Peripheral regional innovation systems: conceptual contributions from Latin America and applications in Argentina

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Abstract

One of the features that differentiates developed or central countries from developing or peripheral countries is the magnitude and intensity of the territorial inequalities within them. In the latter, the structural heterogeneity and the socioeconomic gaps between subnational centers and peripheries are much greater, as well as the variability among central and peripheral situations. Moreover, these gaps present multiple characteristics and particular structural factors. In order to contribute to understanding the center-periphery divergences within developing countries, particularly in techno-productive terms, the chapter discusses, combines and redefines some conceptual foundations of the Latin American structuralist school of thought and the regional innovation systems approach. This conceptual contribution is complemented with a review of different quantitative and qualitative studies from Argentina that seek to identify, characterize and differentiate peripheral regional systems, which can illustrate and inspire the application of such approaches in other developing or peripheral countries.

1. Introduction

The literature on regional innovation systems (RIS) has been expanding and consolidating for about three decades, following the publication of a series of seminal papers in the mid-1990s in Europe. According to the first definitions of the pioneers in the field, a RIS essentially comprises the organizational infrastructure supporting innovation, the productive and business structure of the region and the possible linkages between them. Although European studies initially focused on successful RIS, there has been a growing concern for analyzing less developed, lagging or peripheral regions since the second half of the 2000s (Tödtling and Trippl, 2005). This trend has become even more intense in the last decade (Bai et al., 2024), with several studies that identify different types of peripheral regions from a multidimensional perspective (Nilsen et al., 2023; Tsiotas and Tselios, 2023; Calignano et al., 2024).

In Latin America, following the legacy of Prebisch, the Economic Commission for Latin America and the Caribbean (ECLAC) and the structuralist school of thought, the conceptual distinction between centers and peripheries has been historically present in discussions on technical progress, innovation and national economic development (Cassiolato and Lastres, 1999; Arocena and Sutz, 2000; Cassiolato et al., 2003; Cimoli and Porcile, 2014; Chaves et al., 2020). However, the notion of peripheral RIS was relatively absent at the beginning (Llisterri and Pietrobelli, 2011; Fernández and Comba, 2017). It is only in recent years that some studies have begun to discuss the particular characteristics of innovation systems in peripheral regions within peripheral countries, which some authors call "the periphery of the periphery" (Starobinsky et al., 2020a; 2020b; Niembro and Starobinsky, 2021; Gonzalo et al., 2023).

This chapter aims to deepen the understanding of the center-periphery divergences within developing or peripheral countries, in terms of some structural characteristics of these peripheral economies and their regional innovation systems. Firstly, we discuss and combine some conceptual elements of Latin American structuralism and the regional innovation systems approach to provide a definition or identification of some of the main features of peripheral RIS (in developing or peripheral countries). Secondly, this conceptual contribution is complemented with a review of different quantitative and qualitative studies that seek to identify and characterize peripheral regional innovation systems in Argentina, in some cases emphasizing the diversity or heterogeneity of peripheral situations. Finally, we highlight the main conclusions of the chapter and suggest some theoretical, methodological and policy challenges ahead.

The implicit assumption or hypothesis guiding the chapter is that peripheral RIS in developing or peripheral countries, such as Argentina, face unique structural and systemic challenges that differentiate them from peripheral RIS in developed or central countries.

Among other aspects, these challenges or failures result in weaker institutions, infrastructures and techno-productive capabilities, limited linkages and greater dependence on central regions, requiring broad conceptual frameworks and tailored policy interventions.

2. Innovation systems approach in the periphery: a Latin American path

The asymmetric distribution of technical progress among countries and regions has been at the core of the analysis of Latin American structuralism since its origins. In Prebisch (1950), a pioneering contribution to this approach, the center-periphery conception emerges as a result of the historical expansion of capitalism at the global level. While industrialization in central economies consolidated homogeneous (in terms of intersectoral productivity) and diversified productive structures, peripheral countries show heterogeneous and specialized structures (unequal productivity levels between sectors, with some of them at subsistence levels, and a high degree of specialization in the production and export of primary products). Based on the center-periphery framework, different authors highlight that the international division of labor does not only fail to promote international convergence, but also reinforces the asymmetric distribution of "the fruits of technical progress", reproducing structural problems in the periphery, such as balance of payments imbalances, low productivity levels, unemployment and underemployment, poverty and income inequality (Rodríguez, 1977; 2006; Sztulwark, 2005; Bielschowsky, 2009).

