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Regional development gaps in Argentina: A multidimensional approach to identify the location of policy priorities

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ABSTRACT

Spatial inequalities within Latin American countries have historically attracted the interest of academics, policy-makers, and international agencies. This article aims to provide a multidimensional diagnosis of provincial development gaps in Argentina, in order to identify the location of policy priorities. Therefore, we built a large database, which covers seven development dimensions, and applied multivariate analysis techniques to overcome some analytical limitations of previous studies. Results show the stability of provincial development gaps between 2003 and 2013 and some heterogeneity within geographic regions. Instead, cluster analysis offers a better classification of Argentine provinces according to their development gaps, which can help the government to prioritize the places where development policies are strategic.

Keywords

spatial inequalities; development diagnosis; principal components analysis; cluster analysis.

JEL codes

O18, R11, R58

1. INTRODUCTION

Academic and political interests in regional development have grown in recent decades, due to the persistence and growth of spatial inequalities (Wei, 2015). This can be observed not only throughout the empirical literature from developed countries (Gbohoui et al., 2019; Heidenreich & Wunder, 2008; Iammarino et al., 2018; Martínez-Galarraga et al., 2015; Parente, 2019), but also from developing countries in Asia, Africa, and Latin America (Aroca & Atienza, 2016; Barrios & Strobl, 2009; Cuadrado-Roura & Aroca, 2013; ECLAC, 2010, 2016b; Kanbur et al., 2005; 2006; Milanovic, 2005).

Within this same line, regional inequalities in Argentina have been a permanent topic of analysis and the problem of uneven development among regions or provinces continues until today (Borello, 2016; Cao & Vaca, 2006; Capello et al., 2013; Niembro, 2015; Porto & Elizagaray, 2011). It is important to mention that Argentina is a federal republic with three levels of government, the national or federal state, the provinces (sub-national states), and the local governments or municipalities -Niembro et al. (2016) show the distribution of government functions between these different levels-. Moreover, as we will see later, provinces are usually grouped in geographic regions for statistical or analytical purposes, but these regions do not hold any government status or function. As Cao & Vaca (2006) show, the provinces of the Central region have been historically between the most developed ones, along with some provinces from the Cuyo region (west-central, see Figure 5). The contrary occurs, in general, with the northern provinces. Meanwhile, the southern (Patagonian) provinces are special cases, in the sense that they were later populated, developed, and institutionalized (*provincialized*).

In Latin America, different international agencies have installed the debate about structural development gaps, adopting a multidimensional and complex view of development processes, which transcend the mere growth of GDP per capita (Sen, 1999; Stiglitz et al., 2009; Todaro, 2000)[1]. Likewise, these organizations have executed different exercises of *development gap diagnosis* (DGD) to identify policy and funding priorities (Acevedo et al., 2019; Borensztein et al., 2014; ECLAC, 2012; Pardo Beltrán, 2014). Most of these studies compare development gaps between different countries and only a few analyze sub-national or regional gaps within Latin American countries (RIMISP, 2012, 2014, 2016, 2018).

In the case of Argentina, we can also find recent studies that explore regional development gaps within the country, but they face some limitations. For example, the studies made by ECLAC (2016c, 2017b, 2018, 2019) only cover one province each. Meanwhile, the difficulty to collect homogeneous data from all provinces usually restricts the analysis to only a few specific years, and it also limits the methodologies that can be applied, as in López et al. (2013) and Niembro (2015). In this article, we will try to improve all these aspects.

Another way to analyze spatial inequalities in Latin America has been the construction of regional development indexes, as in the reports of ECLAC (2015b, 2017a) or RIMISP (2016, 2018), but these synthetic indexes lack the complexity and multidimensionality of the analysis of development gaps. Aboal et al. (2018) offer a recent review of different regional indexes developed by local agencies in some Latin American countries.

In Argentina, we can find two indexes of this type, the Provincial Competitiveness Index (ICP, in Spanish) and the Provincial Relative Development Index (IDERP, in Spanish). The ICP was built and actualized for a few years but it was later discontinued (IIEBCC, 2008, 2010, 2012). The IDERP is currently elaborated by the National Directorate of Provincial Affairs (DNAP, Ministry of Economy) and synthesizes, through simple averages, the information of 16 variables in a global synthetic index[2]. Moreover, the results are published for five geographic regions which group the 24 provinces.

[1] This has been influenced by the Millennium Development Objectives and, recently, by the Sustainable Development Objectives 2030.
[2] During the period 2004-2013, similar to the period covered in this article (2003-2013), the IDERP included 17 variables (DINREP, 2015).

The IDERP can be questioned because it uses simple averages, assuming the same weights for all the variables -something similar occurs in López et al. (2013) and Niembro (2015)-, but it also has two other limitations. First, the IDERP presents a general or summarized view of socio-economic development, which precludes the analysis and identification of the strategic dimensions that would require specific public policies to reduce regional gaps (ECLAC, 2016a). Second, although the differentiation between five geographic regions is commonly used in some studies and official statistics, it assumes that each geographic region is relatively homogeneous inwards. In some cases, this assumption can obscure the existence of differences between the grouped provinces and, especially, the need for different policies at least for some provinces. Because of these two issues, the IDERP only offers a ranking of these five geographic regions according to a general or synthetic index (DINREP, 2015)[3], an uninformative result to define policy priorities or their location. In this article, we will provide an alternative classification of Argentine provinces, based on a set of different development gaps.

In other words, the objective of this article is to overcome some of the mentioned limitations and contribute with a multidimensional view of provincial development gaps in Argentina, in order to identify the location of policy priorities. With this goal in mind, we have built a database with 32 variables, organized in seven dimensions, for all Argentine provinces in the period 2003-2013. This large database allows us to follow more complex methodologies than the ones used in the IDERP or previous studies (López et al., 2013; Niembro, 2015). Firstly, through principal component analysis (PCA) we calculate the provincial development gaps in each dimension. Secondly, through cluster analysis we establish a new grouping and classification of Argentine provinces based on the respective development gaps. This empirical typology lets us analyze the evolution of provincial gaps and compare the results with the traditional geographic classification.

[3] More recently, the synthetic index has been also divided in two very general subindexes that separate social and economic variables (DNAP, 2019).

On the other hand, the period of analysis (2003-2013) is not trivial. It represents a relatively homogeneous decade in economic and political terms, since the national government maintained the same political sign. Moreover, there is a controversy about the socio-economic results achieved throughout this decade, between the idea of a *won decade* versus a *lost* or *wasted decade* (Gervasoni & Peruzzotti, 2015; Kessler, 2014; Kulfas, 2016). However, the impact of this decade in the evolution of regional development gaps is not clear yet.

This article is organized as follows. In section 2 we introduce the analytical framework and review other empirical studies. In section 3 we present the methodology and data used. In section 4 we analyze and compare the results from different points of view: the provincial gaps, the gaps between geographic regions, and the gaps according to the typology proposed in this article. Finally, in the last section we present some policy reflections about regional development gaps in Argentina.

2. ANALYTICAL FRAMEWORK AND EMPIRICAL LITERATURE

The development gap idea refers to disparities or inequalities in well-being -in the broad sense of the word- between different countries or regions within a country. This definition goes back to the debate and distinction between growth and development. Although economic growth is considered a key element for gaps reduction, it is a necessary but not a sufficient condition for development, which implies other multiple dimensions. Based on the seminal contributions by authors such as Seers, Todaro, and Sen, or by international organisms like the United Nations Development Programme (UNDP), the definition of development -and therefore of development gaps- should be multidimensional and dynamic. Human progress and well-being respond to a process through which individuals increase their opportunities, expand their liberties, and improve their achievements. In this sense, some of the basic dimensions of development are the access to education and health, the reduction of poverty and inequality, better living standards, among others (ECLAC, 2012; Sen, 1999; Stiglitz et al., 2009; Todaro, 2000; UNDP, 1990).

While the idea of development diagnosis is inspired by *growth diagnosis methodology* (GDM), popularized by Hausmann et al. (2005), the DGD presents a more multidimensional and complex point of view (Borensztein et al., 2014; Kaldewei, 2016; López et al., 2013; Pardo Beltrán, 2014). Several studies in developing countries have implemented the GDM, for example in Argentina (Albrieu & Fanelli, 2008; Castro et al., 2014; Chisari et al., 2007; Sánchez & Butler, 2008). The GDM tries to reveal some specific growth barriers that each country should tackle, since according to Hausmann et al. (2005) the central challenge for developing countries is increasing their growth rates. However, the DGD highlights the existence of other dimensions that exceed economic growth and cannot be evaluated by the GDM. In this sense, the DGD focuses on identifying, evaluating, and prioritizing different obstacles and challenges for national or regional development, and therefore it helps to establish an agenda of strategic public policies (ECLAC, 2012, 2016a; Kaldewei, 2016; Pardo Beltrán, 2014).

