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Looking at regional innovation systems and industrial knowledge bases from the South: An analysis of Argentine provinces[1]

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Abstract:

Studies on regional innovation systems and, particularly, on differentiated knowledge bases are still highly concentrated in Europe. This article presents some original methodologies for adapting these approaches to peripheral countries and regions. Principal component analysis is used to construct two indexes that distinguish the degree of socio-economic development of Argentine provinces and their innovation systems development. The latest innovation survey and cluster analysis techniques are used to identify the predominant knowledge base among industries and then the regional productive specialisation. The results show a relationship between all these dimensions, especially in two large groups of provinces: one of peripheral innovation systems, specialized in symbolic sectors, with low socio-economic development; and the other of core-intermediate systems, with an analytical-synthetic combination and medium-high development. In Argentina, as in many developing countries, narrow and spatially blind innovation policies, dissociated from regional capabilities and production structures, usually reproduce regional inequalities and reinforce peripheral conditions.

Keywords: regional innovation systems, knowledge bases, regional inequalities, peripheral regions.

1. Introduction

The interest in regional innovation systems (RIS) has grown among researchers and policy-makers over the last three decades. This is largely due to the recognition of the central role of innovation for regional development and the need to address regional inequalities (Asheim et al., 2011; Asheim et al., 2016; Isaksen et al., 2018; Niembro, 2019; 2020). In this sense, although early studies usually focused on successful systems, in recent years the attention has shifted to lagging or peripheral RIS (Plechero and Chaminade, 2016; Cló et al., 2018; Eder, 2019a; Niembro and Starobinsky, 2021).

According to this approach (Cooke, 2004; Asheim and Gertler, 2005; Tödtling and Trippl, 2005), regional innovation systems are composed of different subsystems, which are interrelated and also linked to other regional, national, and international systems. The main subsystems are the knowledge generation subsystem (the institutional infrastructure supporting innovation) and the knowledge exploitation subsystem (the regional production structure), which are embedded in a specific regional socio-economic setting. Therefore, the study of peripheral systems requires understanding the particular characteristics of these subsystems, as well as the links between them and with regional socio-economic development.

Since the mid-2000s, the industrial or differentiated knowledge base (DKB) approach has become a common tool for analysing the knowledge exploitation subsystem or regional production structure. Although the study of regional innovation systems has expanded from developed to developing countries, the literature on industrial knowledge bases remains highly concentrated in Europe, with some contributions from the United States and Canada but very few applications in developing countries of the Global South (Isaksen and Trippl, 2017; Eder, 2019a; Mesquita and Fernandes, 2021). In Latin America, RIS studies usually focus on the knowledge generation subsystem but the analysis of the knowledge exploitation subsystem and regional production structures is still very limited, especially from the DKB approach. Furthermore, the discussion on peripheral regional innovation systems, in countries that are also peripheral, is not very frequent in Latin American studies (Fernández and Comba, 2017; Niembro and Starobinsky, 2021).

Therefore, this article seeks to address these research gaps by understanding, for the case of Argentine provinces, the characteristics and links between the level of socio-economic development and the two main RIS subsystems, the scientific-technological infrastructure and the provincial production structure. Based on regional and sectoral data, different multivariate analysis techniques are applied to distinguish the degree of development of the support infrastructure (identifying core, intermediate, and peripheral innovation systems) and the specialisation of provincial production structures according to the different industrial knowledge bases (analytical, synthetic, and symbolic).

In addition, the article makes particular contributions to the empirical literature on differentiated knowledge bases. Firstly, instead of applying to a developing country a classification of occupations or sectors elaborated in the context of developed countries, we empirically obtain a typology of knowledge bases for industrial sectors in Argentina –a research gap highlighted by Krupskaya and Pina (2022)–, based on data from the latest industrial innovation survey and cluster analysis techniques. Secondly, the article helps to identify a group of industries where the symbolic knowledge base is predominant. This is a gap in the empirical literature (Isaksen and Trippl, 2017; Eder, 2019b), which has generally looked at industrial activities through the lens of analytical and synthetic knowledge bases.

Moreover, the article provides a look from the South to a recent line of European studies that analyse the relationship between knowledge bases and RIS development-underdevelopment or their core-periphery configuration (Květoň and Kadlec, 2018; Eder, 2019b). Finally, we explore the links between these dimensions and uneven regional socio-economic development, along with their implications for industrial and technological policies, a research gap highlighted by several authors (Martin, 2012; Boschma, 2018; Eder, 2019b) and where the empirical evidence is still scarce (Blažek and Kadlec, 2019). Thus, the article makes a series of methodological and empirical contributions on regional innovation systems and industrial knowledge bases that can help to extend these studies to peripheral countries and regions beyond Europe.

After this introduction, the article is structured as follows. Section 2 presents the theoretical and empirical framework, while section 3 describes the methodologies and data sources used. Section 4 provides a detailed presentation of the results, which are discussed in section 5, and section 6 concludes.

2. Theoretical and Empirical Framework

2.1. Economic Development and Regional Innovation Systems

This article is based on theoretical and empirical contributions from evolutionary economics, economic geography, and Latin American structuralism. It considers, on the one hand, some debates about economic development and innovation systems under a core-periphery perspective and, on the other hand, the study of regional production structures under the DKB approach. In a context of persistent regional inequalities, the core-periphery approach has been used in European studies to explore the different conditions that limit innovation processes and regional development. However, peripheral regions are traditionally identified on the basis of a few geographic and demographic characteristics, such as distance from urban agglomerations, poor accessibility, or low population density. Several authors highlight the importance of including other social, political, and economic factors to address the multidimensional characteristics of peripheral regions (Kühn, 2015; Eder, 2019b; Glückler et al., 2022).

In the same line, it is interesting to revisit some ideas of Latin American structuralism, since it presents a more complex conception of core-periphery division and proposes a historical-structural view of the evolution of peripheral regions. Through the idea of structural heterogeneity, this approach explores the disparities in regional and sectoral diffusion of technological development within peripheral countries. The conditions for knowledge transfer and technical progress are gradually concentrated in certain regions and sectors that represent the modern segments of the economy (core regions), while at the same time an internal periphery arises. Between these extremes, some regions may acquire intermediate levels of technical development and productivity, reflecting a high degree of regional heterogeneity in terms of production, technology, and capabilities (Prebisch, 1949; Pinto, 1970; 1976).

As a complement to the structuralist vision, the evolutionary conception of innovation systems proposes a systemic approach to analyse the different factors, actors, and institutions involved in the development, diffusion, and use of innovations, emphasising the interactive nature of these processes and the relevance of learning and capacity building (Freeman, 1987; Nelson, 1993; Lundvall, 2007). Given the different trajectories of national, regional, and sectoral systems, it is necessary to take into account the heterogeneity of actors and capabilities in each of these systems. In this sense, the RIS approach permits the analysis of regional inequalities and, in particular, an in-depth examination of lagging or peripheral regions (Torres-Freire et al., 2013; Plechero and Chaminade, 2016; Isaksen et al., 2018; Eder, 2019a; Niembro, 2019; Lastres et al., 2020).

Within RIS studies, it is argued that there are three basic system failures that peripheral regions may face (Tödtling and Trippl, 2005; Martin and Trippl, 2014; Trippl et al., 2016): 1) organisational and institutional thinness, as a result of the absence or inadequacy of some key organisations and institutions of the knowledge generation subsystem; 2) fragmentation or linkage failures, either due to a lack of interactions or an excess that generates rigid and closed networks; and 3) negative lock-in in mature or declining activities and technologies, typical of the specialisation pattern of traditional industrial regions or peripheral regions based on the exploitation of natural resources. The three system failures may overlap, but the most distinctive characteristic of peripheral RIS is their organisational and institutional thinness (Tödtling and Trippl, 2005; Trippl et al., 2016; Zukauskaite et al., 2017). Thus, although the concept of peripheral region is often ambiguous or fuzzy (Kühn, 2015; Isaksen and Karlsen, 2016; Glückler et al., 2022), this approach allows identifying peripheral RIS from the perspective of regional conditions for innovation and economic development (Komninaki, 2015; Isaksen and Karlsen, 2016; Isaksen and Trippl, 2017; Clò et al., 2018).