Although the industrialization processes in Latin America between the 1950s and 1970s achieved some significant progress, mainly in terms of per capita income growth and the generation of endogenous technical capabilities, they also tended to replicate the center-periphery pattern within these countries (Pinto, 1970; 1984; Pinto and Di Filippo, 1979). Based on a port and transportation infrastructure largely inherited from previous decades, together with strong internal population migration, the most dynamic productive and commercial activities tended to concentrate in large cities. Thus, while central regions have higher capital endowment per capita, greater productivity and efficient forms of organization, peripheral regions show a significant weight of subsistence agriculture, as well as urban and service activities with low levels of productivity and little mechanization. This reproduces over time a spatial heterogeneity within Latin American countries, based on inter- and intra-sectoral disparities and technological, productive, commercial and cultural dependence (Pinto, 1970; 1984; Rodríguez, 1977; 2006; Gonzalo, 2023).

Since the 1970s, with the crisis of Fordism and the emergence of a new techno-economic paradigm, mainly driven by information and communication technologies and life sciences, the focus on technological capabilities and regional innovation efforts has increased, both globally and in Latin America. In this context, different neo-Schumpeterian and evolutionary approaches appear in the Global North, emphasizing the importance of technological change

and innovation as key aspects of the competitiveness of companies and regions. In particular, the innovation systems approach emerges as a "focusing device" that highlights the systemic and multidimensional nature of innovation processes, based on the premise that innovations are not the result of isolated efforts, but of a complex network of social, technological and productive interactions (Nelson and Winter, 1982; Freeman, 1995; Edquist, 2005; Lundvall, 2007).

The innovation systems framework has been adopted and adapted by different institutions and epistemic communities in Latin America. For example, the ECLAC has considered and used it since the 1990s (Fajnzylber, 1990; Cimoli, 2005; Cimoli and Porcile, 2014). At the same time, several Latin American researchers seek to merge the contributions of structuralism, the Latin American thought on science, technology and society, and economic evolutionism (Cassiolato and Lastres, 1999; Arocena and Sutz, 2000; Robert and Yoguel, 2010; Gonzalo, 2021; 2023).[1] Given the specificities of the region and the structuralist approach, the conceptual framework of innovation systems adopts distinctive characteristics in its Latin American conception (Cassiolato and Lastres, 2008; Gonzalo, 2021). For example, something not necessarily noted in the mainstream literature on innovation systems is that the peripheral condition involves a series of structural obstacles and serious challenges, due to the historical conformation of asymmetrical relations that favors the retention and accumulation of technical progress in the centers.

Likewise, given the social and territorial nature of the innovation process, the structural analysis of regional dynamics becomes particularly relevant, recognizing that the national level may be too general to understand some phenomena that are more specific to the different regions. In other words, subnational singularities in terms of economic, productive, social and political structures make the regions a relevant level of analysis. Thus, in Latin America and in developing countries in general, the study of national and regional innovation systems requires the adoption of a broad perspective, addressing economic, social, political and geographic factors, and integrating micro, macro and meso-economic levels (Cassiolato and Lastres, 1999; Cassiolato et al., 2020; Trucco and Fernández, 2021). In this sense, Arocena and Sutz (2000) note that in developed countries with relatively consolidated systems, the innovation systems approach is used ex-post (to analyze already existing systems). In contrast, it is used ex-ante in developing countries, as a tool to identify system failures and guide policy discussion, since it is still necessary to promote the development of these systems (Niembro, 2019).

Taking into account the particularities of the Latin American context, some recent studies have advanced on the notion of peripheral RIS and, in turn, on the heterogeneity of the

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[1] It should be noted that the structuralist approach is not only applied in Latin America, but also to study asymmetric development processes in other peripheral regions of the Global South (Gonzalo and Cassiolato; 2016; Gonzalo, 2023).

internal or subnational peripheries (Starobinsky, 2020; Starobinsky et al., 2020a; 2020b; D'Alessandro et al., 2021; Niembro and Starobinsky, 2021; 2023; Gonzalo and Starobinsky, 2023; Gonzalo et al., 2023). These contributions suggest that, apart from sharing certain weaknesses with lagging RIS in developed countries,[2] the regional systems in "the periphery of the periphery" face other structural issues and challenges arising from the general peripheral condition. Among these issues, we can highlight: a) the need to address the geographical, historical, cultural and political specificities of each region in a broad sense; b) structural weaknesses and competitive disadvantages related to infrastructure, connectivity, logistics and transportation (high) costs, and the available energy sources; c) the dependence relationship with the centers and their techno-productive, commercial and political influence; d) low geographic agglomeration (and integration) of people, companies and institutions, with the inability to reach minimum thresholds of entrepreneurial, scientific-technological and financial capabilities; and e) for all these reasons, low relative power and political incidence in decision-making (at the national level) and resource allocation.