In recent years, different studies have evaluated the development gaps for some developing or transition economies. For example, Sinitsina (2012) compares the development gaps between countries from the Commonwealth of Independent States and some from the European Union. Alavi & Ramadan (2008), Brooks et al. (2010), Bui & Vo (2007), Caballero-Anthony (2006), Mat Basir & Abd Aziz (2018), McGillivray & Carpenter (2013), and Menon (2013) analyze the development gaps in Asia. Meanwhile, Acevedo et al. (2019), Borensztein et al. (2014), Pardo Beltrán (2014), and Tezanos Vázquez (2012) study the development gaps for some Latin American countries. At a sub-national or regional level, we can also find several studies that examine development gaps between regions (Alberdi et al., 2016; Czudec et al., 2019; Niembro, 2015; Onofrei & Cigu, 2017; RIMISP, 2012, 2014; Windhani & Hardoyono, 2017), while others provide a multidimensional view of *spatial inequalities* (Aboal et al., 2018; Antunez et al., 2017; Bin, 2016; Meyer et al., 2016; Niembro, 2020; Parente, 2019; Quadrado et al., 2001a; 2001b).

Although, as it is common, there can be many alternative methodologies to address the same topic, it is worth mentioning that the combination of PCA and cluster analysis has been very popular along the empirical literature (Alberdi et al., 2016; Argüelles et al., 2014; Del Campo et al., 2008; Jindrová, 2015; Nakhaei et al., 2014; Niembro, 2017; Quadrado et al., 2001b; Rasic, 2005; Windhani & Hardoyono, 2017). Other studies propose slightly different methods to obtain a geographic regionalization (Assunção et al., 2006; Carvalho et al., 2008; Duque et al., 2012; Pereira & Moreira, 2020), with the aim of guaranteeing that the groups or clusters are formed by strictly neighboring or contiguous spatial units. However, as pointed by some of these authors (Carvalho et al., 2008; Pereira & Moreira, 2020), depending on the research context, the fact that the grouped units are geographically separated may not necessarily be a problematic or complicated result, which is the case of this article. While the traditional geographic regions behind the IDERP or official statistics in Argentina exclusively focus on the physical and spatial location of the provinces, we want to classify Argentine provinces according to their development gaps and without falling in any *spatial or geographic determinism* -nevertheless, as we will see later (Figure 5), these groups will be mainly formed by contiguous provinces-. The general idea is that regional development gaps and, hence, policy priorities do not need to be contiguous. In other words, the national and provincial state should act on these gaps regardless of whether neighboring provinces have the same problems or not, and they have the power and responsibility to do this. Obviously, there are dimensions in which a certain degree of coordination will be needed, as in infrastructure investments, but in others it is not necessarily so.

As we have pointed out, the evidence about regional development gaps in Argentina is limited and presents some weaknesses that this article will try to overcome. Instead of only analyzing some specific provinces (ECLAC, 2016c, 2017b, 2018, 2019) or a few years, we will cover all the provinces in the period 2003-2013. Some studies commonly use simple averages to combine different variables in a single indicator (DINREP, 2015; López et al., 2013; Niembro, 2015) or previously define a set of *ad-hoc* weights (for example, in the ICP). Unlike these methodologies, PCA allows us to statistically define the weights or to construct composed indexes according to the factor loadings and principal components obtained

(Aboal et al., 2018; Bin, 2016; Cahill & Sánchez, 2001; Haq & Zia, 2013; Jurado & Perez-Mayo, 2012; Mahmood & Ahmed, 2014; Piracha et al., 2016; Quadrado et al., 2001b).

Regarding cluster analysis, Ward's method has been one of the most common hierarchical technique in regional studies (Alberdi et al., 2016; Aumayr, 2006; Borello et al., 2016; Jindrová, 2015; Kronthaler, 2005; Quadrado et al., 2001b; Tezanos Vázquez, 2012; Yang & Hu, 2008), although some studies apply, instead, the average linkage method (Figueras et al., 2007; 2009; Nakhaei et al., 2014; Qi, 2015). On the other hand, K-Means is a popular non-hierarchical method (Barbieri et al., 2019; Brauksa, 2013).

In Argentina, we can also find some previous regional studies that are connected with this article. Among them, Nuñez Miñana (1972) offers one of the first contributions in the elaboration of a typology of Argentine provinces. Moreover, it became a point of reference to compare other typologies obtained (Porto, 1995). Cicowiez (2003) uses PCA to elaborate a provinces ranking, based on socioeconomic synthetic indexes, and then compares it with Nuñez Miñana. In a similar vein, Figueras et al. (2007; 2009) make a cluster analysis -using the average linkage method- and obtain provincial typologies for several years (1970, 1991 and 2001), which are then compared with Nuñez Miñana and Porto.

As we can appreciate, most of regional research and typologies focus on Argentine provinces, since provincial data is usually more available. In a smaller geographic scale, the studies of Borello et al. (2016) and ECLAC (2015a) divide the country into 55 *ad-hoc* micro-regions and use Ward's clustering method to define an empirical typology. On the other hand, and in addition to regional synthetic indexes already mentioned (ICP and IDERP), we can also find some Quality of Life Indexes, sometimes calculated at a provincial level (Velázquez et al., 2004) but mostly for Argentine departments[4] (Velázquez, 2001; 2008; 2016; Velázquez et al., 2014).

3. DATA AND METHODOLOGY

[4] Departments are a territorial division within Argentine provinces, but data for this smaller geographical scale mostly come from population census every 10 years.

3.1. Indicators and sources of information

In this article, we quantify and analyze the evolution of provincial development gaps in Argentina along the following dimensions: education, health, infrastructure, information and communications technology (ICT), science, technology, and innovation (STI), private and business development, and financial system. Each one of these development areas is composed of a set of specific indicators that cover different aspects (see Table 1). A usual restriction in this type of exercise is the availability of regional data, which could difficult the selection of dimensions and variables. Many variables that are collected or calculated for the country as a whole are not available for all Argentine provinces. This represents the first loss of potential information. Another complex issue is collecting comparable information for several years. Despite these limitations, we were able to gather and build a total of 32 indicators for the period 2003-2013, which allowed us to adequately address 7 development areas[5]. As can be seen in the descriptive statistics -calculated along the 24 provinces, based on the averages of each province in the period 2003-2013-, there are considerable levels of heterogeneity among Argentine provinces.

[5] A subset of 18 indicators that does not include some dimensions, such as health or infrastructure, was used by Niembro (2020) to analyze a different set of questions, under an also different conceptual framework.

Table 1. Indicators, descriptive statistics, and data sources

Dimensions and Indicators	Mean	Est. Dev.	Min	Max	Own elaboration based on data from
Education					
Illiterate population of 10 or more years (%)	2.7	1.4	0.5	6.0	INDEC (National Institute of Statistics and Censuses)
Gross enrollment rate in primary education	115.5	5.6	106.2	126.7	Ministry of Education and INDEC*
Gross enrollment rate in secondary education	86.2	10.9	64.5	121.9	Ministry of Education and INDEC*
Overage rate in primary education	24.2	8.4	10.9	42.7	Ministry of Education
Overage rate in secondary school	39.6	5.7	28.3	50.0	Ministry of Education
Effective promotion rate in primary education	93.0	3.3	84.0	98.1	Ministry of Education
Effective promotion rate in secondary education	78.5	2.7	74.3	84.4	Ministry of Education
Population of 20 or more years who completed their higher education (%)	6.0	3.1	2.7	19.1	INDEC*
Health					
Life expectancy at birth	74.9	1.1	72.2	76.9	INDEC*
Infant mortality rate per 1,000 live births	13.0	3.0	7.6	20.9	Ministry of Health
Maternal mortality rate per 10,000 live births	5.2	2.7	1.5	13.1	Ministry of Health
Age-adjusted mortality rate per 1,000 inhabitants	7.0	0.6	6.0	8.5	Ministry of Health
Infrastructure					
Kilometers of total road network (national and provincial) per 100 square kilometers of surface	9.7	6.2	3.7	32.2	Vialidad Nacional, Consejo Vial Federal, ONDAT-UTN, INDEC
Kilometers of total road network (national and provincial) per 1,000 inhabitants	11.3	8.5	0.0	35.5	Vialidad Nacional, Consejo Vial Federal, ONDAT-UTN, INDEC
Deaths in traffic accidents per 100,000 inhabitants	21.1	5.6	6.6	31.7	NGO Luchemos por la Vida and INDEC
Fuel consumption (cubic meters of diesel and gasoline) per inhabitant	0.5	0.3	0.2	1.4	Secretary of Energy and INDEC
Total electricity consumption (kilowatt-hour) per inhabitant	2287.6	1280.2	889.6	6550.7	Secretary of Energy and INDEC
Information and Communications Technology (ICT)					
Proportion of households with computers (%)	37.9	12.4	19.8	66.9	INDEC*
Proportion of households with internet access (%)	24.0	11.4	10.8	54.7	INDEC*
Proportion of households with telephone line (%)	43.9	14.1	25.1	85.4	INDEC*
Proportion of households with cell phone (%)	65.0	6.9	54.4	81.1	INDEC*
Science, Technology and Innovation (STI)					
Total expenditure on scientific and technological activities per inhabitant	192.4	127.9	60.4	623.6	Ministry of Science, Technology and Innovation and INDEC
R&D personnel (full-time equivalent) per 10,000 inhabitants of 20 or more years	20.5	12.4	6.2	60.9	Ministry of Science, Technology and Innovation and INDEC*
Proportion of industrial employment in branches of medium-high and high technological intensity (%)**	19.1	11.7	3.5	40.0	Ministry of Labor
Proportion of services employment in knowledge-intensive branches (%)***	13.2	3.5	8.1	23.7	Ministry of Labor
Private and business development					
Formal employment per 100 inhabitants of 20 or more years	19.9	11.9	7.1	63.7	Ministry of Labor and INDEC*
Proportion of employees with high education level (incomplete or complete higher education) (%)	31.7	6.6	24.3	57.5	INDEC****
Density of companies (total per 1,000 inhabitants of 20 or more years)	21.0	10.8	8.9	59.9	Ministry of Labor and INDEC*
Fertility of companies (openings of new companies per 1,000 inhabitants of 20 years and more)	2.3	1.2	0.9	6.0	Ministry of Labor and INDEC*
Financial system					
Banks subsidiaries per 100,000 inhabitants	10.5	7.1	3.3	32.9	Central Bank of Argentina and INDEC
Loans to the non-financial private sector per inhabitant	3502.6	5702.3	861.5	29243.3	Central Bank of Argentina and INDEC
Deposits of the non-financial private sector per inhabitant	4362.9	6902.3	934.6	35529.8	Central Bank of Argentina and INDEC