In Latin America, the core-periphery approach has been present in debates on technical progress, innovation, and national development (Kattel and Primi, 2012; Cimoli and Porcile, 2013), as well as in studies on national innovation systems (Arocena and Sutz, 2000; Albuquerque, 2007; Chaves et al., 2020). Likewise, the distinction between core and periphery has been used in Argentina to analyse the position of the different provinces in the national production system (Cao and Vaca, 2006; Calá et al., 2015), but the notion of peripheral RIS has been relatively absent (Fernández and Comba, 2017; Pasciaroni et al., 2018; Niembro and Starobinsky, 2021).

Although not strictly from a systemic and core-periphery approach, it should be noted that several studies in Europe and Latin America have explored the relationship between regional socio-economic development (usually from the point of view of per capita gross domestic product) and scientific-technological development (Howells, 2005; Sterlacchini, 2006; Martínez Pellitero et al., 2008; Sánchez Tovar et al., 2014; Blažek and Kadlec, 2019; Beneli et al., 2022).

2.2. Regional Production Structures and Knowledge Bases

Given that innovation and learning capabilities are rooted in the production structure of each region, sectoral differences are crucial for understanding the divergence in regional development patterns. What firms and regions can do and learn in the future largely depends on what they have been doing, their accumulated experience and capabilities, the problems they have faced, and pre-existing interactions with other agents, among other factors. Within RIS studies and since the first contributions in the mid-2000s (Asheim and Coenen, 2005; Asheim and Gertler, 2005; Asheim et al., 2007), the DKB approach has been the most common tool for analysing the differences in regional production structures (Martin, 2012; Blažek and Kadlec, 2019; Eder, 2019b) and also for thinking innovation policies that address these differences (Asheim et al., 2011; Martin et al., 2011; Martin and Trippl, 2014). This literature has developed different concepts, first industrial knowledge bases, then differentiated knowledge bases, and more recently combined knowledge bases (Manniche et al., 2017). The first two belong to the first generation of this literature –DKB 1.0, according to Boschma (2018)–, while the last one is associated with the second and more recent trajectory (DKB 2.0).

The DKB approach suggests that a dominant or critical knowledge base and a predominant mode of innovation and learning can be identified in the different economic activities: 1) analytical, in cases of science-based knowledge and STI mode of innovation (for science, technology, and innovation); 2) synthetic, in cases of engineering and practical knowledge and DUI mode of innovation (for learning by doing, using, or interacting); and 3) symbolic, when knowledge is artistic, creative, or cultural and innovation activities are more informal or non-technological (Manniche, 2012), involving the creation of symbols and aesthetic qualities (see Table 1 for other details). Although the symbolic knowledge base has been mostly linked to different service sectors, some authors recognise that it can also be embedded in industrial activities (Martin et al., 2011; Manniche, 2012; Martin and Trippl, 2014; van Tuijl et al., 2016). Like any taxonomy, the classification of knowledge bases implies a simplification of reality into a few ideal types, whereas “firms and meso- and macro-level social systems (sectors, clusters, regions, etc.) rarely rely on one single knowledge base” (Manniche, 2012, p. 1823).

[Table 1 about here]

Although the taxonomy of knowledge bases was initially used to contextualise and compare case studies, quantitative analyses have increased in recent years (Boschma, 2018), based on the exploitation of different regional databases (Martin, 2012; Grillitsch et al., 2017; Květoň and Kadlec, 2018; Blažek and Kadlec, 2019; Eder, 2019b). Furthermore, recent empirical studies have analysed the coexistence or combination of different knowledge bases in firms and regions (Strambach and Klement, 2012; Grillitsch et al., 2017; Manniche et al., 2017; Eder, 2019b; Grillitsch et al., 2019). However, this literature is mainly focused on developed countries, especially from Europe, and the regional landscape of the different knowledge bases in developing countries of the Global South is still underexplored (Chaminade, 2011; Santos and Marcellino, 2016; Mesquita and Fernandes, 2021; Mesquita et al., 2021). The article contributes to this emerging line of research, providing evidence from Argentina and some analytical tools that can be used in future studies.

3. Data and Methodology

3.1. Level of Socio-economic Development and of the Regional Innovation System

This article proposes the implementation of multivariate analysis techniques to process and systematise different variables related to the scientific-technological infrastructure, the regional production structure, and regional socio-economic development. The geographic unit of analysis is the Argentine provinces. This coincides with several pioneers of the RIS approach (Cooke et al., 1997; Asheim and Coenen, 2005), who give priority to the administrative or governance dimension at the subnational level (Navarro and Gibaja, 2009), as well as with other studies in Latin American countries (Crespi and D'Este, 2011; Sánchez Tovar et al., 2014). In addition, the provinces are the main subnational level for which statistics are produced in Argentina. As a possible limitation, we should note that the Argentine provinces may be large units of analysis. Unfortunately, information for smaller geographic areas is unavailable.

Firstly, the level of RIS development is distinguished from the perspective of the support infrastructure, the scientific-technological system, and regional conditions for innovation (Komninaki, 2015; Isaksen and Karlsen, 2016; Isaksen and Trippl, 2017). In line with Eder (2019b), we calculate a synthetic index that reflects the relative degree of development of the innovation system (RIS Index) and allows us to identify different groups of core, intermediate, and peripheral systems. However, instead of using ad-hoc weights or simple averages to combine the different indicators in this synthetic index, we employ principal component analysis (as in Sterlacchini, 2006; Martínez Pellitero et al., 2008; Květoň and Kadlec, 2018). The main objective of this technique is to understand the links between related variables and to synthesise most of this information into a smaller number of common dimensions (Johnson and Wichern, 2008; Hair et al., 2010).

Given the scarcity of regional statistics on science, technology, and innovation in Argentina, for the construction of the RIS Index (Table 2) we consider indicators of researchers and R&D investment (as in Květoň and Kadlec, 2018; Eder, 2019b; Beneli et al., 2022; Martinidis et al., 2021), employment in knowledge-intensive services (Sterlacchini, 2006; Květoň and Kadlec, 2018; Martinidis et al., 2021), and firm entry as a proxy of entrepreneurship[2] (Chang et al., 2012; Brown, 2016). All these indicators are expressed in relative terms (according to provincial population or in percentages) and not in absolute terms, to avoid the results being biased by the size of the main provinces (Navarro and Gibaja, 2009).

[Table 2 about here]

As usual, the big issue with any index is the nature of the available data, something that also affects some European indexes, such as the Regional Innovation Scoreboard (Trippl et al., 2016; Martinidis et al., 2021). According to Trippl et al. (2016, 41), the “advances that have been made in conceptual debates on specificities of less-developed regions are only partly reflected in existing empirical approaches”, and there is still “a tendency to measure narrowly defined RIS”. Nevertheless, low R&D investment and, above all, problems with human capital (Martinidis et al., 2021) have been traditional characteristics of peripheral systems (Isaksen and Karlsen, 2016; Isaksen and Trippl, 2017; Eder, 2019a).

The period of analysis (2014-2017) responds to the time window (2014-2016) of the latest National Survey of Employment and Innovation Dynamics (ENDEI, in Spanish), the source used to identify the predominant knowledge base among industrial sectors in Argentina, and the indicators available (circa 2017) to describe the level of socio-economic development of Argentine provinces.

A major problem in Argentina is that, since the mid-2000s, there are no official and methodologically consistent gross domestic product (GDP) data for all provinces. For this reason, three different indicators are considered: the estimation of provincial GDPs by a private consulting firm, the average per capita household income (from an official annual survey of urban households), and the Human Development Index (HDI) elaborated by the United Nations Development Programme (UNDP), which takes into account other dimensions beyond income, such as health and education. As before, we obtain a synthetic index of socio-economic development (called ISED) using principal component analysis.

