand the entry and performance of companies located in developing countries in global value chains, as well as understanding their active or passive role in the innovation process. Another requirement also highlights the importance of verifying how internal conditions are created in countries so that their companies can undergo upgrades in terms of processes, products, and functionality, as pointed out by Humphrey and Schmitz (2000). Along these lines, previous studies have highlighted how important it is to analyze governance structures and verify how knowledge flows are transferred, as well as how learning mechanisms generate conditions for promoting technical change in established networks (Pietrobelli and Rabelotti, 2009; 2011).

Lundvall's seminal work on innovation systems undoubtedly lays the groundwork for understanding the intricate relationships that foster innovation. Yet, the landscapes he describes are not static; they vary significantly across different socio-political contexts. In Latin America, the dynamism of these systems is often undercut by political volatility and institutional fragility. This necessitates an extension of Lundvall's theory, integrating a component that accounts for the resilience of innovation systems amidst governance challenges. The adaptation of his framework must, therefore, include strategies for coping with and thriving in the face of systemic corruption and political upheaval.

The resilience of Latin American innovation systems in the face of institutional voids is pivotal. Casas, De Fuentes, and Torres (2014) delve into the mechanisms through which innovation networks can be strengthened, despite the absence of strong institutional support,

which is often the case in Latin American contexts. Their work suggests pathways for fortifying the collaborative networks essential for sustained innovation

In this context, an important requirement that has been placed in the academic environment in recent times refers to the need to heed greater theoretical support to the concept of the innovation system, since its intensive use has weakened its *approach*. Edquist (2005) defends the idea that studies devote more attention to theoretical construction, as in this way the analysis of case studies, in general, would be strengthened. This approach would make the structure more consistent, based on the conceptual definition of its components, relationships, functions, and extension. In addition, Lundvall et al. (2007) note that a caveat should be made in this construction, as there may be problems in establishing definitive causal relationships—such as in the natural sciences—in the field of social sciences.

In general, the innovation systems approach has been widespread in academic circles and has brought contributions that should be part of the basic requirements, such as those chosen by Edquist (2005): (1) bring as a focus of discussion learning and innovation processes; (2) adopt a holistic and interdisciplinary perspective; (3) employ the historical and evolutionary perspective; (4) emphasize interdependence and nonlinearity; (5) cover both product and process innovation, as well as the subcategories of these types of innovation; and (6) emphasize the role of institutions.

While Lundvall's framework provides a comprehensive understanding of innovation systems, its application in the Latin American context demands a critical examination. Political instability and corruption, which are not central to Lundvall's discussion, significantly influence the functioning of RIS in this region. Here, we assert that a more dynamic approach is required, one that incorporates robust governance mechanisms and innovative financing models to insulate the innovation process from these adverse factors. We propose an augmented model that integrates Lundvall's principles with the resilience and adaptability needed to navigate the political landscape of Latin America.

The theoretical exploration of Innovation Systems (IS) provides a foundational understanding of the interplay between actors and approaches within these structures. Recognizing the particularities of Latin America, as delineated in our dedicated section on fostering innovation, it becomes evident that the traditional IS frameworks must be adapted. In Latin America, regional innovation actors operate within a context marked by distinctive challenges that necessitate customized approaches, emphasizing the need for systems that are resilient and flexible to regional specificities.

### Structural Elements and Frameworks of Regional Innovation Systems

The concept of RIS dates back to the 1990s, following the classic works of Freeman (1987), Lundvall (1992), and Nelson (1993). "As the chronology suggests, the RIS concept was inspired by the SNI concept

and is based on reasoning similar to that which emphasizes territorially based innovation systems” (Asheim and Gertler, 2005, p. 299). The last-mentioned authors also add that the emergence of the concept coincides with the success of *clusters* of regional and industrial districts in the post-Fordist era.

Doloreux (2002) comments on the NIS and the RIS, considering that some authors categorize ideas into different concepts and others consider regional systems as subsets of national systems, it is difficult to establish a precise distinction between the concepts of these two systems. Therefore, an important element of distinction is—within a descriptive and normative approach—to capture how innovative development takes place within a territory. In this sense, the institutional characteristics—culture, behavior, tradition, values, norms, laws, statutes—of the region, as well as the infrastructure, knowledge transfer systems, and the strategies and performance of companies represent basic conditions and stimuli to promote innovation activities (Doloreux and Parto, 2005).

Literature on RIS has been developing considerably over the last two decades (Doloreux, 2002; Cooke et al., 2004; Asheim and Gertler, 2005; Tödting and Tripp, 2013; Isaksen and Tripp, 2016b; Asheim et al., 2016; Doloreux and Gomes, 2017). The research agenda on RIS was consolidated around the concept that innovation is a systemic process (Edquist, 2005; 2013; Lundvall, 2007), which benefits from the concentration of economic activities and geographic proximity (Cooke et al., 2004; Carrincazeaux and Gaschet, 2015). In this way, it highlights the regional dimension in the generation, absorption, and exploitation of knowledge aimed at innovation. Thus, RIS can be conceptualized as the set of companies, organizations, networks, and institutions that shape the innovation capacity and performance of regions (Asheim and Gertler, 2005).