Source: Own elaboration. Notes: *Intercensal projections of data -and in the case of ICT of the ENTIC 2011 and 2015-. **Own classification based on CEP (2007) and Loschky (2010). The branch of radio, television, and communications equipment is not included as it significantly biases the results of Tierra del Fuego. ***Own classification that includes software and information services, research and development, legal, accounting and business services, and cinematography, radio, and television (it does not include financial and insurance services). ****In provinces with more than one urban agglomeration, the results are weighted according to the proportion of employees.

Regarding the nature of these indicators, we aimed to apply a criterion as homogeneous as possible throughout all development areas, using *output* or *outcomes* indicators instead of variables that refer to *inputs*, such as expenditures or personnel. In other words, we wanted to concentrate the diagnosis of each development dimension on its *ends* and not necessarily on its *means*. However, we had to make some exceptions in the case of STI, since the information available at a provincial level only responds to researchers and expenditures (*inputs*) in the field, but not to the results or *outcomes* obtained.

Another point to highlight is the need to work with provincial variables expressed in relative terms -for example, divided by provincial population-. This is important to avoid results biased because of the size of the main Argentine provinces, which, as usual, not only concentrate most of the resources, infrastructure, and production, but also most of the population.

3.2. Multivariate analysis techniques

As we mentioned, we firstly employ PCA to synthesize the information shared by the indicators in each dimension and, correspondingly, we obtain seven development gaps for all Argentine provinces between 2003 and 2013. This technique was previously proposed, for example, by Borensztein et al. (2014) and López et al. (2013; 2014) in their analysis of inter-national development gaps, but it has not been yet applied to describe regional development gaps within Argentina.

PCA help us to convert a set of correlated variables in a lower number of uncorrelated factors (for technical details see Hair et al., 2010; Härdle and Simar, 2015; Johnson and Wichern, 2008). Therefore, factorial analysis is many times a means to an end rather than an end in itself (Johnson and Wichern, 2008), since the results can be used as intermediate inputs for other techniques, such as cluster analysis.

An important issue is that both PCA and cluster analysis are sensitive to the use of different scales or measures, so it is initially necessary to standardize the variables (Hair et al., 2010; Johnson & Wichern, 2008). We follow the traditional calculation of Z scores -by default in several statistical software-, which consists in subtracting the mean to the original variables and then dividing them by the standard deviation. Once standardized, the mean equals zero and the standard deviation equals one. Meanwhile, the components or factor scores obtained from PCA are also standardized as Z scores and have the same characteristics by default, so they represent a good input for the following cluster analysis. Moreover, because of the form of calculation, Z scores are, precisely, a measure of provincial gaps regarding the mean in each indicator (as highlighted by López et al., 2013; Niembro, 2015), and therefore the principal components synthesize the provincial development gaps in each dimension.

Before implementing PCA we need to take into account two other issues. Firstly, we reverse the Z scores for the indicators that have a negative nature. For example, in the case of health, if a province has a mortality rate higher than the average, this indicator must be considered as a negative gap. Secondly, we validate that the indicators included in each dimension are adequate for the implementation of PCA (Table 2), checking Bartlett's test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy (Hair et al., 2010; OECD, 2008).

In order to define how many components should be extracted, we follow the traditional Kaiser's criterion, which consists in keeping all the principal components with an eigenvalue bigger than one. In this sense, we only keep the first principal component in five of the seven dimensions, and its factor score represents the corresponding development gap. Instead, in the dimensions of education and infrastructure, we keep the first two principal components (Table 2). In line with the methodology proposed by Cicowiez (2003) and Martínez Pellitero et al. (2008a; 2008b), we combine these two principal components in a single measure by weighting them according to the proportion of the variance explained by each one, over the total or cumulative variance that they together explain.

Table 2. Adequacy tests and components extracted by PCA

		Education	Health	Infras-tructure	ICT	STI	Private developm.	Financial system
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO > 0.5)		0.664	0.767	0.567	0.773	0.653	0.775	0.632
Bartlett's Test of Sphericity	Chi-Square	1886.83	625.01	408.46	1263.27	806.41	1298.36	1347.05
	Df	28	6	10	6	6	6	3
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kaiser criterion: Eigenvalues > 1	Number of components	2	1	2	1	1	1	1
	Cumulative variance	73.51%	88.12%	74.11%	86.03%	67.52%	83.82%	82.84%
	PC1 variance	53.87%	88.12%	42.92%	86.03%	67.52%	83.82%	82.84%
	PC2 variance	19.64%	-	31.19%	-	-	-	-

Source: Own elaboration.

While factor analysis is usually used to group variables based on existing correlation patterns, clustering methods aim to generate groups of objects or cases, according to the similarity or *proximity* along the different variables analyzed (Hair et al., 2010). Therefore, cluster analysis maximizes the homogeneity between the provinces included in each group and, at the same time, the heterogeneity between clusters (for technical details see Hair et al., 2010; Härdle and Simar, 2015; Johnson and Wichern, 2008; OECD, 2008). However, it is worth highlighting that this does not mean the conformation of *territorial clusters*, in the spatial sense of the word.

Based on the development gaps previously obtained from PCA, we use cluster analysis to classify the provinces in different years, especially comparing the two extreme years of 2003 and 2013 (in line with Koisova & Haviernikova, 2016; Quadrado et al., 2001b; Yang & Hu, 2008). Since the use of different methods or distance measures can commonly lead to different solutions, we compare the clusters obtained using different hierarchical and non-hierarchical methods (as argued by Argüelles et al., 2014; Del Campo et al., 2008; Hollanders et al., 2012; Niembro, 2017; Poledníková, 2014; Rovan & Sambt, 2003), in order to verify the consistency and robustness of the results (Hair et al., 2010; Johnson & Wichern, 2008). Regarding distance measures, we use the Euclidean distance, the most usual for K-Means, and the squared Euclidean distance, frequently applied in hierarchical techniques, such as average linkage, and especially recommended for Ward's method.

In hierarchical methods, one of the simplest and most common rules to define the number of clusters consists in analyzing the change in heterogeneity in each stage of the agglomerative process[6] (Hair et al., 2010). Specifically, we used the agglomeration coefficient as the heterogeneity measure. This coefficient measures the distance at which clusters are formed -for the average linkage method- or the intra-cluster sum of squared errors -for Ward's method-. This also helps us to define the starting point for K-Means, since in this non-hierarchical technique it is initially necessary to define the number of clusters to form.

[6] When combining step by step different objects -in this case, provinces- and reducing the number of clusters, the heterogeneity inside these clusters tends to increase. If the heterogeneity measure shows a sudden increase when combining two clusters, we can decide not to take that step and keep the previous number of clusters as a final solution.

4. RESULTS

4.1. Development gaps by province and geographic region

In this section, we present the results obtained through PCA and the methodology previously described. Figure 1 and Table 3 show comparatively the (standardized) values for each development gap in the two extreme years of 2003 and 2013[7]. In Figure 1 we exhibit the average gaps for each geographic region and in Table 3, the provincial gaps[8]. In Annex 1 we present a set of graphs for each dimension comparing 2003, 2008 -an intermediate year- and 2013, and we order the provinces by their gaps in 2013, without any former regional classification.