3.2. Empirical Typology of Industrial Knowledge Bases and Regional Specialisation

As mentioned, one of the main contributions of this article is the identification of knowledge bases among industrial sectors in Argentina, to avoid applying classifications or categories from developed countries (such as those by Asheim and Hansen, 2009; Aslesen and Freel, 2012). In Argentina there are scarce data about types of occupations or workforce education to analyse the regional weight of the different knowledge bases. For this reason, we resort to the latest industrial innovation survey, the ENDEI 2014-2016, in line with the sources used by Herstad et al. (2014), Sedita et al. (2017), and Eder (2019b). However, instead of looking at a single dimension –such as the importance of different sources of information for innovation (Herstad et al., 2014; Sedita et al., 2017)–, we study a set of multiple variables (see Table 3) using cluster analysis techniques[3]. In particular, we compare the results obtained by Ward's hierarchical method and the K-means non-hierarchical method to check their consistency and robustness (Johnson and Wichern, 2008; Hair et al., 2010).

Cluster analysis helps to identify different groups of industrial sectors with relatively homogeneous characteristics within each one and, at the same time, with heterogeneous characteristics between groups (Hair et al., 2010). The values of each cluster in the different variables are then compared with the stylised or expected features for each knowledge base. Although we recognise that the association of each industrial sector with a specific knowledge base is a simplification of reality, "the idea is to associate an industry with a knowledge base that best characterises the industry" (Innocenti and Lazzeretti, 2019, p. 2038).

[Table 3 about here]

Based on the classification of industrial sectors in Argentina according to the predominant knowledge base, we calculate the weight of each knowledge base in formal industrial employment at the national level and for each province[4]. Then, the percentage of each knowledge base in the provinces is divided by the percentage at the national level, obtaining the provincial location quotients (LQs). From previous studies (Martin, 2012; Květoň and Kadlec, 2018; Blažek and Kadlec, 2019), LQs above 1.25 show strong regional specialisations in that knowledge base[5], LQs between 1 and 1.25 represent weak specialisations, while LQs below 0.75 indicate a low relevance of that knowledge base. In addition, some provinces may show specialisations in more than one knowledge base, representing the coexistence or combination of knowledge bases (Martin, 2012; Strambach and Klement, 2012; Eder, 2019b).

The ENDEI data reflect the average of firms' responses from 2014 to 2016, in order to work with robust values (Grillitsch et al., 2017; Blažek and Kadlec, 2019). Similarly, we calculate the 2014-2017 average of the location quotients for each province, and the 2014-2017 average of the RIS Index (and the variables that compose it). With the exception of the location quotients, the other results are presented in Z-scores for ease of comparison.

4. Results

4.1. Socio-economic and RIS Development

Regarding the construction of the RIS Index, the use of principal component analysis is supported by the presence of high correlations and communalities, a Kaiser-Meyer-Olkin (KMO) sampling adequacy measure of 0.82 (well above the minimum of 0.50), and compliance with Bartlett's test of sphericity (Hair et al., 2010). Only the first component satisfies the traditional Kaiser criterion, which consists of retaining those principal components with eigenvalues greater than one. This first component, whose estimate or factor score will be our index, accounts for 78% of the total variability.

Table 4 shows the 2014-2017 average of the RIS Index and the different variables that compose it (in Z scores). It is worth noting that, as shown in other studies (Niembro, 2020; Niembro and Starobinsky, 2021), the average is a good indicator of the situation of Argentine provinces in this period, since there is high stability in the values from year to year. According to Eder (2019b, p. 48), the quantitative analysis of RIS development takes the form of “a continuum”, where “not all regions are clearly peripheral or central when various indicators are considered (…) [and] in between these extremes intermediate regions can be found that share characteristics of both peripheral and central regions”. Like this author, provinces with an index above zero (the general mean) are considered core systems. Then, intermediate systems are those provinces with a slightly negative index (between 0 and -0.25, a quarter of a standard deviation), and peripheral RIS are those with a negative index below -0.25.

As an approximation to the continuum of provincial situations, two subgroups are distinguished within core and peripheral RIS, based on the analysis of the different variables that compose the index. Among core systems, two provinces are consistently above the general mean, with a marked difference in the case of the Autonomous City of Buenos Aires (CABA, in Spanish). The remaining six core systems show negative standardised values in one or two indicators. The opposite happens with peripheral RIS. Four of them have positive standardised values in one variable, while the remaining seven provinces are consistently below the general mean. Beyond this internal division, this group is mostly composed of northern provinces (except Tucumán), along with Santa Cruz and Entre Ríos (Figure 1).

[Table 4 about here]

[Figure 1 about here]

As before, the use of principal component analysis to calculate the index of socio-economic development is supported by a KMO measure of 0.71, the verification of Bartlett's test of sphericity, and the presence of high correlations and communalities. Again, following the Kaiser criterion, we extract only the first component, which accounts for 93% of the total variability.

Using the same criteria as above for the values of this index, we distinguish provinces with high, intermediate, and low socio-economic development (Table 5). There are also some differences within these groups. On the one hand, two provinces show a positive index but have negative standardised values of per capita gross domestic product. On the other hand, two of the least developed provinces have Human Development Index values that are not as negative as the others –and which are similar, for example, to the value of the province of Buenos Aires–.

The provinces with low socio-economic development coincide to a large extent with peripheral RIS and, once again, cover almost all the northern part of the country. In this case, the exceptions are Catamarca, which appears among the provinces with intermediate development, and Tucumán, which is now among the underdeveloped provinces. Santa Cruz and Entre Ríos are the other exceptions with respect to peripheral systems, as they are in a better relative position in terms of socio-economic development.

[Table 5 about here]

4.2. Industrial Knowledge Bases and Provincial Specialisation

Regarding the classification of industrial sectors, we follow one of the simplest rules for defining the number of clusters, which consists of analysing the change in heterogeneity –specifically, the within-cluster sum of squares provided by Ward's method– for each stage of the agglomerative process (Hair et al., 2010). This rule shows a minimum value when four clusters are formed. This also provides the starting point for K-means, since in non-hierarchical methods it is necessary to initially establish the number of clusters. Although these different methods often lead to different results, both techniques show the same composition for the four groups of industrial sectors.

Cluster analysis identifies three groups of sectors that coincide with the three knowledge bases, and a special cluster consisting solely of the pharmaceutical industry. This is an extreme case within analytical knowledge-based sectors, where R&D activities and staff and linkages with other agents for innovation projects are predominant (Table 6). In synthetic sectors, skilled workers are focused on other innovation activities, especially on industrial design and engineering, and external linkages are less frequent. In the case of symbolic sectors, the employment devoted to traditional or formal innovation activities is very limited and, among the innovation activities captured by the survey, firms are notoriously biased towards the acquisition of machinery and equipment. However, many of the firms in these sectors claim to have introduced innovations without necessarily resorting to the formal innovation activities surveyed by the ENDEI. This suggests, for example, that these firms may have improved or changed some attributes of their products (aesthetics, appearance, quality) through informal or symbolic activities, which do not require formal linkages with external agents. Figure 2 provides an aggregate comparison of the three groups of sectors along the different dimensions of analysis, including the analytical knowledge base with and without the pharmaceutical industry.

[Table 6 about here]

[Figure 2 about here]

Based on this classification of industrial knowledge bases for Argentina, Table 7 shows the location quotients and the type of specialisation or coexistence of specialisations for each province. In the last column (and also in Figure 3), capital letters are used to highlight strong specialisations (values highlighted in bold) and lowercase letters for weak specialisations. At first glance, the symbolic knowledge base seems to be the most balanced or territorially distributed in Argentina, given the lower frequency of extreme values (very high or very low location quotients) than in the other knowledge bases. This may be because these industries are based on natural resources widely available in Argentina, which are used, for example, in the production of food and beverages, leather, or paper.

[Table 7 about here]

Finally, Figure 3 –inspired by Martin (2012)– helps to visualise how many provinces are specialised in one predominant knowledge base or several knowledge bases. Two main groups are observed: nine provinces specialised in the symbolic base and seven provinces where the analytical and synthetic specialisations coexist. The other combinations of knowledge bases are less frequent, as well as the specialisation only in the analytical or synthetic knowledge base.