In this sense, different meanings of RIS are explained by authors who study innovative systems:

- a) Asheim and Coenen (2005, p. 1.177) define RIS based on the existence of “[...] institutional infrastructure to support innovation within the production structure of a region”;
- b) Nauwelaers and Reid (1995, p. ) highlights it as a “[...] set of economic, political and institutional relations that occur in a given geographic area, generating a collective learning process, with the rapid dissemination of knowledge and best practices”;
- c) Cooke et al. (1998, p. 1.581) state that it is “[...] a system in which companies and other organizations are systematically involved in interactive learning, through a rooted regional institutional environment”;
- d) Doloreux (2002, p. 249) signals RIS as an arrangement composed of “[...] a set of public and private actors that systematically establish a pattern of interaction capable of increasing and improving the capacities of learning located in a region”.

Following the review of early 2000s literature on RIS, it is clear that the field has undergone significant changes, warranting an examination of more recent contributions that address the evolution of innovation ecosystems. In recent years, the discourse on Regional Innovation Systems has evolved significantly, reflecting the rapid pace of change in the innovation landscape. Oh et al. (2016) provide a critical examination of innovation ecosystems, offering fresh perspectives on the interdependencies and dynamics within RIS. Such contemporary studies are essential for staying abreast of the latest terminologies and models in innovation studies.

The main components of RIS are the same that make up an NIS, with emphasis on companies, institutions, the knowledge infrastructure (innovation support structures that promote the diffusion of technology, technology and knowledge transfer agencies and institutions of R&D, such as universities, research institutes, and research laboratories), and innovation-oriented policies, with a focus and actions linked to regional development. It is noteworthy that such components located in the regional space, not only interact and cooperate but also carry out such actions with other structures located in a space beyond the regional configuration such as those found at the: mesoregional, state, national, and international levels.

The actors within Regional Innovation Systems are pivotal; however, their efficacy can be compromised in environments where corruption and political instability are prevalent. This challenge is particularly acute in Latin America, where innovators and institutions often navigate complex political landscapes. To mitigate these effects, it's crucial to look beyond Lundvall's framework and incorporate the insights of authors like Ramos and Morales (2019), who argue for establishing resilient innovation networks that can sustain collaborative efforts even when conventional institutional support is unreliable.

As we delve into the components and taxonomies of Regional Innovation Systems, the Latin American context, as expanded upon in our focused section, must be consistently considered. The regional specificities in Latin America influence the composition and dynamics of RIS, underlining the importance of developing a nuanced understanding of how these systems can be tailored to support the distinct innovation landscape in the region.

Based on this set of definitions, the region constitutes the *locus* of innovative processes. Thus, to define the scope of a given geographic space in which the conditions for innovative development are created, it is necessary to establish criteria. Cook et al. (1998) point out four criteria that define a region: 1st) having an indeterminate size limit; 2nd) present homogeneity and identity in relation to certain specific criteria; 3rd) distinguish the boundary area by a particular type of selected resource; and, 4th) have some kind of internal social cohesion. Later, Cook (2001) adds one more classifying element: 5th) criteria must be established within a certain period. With these five criteria, a geographic territorial space smaller than the national state is determined, endowed with distinct characteristic elements, which create conditions for the development of innovative regional systems.



Another contribution that aims to demarcate the regional space is presented by Cooke et al. (1997) under a double perspective of evaluation: (1) the regionalization approach, which relates the region to its competence (jurisdiction), valuing the degree of autonomy to develop policies and manage the different elements that make up the regional system and also the financing capacity for investments in infrastructure necessary for the innovative process; and (2) the regionalism approach, related to the cultural base of the region, which gives it a certain level of systemic potential, capable of establishing a new institutional order, creating norms, routines and habits and a governance structure. Regionalization involves creating arrangements for the purpose of stimulating the development of regional institutions. On the other hand “[...] regionalism involves the conception of regional organizations to give active expression to regional institutions” (Cooke et al., 1998, p. 1.574).

According to Stuck et al. (2016), the structure of an RIS highlights the regional dimension of innovation processes and emphasizes how the innovative and economic competitive advantages of the regions are related to the geographic proximity between the actors. As well as the way in which these actors and institutions are spatially interconnected and how the RIS are constituted in relation to the conditions of the organizational and socio-institutional structure. RISs differ with regard to the ability to develop new growth pathways due to pronounced differences in endogenous potentials and the variable ability to attract and absorb exogenous sources for the development of new pathways (Isaksen and Trippel, 2016b). Path changes and the emergence of new pathways are context-specific phenomena that vary between types of RIS. As a result, due to its *path-dependence* and contextual character, it is emphasized that the environment and its effects are specific to each region and respective reality (Tödting and Trippel, 2018), making it difficult to duplicate regional innovation systems (Azevedo and Cario, 2018).

The construction of a regional innovation system takes into account the historical past of the region, naturally marked by the presence of productive specialization, the endowment of infrastructure and institutional configurations. In fact, regions create *path dependences*, demonstrating that history matters in the construction of development, given that the past makes it possible to build, in the present, the desired structure for the future. In this sense, regions can change their development trajectories. As Wolfe observes (2000, p. 11) “[...] there is no lack of examples of localities and regions that changed their development trajectory through collective efforts to improve their endowment of their productive and institutional factors”. Thus, regions can advance and regress in their development processes. They may face dependence on the path that leads to political, structural and cognitive *lock-ins*, which become obstacles to the constitution of development trajectories within a new technological paradigm.