A first aspect to highlight is the relative stability in both regional and provincial gaps between 2003 and 2013, or in other words, the absence of deep changes during this decade[9]. The only exception seems to be the case of health, where the variability through time is bigger (see Annex 1) and also the difference between the most laggard region and the most advanced one. On the contrary, 3 of the 5 geographic regions remain near to the average (zero) in education, while the STI dimension shows similar values between the regions with positive gaps (3 of 5) and the ones with negative gaps (the other two).

From the geographic perspective of Figure 1, two regions constantly show negative development gaps in all dimensions: firstly, the Argentine North East region (NEA, in Spanish), and secondly, the Argentine North West region (NOA, in Spanish). In general, development gaps are more pronounced in NEA, especially in education and health, and all the provinces of this region have near or similar negative gaps. Instead, there is more variability or heterogeneity between northwestern provinces, as shown for example in education and, to a lesser extent, in health (see Table 3).

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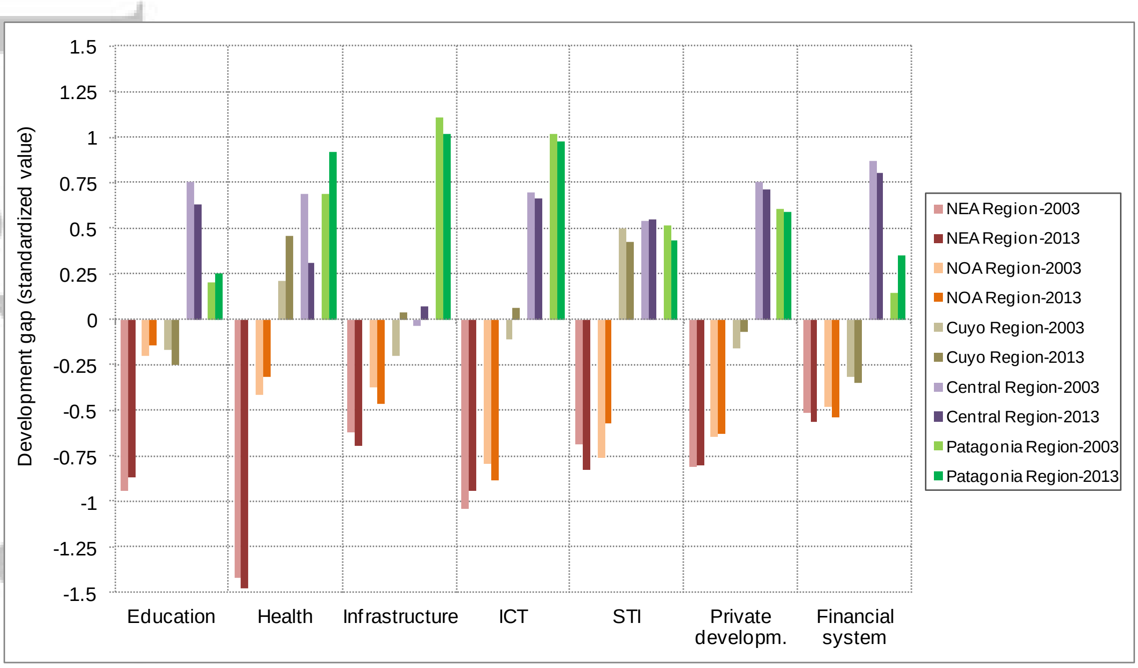
[7] For a matter of simplicity we only expose here the development gaps for these two years, but development gaps for the rest of the period have been also calculated.

[8] In Table 3 we highlight the negative development gaps according to a scale that reflects their seriousness: in light grey, gaps slightly negative (up to 0,25, a quarter of standard deviation); in an intermediate grey, negative gaps (between 0,25 and 1 standard deviation); and in dark grey, very negative gaps (over 1 standard deviation with respect to the average).

[9] Although the IDERP only offers a synthetic view of regional development, instead of a multidimensional one, it also shows that the ranking of geographic regions do not change between 2004 and 2013 (DINREP, 2015).

Figure 1. Development gaps by geographic region (2003 vs. 2013)



Source: Own elaboration.

Table 3. Detail of provincial development gaps (2003 vs. 2013, standardized values)

REGION / Province	Education		Health		Infrastructure		ICT		STI		Private developm.		Financial system	
	2003	2013	2003	2013	2003	2013	2003	2013	2003	2013	2003	2013	2003	2013
NORTHEAST (NEA)	**-0.94**	**-0.87**	**-1.42**	**-1.48**	**-0.62**	**-0.70**	**-1.04**	**-0.94**	**-0.69**	**-0.83**	**-0.81**	**-0.81**	**-0.51**	**-0.57**
Chaco	-0.77	-0.62	-2.31	-1.71	-0.60	-0.50	-1.05	-0.74	-0.88	-0.32	-0.70	-0.83	-0.43	-0.54
Corrientes	-0.93	-1.40	-0.91	-1.51	-0.52	-0.71	-0.81	-0.62	-0.68	-0.90	-0.77	-0.58	-0.47	-0.45
Formosa	-0.72	-0.62	-1.81	-1.82	-0.55	-0.75	-1.27	-1.29	-0.58	-1.19	-1.24	-1.32	-0.65	-0.73
Misiones	-1.35	-0.83	-0.68	-0.88	-0.81	-0.84	-1.04	-1.11	-0.61	-0.92	-0.54	-0.49	-0.50	-0.55
NORTHWEAST (NOA)	**-0.21**	**-0.14**	**-0.42**	**-0.31**	**-0.37**	**-0.47**	**-0.79**	**-0.88**	**-0.76**	**-0.57**	**-0.64**	**-0.63**	**-0.49**	**-0.54**
Catamarca	0.33	0.06	0.40	0.71	0.06	0.43	-0.65	-0.63	-0.87	-0.56	-0.57	-0.50	-0.50	-0.56
Jujuy	-0.25	0.24	-0.90	-0.21	-0.82	-0.93	-0.93	-1.03	-1.11	-1.06	-0.77	-0.82	-0.58	-0.59
La Rioja	-0.11	0.05	-0.89	-0.84	-0.04	-0.11	-0.47	-0.37	-1.00	-0.06	-0.47	-0.73	-0.30	-0.49
Salta	-0.20	-0.46	-0.40	-0.89	-0.27	-0.65	-0.89	-1.11	-0.47	-0.81	-0.51	-0.30	-0.54	-0.52
Santiago del Estero	-1.09	-1.13	0.11	-0.36	-0.74	-0.87	-1.24	-1.42	-1.30	-1.36	-1.03	-0.99	-0.56	-0.56
Tucumán	0.09	0.39	-0.84	-0.30	-0.42	-0.67	-0.58	-0.73	0.18	0.40	-0.51	-0.43	-0.44	-0.51
CUYO	**-0.17**	**-0.25**	**0.21**	**0.46**	**-0.20**	**0.03**	**-0.11**	**0.06**	**0.50**	**0.43**	**-0.16**	**-0.07**	**-0.32**	**-0.35**
Mendoza	0.20	0.06	1.06	0.92	-0.24	0.03	0.06	0.08	-0.07	-0.03	0.07	0.19	-0.22	-0.29
San Juan	-0.66	-0.73	-0.35	-0.58	-0.50	-0.25	-0.32	-0.66	0.06	0.11	-0.44	-0.28	-0.46	-0.52
San Luis	-0.05	-0.08	-0.08	1.04	0.14	0.33	-0.06	0.76	1.50	1.20	-0.11	-0.12	-0.28	-0.24
CENTRAL	**0.75**	**0.63**	**0.69**	**0.31**	**-0.04**	**0.07**	**0.70**	**0.66**	**0.54**	**0.55**	**0.76**	**0.71**	**0.87**	**0.80**
CABA	2.76	2.61	1.85	1.41	0.12	0.27	2.76	1.77	3.41	3.08	3.99	3.88	4.35	4.25
Buenos Aires	0.43	0.21	0.25	-0.28	-0.34	-0.13	0.54	0.61	0.25	0.23	-0.47	-0.46	-0.24	-0.28
Córdoba	0.59	0.58	0.82	0.27	-0.20	-0.06	0.45	0.44	0.40	0.98	0.41	0.54	0.05	0.01
Entre Ríos	-0.14	-0.31	-0.10	0.00	-0.22	-0.19	-0.28	0.14	-0.78	-0.97	-0.21	-0.10	-0.16	-0.25
La Pampa	0.49	0.47	0.89	0.59	0.45	0.53	0.36	0.45	-0.30	-0.45	0.45	0.22	1.11	0.98
Santa Fe	0.38	0.23	0.43	-0.14	-0.05	0.01	0.35	0.58	0.26	0.44	0.36	0.18	0.09	0.12
PATAGONIA	**0.20**	**0.26**	**0.69**	**0.92**	**1.11**	**1.01**	**1.01**	**0.98**	**0.52**	**0.43**	**0.61**	**0.59**	**0.15**	**0.35**
Chubut	0.09	0.13	0.06	0.76	2.05	1.67	0.68	0.79	0.33	0.24	0.56	0.27	0.35	0.41
Neuquén	0.11	0.00	1.46	1.30	0.48	0.52	0.55	0.55	0.36	0.26	0.35	0.53	-0.08	0.20
Río Negro	-0.17	0.15	0.80	0.66	0.13	0.35	0.22	0.21	0.44	1.15	0.29	0.38	-0.21	-0.21
Santa Cruz	-0.14	0.07	-0.36	-0.07	1.75	1.65	1.22	1.25	0.29	0.10	0.66	0.43	0.32	0.23
Tierra del Fuego	1.11	0.93	1.47	1.92	1.13	0.88	2.41	2.10	1.17	0.42	1.20	1.33	0.35	1.10

Source: Own elaboration.