These contributions can help to deepen the discussion on peripheral RIS in developing or peripheral countries, incorporating other structural dimensions of their condition that cannot be solved only with policies or resources in science and technology. It is also evident that not all peripheral RIS have the same characteristics. Instead, there are heterogeneous peripheries, with distinctive features and/or different intensities, as highlighted by some studies that are explored below (Niembro and Starobinsky, 2021; 2023).

3. Quantitative studies on (peripheral) RIS in Argentina: background and challenges

As noted in some reviews (Doloreux and Porto Gomez, 2017; Bai et al., 2024), an important part of the literature on regional innovation systems has been devoted to the "typological study of RIS", that is, to empirically classify and characterize the regions, generally using multivariate analysis techniques based on science, technology and innovation (STI) indicators and, in more multidimensional studies, also socioeconomic variables.[3] Other contributions have built regional innovation indexes on the basis of simpler but also limited methods, such as the use of simple averages or ad-hoc weights. A second noteworthy aspect of the reviews is the concentration of papers in central countries, mainly in Europe (Doloreux and Porto Gomez, 2017; López-Rubio et al., 2022), while RIS studies in less

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[2] The European literature on SRI highlights three common system failures (Tödtling and Trippl, 2005; Martin and Trippl, 2014; Trippl et al., 2016): organizational thinness, due to the absence or inadequacy of some key organizations for the generation and diffusion of knowledge; fragmentation or linkage failures, due to a lack of interactions or an excess that generates closed networks; and lock-in in mature or declining activities and technologies, common in traditional manufacturing regions in Europe and also in peripheral regions dependent on the exploitation of natural resources.

[3] Although it is common to combine factor and cluster analysis in empirical typologies, some studies use them separately. Factor analysis can be employed to identify principal components (dimensions) for a simpler regional characterization or to construct synthetic indexes to rank the regions. On the other hand, some studies use clustering techniques without previously applying factor analysis, but based on the original variables.

developed countries are still scarce. In Latin America, we can highlight some efforts to develop empirical typologies (Llisterri and Pietrobelli, 2011; Sánchez Tovar et al., 2014; Valdez-Lafarga and León-Balderrama, 2015; Bernal Pérez, 2018) and synthetic regional innovation indexes (Beneli et al., 2022; DNP-OCYT, 2022; Villarroel and Albis, 2024) for Brazil, Chile, Colombia, Mexico and Peru.

A review of the contributions from Argentina reveals some particularities of these studies in developing or peripheral countries, where regional STI data are scarce or much less than those available in Europe. Firstly, this has led to a certain delay in addressing these topics. For example, the first empirical typology for Argentine provinces is provided by Niembro (2017), based on a multivariate analysis (factor and cluster analysis) of data circa 2010. This initial study highlights the heterogeneity of RIS within the country, since the capital district, specialized in services and with high STI development,[4] coexists with some (southern) provinces of primary productive pattern but with scientific poles, and also with northern provinces with a primary profile and a highly underdeveloped STI system (these are identified as peripheral RIS, located in the historically most backward region of the country). However, this typology also presents a very particular cluster, which includes four of the provinces with higher economic and productive development (beyond the capital), together with other provinces with varying levels of development, productive profiles and scientific capabilities. Niembro (2017) suggests that this group may be reflecting a characteristic of several regional innovation systems in peripheral countries, as they are mostly intermediate, emerging or immature.

Secondly, a noteworthy feature of Argentina, in contrast to more developed countries, is the greater weight of the public sector in terms of R&D investment. According to data from RICYT (Ibero-American Network of Science and Technology Indicators) for the period 2018-2020, only 23% of R&D in Argentina is funded by companies, compared to 45% in Brazil, 49% in Spain and Portugal or 65% in the United States, being even much lower than the Latin American average (36%). For this reason, those empirical studies that analyze aggregate regional STI data (such as total investment in R&D or researchers over population) tend to reflect mainly the situation of the public sector. Moreover, unlike European studies that commonly use data on private R&D, innovation or patents, this type of information is much more limited in Argentina. For example, it is only in the last decade that business innovation surveys have included the geographic dimension, although the results are published for macro-regions grouping several provinces (which are equivalent to entire European countries in terms of size and diversity). In this sense, Borello's (2016) research on the geography of innovation represents an (or the) exception in Argentina. Based on an