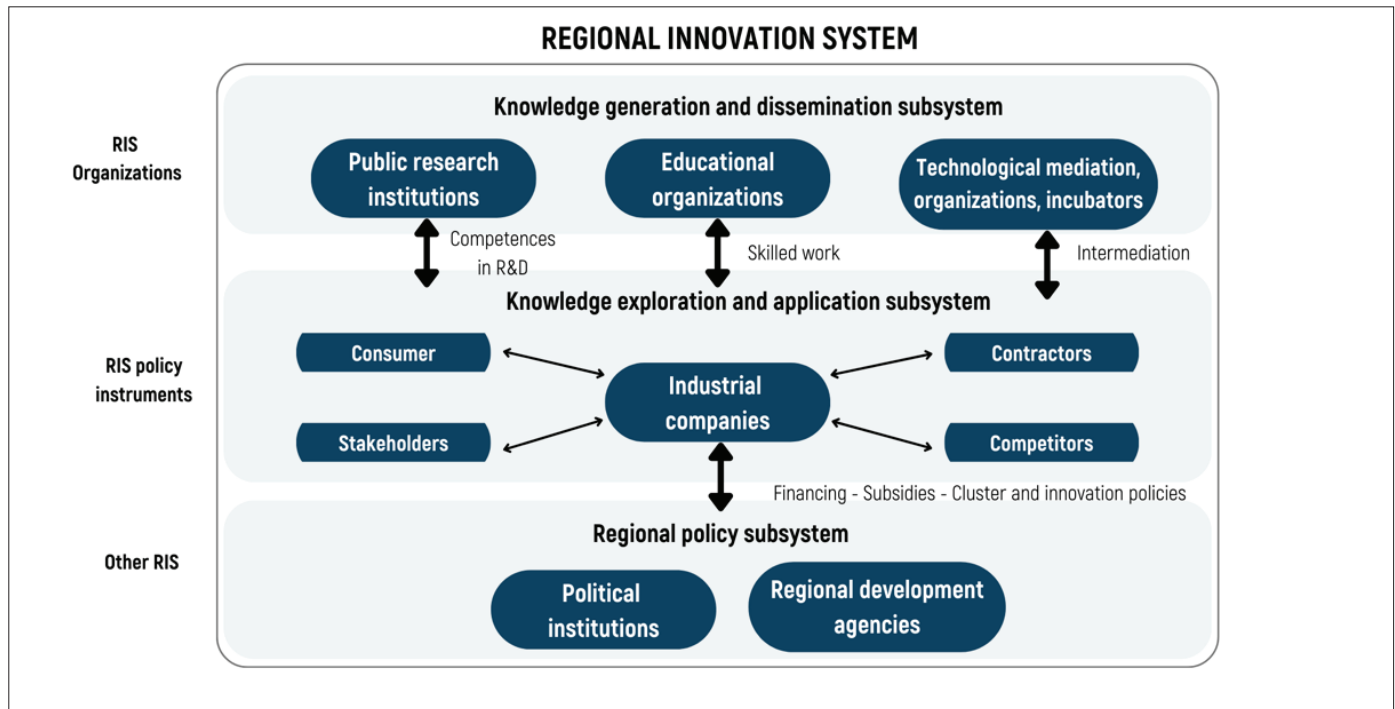
In the innovative processes of the RIS, the circulation and sharing of localized knowledge are crucial. Local interactions are a bedrock for fostering learning and knowledge acquisition processes. Asheim et al. (2019) elucidate that factors such as the mobility of qualified workers facilitate the cross-pollination of ideas and skills, which is vital for innovation. Collaborative efforts between agents, such as joint ventures or partnerships, lead to sharing and amalgamation of diverse knowledge bases. Moreover, the incidental insights, often referred to as ‘local knowledge spillovers,’ occur when proximity allows for informal exchanges and serendipitous sharing of insights. Formal dissemination through publications and conferences also plays a role, allowing for a broader distribution of knowledge that transcends geographic limitations. Lastly, the direct connections with the market enable real-time feedback and alignment of innovative activities with market needs. Garcia et al. (2020) add to this discourse by observing that while the first three factors—mobility of workers, collaboration, and spillovers—typically benefit from geographical closeness, the latter two—publications and market connections—are less reliant on physical proximity, thanks to digital communication platforms and global networks.

The contribution of non-local knowledge in promoting innovative regional development must also be considered. Depending on the content of this knowledge, it can lead to the development of new pathways in different RIS. However, Trippel et al. (2017) call attention to take into account the characteristics of each RIS—standardized, diversified, specialized, etc. As each type of RIS has a distinct structure, the needs of external sources vary, as well as their ability to attract and absorb outside knowledge for their own benefit.

As we consider the contributions of seminal authors in the RIS domain, such as Lundvall and others, it is essential to integrate the insights from more recent studies that build upon and extend these foundational theories. To this end, the work of Trippel et al. (2017) is particularly notable, as it provides a nuanced perspective on the multi-faceted nature of regional innovation systems. Their analysis delves into the complexities of systemic interactions and the interplay between regional stakeholders, offering a contemporary lens through which we can examine the evolution of RIS. Incorporating such recent scholarly work enriches our understanding of RIS dynamics and underscores the importance of evolving the theoretical framework to address current and emerging challenges within the field.

The literature suggests identifying an RIS from an interactive scheme of three subsystems, as proposed in the systematization performed by Tödting and Trippel (2005) and Arancegui (2009). As can be seen in Figure 2, the three subsystems mentioned comprise, on the one hand, the generation and dissemination of knowledge; on the other, the use of this knowledge by the productive sector; and, finally, a specific subsystem for the formulation and implementation of policies at the regional level.