[Figure 3 about here]

4.3. Interactions between the Development of Regional Innovation System and Industrial Knowledge Bases

Reproducing the scheme proposed by Eder (2019b), Figure 4 shows the links between the degree of RIS development and the type of specialisation or coexistence of industrial knowledge bases. In addition, the level of socio-economic development of Argentine provinces is reflected in the font colour[6]. An exploratory analysis of these dimensions allows us to identify two main groups of nine provinces each, which largely coincide with what was expected according to previous studies. However, there are also a couple of provinces that do not fit these patterns (or are exceptions to them) and, finally, a group of four provinces with a particular combination of types of regional innovation systems, socio-economic development, and knowledge base.

In the lower-left group, 8 of the 9 provinces belong to the north of the country. These are peripheral RIS with a symbolic knowledge base (or combined with synthetic) and low socio-economic development (only two provinces have an intermediate level of development). At the other extreme, the upper-right group includes most of the core and intermediate systems, which are specialised in analytical and/or synthetic knowledge bases (especially combined) and have a high or intermediate level of socio-economic development (except for one case of low development).

In contrast to these main groups, Figure 4 also shows a group of four core or intermediate systems, specialised in the symbolic knowledge base and with different levels of socio-economic development. On the one hand, these cases could be revealing a mismatch between scientific-technological policies and infrastructures and the predominant production structures in some provinces. On the other hand, they could also be reflecting the possibility that greater RIS development may lead to higher levels of socio-economic development through other means than the specialisation in analytical and/or synthetic bases; for example, through higher incomes as a result of greater human capital, more innovations or activities of greater complexity within the same symbolic sectors, or the promotion of (related) diversification. Although the evidence is not categorical, a comparison between the peripheral RIS specialised in symbolic sectors and the core-intermediate systems with the same specialisation (the bottom of Figure 4) shows that the level of socio-economic development tends to be higher in the second group.

[Figure 4 about here]

5. Discussion and Policy Implications

As noted by Boschma (2018, p. 30), this article is part of “a tendency to employ a wider range of mixed methods, including quantitative studies that allow for more systemic testing, as compared to the DKB 1.0 literature that clearly favoured a comparative case study approach". In particular, the methodology and results help to fill some research gaps, such as the "systematic comparisons of regions" (Eder, 2019a, p. 119), the "empirically informed research on differentiated knowledge bases" (Martin, 2012, p. 1580) or the definition of methods for "identifying empirically knowledge bases" (Pina and Tether, 2016, p. 401), and the analysis of the "mutual relationships among knowledge bases, R&D structure and innovation and socioeconomic performance" (Blažek and Kadlec, 2019, p. 41). Regarding the last issue, the evidence from Argentina is in line with previous studies, especially from Europe but also from Brazil (Howells, 2005; Sterlacchini, 2006; Martínez Pellitero et al., 2008; Torres-Freire et al., 2013; Blažek and Kadlec, 2019; Beneli et al., 2022), which show a quite direct relationship between the degree of RIS development and regional socio-economic development.

In terms of the empirical identification of the predominant knowledge base among industrial sectors in Argentina, our classification largely coincides with the evidence from Norwegian firms presented by Aslesen and Freel (2012). However, the proposed methodology allows us to identify a group of industries that, in the case of Argentina, are predominantly related to the symbolic knowledge base. The same industrial sectors are often classified as synthetic in European studies, given that the symbolic knowledge base is usually confined to service sectors (Aslesen and Freel, 2012; Martin, 2012; Herstad et al., 2014; Sedita et al., 2017). This may be one of the reasons why, unlike the evidence from Europe, the symbolic knowledge base is the most territorially balanced in Argentina. Martin (2012) shows that the synthetic knowledge base is the most balanced among Swedish regions. Květoň and Kadlec (2018, p. 1375) also note that "the synthetic knowledge base is the most common type in the majority of European regions", while Blažek and Kadlec (2019, p. 43) highlight that "employment in the synthetic knowledge base dominates in all types of regions". Part of these discrepancies may be due to idiosyncratic differences in regional production structures, such as the specialisation of many Argentine provinces in natural resource-based industries. Nevertheless, the fact that the symbolic knowledge base has been mainly associated with service sectors could be generating a bias in European studies, increasing the share of the synthetic knowledge base among industrial sectors. This is an interesting issue that could be addressed in future analyses of European regions.

Regarding the exploratory analysis of the links between the degree of RIS development and the type of specialisation or coexistence of industrial knowledge bases, the evidence for the Argentine provinces not only coincides with what is theoretically expected but also shows a clearer pattern of associations than what Eder (2019b) finds in Austria, for example. The group of peripheral RIS with a symbolic knowledge base (or combined with synthetic) is in line with Květoň and Kadlec (2018), who connect symbolic activities with weak or organisationally thin innovation systems. Likewise, several authors argue that peripheral RIS are usually specialised in traditional or natural resource-based activities (Tödtling and Trippl, 2005; Isaksen and Karlsen, 2016; Isaksen and Trippl, 2017; Eder, 2019b).

As for the group of core or intermediate RIS, specialised in analytical and/or synthetic knowledge bases, Květoň and Kadlec (2018) also note the link between the analytical base and more developed innovation systems. However, it is worth highlighting some issues in the case of Argentina. Firstly, there are different exceptions to this relationship, such as the provinces of Santa Cruz and partly of Formosa, with an analytical base but peripheral RIS – Eder (2019b) also shows similar exceptions–, or the group of four core-intermediate systems but specialised in the symbolic base. As Eder (2019b, p. 49) notes, "central regions might possess an underdeveloped analytical knowledge base". Secondly, in the case of Argentine provinces, the higher levels of development are not only related to the analytical knowledge base but especially to the coexistence or combination with the synthetic knowledge base (Grillitsch et al., 2017; Eder, 2019b).

Beyond these caveats, the two main groups, which account for 75% of Argentine provinces, seem to reproduce a core-periphery division from a structuralist perspective. In general, peripheral provinces are specialised in natural resource-based activities with low technological intensity, have fewer scientific-technological capabilities and also lower levels of income, welfare, and socio-economic development. The opposite tends to occur in core provinces (and in the intermediate ones, following the categories used in this article). This duality is in line, for example, with the evidence provided by Rodriguez-Pose et al. (2021) for Chinese cities.

As Eder (2019b) notes, the diversity of peripheral and core regions increases the complexity of designing and implementing regional development policies and, specifically, regional innovation policies. Therefore, "a nuanced understanding of institutional structures, system failures and industrial knowledge bases is necessary to design policy approaches that can account for the complexity and diversity of regional innovation systems" (Martin and Trippl, 2014, p. 31). RIS and DKB approaches not only provide analytical frameworks for diagnosing structural problems and system failures but also help to recognise "the superiority of place-based, customized and broad based innovation system policies over spatially-blind and narrow R&D policies" (Isaksen et al., 2018, p. 2). Best practice models or traditional STI policy instruments are usually designed to promote the analytical knowledge base (Martin et al., 2011; Martin and Trippl, 2014), while synthetic and, especially, symbolic industries require a broad mix of policy measures (Martin and Trippl, 2014; Asheim et al., 2016). It is necessary to understand that, although innovation in the periphery may be scarce or affected by several problems, it is not inexistent. Innovation processes in the periphery seem to be qualitatively different from those in core regions, less based on R&D or other formal innovation activities and more dependent on informal or symbolic activities (Kruss, 2018; Květoň and Kadlec, 2018; Eder, 2019a; 2019b; Niembro and Starobinsky, 2021).

Both the European literature and some contributions from Latin America recognise that the problems faced by peripheral RIS are very complex and multidimensional. Therefore, it is not enough to support only one subsystem –for example, traditional policies aimed at strengthening the scientific-technological infrastructure– (Clò et al., 2018; Guimón, 2018; Kruss, 2018) or "a single function among those that are essential in innovation systems, but rather it is necessary to strengthen all the functions: the interaction between the agents of the regional system, firms' capacity to absorb new knowledge, and the region's STI infrastructure" (Llisterri and Pietrobelli, 2011, p. 108).