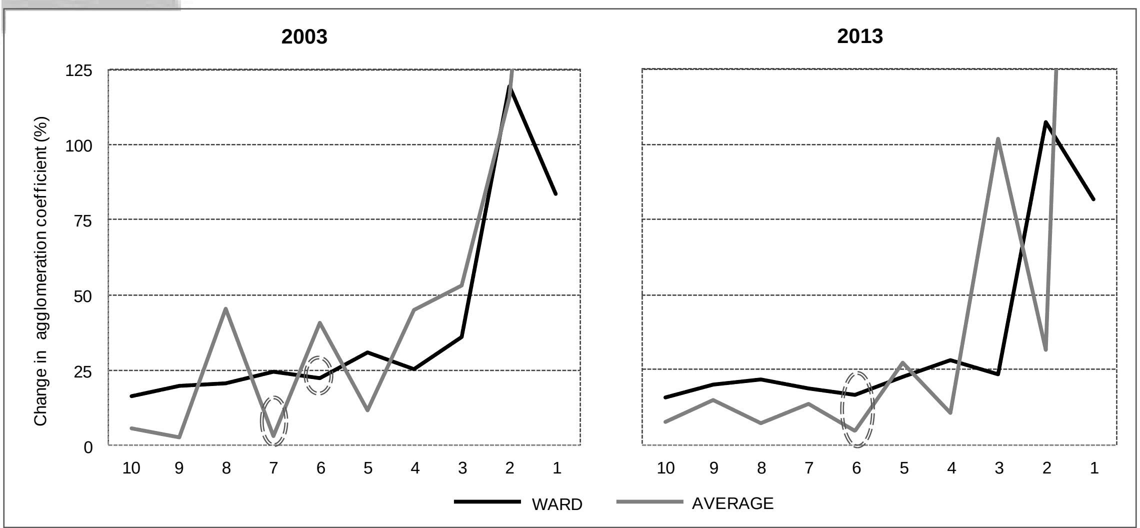
The Cuyo region presents an intermediate position, with several gaps around the average (zero). The most negative regional gap is in financial development, and to a lesser extent in education. However, the greatest problems within this region are generally observed in San Juan, which shows a situation quite different from the other two provinces (see Table 3).

On the other hand, the Central and Patagonia regions generally show positive development gaps and they alternate the first place in the different dimensions. The Central region exhibits an infrastructure gap near to the average, while it has the leadership in education and financial development. Patagonia presents slightly positive gaps in education and financial development, but better results in the other dimensions. However, the relative position of the different provinces within these regions is much more heterogeneous in the Central area than in Patagonia, as Table 3 shows.

4.2. An alternative provincial classification through cluster analysis

The above-mentioned heterogeneity within some geographic regions lets us propose an alternative classification, with the aim of grouping the provinces according to their development gaps. As highlighted in Figure 2, we opt for the formation of six clusters in most cases. Except for the average linkage method in 2003, where it seems pertinent to form seven groups. However, as we will see in Table 4, this only implies to distinguish one special case (San Luis) that in the other classifications belongs to cluster D.

Figure 2. Change in heterogeneity by number of clusters



Source: Own elaboration.

Regardless of this particular case, some other clusters only have one or two provinces both in 2003 and 2013, such as cluster A with the Autonomous City of Buenos Aires (CABA, in Spanish), cluster B with Tierra del Fuego, and cluster C with Chubut and Santa Cruz. This is a very common situation in other studies of Latin American countries, where some sub-national states usually present outstanding characteristics and are identified as particular cases or *clusters* (Bernal Perez, 2018; Crespi & D'Este, 2011; Figueras et al., 2009; Niembro, 2017; Sánchez Tovar et al., 2014; Valdez-Lafarga & León-Balderrama, 2015; Vivar et al., 2010), and it also occurs within several European countries (Alberdi et al., 2016; Buesa et al., 2006; Jindrová, 2015; Kronthaler, 2005; Navarro & Gibaja, 2009; Poledníková, 2014; Zitek & Klimova, 2016)[10].

Then, cluster D is formed by 8 Argentine provinces, a third of the total. Like San Luis province, La Pampa also appears as another possible border case, since it could be part of cluster C according to some techniques. However, as most of the empirical literature, we prioritize Ward's method. According to this clustering technique and also to the other two methods, cluster E includes 6 provinces in 2003 and 5 in 2013, because Salta moves to cluster F. The evolution of cluster F is also interesting, since 4 provinces appear near to the border with cluster E in 2003, as shown by its alternative location according to the other techniques. However, the situation is quite different in 2013, which could suggest that they have been consolidated within cluster F throughout this decade.

[10] As these studies aim to analyze the situation of all the regions or spatial units within a country, it is not common to exclude the regions that are presumed statistically different from the rest, but rather these regions are usually recognized as separate cases or special clusters.

Table 4. Provinces by cluster, according to different methods (2003 vs. 2013)

2003				2013			
Provinces	Average (7)	**Ward (6)**	K-Means (6)	Provinces	Average (6)	**Ward (6)**	K-Means (6)
CABA	A	**A**	A	CABA	A	**A**	A
Tierra del Fuego	B	**B**	B	Tierra del Fuego	B	**B**	B
Chubut	C	**C**	C	Chubut	C	**C**	C
Santa Cruz	C	**C**	C	Santa Cruz	C	**C**	C
La Pampa	D	**D**	C	La Pampa	C	**D**	C
Buenos Aires	D	**D**	D	Buenos Aires	D	**D**	D
Santa Fe	D	**D**	D	Santa Fe	D	**D**	D
Córdoba	D	**D**	D	Córdoba	D	**D**	D
Mendoza	D	**D**	D	Mendoza	D	**D**	D
Neuquén	D	**D**	D	Neuquén	D	**D**	D
Río Negro	D	**D**	D	Río Negro	D	**D**	D
San Luis	***D***	**D**	D	San Luis	D	**D**	D
Catamarca	E	**E**	E	Catamarca	E	**E**	E
Entre Ríos	E	**E**	E	Entre Ríos	E	**E**	E
La Rioja	E	**E**	E	La Rioja	E	**E**	E
San Juan	E	**E**	E	San Juan	E	**E**	E
Tucumán	E	**E**	E	Tucumán	E	**E**	E
Salta	E	**E**	E	Jujuy	F	**F**	E
Corrientes	E	**F**	E	Chaco	F	**F**	F
Jujuy	E	**F**	E	Corrientes	F	**F**	F
Misiones	E	**F**	E	Formosa	F	**F**	F
Santiago del Estero	E	**F**	E	Misiones	F	**F**	F
Chaco	F	**F**	F	Salta	F	**F**	F
Formosa	F	**F**	F	Santiago del Estero	F	**F**	F

Source: Own elaboration.

The relative stability between the classifications with Ward's method -except for the case of Salta that moves from cluster E to F- reveals the persistence of provincial inequalities along this decade. The heterogeneity between the six clusters obtained for 2003 and 2013 is also shown by the analysis of variance (Table 5), since the average of the different clusters is significantly different from each other, in all dimensions.

Table 5. Analysis of variance (ANOVA)

Dimension	Sum of squares		Degrees of freedom	Mean square		F	
	2003	2013	2003 & 2013	2003	2013	2003	2013
Education	13.791	11.377	5	2.758	2.275	28.119***	15.056***
Health	17.390	16.283	5	3.478	3.257	9.506***	9.062***
Infrastructure	11.597	10.731	5	2.319	2.146	40.743***	31.299***
ICT	24.395	19.933	5	4.879	3.987	97.733***	49.449***
STI	20.019	17.846	5	4.004	3.569	19.848***	14.866***
Private developm.	23.782	22.273	5	4.756	4.455	76.041***	46.789***
Financial system	21.950	22.813	5	4.390	4.563	49.666***	59.556***

Source: Own elaboration.
Significance level: * p<0,05; ** p<0,01; *** p<0,001.

4.3. Re-reading regional development gaps

The six clusters obtained give us the possibility to analyze regional development gaps from a new point of view and to define an empirical typology. As shown in Figure 3, the first three clusters -and the four provinces included there- correspond to *special cases of developed provinces*[11]. Firstly, the CABA (cluster A) presents very high positive gaps in almost all dimensions -especially in education, STI, financial and business development-, and in second place appears Tierra del Fuego (cluster B)[12]. Meanwhile, cluster C is generally behind these two special provinces, except for the infrastructure dimension.