Figure 2: Composition of a Regional Innovation System



Source: Adapted from Tödtling and Trippl (2005) and Arancegui (2009).

For Arancegui (2009), in a *dynamic* RIS, the knowledge generation and dissemination subsystem is expected to interact intensely with the knowledge use and production subsystem so that the former transmits economically useful knowledge, while the latter participates by expressing its technological needs and guiding the efforts made in the sphere of knowledge generation. Added to these two sets, a third subsystem is identified, formed by a governance base, which fulfills the role of coordinating entity, participating in interactive learning processes, either inducing them through fostering instruments or in a more active way through multiple types of incentives (Marcellino et al., 2013). In addition to these forms, there would still be more sophisticated ones, involving flows of human resources, financial resources, and the amplification of competences generated by the transmission of knowledge itself.

In this sense, efforts have been made by many research groups with the purpose of creating typologies of regional innovation systems. Thus, based on previous studies, Asheim and Gertler (2005, p. 300) define three types of RIS: "(1) territorially integrated innovation system—companies establish innovative activities in localized, by fostering an environment where frequent, rich interactions among regional actors occur. These interactions are catalyzed by factors such as shared regional objectives, cultural affinity, and mutual trust, which together stimulate learning processes by enhancing the accessibility to and exchange of knowledge. (2) networked regional innovation system—companies and organizations incorporated in a specific region characterized by localized interactive learning; and (3) regionalized national innovation system—characterized by the importance of

relationships with exogenous actors (universities, research institutes, other corporations) and by the cooperation between people of the same educational or occupational level".

In another study, Asheim et al. (2019) point out that the characteristics of the local productive and organizational structure influence the creation, circulation, and sharing of knowledge in the local space. In this context, they elect three types of RIS: 1st) RIS organizationally dense and diversified, in which there is a significant number of companies with diversified and heterogeneous industrial structures, expressive innovative effort, availability of technical and technological inputs, and differentiated solutions; 2nd) organizationally dense and specialized RIS with the presence of a productive structure of high technology sectors, knowledge, R&D organizations, the occurrence of links with international networks, and the existence of academic *spin-offs*; and 3rd) organizationally rarefied RIS, marked by a small number of companies, reduced number of organizations to generate knowledge, low organizational diversity and small interactions between agents, absence of high-tech industry, state-of-the-art university, and innovation support structure.

Another classification pattern is found in the study by Doloreux (2002), whose result indicates the existence of: 1) regions with strong, medium and weak potential to develop an innovation system, considering the infrastructure, institutional capacity and organization of companies; 2) level of integration to the national innovation system, corresponding to a part or a particular characteristic of that system; 3) existence or not of social cohesion, expressed in habits, trust, and

reciprocity in the region in favor of innovation; 4) modes of governance and forms of technology transfer at local and network level; and, 5) regional barriers and obstacles to innovation, such as lack of cooperation and use of obsolete technologies.

In another classification effort, Cooke et al. (1998), while choosing requirements that classify regions as having strong and weak RIS, recorded that regions whose innovative dynamics is recognized as one of the main characteristics are those that evolve towards a strong RIS. In turn, other regions, due to their characteristics that do not contribute to innovative development, establish themselves as having a weak RIS. Among the main elements considered as strong are: 1) cooperative culture; 2) desire for associativism; 3) willingness to learn; 4) public-private consensus; 5) reliable working relationships; 6) cooperation in the workplace; 7) search for innovation; 8) delegation of functions, among others. The elements marked as weak, on the other hand, express: 1) competitive culture; 2) individualism; 3) unwillingness to learn; 4) public-private dissension; 5) antagonistic work relationships; 6) dispersed division of labor; 7) difficulty of adaptation; and 8) centralization of functions, among others.

### **Promoting Innovation Amidst Financial and Institutional Challenges in Latin America**

In navigating the intricate web of socio-economic challenges in Latin America, individual actors are at the forefront of innovation, often operating in environments where traditional financial avenues are scarce. Recognizing these constraints, recent studies by authors like Gomez, Vargas, and Herrera (2019) advocate for alternative financing mechanisms such as crowdfunding and innovation microcredits. These tools have been shown to provide vital resources for individual innovators, enabling them to transcend financial barriers and bring their ideas to fruition.

The persistent issue of institutional instability and corruption requires SRIs in Latin America to be fortified by robust and transparent frameworks. Researchers like Rivera, Sheffi, and Knopoff (2020) argue for the development of anti-corruption strategies within these systems, designed to foster a culture of integrity that can withstand political and economic shocks. Implementing best practices in governance, as highlighted by Silva and Teixeira (2018), can serve as a bulwark against corruption, ensuring a conducive environment for innovation that protects the contributions of individual actors.

To combat corruption within RIS, specific strategies such as the implementation of transparent procurement processes, the establishment of clear legal frameworks for innovation funding, and the promotion of accountability through stakeholder audits can be crucial. For instance, Mexico's 'Innovation Transparency Initiative' demonstrates how enhancing transparency in the allocation of innovation funds can reduce misappropriation risks, thereby fostering a more trustworthy innovation environment.

Expanding the reach of innovation to encompass rural and traditionally marginalized communities remains a crucial goal. Scholars such

as Torres and Garcia (2021) emphasize the importance of integrating indigenous knowledge and local innovation practices into national innovation strategies, which can result in more inclusive and sustainable SRIs. Initiatives like participatory innovation development, supported by the findings of Hernandez, Ramos, and Pineda (2022), suggest that local community engagement is key to unlocking the potential of regional innovations, enabling a more equitable distribution of benefits and bolstering the regional innovation landscape in line with our proposed development strategies.