The findings of this article allow us to highlight, at least in general terms, some dimensions to be considered in the design of technological and innovation policies and also of productive or industrial policies in Argentina. Identifying a group of nine lagging provinces with peripheral RIS, lower socio-economic development, and less diversified and complex production structures suggests the presence of vicious circles that are not being addressed by public policies. In order to reduce regional inequalities, policies should be specifically designed for these regions, including innovation, industrial, and other social and economic policies. Horizontal and spatially blind policies, in which all actors, sectors, and regions are treated as "equals" in the competition for resources, do not consider the heterogeneous regional capacities and production structures and usually reproduce the concentration of resources in core regions.

In addition, we have seen that regional socio-economic development, innovation systems and production structures are interrelated. Therefore, the different policies should not be planned and executed separately but as parts of a comprehensive and integral development plan. Industrial diversification and upgrading policies that do not consider regional scientific and technological capabilities will probably not have the expected impact. If the policy is limited to strengthening public investment in science and technology, but without diversifying or making the regional production structure more complex, it is likely that these capacities will not be exploited.

6. Conclusions

This article sought to contribute to the understanding of the characteristics and links between the level of socio-economic development of Argentine provinces and the two main RIS subsystems, through a novel application of different multivariate analysis techniques in this type of studies. On the one hand, principal component analysis is used to construct two indexes that allow us to distinguish the relative degree of socio-economic and RIS development, identifying core, intermediate, and peripheral systems. On the other hand, we study the provincial production structures from an empirical typology of industrial knowledge bases (analytical, synthetic, and symbolic), based on sectoral data and cluster analysis techniques. Crossing these dimensions, two main groups are identified: one formed by provinces specialised in symbolic sectors, with peripheral RIS and low socio-economic development; and the other with an analytical-synthetic combination, core or intermediate systems, and medium-high development.

These main groups, as well as some exceptions –in particular, a group of four provinces with core or intermediate RIS but a symbolic knowledge base–, call for a discussion of technological and innovation policies and their role in the regional development policy mix. The relationships highlighted in the article suggest that narrow R&D policies, dissociated from industrial and production policies, can generate mismatches between regional scientific-technological capabilities and the knowledge demands of local industries. In addition, policies of this nature tend to reproduce and reinforce the centrality of the provinces with more developed innovation systems and analytical knowledge-based industries.

Therefore, it is important to promote the design of articulated, differentiated, and targeted policies, especially to strengthen peripheral RIS, where the symbolic knowledge base and lower technological and innovation capabilities are predominant. As Eder (2019c, p. 8) notes "every region requires tailor-made concepts based on a detailed analysis of the strengths and weaknesses of the region in question". Beyond these general policy guidelines, the study of the dimensions analysed in this article should be deepened for each Argentine province and within each province, in order to fully understand their peculiarities and possible trajectories.

Finally, the article represents a starting point for future research seeking to deepen the issues discussed or to overcome some of the limitations of our analysis. On the one hand, although the article only provides evidence from Argentina, the proposed methodologies could be applied in (and the results compared with) other developing countries of the Global South. On the other hand, given the different limitations of the data available in Argentina, future studies in other countries could reinforce the notion of systems –e.g. with indicators that take into account the interactions between RIS agents–, deepen the geographic or regional scope –e.g. by examining intra-provincial heterogeneities on the basis of smaller geographic units–, and strengthen the study of regional production structures –e.g. by classifying the knowledge bases of primary and service sectors, by analysing production data rather than employment data, or exploring the combination of knowledge bases within the firms of each region–. Finally, a pending issue of this article but also of the empirical literature on these topics (Martin, 2012; Manniche et al., 2017; Boschma, 2018; Eder, 2019a; 2019b) is to move from a static analysis to a dynamic and co-evolutionary approach.

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Notes

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[2] This indicator covers all tax-registered firms in all sectors. Although it could be argued that some activities (for example, retail or personal services) should not be part of the indicator, the available information does not have that level of disaggregation. On the other hand, in a Latin American context of high informality, the indicator acknowledges the effort behind formal (tax-registered) entrepreneurship, regardless of the sector.

[3] It is worth noting that the data on R&D staff and investment used for the typology of industrial knowledge bases are qualitatively different from those used in the construction of the RIS Index. In the second case, it is aggregated data on staff and investment in both the public and private sectors. As in other developing countries, but unlike developed countries, the public sector has an overwhelming share in Argentina. For example, in 2017 it accounted for 73% of R&D and 88% of researchers in the country. In contrast, the ENDEI surveys part of that small proportion of investment and staff in the private sector, particularly in industrial firms.

[4] As our classification of knowledge bases only covers industrial sectors, the other primary and service sectors that are part of the provincial production structures are not taken into account in this analysis. Since these other sectors are not included in innovation surveys in Argentina, we cannot empirically identify their predominant knowledge base.

[5] In fact, Blažek and Kadlec (2019) take a lower value, of 1.20.

[6] The appendix details the categories assigned to each province in the three dimensions of analysis and the abbreviations used in Figure 4.

Appendix

Table 8. Categories in the three dimensions of analysis and abbreviations

Province	Abbreviation	RIS	Development	Knowledge Base
Buenos Aires	PBA	Intermediate	Intermediate	AN-SYNT
CABA	CABA	Core	High	ANALYTICAL
Catamarca	CAT	Peripheral (+)	Intermediate	symbolic
Chaco	CHA	Peripheral (+)	Low	synthetic
Chubut	CHU	Core (-)	High	SYNTHETIC
Córdoba	CDB	Core	High (-)	an-SYNT
Corrientes	COR	Peripheral	Low	synt-symb
Entre Ríos	ER	Peripheral	Intermediate	synt-symb
Formosa	FO	Peripheral	Low	AN-symb
Jujuy	JU	Peripheral	Low	SYMBOLIC
La Pampa	LP	Intermediate	High	*SYMBOLIC*
La Rioja	LR	Peripheral (+)	Low	SYMBOLIC
Mendoza	ME	Intermediate	Intermediate	symbolic
Misiones	MI	Peripheral	Low	SYNT-*symb*
Neuquén	NQN	Intermediate	High	AN-synt
Río Negro	RN	Core (-)	High (-)	*SYMBOLIC*
Salta	SA	Peripheral	Low	SYMBOLIC
San Juan	SJ	Intermediate	Low (+)	an-synt
San Luis	SL	Core (-)	Intermediate	*AN*-SYNT
Santa Cruz	SC	Peripheral (+)	High	ANALYTICAL
Santa Fe	SF	Core (-)	High	AN-SYNT
Santiago del Estero	SDE	Peripheral	Low	symbolic
Tierra del Fuego	TDF	Core (-)	High	AN-SYNT
Tucumán	TU	Core (-)	Low (+)	symbolic

Tables and figures

Table 1. Theoretical taxonomy of knowledge bases

	Analytical	Synthetic	Symbolic
Knowledge types	Highly codified, scientific, deductive, and formal (know-why)	Partially codified, with a high tacit component, and applied to problem solving (engineering know-how)	High dependence on tacit, cultural, artisanal and creative knowledge (know-who)
Knowledge creation, types of innovation and R&D relevance	Development of new knowledge and technologies, with a central role of R&D and formal collaborations	Application or combination of knowledge in a novel way, to solve problems or customise products; applied and selective R&D	Creative process of reusing knowledge, challenging conventions, and creating new meanings or desired aesthetic qualities; infrequent R&D
Linkages and formalisation of knowledge sharing	Frequent and formal links between firms (R&D areas) and with research centres	Interactive learning with customers and suppliers, with an intermediate level of formalisation	Predominance of experimentation and introspection in project teams, with occasional and informal interactions with the community
Examples of industries (and services)	Nanotechnology, Biotechnology, Pharmaceuticals (IT Services)	Machinery, Shipbuilding, Chemicals (Financial Services)	Food, Wines, Textile-Apparel, Furniture (Audiovisual services, Publishing, Advertising)

Source: Own elaboration based on Asheim et al. (2007), Martin (2012), and Martin and Moodysson (2013).