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[4] The identification of a particular cluster, comprising only one special region, is also common in other Latin American studies, as well as in studies of a single European country.

official survey that was later discontinued, the author gathers a large number of variables describing the innovative effort of industrial small and medium-sized enterprises (SMEs) in the period 2006-2008 and builds a synthetic index to rank the provinces and analyze their relative position.[5]

Thirdly, in addition to the scarcity of regional information (particularly on business innovation and linkages with public scientific organizations), there is a lack of regular updating or, as mentioned above, interruptions of surveys and statistical series. As a result, many studies are limited to providing "snapshots" of a particular moment and it is difficult and costly to sustain efforts over time. Two examples are the Provincial Competitiveness Index, elaborated between 2007 and (for the last time) in 2012 (IIEBCC, 2012), and the analysis of provincial asymmetries in Barletta and Erbes (2021), where in both cases STI is included as a dimension or sub-index. Despite the limitations of these studies to describe RIS dynamics or trajectories, Niembro's (2020) results for the period 2003-2013 show low variability or relative stability of provincial characteristics and, above all, of RIS disparities throughout that decade. This supports the idea that "RISs tend to be relatively stable phenomena" (Tödtling and Trippl, 2013: 298), since institutions, support infrastructures and productive structures have a high degree of inertia or path-dependence and, in general, changes (when they occur) only take place in the long term.

Lastly, it is only in recent years that some studies have deepened and gone beyond the center-periphery dichotomy. For example, based on the construction of a multidimensional synthetic index, Niembro and Starobinsky (2021) classify the RIS into three groups, identifying a set of intermediate systems. This heterogeneity of situations, especially within the centers and peripheries, is accentuated in a later article (Niembro and Starobinsky, 2023), in which they identify five groups: central, central (-), intermediate, peripheral (+) and peripheral. These different RIS conditions are also related to the predominant knowledge bases in the productive structure and to the level of provincial socioeconomic development.

As expected, the use of different variables (in quantity and type), methodologies and years or periods of analysis usually translates into (partially) different SRI classifications, which we summarize in the Annex and also map in Figure 1. This variability of results has given rise to some studies that try to identify stylized facts, proposing the construction of a provincial "meta-classification" or "typology of typologies", by means of clustering techniques (Niembro and Calá, 2023). Although it is possible to detect some regularities, especially at the extremes of the "more central" and "more peripheral" RIS, the situation is quite variable in an intermediate set of provinces. Following the logic of differentiation between peripheral RIS

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[5] In the Annex table (which brings together the provincial classifications of the different studies in Argentina), it can be seen that some provinces appear better (or worse) positioned in terms of business innovation (Borello, 2016) than in the first studies (columns) of the table, where the indicators are mainly focused on scientific capabilities in the public sector.

(or, more generally, of the "not strictly central" RIS) introduced by Niembro and Starobinsky (2021; 2023), we can refer as semi-centers (or "centers minus") to a group of provinces that have some characteristics close to central RIS (in particular, a certain strength of the public scientific system) but with ingredients of the periphery (for example, less technological and innovative efforts by firms). On the other hand, provinces in an intermediate or semi-peripheral situation also combine favorable and unfavorable aspects, but with a greater weight of the latter ones. Finally, within the set of peripheral RIS in Argentina, we can distinguish some degrees or intensities, from a couple of extreme situations, passing through the core of peripheral systems, to some more moderate cases (or "peripheries plus").