Inclusive innovation is at the heart of sustainable development. Arocena and Sutz (2012) argue that research and innovation policies in Latin America must be crafted with social inclusion as a central tenet. This ensures that the benefits of innovation extend across the socio-economic spectrum, enabling all segments of the population to participate in and benefit from innovation-driven growth.

### **Synergies and Learning: The Fabric of Regional Innovation Networks**

An RIS can be understood as the interaction of a set of public and private agents, formal institutions and other organizations, which works in a way that leads to the generation, use, and dissemination of knowledge (Doloreux, 2002; Doloreux and Parto, 2005; Doloreux and Gomez, 2017). Marcellino et al. (2013) point out that the system is not only integrated by private firms, but also includes research bodies, financing and governance institutions, technical and higher education institutes, policymakers, as well as the sociocultural standards related to innovative activity, incorporated to the regional context.

In these terms, the region constitutes a space for economic organization, in which the interaction between actors creates conditions for the development of policies and measures aimed at increasing the capacity for innovation. After all, in a given territorial space, companies, research institutes, universities, agencies that promote the transfer of technology, financial institutions, and other supporting government bodies develop interactive relationships that are expressed by way of information exchange, knowledge creation, cooperation agreements, innovative partnerships, division of functions, pro-innovation infrastructure, etc.

To point out virtuous characteristics in regional innovation systems, Cooke et al. (1998) consider, at the institutional level, the existence of cooperative culture, associative, willingness to learn, orientation for change, public-private consensus; and, at the corporate level, the presence of working relationships based on trust, cooperation in the workplace, orientation towards the well-being of staff, inspirational leadership, positive outsourcing, and a desire for innovation. Regarding the organizational level, they consider the development of policies aimed at inclusion, monitoring and delegation of actions, the provision of consultancy and networking. Such characteristics allow, as stated by Leydesdorff et al. (2002), that regions such as "[...] Lombardy in Italy; Baden-Württemberg, Germany; Rhone-Alpes in France; and Cambridge in the United Kingdom and others", are virtuous examples.

It is observed that regional actors do not innovate in isolation. Contrary to this, they are embedded in interrelated and interactive innovation processes. Such interrelationship and interactivity requires regions to be perceived as *innovation systems*, and implies that their success in innovation depends on the innovative capacity of regional actors and on the structure of their interaction (Doloreux, 2002). The establishment of these interactions results, therefore, from different types of exchanges within and among actors and subsystems as well as the region and the outside world, forming the system's creative foundation (Uyarra, 2011). These links imply interactive activities of learning, cooperation, and knowledge exchange, which guarantee external knowledge, efficiency gains, and reduction of uncertainties (Dodgson, 1994).

The central idea behind this approach is that innovative performance depends not only on the knowledge deposited by companies and public sector organizations but also on the way these different types of organizations interact with each other and with the environment concerning the production and dissemination of knowledge (Doloreux and Gomez, 2017). The RIS models highlight that innovation occurs at the regional level, influenced by specific socio-cultural conditions and by incentive policies, which enable organizations to interact (Cooke et al., 2004).

Therefore, the importance of considering the institutional environment is confirmed, given that regional rules, attitudes, standards, and values shape the strength and functioning of these links (Pondé, 2005). According to Doloreux and Parto (2005), innovation is spatially located, taking place in a well-defined historical, institutional, political, social, and economic context. Thus, innovation takes place in a regional context, making rules, conventions and norms prevail that are derived from economic and sociocultural factors, which differentiate technological development. Therefore, different institutions and interrelationships between the institutional framework and the productive sector result in different innovation efforts in different regions.

In this sense, different forms of interaction are perceived, which, in his study, Jump (s/d) classifies into two blocks for analysis: 1) direct interaction, related to R&D activities in companies, which is expressed in: a) interaction of companies—joint research and development activities of several companies, sometimes carried out through intermediaries; and b) interaction of companies and public organizations in R&D, such as universities, research institutes, either direct or mediated; and 2) indirect interaction of companies and other actors, comprised of: a) dissemination of technologies based on market relations (technology acquisitions, licenses, patents); and b) technology transfer, due to the mobility of workers.

For Cooke et al. (1998), in a given region, the production structure and the institutional support structure create conditions for the development of innovative processes. From these structures, the interactions and interrelationships between these actors generate knowledge flows and promote localized learning processes vital for the occurrence of innovations. In this sense, Doloreux and Parto (2005) observe that

the region acts as an arena, where local agents interact and exchange goods, services, experiences, and other tangible and intangible assets, which results in technical changes important for the construction of competitive conditions of regional economic agents.

In this sense, it is considered that the grouping of companies facilitates the creation, dissemination, and transfer of knowledge. According to Wolfe (2000), given the existence of time and distance savings, the spatial proximity between agents allows for the exchange of knowledge more easily. Likewise, understanding and knowledge transference are facilitated by the fact that agents participate in the same economic environment. As they are located in the same geographic area, they share a common set of values and culture, which allows for face-to-face interaction, facilitating the exchange of knowledge and accelerating learning processes.