Table 2. Indicators and data sources for the two indexes

Indicators used for:	**Name**	**Sources**
RIS Index (by province, 2014-2017)		
Per capita R&D investment (current values)	RD	Ministry of Science, Technology, and Innovation, and National Institute of Statistics and Census
Full-Time Equivalent (FTE) Researchers per 10,000 inhabitants	RES	
Full-Time Equivalent (FTE) Fellows per 10,000 inhabitants	FEL	
Share of total employment in knowledge-intensive services (%)	KIS	Employment and Business Dynamics Observatory, and National Institute of Statistics and Census
Firm entry (openings per 10,000 inhabitants)	ENT	
Index of Socio-Economic Development (by province, circa 2017)		
Per capita Gross Domestic Product (current values, 2018)	GDP	Federico Muñoz and Associates, and National Institute of Statistics and Census
Average per capita Household Income (3rd quarter 2017)	AHI	National Institute of Statistics and Census
Human Development Index (2016)	HDI	United Nations Development Programme

Source: Own elaboration.

Table 3. Indicators for the typology of industrial knowledge bases (by sector, from ENDEI 2014-2016)

Indicator	Expectation of knowledge base	
	Highest value	**Lowest value**
Share of total employment that is qualified personnel (%)	Analytical/Synthetic	Symbolic
Share of total employment in innovation activities (%)	Analytical/Synthetic	Symbolic
Share of total employment in R&D activities (%)	Analytical	Symbolic
Share of total expenditure on innovation activities in internal or external (outsourced) R&D	Analytical	Symbolic
Share of total expenditure on innovation activities in industrial design and engineering (%)	Synthetic	Symbolic
Share of total expenditure on innovation activities in acquisition of machinery, equipment, hardware, and software (%)	Synthetic/Symbolic	Analytical
Share of total firms that conducted innovation activities and introduced innovations (%)	Analytical/Synthetic	Symbolic
Share of total firms that did not conduct innovation activities but introduced innovations (%)	Symbolic	Analytical
Share of total firms linked to another agent or organisation for innovation and technological development activities (%)	Analytical	Symbolic

Source: Own elaboration.

Table 4. RIS index and variables (in Z scores, average 2014-2017)

	RIS Index	R&D	Resear-chers	Fellows	KIS	Firm Entry	RIS Classification
CABA	3.93	3.21	3.22	3.74	3.56	3.43	Core
Córdoba	0.69	0.24	0.50	0.82	1.03	0.49	
Río Negro	1.43	2.84	1.58	1.33	-0.55	0.71	Core (-)
San Luis	0.65	0.03	1.76	0.88	-0.14	0.13	
Tierra del Fuego	0.37	0.26	-0.03	0.04	-0.03	1.38	
Chubut	0.21	0.07	0.01	0.38	-0.39	0.74	
Santa Fe	0.08	-0.10	0.08	0.17	0.09	0.10	
Tucumán*	0.02	-0.12	0.14	0.19	0.79	-0.80	
La Pampa	-0.01	-0.12	0.06	-0.25	-0.16	0.40	Intermediate
Mendoza	-0.04	-0.27	0.05	-0.11	0.22	-0.02	
San Juan	-0.06	-0.05	0.06	0.37	-0.30	-0.41	
Neuquén	-0.07	-0.42	-0.60	-0.62	0.81	0.75	
Buenos Aires	-0.18	-0.07	-0.29	-0.26	0.11	-0.23	
Santa Cruz	-0.30	-0.28	-0.46	-0.89	-0.22	0.61	Peripheral (+)
Chaco	-0.48	-0.53	-0.93	-0.77	1.32	-0.84	
Catamarca	-0.53	-0.33	0.12	-0.65	-1.04	-0.51	
La Rioja	-0.55	-0.35	0.03	-0.27	-1.20	-0.74	
Salta	-0.55	-0.57	-0.68	-0.39	-0.11	-0.59	Peripheral
Corrientes	-0.56	-0.52	-0.59	-0.39	-0.18	-0.70	
Misiones	-0.67	-0.59	-0.83	-0.39	-0.40	-0.69	
Jujuy	-0.71	-0.43	-0.51	-0.47	-0.96	-0.80	
Entre Ríos	-0.77	-0.55	-0.74	-0.80	-0.97	-0.35	
Santiago del Estero	-0.86	-0.72	-0.90	-0.63	-0.64	-0.87	
Formosa	-1.06	-0.62	-1.05	-1.05	-0.64	-1.19	

Source: Own elaboration.

Note: Tucumán is a borderline case, which could be also classified as intermediate (+).

Table 5. Index of socio-economic development and variables (Z-Scores, circa 2017)

	ISED	GDP	AHI	HDI	Development
CABA	2.43	2.23	2.52	2.30	High
Tierra del Fuego	2.32	1.91	2.39	2.41	
Santa Cruz	1.33	1.86	1.06	0.97	
Neuquén	1.20	2.13	0.84	0.53	
Chubut	1.01	0.76	1.07	1.08	
La Pampa	0.43	0.07	0.59	0.59	
Santa Fe	0.14	0.03	0.24	0.14	
Río Negro	0.06	-0.25	0.39	0.03	High (-)
Córdoba	0.03	-0.12	0.05	0.14	
Entre Ríos	-0.12	-0.38	-0.07	0.09	Intermediate
San Luis	-0.13	-0.24	-0.45	0.31	
Catamarca	-0.14	-0.14	-0.28	0.03	
Mendoza	-0.20	-0.31	-0.40	0.14	
Buenos Aires	-0.24	-0.35	-0.01	-0.36	
San Juan	-0.47	-0.53	-0.52	-0.30	Low (+)
Tucumán	-0.61	-0.78	-0.68	-0.30	
La Rioja	-0.62	-0.62	-0.61	-0.58	Low
Salta	-0.64	-0.60	-0.53	-0.74	
Jujuy	-0.77	-0.75	-0.95	-0.52	
Misiones	-0.77	-0.84	-0.60	-0.80	
Corrientes	-0.90	-0.77	-0.82	-1.02	
Formosa	-1.03	-0.93	-0.88	-1.19	
Santiago del Estero	-1.12	-0.66	-1.12	-1.46	
Chaco	-1.20	-0.71	-1.24	-1.52	

Source: Own elaboration.

Note: the font colour in the last column will be reflected in Figure 4.

Table 6. Classification of industrial sectors according to knowledge bases (Z-Scores, average 2014-2016)

		Employment composition			Types of innovation activities			Innovation activities - Innovator		Linkages for innovation & technological development
		Qualified	In innovation activities	In R&D	R&D (internal & external)	Industrial design & engineering	Machinery, equipment, hardware, & software	Conducted innovation activities & introduced innovations	No innovation activities but introduced innovations	
Analytical	**Pharmaceutical**	2.59	0.76	**2.50**	3.02	-1.35	-2.53	**0.95**	-0.93	**1.59**
	Chemical and petrochemical	0.45	0.12	**1.09**	0.92	1.26	-1.37	**0.27**	-0.33	**0.98**
	Electrical equipment and appliances, radio and TV	-0.21	1.87	**0.92**	-0.00	0.22	-0.06	**1.14**	-0.95	**1.42**
	Machinery and equipment	0.62	1.56	**0.44**	0.12	1.60	-0.54	**1.40**	-1.27	**0.37**
Synthetic	Automotive, shipbuilding, and railway industry	**0.65**	-0.56	-0.60	-0.66	**0.96**	0.39	0.21	-0.27	0.47
	Iron, steel and metallurgy	0.44	**0.14**	-0.60	-0.27	**0.84**	-0.16	-0.66	0.03	-0.47
	Other industries	-0.60	**0.02**	0.17	-0.35	**0.42**	0.32	0.15	-0.70	0.48
	Wood and furniture	-1.26	**0.38**	-0.70	-0.38	**0.38**	0.20	-0.40	0.25	-0.65
	Rubber and plastic	-0.39	**0.16**	-0.24	-0.53	-0.83	0.87	**1.28**	-0.71	0.20
Symbolic	Textile and apparel	-0.96	-1.01	-0.63	-0.34	-0.46	**0.41**	-1.55	**1.90**	**-1.41**
	Leather and footwear	-0.83	-1.09	-0.78	-0.29	-1.02	**0.74**	-0.39	**1.46**	**-0.93**
	Paper and edition	0.08	-1.14	-0.74	-0.70	-1.18	**1.07**	-1.30	**1.26**	**-1.39**
	Food, beverage, and tobacco	-0.59	-1.21	-0.82	-0.54	-0.84	**0.68**	-1.10	**0.25**	**-0.67**

Source: Own elaboration.