On the other hand, cluster D gathers the *other developed provinces* (ODP). In general, this cluster shows positive development gaps but slightly over the average. However, in some dimensions, such as education, health, and STI, cluster D presents higher values than cluster C.

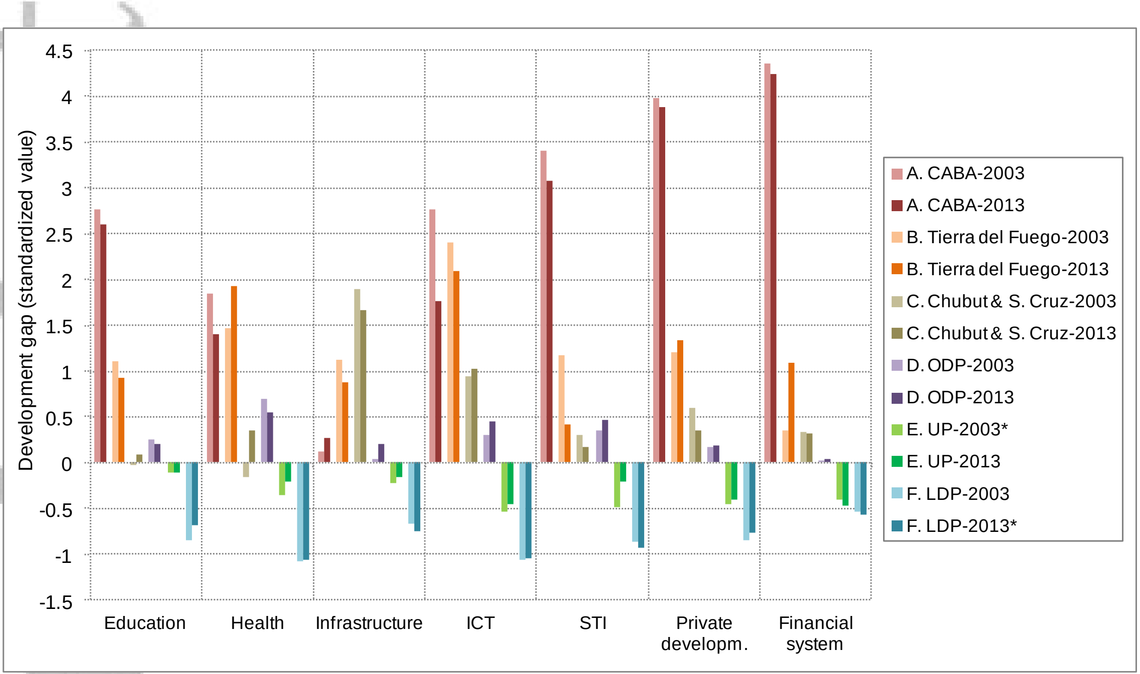
Finally, clusters E and F show negative development gaps in all dimensions. However, while cluster E brings together some *underdeveloped provinces* (UP), cluster F gathers the *least*

[11] We recognize that development and underdevelopment are relative concepts. In this case, they are only used to compare between Argentine provinces. Within a same (developing) country, we can say that one province is relatively developed in comparison with the others, but this does not mean that this province has similar characteristics to a developed country.

[12] At the beginning of the nineties these jurisdictions were the last to obtain their autonomy from national government and the capacity to elect their own governors. Moreover, they represent realities and economies with a strong urban nature, which is obvious for the CABA, but is also the case of Tierra del Fuego, since its population is highly concentrated in two major cities, Río Grande and Ushuaia.

developed provinces (LDP), because of the relative magnitude of their gaps. In general, the negative development gaps of cluster F more than double those of cluster E, except for financial development, where they are relatively similar. It is worth mentioning that these comments are independent of the inclusion of Salta in Cluster E for 2003 and, then, in Cluster F for 2013, as shown in Figure 4.

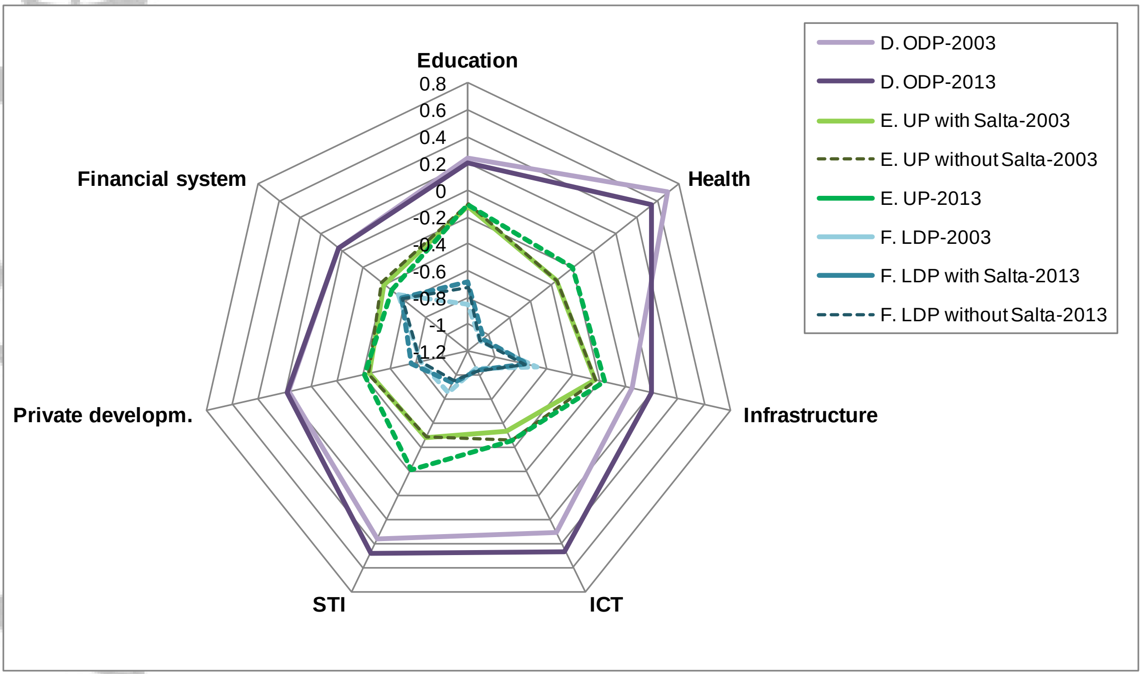
Figure 3. Development gaps by cluster (2003 vs. 2013)



Source: Own elaboration. Note *: Includes Salta province.

In Figure 4, we leave aside the *special cases* (clusters A, B, and C) and concentrate on clusters D, E, and F, which account for 20 of the 24 Argentine provinces. Between 2003 and 2013, the ODP and UP have maintained or improved their development gaps in most dimensions, with the exceptions of health -and, to a lesser extent, of education- in cluster D and of financial development in cluster E. On the contrary, improvements seem to have been very limited in the LDP, a group that needs much bigger progress to reduce its negative development gaps. We only observe some degree of improvement in education and business development but in parallel some setbacks in STI and infrastructure.

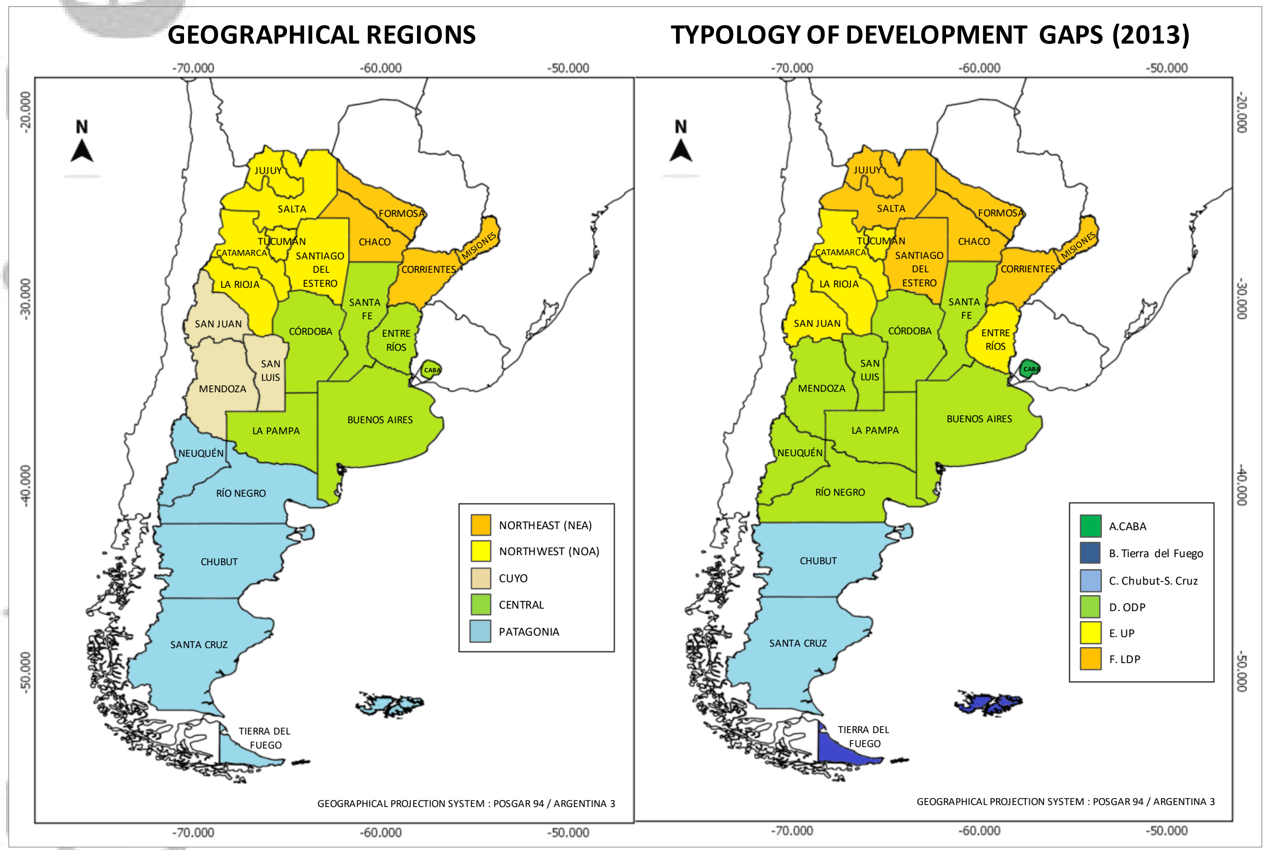
Figure 4. Evolution of development gaps (clusters D, E, and F)