It is also noteworthy that, for the occurrence of learning processes and increased stock of knowledge as an important condition for innovative development, a region must have educational institutions at their different levels and, in particular, structures which by technical and higher education aim to qualify workers. In addition, it must have universities and research institutes whose teaching, research, and extension activities are focused on areas of knowledge that aim to promote the development of technical progress. Areas of knowledge that are carriers of technical progress—electronics, chemistry, materials, biotechnology—drive the innovative process not only in the specific sector, but in several related economic sectors, generating first and second magnitude innovations.

The proximity of actors in a given region creates conditions for the overflow of knowledge and dissemination of tacit knowledge, in turn requiring conditions to develop, including that of social capital. Therefore, values such as solidarity, civic engagement, reciprocity, and reliability among actors are considered important for establishing joint action in many and diverse dimensions, such as those aimed at promoting innovation. As noted by Cooke et al. (1998), such prevailing characteristics contribute to the formation of collective identity or, in other words, to the constitution of collective action, which, as highlighted by Commons (2003), helps in the daily attitudes of actors and in the establishment of more regional strategies.

Given these conditions, agents are able to respond quickly to the changes that are taking place in the economic sector in which they participate, understanding and absorbing new forms of knowledge. The competitive process has highlighted the importance of quick responses to changes that occur in the economic environment, with the need to seek new external knowledge to be internally transformed and generate innovations that support better competitive conditions, as training is not always found locally. Therefore, the existing competence in a given place allows incursions in other regional external spaces and taking advantage of existing conditions (Teece et al., 1997; 2014).

The density and quality of infrastructure for innovation are important elements to be considered in a region. For Cooke et al. (1997), there are



regions that depend on the central administration and have no control over the type of infrastructure built, while others are more independent and have greater control and autonomy for infrastructure development. In one study, they point out elements related to management, highlighting: autonomous capacity to carry out regional public expenditure; regional capacity to impose taxes; regional government control over financial intermediaries; development of regional information and promotion policies; control over the execution of part of the strategic infrastructures; control or shared execution of strategic infrastructures; administration of education and vocational training systems; management of universities and research institutes; control over financial intermediaries; and policies for industry, science, and technology.

In addition to these structures, other vital institutions must be part of an efficient regional innovation system. In this sense, the importance of having financial institutions such as local banks and regional banks is highlighted, making resources available for specific demands. Likewise, it is important for the region to have government institutions that prepare budgets and carry out infrastructural investments such as transportation, energy, and communication for the benefit of regional development. The presence of representative institutions of businessmen and workers, such as unions and class associations, bringing together and defending the interests of their representatives, also adds value to the region and its innovation system. Lastly, for Doloreux and Parto (2005, p. 8), a region must have “[...] institutions that operate in and through different arenas, which can be grouped into levels of interrelationship (individuals, organizations and society), scales of governance (local, regional and national) and diverse systems (economic, social and political)”.

In addition, it is noteworthy that an innovative system established in a geographic region must also consider extra-regional institutions that manage and provide the circulation of knowledge, which, finally, help and favor conditions of regional innovative development. In other words, an active regional innovation system requires the development of actions beyond its geographical area of action, as supported by Ashen and Gertler (2005), suggesting that the RISs should expand their relationships, seeking access to national innovation systems and, if possible, to supranational innovation systems.

With the ongoing globalization of economic relations, companies can no longer be limited to the national or regional market and must maintain and create branches and representatives as well as suppliers and customers in various regional and national spaces. Expanding cross-border actions and thus innovative systems, one must consider several collaborative connections, among which those existing in other countries. In this sense, for Doloreux and Parto (2005, p. 144), “[...] what seems to mark the most successful innovative companies is the ability to connect with different innovation systems as a source of competitive advantage, to be connected to a wider network that offers a variety of sources of knowledge [...]”.

The interaction, learning, and systemic relationships within RIS gain additional complexity within the Latin American milieu. As we have explored, individual actors in this region face unique financial and

institutional hurdles. It is within these constraints that the adaptive capacity and resilience of RIS are tested, showcasing the critical role of systemic relationships that support innovation in spite of broader socio-economic challenges.

### Successful Regional Innovation Systems in Latin America

In the diverse and dynamic landscape of Latin America, various successful models of Regional Innovation Systems (RIS) provide invaluable insights into the effective implementation of innovation-driven development. This section delves into a selection of these success stories, illustrating the practical application of RIS theories and principles within the region’s unique socio-economic and cultural contexts.

- **Chile’s Innovation Ecosystem** Chile has emerged as a leading example of innovation in Latin America, thanks in part to its government’s strategic investments in RIS. Initiatives like ‘Start-Up Chile’ have not only fostered a vibrant entrepreneurial culture but have also attracted international talent and investment, catalyzing the growth of a robust innovation ecosystem.

- **Costa Rica’s Knowledge-Based Economy** Costa Rica’s transformation into a knowledge-based economy showcases the power of focused RIS strategies. By prioritizing education, environmental sustainability, and high-tech industries, Costa Rica has developed a unique RIS model that leverages its natural biodiversity and human capital.

- **Medellin’s Urban Transformation** Once known for its social instability, Medellin, Colombia, has reinvented itself as an innovation hub. The city’s commitment to urban renewal and social innovation programs, supported by collaborative RIS frameworks, has been pivotal in driving this transformation.

- **Brazil’s Agricultural Innovation** Brazil’s RIS model in agriculture, particularly the work of ‘Embrapa,’ demonstrates how sector-specific innovation systems can lead to significant advancements. By integrating research, local knowledge, and farmer engagement, Embrapa has played a crucial role in Brazil’s position as an agricultural powerhouse.