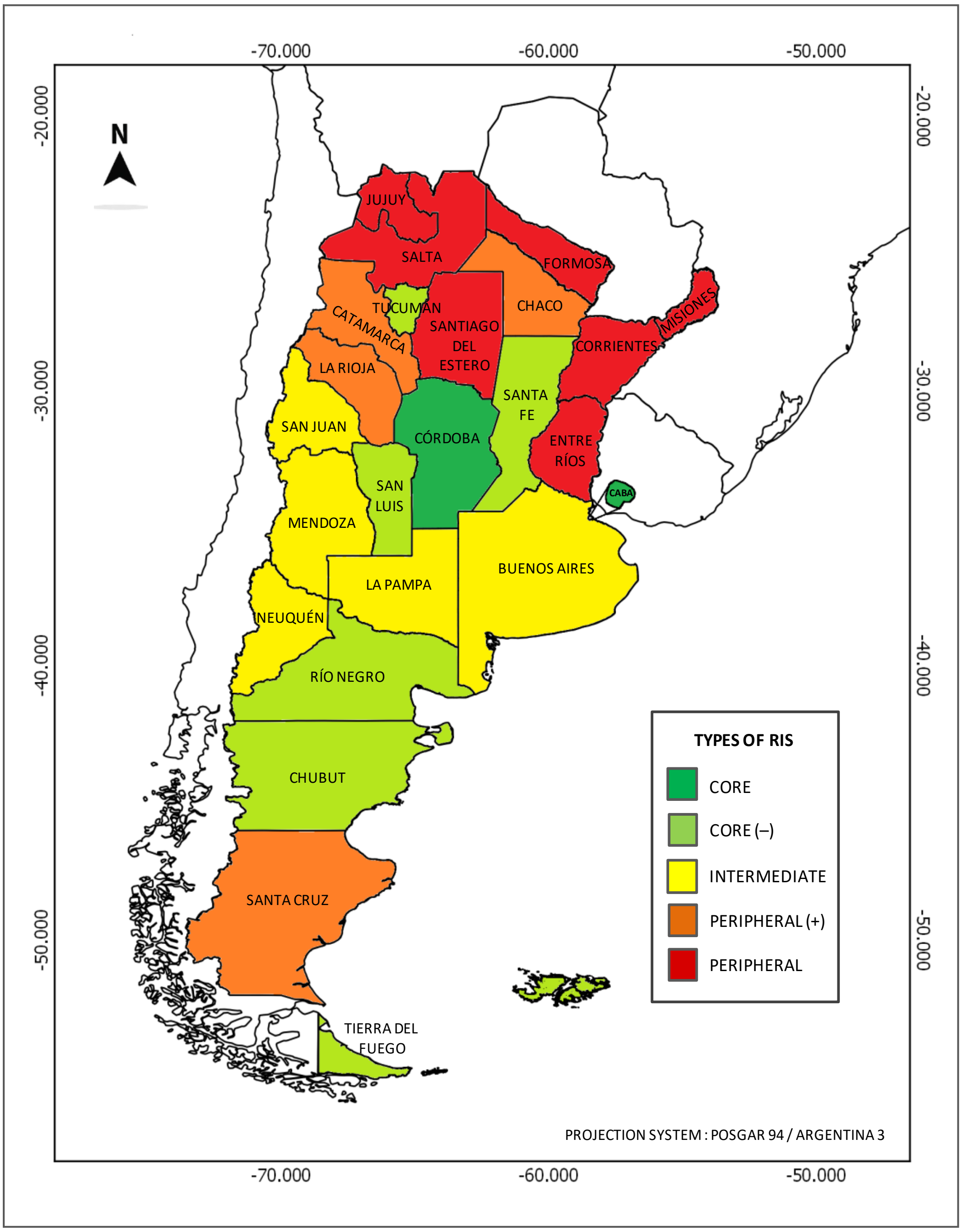
Table 7. Provincial specialisation or combination of knowledge bases (LQ values, 2014-2017 average)

	Analytical	Synthetic	Symbolic	Specialisation or Combination
CABA	**1.82**	0.80	0.90	ANALYTICAL
Santa Cruz	**1.68**	0.87	0.90	ANALYTICAL
Neuquén	**2.48**	1.17	0.59	AN-synt
Tierra del Fuego	**2.53**	**1.27**	0.53	AN-SYNT
Santa Fe	**1.43**	**1.45**	0.71	AN-SYNT
Buenos Aires	**1.31**	**1.59**	0.68	AN-SYNT
San Luis	***1.24***	**1.38**	0.78	*AN*-SYNT
Córdoba	1.19	**1.57**	0.71	an-SYNT
San Juan	1.13	1.21	0.88	an-synt
Chubut	0.93	**1.29**	0.89	SYNTHETIC
Chaco	0.86	1.23	0.93	synthetic
Misiones	0.13	**1.49**	*0.99*	SYNT-*symb*
Corrientes	0.26	1.16	1.10	synt-symb
Entre Ríos	0.66	1.14	1.02	synt-symb
La Rioja	0.28	0.32	**1.45**	SYMBOLIC
Jujuy	0.09	0.53	**1.41**	SYMBOLIC
Salta	0.53	0.61	**1.27**	SYMBOLIC
Río Negro	0.54	0.68	***1.24***	*SYMBOLIC*
La Pampa	0.31	0.80	***1.24***	*SYMBOLIC*
Tucumán	0.72	0.63	1.22	symbolic
Catamarca	0.94	0.59	1.19	symbolic
Mendoza	0.79	0.68	1.18	symbolic
Santiago del Estero	0.42	0.95	1.16	symbolic
Formosa*	**1.72**	0.58	1.01	AN-symb

Source: Own elaboration.

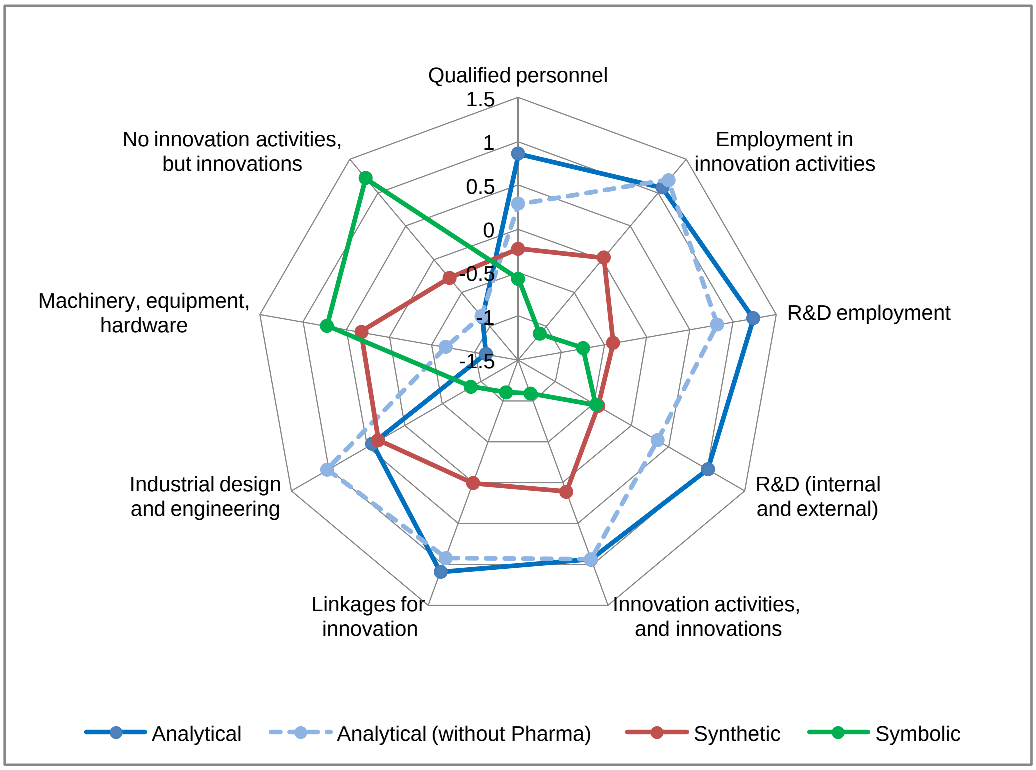
Notes: italics indicate cases where the criterion is relaxed one decimal, both for strong (1.24) and weak (0.99) specialisations. Values below 0.75 are highlighted in red. *Formosa is the only particular case that combines analytical and symbolic knowledge bases, but it is located close to the latter due to its greater weight in provincial employment.