Source: Own elaboration.

At this point, we believe that the empirical typology derived from cluster analysis represents an improvement for the study of regional development gaps. The traditional geographic regions usually end up hiding some heterogeneity within them, as shown in Figure 5 and Table 6. In the Central region, as in the country in general, we can highlight the special case of the CABA, which presents a very high development level compared to the rest of the country, something very common in the case of the Capital cities or metropolitan areas in Latin America. Within the same region, we also find four other developed provinces, but also one province (Entre Ríos) that presents some degree of underdevelopment. Meanwhile, along the clusters with two or more provinces, Entre Ríos is the only case -or the exception- that is not contiguous to the other provinces of the same type.

Figure 5. Maps of Argentine provinces, geographic regions, and clusters typology



Source: Own elaboration.

Something similar occurs in the Cuyo region, with two developed provinces and one underdeveloped (San Juan), according to our typology. While all Patagonian provinces can be understood as developed, one of them has some outstanding characteristics (similarly to the CABA) and two other provinces also represent special cases. On the contrary, the NOA region includes the rest of the *underdeveloped provinces* and some of the *least developed* ones. Only in the case of the NEA region all the provinces are situated in the same cluster, specifically the one of LDP.

Although we must recognize that identifying which specific policies should be employed in each location requires further in-deep studies, Table 6 offers an aggregated or summarized view about some general priorities, showing the differences between the negative development gaps for each geographic region and for each alternative cluster. In the last row and column, the dimensions with strong negative development gaps are highlighted in bold, while the others are weak gaps (according to the previous Figures 1 and 3). From a geographic perspective, the Central and Patagonia regions have practically no negative gaps, except for some weaknesses in infrastructure in the central area. However, according to our typology, the absence of negative gaps is limited to the special cases of the CABA and Tierra del Fuego (clusters A and B) and, to a lesser extent, to cluster C, where Chubut and Santa Cruz show some little problems in education and health. For the ODP or cluster D -a group that also includes two provinces from the Cuyo region-, financial development seems a priority, and some progress in infrastructure can still be made.

On the other hand, the NOA and NEA regions, as well as clusters E and F, have negative gaps in all the dimensions. Nevertheless, there are differences between the three most worrying dimensions -the most negative gaps in each case-, at the same time that the group of UP is not only limited to northern provinces.

Table 6. Differences between clusters and geographic regions

		Clusters / Typology						Priorities (negative gaps)
		Special cases						
		A. CABA	B. Tierra del Fuego	C. Chubut-Santa Cruz	D. ODP	E. UP	F. LDP	
Geographic regions	Central	1			4	1		Infrastructure
	Patagonia		1	2	2			-
	Cuyo				2	1		**Finance, Education, Private dev.**
	NOA					2003=4 2013=3	2003=2 2013=3	**All: ICT, Private dev., STI**
	NEA						4	**All: Health, ICT, Education**
Priorities (negative gaps)		-	-	Education, Health	**Finance,** Infrastructure	**All: Finance, Private dev., ICT**	**All: Health, ICT, STI**	

Source: Own elaboration.

5. CONCLUSIONS

Latin America is known as one of the most unequal regions in the world and these inequalities are reflected within the countries, in terms of deep spatial inequalities. In the case of Argentina, the inequalities between geographic regions and provinces have been a historical problem.

In order to design regional development policies, it is necessary to have a good diagnosis of regional and provincial development gaps. This can help to define the location of policy priorities and to guide funds and promotion policies with more spatial equity in mind. Throughout this article, we seek to contribute with a multidimensional view of provincial development gaps in Argentina, instead of the synthetic approach of some indexes like the IDERP. In this sense, we built a large database, covering seven development dimensions, and we applied different multivariate analysis techniques to overcome some limitations found in previous studies.

One of the results shown along this article is the stability or persistence of provincial development gaps throughout the period 2003-2013. Although this period could be considered as *a won decade* due to some good socio-economic results in the national aggregate -for example, GDP growth, reduction of unemployment and poverty, among others-, in terms of spatial inequalities it seems that Argentina has lost an opportunity to reverse its deep regional gaps. Despite the many differences with the IDERP, it is worth noting that its ranking of geographic regions has not changed throughout this decade (DINREP, 2015).

Moreover, cluster analysis reveals the consolidation of provincial inequalities between 2003 and 2013, especially for the worrying cases of the *least developed provinces*. Undoubtedly, this group of provinces must be at the forefront of political priorities to achieve a more equitable regional development. The evolution of their development gaps during this decade has been very limited, with few and reduced improvements and, what is still worse, some setbacks in their already negative gaps. These provinces seem to be immersed in a deep underdevelopment trap. Therefore, they need a comprehensive set of public policies that tackle the negative gaps in each and all development dimensions.

The limitations or problems of the classification in geographic regions are another lesson of this study. Since Argentine official statistics and indexes, like the IDERP, generally use this classification, it could obscure or confuse the real levels of regional development or the composition of each development gap. For example, while all provinces from the NEA region are classified as LDP, according to our typology, this group also includes some northwestern (NOA) provinces. Meanwhile, we classify another part of the NOA region as *underdeveloped provinces*, but they do not show such a critical situation as northeastern (NEA) provinces or the LDP. These geographic heterogeneities are deepened if we take into account that one province from the Cuyo region and another one from the Central region also appear within the UP. In this sense, if policy-makers only focus, as it is common, in Argentina's north area -the NEA and NOA regions-, this could obscure the existence of differences within this big area and also ignore some provinces from other geographic regions that have some similar characteristics and thus require similar policies.

As the typology proposed in this article is based on different provincial development gaps, it can be used as an alternative instrument for the design, evaluation, and prioritization of regional development policies. Obviously, this type of exercise and their results are dependent on data availability, their update over time, the introduction or subtraction of different dimensions, the use of different statistical techniques or regionalization methods, among other aspects which represent interesting research avenues in the future. In this sense, the typology proposed must not be interpreted as a definitive or unquestionable classification. On the contrary, we expect that this article could stimulate the analysis of spatial inequalities in Argentina, as well as the debate about the public policies needed to tackle regional development gaps.