Figure 1. Map of RIS typology in Argentina
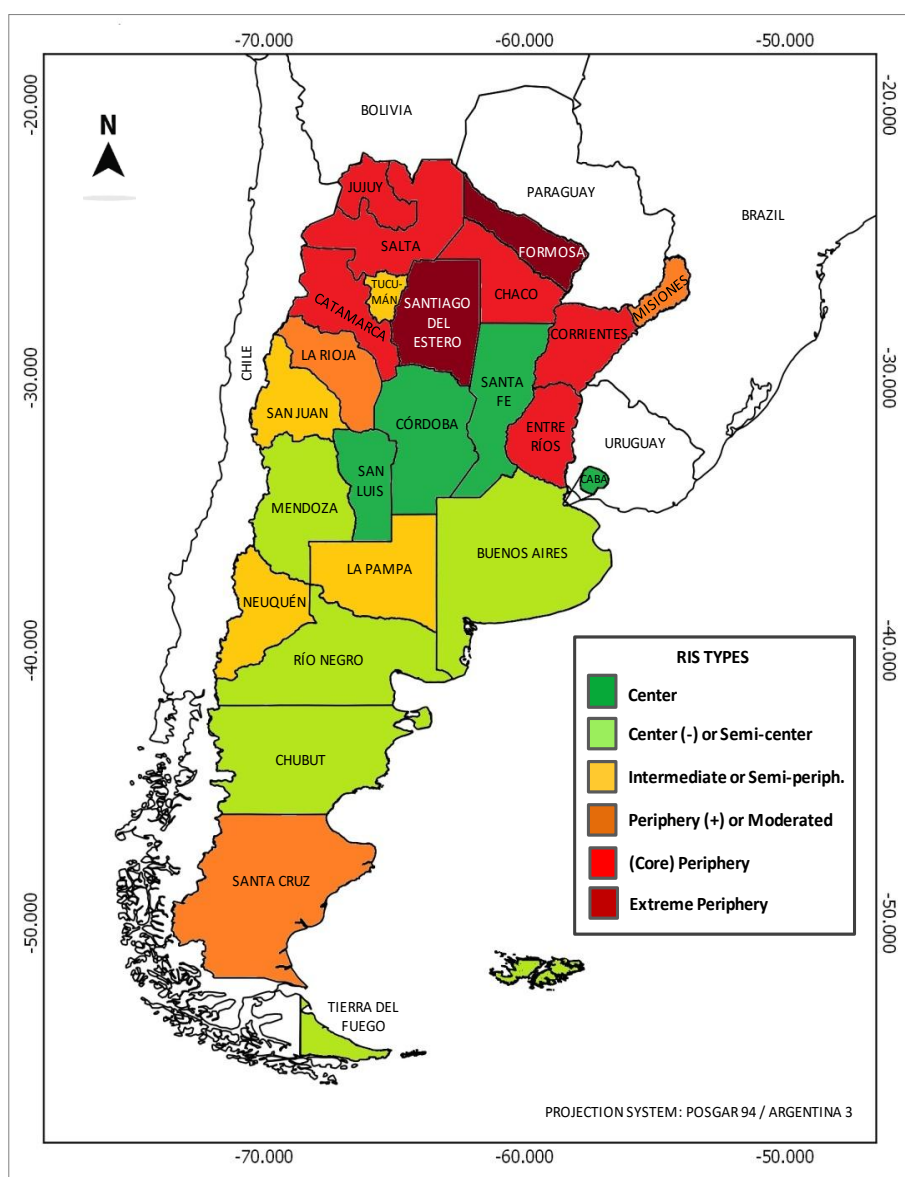
Source: own elaboration (for details, see Annex).

In sum, the different quantitative studies in Argentina highlight the regional heterogeneity and structural inequalities within a developing or peripheral country and the existence of more diverse (or not strictly dichotomous) center-periphery patterns in terms of regional innovation systems.[6] This evidence also allows us to identify some common characteristics of the RIS in "the periphery of the periphery" (keeping in mind that the degree or intensity varies from extreme peripheral situations to more moderate or semi-peripheral ones). Regarding STI support organizations, peripheral RIS are poorly endowed with infrastructure, equipment and resources in general (scholarship holders, researchers, access to scientific funding, among others), which to a greater extent are concentrated in public universities (more oriented to education than to R&D). Furthermore, there is usually a low (or lower relative to central RIS) presence of other technology agencies, such as those oriented to industrial or special "missions" (e.g., defense, nuclear energy, space and satellite development) (Niembro and Starobinsky, 2021; ECLAC-MINCYT, 2023).

With respect to the productive and business structure, peripheral regions tend to specialize in primary or natural resource-based activities, usually combined with low-productivity services. In the innovation surveys, which in Argentina are limited to manufacturing companies, the results show that there are few innovation efforts (or biased towards the acquisition of machinery and "incorporated technology") and a lack (or low complexity) of linkages with the public scientific sector, which are more oriented towards professional training in universities than to generating new knowledge or technological developments. In addition, companies in peripheral RIS often do not have access to (public) technological financing, or only occasionally (Niembro and Starobinsky, 2021; ECLAC-MINCYT, 2023).

Meanwhile, SRI studies with a broad or multidimensional perspective (beyond strictly STI indicators) show that the above issues are crossed by other structural limitations of peripheral regions, such as an underdeveloped financial system, less modern production and connectivity infrastructures (ICTs, transportation, energy), a high level of labor informality and low business density, weak educational performance in general (especially at the tertiary or higher education level), among other aspects (Niembro, 2017; 2020).