Figure 1. Map of Argentine provinces by type of RIS



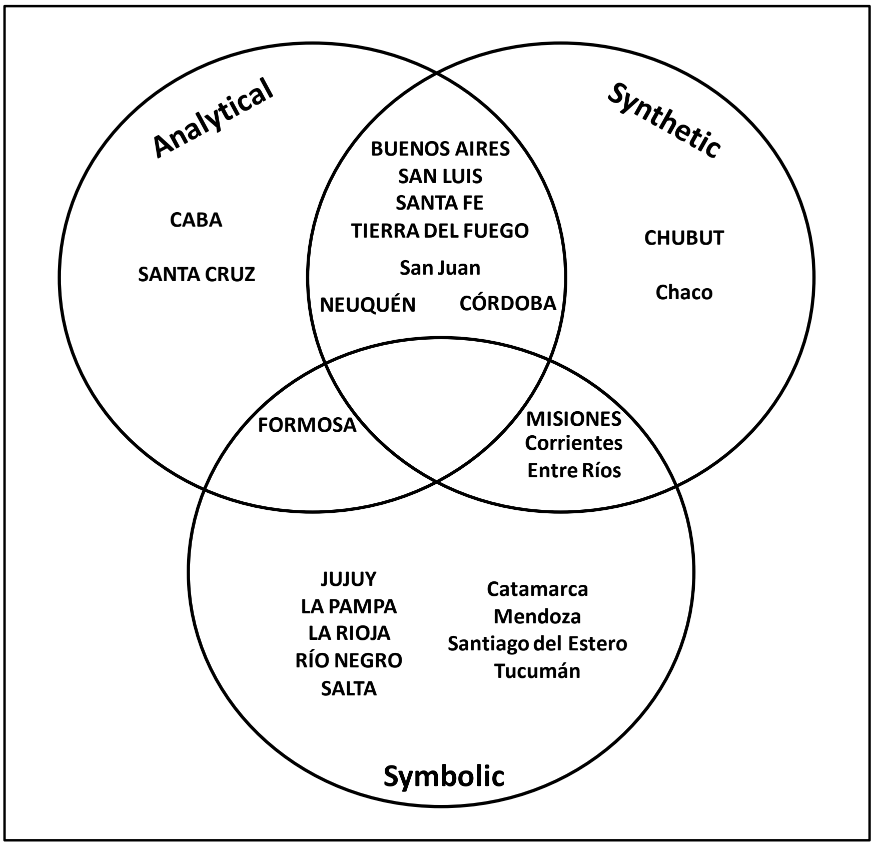
Source: Own elaboration.

Figure 2. Mean values of each group of sectors (Z-Scores, average 2014-2016)



Source: Own elaboration.

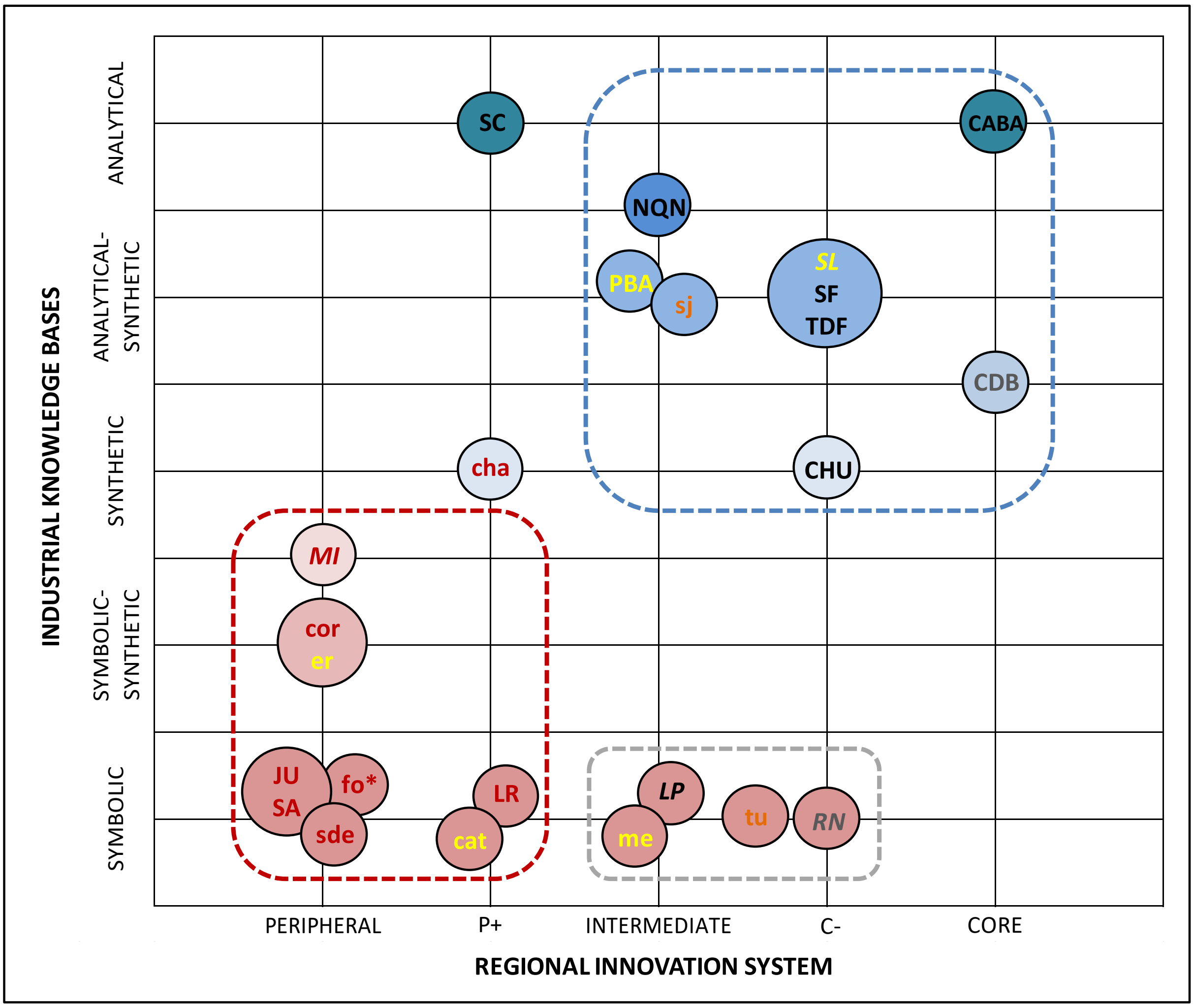
Figure 3. Specialisation or combination of knowledge bases



Source: Own elaboration.

Note: in combined cases but with different degrees of specialisation, the province (in capital letters) is located closer to the knowledge base with the highest specialisation.

Figure 4. RIS development and industrial knowledge bases



Source: Own elaboration.

Notes: RIS development according to Table 3. Knowledge bases according to Table 6 (capital letters for strong specialisations and lowercase for weak specialisations; in combined cases with different degrees of specialisation, the province is located closer to the highest specialisation). Socio-economic development according to Table 4 (reflected in the font colour). Abbreviations can be consulted in the appendix. *Formosa is the only particular case that combines analytical and symbolic knowledge bases, but it is located in the latter due to its greater weight in provincial employment.