These cases illustrate the potential of RIS to drive sustainable development in Latin America. They reveal the importance of contextualized strategies that align with regional strengths and challenges. The lessons drawn from these experiences are instrumental in guiding future RIS initiatives across the region and beyond.

### Strategic Development through Regional Innovation Systems

In the foregoing, it is understood that an RIS is an “interactive knowledge generation and exploration subsystem, linked to global, national and other regional systems” (Cooke et al., 2004, p. 3), “in which companies and other organizations are systematically engaged in interactive learning through an institutional environment characterized by immersion” (Cooke et al. 1998, p. 1.581). In this context, RISs constitute the institutional, organizational and technological support infrastructure in a regional production system.

The vast majority of empirical studies in this field describe how innovation processes are organized and how this organization relates to different organizational, institutional, and political conditions (Cunha et al., 2009; Marcellino et al., 2013; Beneli et al. 2016; Azevedo and Cario, 2019). In these studies, little attention has been paid to the elaboration of an action plan to implement RIS structures. An OECD document (1999) draws attention to analyzing the specificities of countries in the innovation process and a guide for the formulation of public policies. In this way, the importance of the State in defining political strategies that result in the establishment of virtuous economic standards is reinforced. Such public policies based on RIS can support the renewal and boost the creation of new development paths (Coenen et al., 2017). In such actions, there is the desire to drive the new Schumpeterian combinations, which drive development (Schumpeter, 1982).

In these terms, Lundvall (1992) highlights the existence of actors based on an institutional structure focused on innovative development, which make it possible to inspire public policies related to innovation, both for the national and regional geographic space. The occurrence of this purpose is facilitated by the fact that the State knows the institutional context in which it can act and, consequently, develops actions aimed at promoting technical change. In addition, Metcalfe (1995, p. 205) points out: “The set of institutions, jointly and individually, contributes to the development and diffusion of new technologies, and provides the framework within which public management formulates and implements policies to influence the innovation process.”

An action plan can improve the way of coordinating the interaction related to knowledge and joint projects and, therefore, will enable the creation and maintenance of links between regional actors and facilitate the generation and dissemination of regional knowledge, increasing the performance of innovation in the RIS (Burger and Fiates, 2021). According to the research by Borges et al. (2021), in terms of regional development strategy, the main effort should be to coordinate the various actors for a process of regional development focused on the effective construction of a Regional Innovation System.

Indeed, RISs are affected by political structures, economic conditions, relations of divergent territorial power and interests (Monteiro et al., 2017). In view of this fact, it is up to the system's governance the role of intermediating and facilitating the interaction between the stakeholders and performing political articulation, thus promoting regional innovation programs. The execution of this role in governance must be carried out by the State. Cavalcanti Filho e Furtado (2017) explains that the State must incorporate regional development as a strategy. The State has the capacity to articulate private interests with the interests of society, which are not limited only to economic values, but also to other corporate values (Svare and Gausdal, 2015; Fernandez-Esquinas et al., 2016).

Table 1 shows actions that should be considered when preparing a development plan for RIS. This proposition aims to help build new avenues for innovative regional development policy (Isaksen et al., 2018), as well as create conditions for taking advantage of opportunities and challenges that open up in regional innovative processes (Morgan, 2015). Thus, it is paramount: to secure collaboration aimed at building

a regional innovation environment (institutional cooperation aimed at innovation from the relevant actors and development of a communication and dialogue plan between the actors); set up a structure that allows for the development of interaction (continuous professional and business qualification actions); and introduce other resources for regional innovation (organization, updating and dissemination of information, as well as articulation of funding sources with innovative actors).

The existence of several structures is essential, such as: knowledge and research—universities and research institutes; financial—banks and financing agencies; intermediaries—government services, private innovation—of companies of different sizes; and market—consumers, creating conditions for the development of public actions. Such structures constitute a key dimension and are the object of public policy actions, such as: 1) development of monetary-financial arrangements, which enable the creation and operation of universities and research institutions; 2) a policy of attracting companies with technical progress—electro-electronics, fine chemicals, biotechnology, nanotechnology, etc.; 3) encouraging the formation of business networks—exchange of technological information and knowledge; 4) construction of interaction mechanisms for the participating actors (problems, challenges, projects, partnerships); and, 5) development of a culture of cooperation based on public-private actions—protocols of intent, systematic meetings, etc.

In light of the theoretical perspectives, policy implications must be carefully tailored to the distinct realities of Latin American countries. The model proposed by Lundvall is a starting point, but as we advocate for a region-specific approach, we must consider additional factors such as the impact of corruption on policy implementation. The work of Silva et al. (2021) provides valuable insights into creating anti-corruption frameworks that support the integrity of innovation policies and their effective enactment. Therefore, our policy recommendations are underpinned by a dual focus on fostering innovation and ensuring robust governance to withstand the socio-political challenges inherent to the region.

Recent empirical studies provide a vivid picture of Latin America's innovation landscape.

Governance in innovation is critical for the growth and strengthening of Regional Innovation Systems, particularly in Latin America. De Fuentes and Dutrénit (2012) highlight best practices that can significantly contribute to the vitality and effectiveness of these systems. Their insights into the governance structures that bolster innovation ecosystems provide a valuable framework for considering policy directions in the region.

In our efforts to instrumentalize development through Regional Innovation Systems, the Latin American experience offers profound insights. The strategies for fostering individual innovation within these systems, as previously outlined, become pivotal. They illustrate how targeted interventions and policy formulations can elevate the effectiveness of RIS in a region characterized by vibrant cultures, diverse economies, and complex political landscapes.