4. Case studies of Argentina's peripheral RIS: background and challenges of qualitative approaches

As a complement to quantitative approaches, qualitative analysis, particularly case studies, allows us to explore some phenomena and dimensions that are not necessarily quantifiable and to address some understudied questions and context-specific evolutionary processes. By combining a variety of analytical tools and techniques (in-depth interviews with key

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[6] It is worth noting that the literature on regional disparities in Argentina is extensive and goes beyond RIS studies (for references, see Niembro and Sarmiento, 2021; Abeles and Villafañe, 2022).

informants, documentary analysis, focus groups, participant and non-participant observation, among others), qualitative analysis examines why and how the phenomena under study are socially constructed, considering multiple dimensions to explain the attitudes and behaviors of the actors. In addition to exemplifying some results of quantitative studies with concrete experiences, case studies delve deeper into the particularities of the processes studied, highlighting that they cannot be separated from the context and their historical-structural trajectory. However, like quantitative approaches, they also have some limitations and opportunities for improvement. Among the most relevant ones, we can mention the limited capacity to generalize the reflections to other contexts, problems of partiality regarding the information gathered from the interviews, case selection biases and limited access to some key informants (Yin, 1984; Bericat, 1998; Eisenhardt, 1999; Vasilachis de Gialdino, 2006).

In particular, case studies on innovation systems (or technological linkages and innovation processes in regional contexts) in Latin America and Argentina are mostly focused on virtuous or successful experiences (Cassiolato and Lastres, 1999; Cassiolato et al., 2003; Llisterri and Pietrobelli, 2011; Planas Serralta and Fernández de Lucio, 2018; Melamed-Varela et al., 2019; Ordóñez-Matamoros et al., 2021).[7] In this sense, the integrality of regional situations (especially incorporating lagging or peripheral cases) is addressed to a lesser extent than in the quantitative analyses mentioned above.

Different studies in Argentina account for RIS dynamics in central (or semi-central) provinces and cities, highlighting the efforts of particular individuals (scientists and technologists) to establish relationships with the productive system, rather than through a deliberate or planned policy of network generation (ECLAC-MINCYT, 2023). The presence of dynamic private actors, such as industry chambers, is also frequent in virtuous cases, leading to certain coherence between tangible and intangible capabilities and productive structures. However, there are also some limitations in these systems, such as a low level of cooperation between firms and other local organizations, asymmetries of power and information between actors and a low demand for knowledge from the productive sector, among others.

Some studies also focus on specific issues, such as distinguishing firms' behavior according to the origin of their capital. This is a central concern in developing countries, as although multinational companies often have superior capabilities, they usually concentrate the most knowledge-intensive activities at their headquarters and establish fewer linkages to local scientific organizations, industrial chambers, customers and suppliers in peripheral regions. Other studies highlight the role of local governments (through the implementation of oriented strategic development plans and techno-productive policies), as well as that of universities

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[7] See ECLAC-MINCYT (2023) for a review of more than 20 papers or cases studied in Argentina. Some of these studies do not specifically adopt the RIS approach but use frameworks that address related processes, such as clusters or entrepreneurial ecosystems.

and science and technology organizations on territorial dynamics. Unlike in developed countries, the role of these latter actors is mainly focused on education and training activities. Even though there are university-business cooperation initiatives, they do not usually involve the generation of new knowledge, R&D or the creation of spin-offs, but are restricted to transfer or consulting services (ECLAC-MINCYT, 2023).

Although these cases have an analytical interest inherent to the study of virtuous or successful processes, the lack of analysis of peripheral RIS is restricting a holistic understanding of these situations and a better adaptation of STI and productive policies to peripheral conditions. This is particularly relevant since the peripheral condition does not tend to revert over time, but rather we observe path-dependent trajectories (or vicious cycles), as some quantitative studies show.

In this sense, it is worth mentioning some original research on RIS dynamics in the internal periphery of Argentina, which has mainly focused on some provinces in the North of the country, the region with the lowest relative development (and that quantitative studies agree in classifying them as peripheral RIS). In a pioneering study, Yoguel et al. (2006) examined different RIS throughout the country, including two peripheral northern cases like Jujuy and Salta (see Annex and Figure 1). Among their different problems, the authors highlight that these regions have a dual productive system (in which internationally competitive companies coexist with subsistence activities), scarce technological capabilities in SMEs, weak linkages (and knowledge exploitation) between the productive sector and STI organizations (due to different times and "languages"), scarce use of instruments that promote innovation and technological development, lack of cooperation with local governments and absence of locally or regionally oriented policies. The latter is related to the limited resources of regional (peripheral) governments to support STI policies versus other more pressing priorities (health, education, security), and to the irregularity and discretionality of the funds they may receive from the national level.

More recently, we can mention a series of RIS studies focused on the province of La Rioja and the trajectory of some of its main organizations, in a context of internal periphery (or "periphery of the periphery") in which historical-structural issues become particularly relevant (Starobinsky, 2020; Starobinsky et al., 2020a; Starobinsky et al., 2020b; D'Alessandro et al., 2021; ECLAC, 2021; Gonzalo and Starobinsky, 2023; Gonzalo et al., 2023). Among the main findings in terms of structural conditions, these studies highlight the remoteness from the country's commercial centers and ports, technological and commercial dependence, lack of agglomeration economies, limited transport and telecommunications infrastructure, water scarcity, high logistics and energy costs, scarcity of skilled human resources and resource drain, low business density and a strong weight of the public sector in the economic and labor structure, together with the inadequacy and lack of stability of public policies.

Furthermore, these studies provide an in-depth analysis of some specific dynamics of capability and linkage building within peripheral RIS in peripheral countries, which possibly resemble what happens in other regions of similar development (although it would be interesting to replicate this type of analysis in more peripheral regions to identify commonalities as well as differences). In general terms, even though some relevant public STI organizations, companies, industrial chambers and government actions are identified, there are several weaknesses within the RIS such as: a) heterogeneity of techno-productive capabilities, with cutting-edge actors operating close to the technological frontier with international insertion, as well as a wide range of small farmers and micro-SMEs working at a subsistence level; b) limited recognition and relationships between actors, which prevents the building of virtuous linkages on a sustained basis; c) high obstacles to access national funding and horizontal public policies (usually captured by companies in central regions); d) scarce presence and weakness of technology transfer organizations; and finally e) different environmental conditions, ranging from national macroeconomic volatility and multiple infrastructure limitations (in a country with a vast territory) to the regional productive profile and sectoral specialization, as well as cultural and political issues specific to the territory.

5. Final remarks

In-depth studies on the dynamics and structures of peripheral RIS in Latin America are still limited, although the problems of territorial concentration of technical progress, regional and sectoral heterogeneity, and their socioeconomic consequences (informality, unemployment and structural poverty, among others) are currently widespread in the region. In this chapter, we seek to contextualize, review and combine some conceptual elements of Latin American structuralism and the innovation systems approach to show that the RIS "in the periphery of the periphery" are not only characterized by the weaknesses of peripheral RIS identified in the European literature, such as the lack of maturity of the scientific system, limited techno-productive capabilities and weak linkages. In addition, they face some specific structural limitations that reinforce their general peripheral conditions in terms of infrastructure, capabilities of actors and institutions, public policy failures and technological and commercial dependence of the centers, which have historically restricted the development of these lagging regions.

In order to provide empirical evidence of these processes, we review different studies from Argentina, based on both quantitative and qualitative methodological designs. Thus, we illustrate the application of a varied portfolio of analytical tools for the construction of new indicators (and classifications) of STI and productive capabilities, and for conducting case studies, in peripheral contexts with limited availability of information. The quantitative studies offer a diagnosis and comparative analysis of the characteristics of Argentine RIS at the

provincial level, highlighting the heterogeneity between them and, especially, the diversity of peripheral situations, as well as their relative stability over time. On the other hand, the case studies explore the particularities of some peripheral RIS in the north of the country (particularly, the most analyzed case of the province of La Rioja), expanding the quantitative results regarding the structural capacities and limitations of this type of systems, as well as incorporating other historical, environmental, political and cultural dimensions.

However, RIS studies in Argentina also present different limitations that open the door to future research. As mentioned, the scarcity of regional data (especially on business innovation and linkages) may generate some variability in the results depending on the indicators used, which encourages the exploration of new alternative sources to validate the robustness of the quantitative analysis. It would also be desirable to have (or build) longer statistical series, to examine the trends or possible changes in RIS dynamics. Regarding qualitative studies, in addition to the usual lack of generalizability of the findings, many peripheral regions of Argentina have not yet been studied in depth. For both quantitative and qualitative approaches, it would be interesting to carry out comparative studies with other developing or peripheral countries of Latin America and the Global South in general.