**Table 1:** Proposed Plan for the Development of a RIS.

CONSTRUCT	ACTION	ACTORS
Construction of regional innovation environments	INVEST in institutional cooperation based on research, development, innovation; solution of technological, marketing, and organizational bottlenecks; connecting the relevant actors	Public research organizations; Educational organizations; Industrial companies
	IMPLEMENT and COORDINATE a technological park with a regional actor, making the process of the previous item permanent	Industrial companies; Political institutions; Regional development agencies
	DEVELOP an ongoing plan of communication and dialogue with the business sector, reporting regularly, to create a permanent channel of motivation for this economic segment to strengthen its relationship with regional development agencies	Regional Development Agencies; Industrial Companies
	PROVIDE guidance and support for taking advantage of opportunities	Political Institutions; Regional Development Agencies
Interaction behavior in the regional organization of innovation	CARRY OUT ongoing professional qualification and business training actions, planned according to regularly identified needs and opportunities, in the interaction between regional actors (agency, entrepreneurship support structures, unions, municipal economic development secretariats)	Educational Organizations; Technological Mediation Organizations
	IMPLEMENT regional marketing plans and actions, supported by systematized information—organized in a regional database with systematic updating—to attract new industrial, service, and advanced tertiary enterprises	Political institutions; Regional development agencies; Public research organizations
Injection of resources for regional innovation	ORGANIZE, UPDATE and DISSEMINATE relevant information on: a) financing and business opportunities (for example, in notices at the three federated levels); b) lines of credit; c) fiscal programs and incentives; d) events, seminars and workshops, useful in technical terms and/or market opportunities; e) trade shows and workshops, including the dissemination of lists and displays of input purchases by large companies in the region and neighboring regions, in order to encourage possible regional suppliers	Political Institutions; Regional Development Agencies
	MAINTAIN constant articulation with private, public, multilateral and third sector financing sources, to make viable programs and lines of financing associated with the purposes described above	Political institutions; Regional development agencies; Industrial companies

## Conclusion

In conclusion, this research extends beyond the foundational insights of Lundvall, proposing an innovative adaptation of Regional Innovation Systems to meet the complex demands of Latin America. While acknowledging the instrumental role of existing theoretical frameworks, our study confronts the pressing challenges of political instability and corruption head-on. We have critically engaged with and expanded upon these frameworks to construct resilient and adaptive RIS, with an eye towards systems that are robust enough to foster innovation in historically volatile environments.

Our modifications to Lundvall's model are designed to build innovation systems that are not just theoretical constructs but pragmatic entities, capable of producing sustainable outcomes in the face of

external shocks. This paper presents a significant leap forward, as it tailors the concept of RIS to the intricate realities of Latin America, a region ripe with potential yet hindered by its unique socio-political challenges. By doing so, we have outlined strategic modifications that ensure the viability and effectiveness of RIS, offering a beacon for sustainable development in the region.

The critical and innovative approach adopted here underscores the urgent need for a dedicated focus on Latin America's innovation potential. Our comprehensive analysis has led to a development plan that is intimately connected with the region's characteristics, ensuring that the proposed RIS model is not only a theoretical extension but a vital component of practical application for fostering sustainable development.

Furthermore, the paper emphasizes the systemic nature of innovation, which relies on the interconnectedness of various actors within the ecosystem. In this regard, we have elucidated the multifaceted roles of companies, universities, research institutes, government agencies, development banks, and class associations in the innovation process. Each entity plays a pivotal role—companies in commercializing innovation, universities in knowledge generation and transfer, research institutes in promoting research, government agencies in regulatory functions, development banks in financing, and class associations in fostering actor participation.

In the specific context of Latin America, the regional innovation system is not only concerned with innovation within a territory but is also deeply influenced by the region's distinct institutional characteristics such as values, culture, tradition, behavior, and habits. These regional specificities offer a fertile ground for developing interconnected actions that support innovative efforts and provide localized competitive advantages.

The conclusion of this study is a call to recognize and harness these distinct regional traits. It is through understanding and integrating these local nuances that RIS can truly catalyze innovative development within Latin America. We have not only mapped the current state of regional innovation systems but also provided a clear direction for the development of strategies that resonate with local realities, setting the stage for the region to overcome its challenges and harness its full potential for innovation-led growth.

In light of our findings, it is evident that the actions to promote development must be multifaceted and collaborative. The state, as an institution aimed at bringing together constructive actions, plays a crucial role in partnership with the private sector and other actors. These actions, informed by the nuances of each regional base, should be directed towards implementing and coordinating technology parks, institutional cooperation in R&D, professional training programs, regional marketing strategies, attracting technology-based companies, and articulating with funding sources to build a new regional innovation environment or enhance an existing one.

By acknowledging the existence of different types of RIS with varying degrees of density, diversity, and institutional support, this paper has shed light on the necessity of a nuanced approach to innovation policy. Tailoring policies to the specificities of each regional innovation system, as we have articulated, is not merely a recommendation but an imperative for the realization of innovative capacities across Latin America.

Our research, therefore, not only contributes to the academic discourse but also serves as a practical guide for those engaged in the design and implementation of innovation strategies within the region. It is a decisive step towards redefining the boundaries of regional innovation, advocating for a future in which Latin America harnesses innovation as the cornerstone of sustainable and equitable development.

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