Given that innovation processes are multidimensional and territorially embedded, in this chapter we stress the need for renewed theoretical and methodological approaches, along with the combination or triangulation of methods, to carry out a comprehensive analysis of the unequal dynamics of development in international and subnational peripheries. Structural heterogeneity, specialization in sectors of low technological intensity, lower techno-productive and scientific-technological capabilities, scarce linkages and technology transfer, lack of public-private cooperation, intermittency and low complexity of relations and different infrastructural weaknesses are all characteristic features of peripheral RIS (in peripheral countries). In addition to being diagnosed, typified and classified on the basis of quantitative analyses, it is necessary to carry out qualitative studies in different contexts to better understand the depth of these questions and to provide tailor-made (policy) responses. The dialogue between methods is still a pending issue and qualitative studies are not usually framed in relation to the results of quantitative research, thus remaining as isolated cases. In this way, we identify the theoretical-methodological challenge of complementing different approaches, both to enrich the conceptual discussion and to strengthen the empirical findings.

The above leads us to affirm that, from the point of view of policy discussion in peripheral countries and regions, the construction or strengthening of innovation systems should be understood as a central component of broader and integral development strategies. In turn, this implies a more comprehensive view of what is meant by innovation (and productive development) policies, which should not be limited only to the most common aspects of

science and technology promotion, but must also consider other multiple structural dimensions: organizational, institutional, educational, financial, commercial, sectoral-industrial, infrastructural, relational, among others. Likewise, given that these regions are usually immersed in path-dependent dynamics, exogenous impulses, like the attraction (and embedding) of companies or the generation of networks with extra-regional partners, can help to gradually overcome negative lock-ins and to develop new activities and technological trajectories. As a complement to strong national STI interventions in terms of resources and capabilities (which usually have a top-down logic in Latin America), there should be a gradual transition towards more associative models of multilevel governance and coordination, with the ultimate goal of generating policies better adapted to the particularities, needs and opportunities of each regional and local context, particularly taking into account the heterogeneous conditions of the internal peripheries.

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Annex. RIS classifications in Argentina among different quantitative studies

Province	Geographic macro-region	Barletta & Erbes (2021)	Niembro & Starobinsky (2023)	IIEBCC (2012)	Borello (2016)	Niembro (2020)	Niembro (2017)	RIS type
CABA	Center-east (Pampean)	1	1	1	1	1	1	Center
San Luis	Center-west (Cuyo)	2	2	1	2	3	3	Center
Córdoba	Center-east (Pampean)	2	1	2	2	3	5	Center
Santa Fe	Center-east (Pampean)	2	2	2	1	3	5	Center
Río Negro	South (Patagonia)	2	2	1	5	3	2	Center (-) or Semi-center
Tierra del Fuego	South (Patagonia)	3	2	2	4	2	4	Center (-) or Semi-center
Chubut	South (Patagonia)	3	2	3	4	3	4	Center (-) or Semi-center
Buenos Aires	Center-east (Pampean)	3	3	3	3	4	5	Center (-) or Semi-center
Mendoza	Center-west (Cuyo)	3	3	3	3	4	5	Center (-) or Semi-center
La Pampa	Center-east (Pampean)	4	3	2	5	3	2	Intermediate or Semi-periphery
Neuquén	South (Patagonia)	5	3	2	3	3	5	Intermediate or Semi-periphery
Tucumán	North-west	3	2	3	6	4	5	Intermediate or Semi-periphery
San Juan	Center-west (Cuyo)	3	3	2	5	5	5	Intermediate or Semi-periphery
Santa Cruz	South (Patagonia)	5	4	4	2	3	4	Periphery (+) or moderated
La Rioja	North-west	3	4	3	4	5	3	Periphery (+) or moderated
Misiones	North-east	5	5	4	3	5	5	Periphery (+) or moderated
Catamarca	North-west	4	4	3	6	5	6	(Core) Periphery
Entre Ríos	Center-east (Pampean)	4	5	4	4	5	6	(Core) Periphery
Chaco	North-east	5	4	4	6	5	6	(Core) Periphery
Salta	North-west	4	5	4	6	5	6	(Core) Periphery
Corrientes	North-east	4	5	5	5	5	6	(Core) Periphery
Jujuy	North-west	4	5	5	5	5	6	(Core) Periphery
Santiago del Estero	North-west	5	5	4	6	6	6	Extreme Periphery
Formosa	North-east	5	5	5	6	6	6	Extreme Periphery

Source: own elaboration based on the compilation of results by Niembro and Calá (2023). Notes: the numbers and colors range from the first group (or case) in the best relative position (1, in intense green) to the last and worst scenario (5 or 6, in intense red). The final classification shown in the last column responds to two criteria: first, the overall average position (group number) of each province; and second, the number of studies in which each province appears among the worst (or best) groups.