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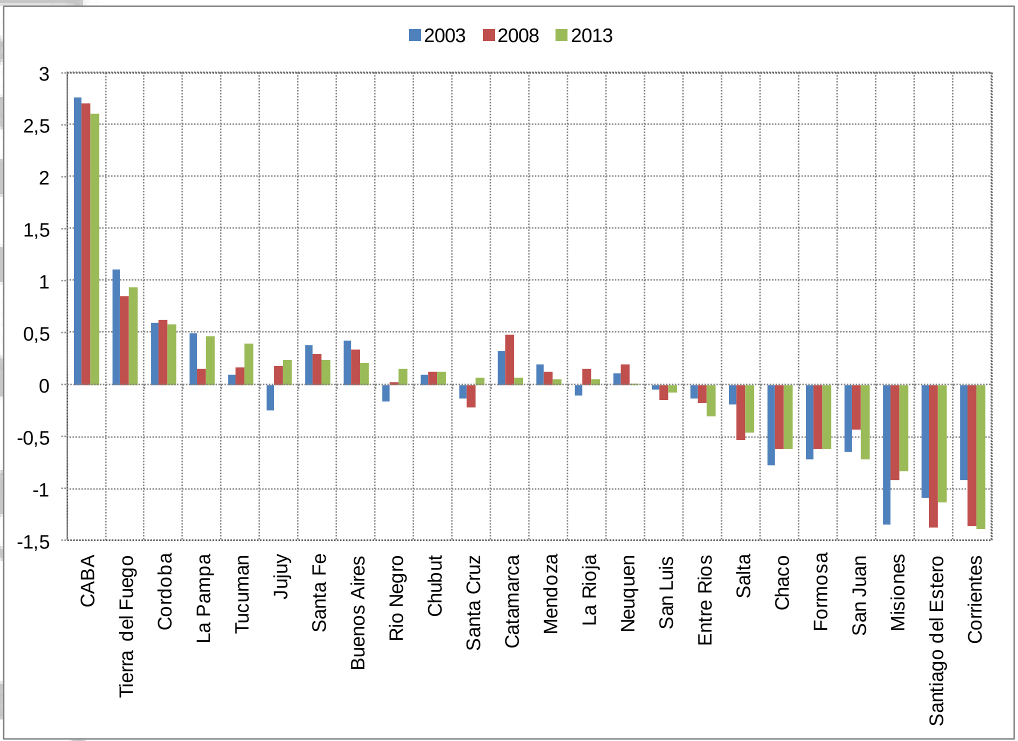
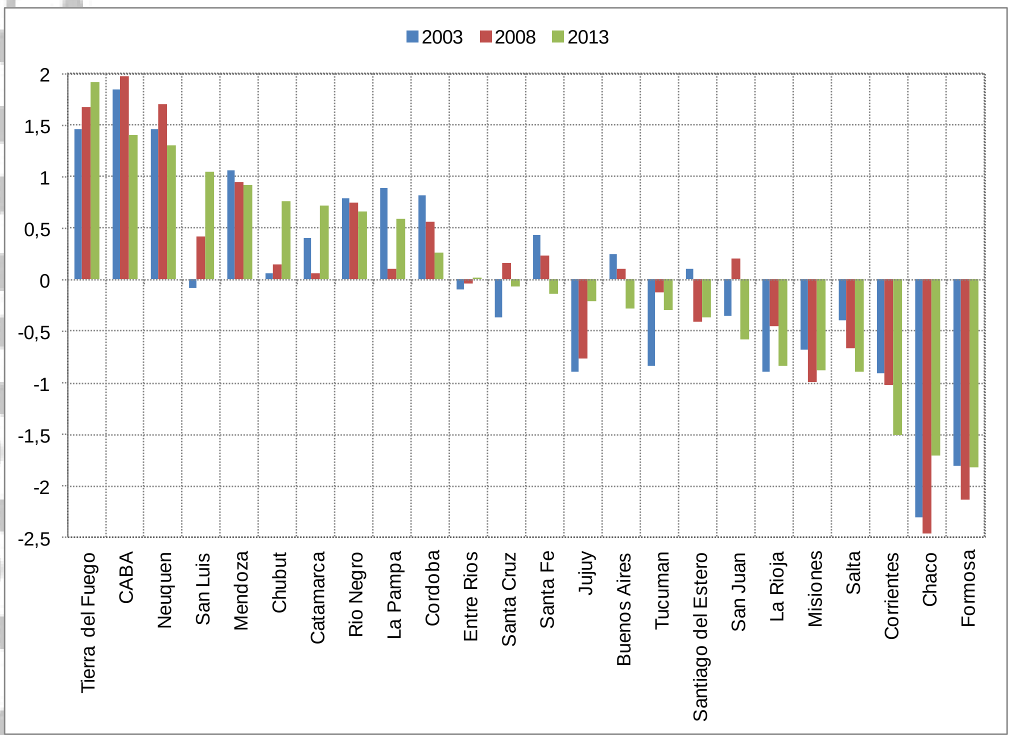
Annex 1. Development gaps by dimension

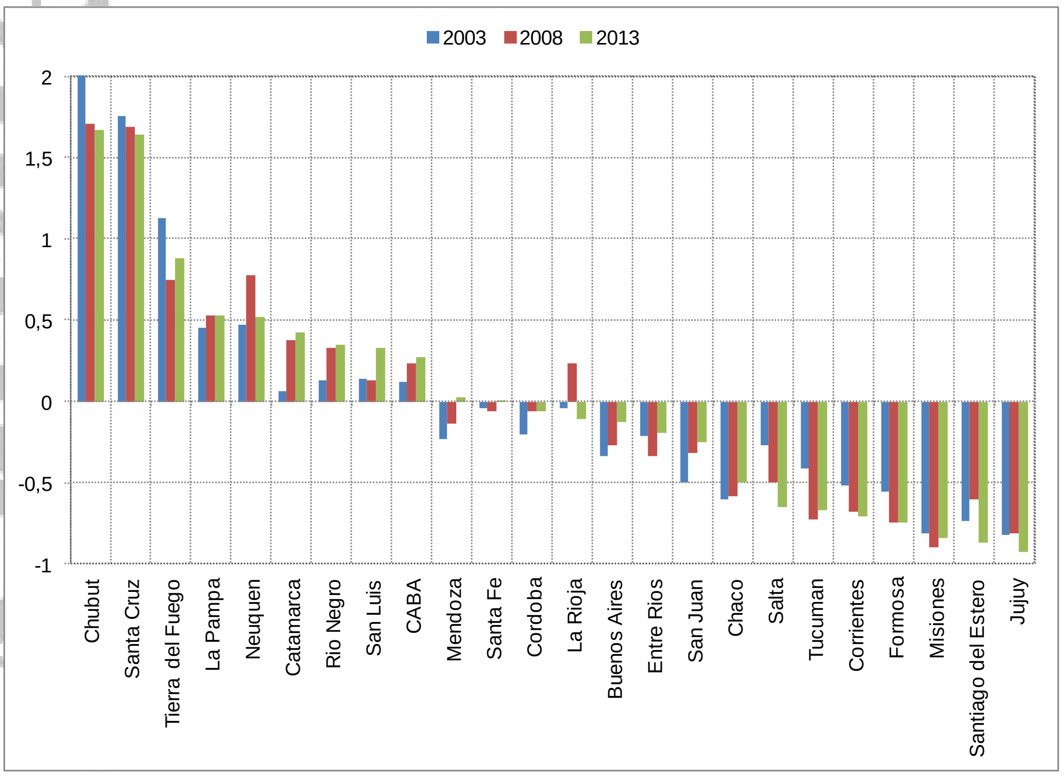
i. Education



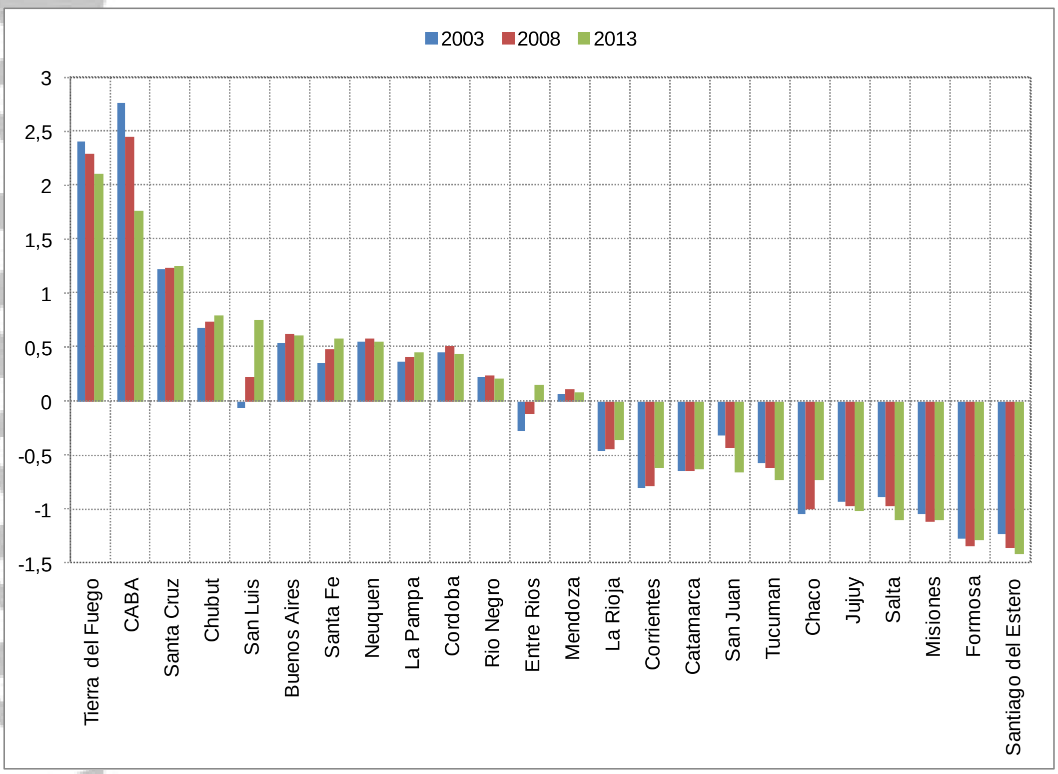
ii. Health



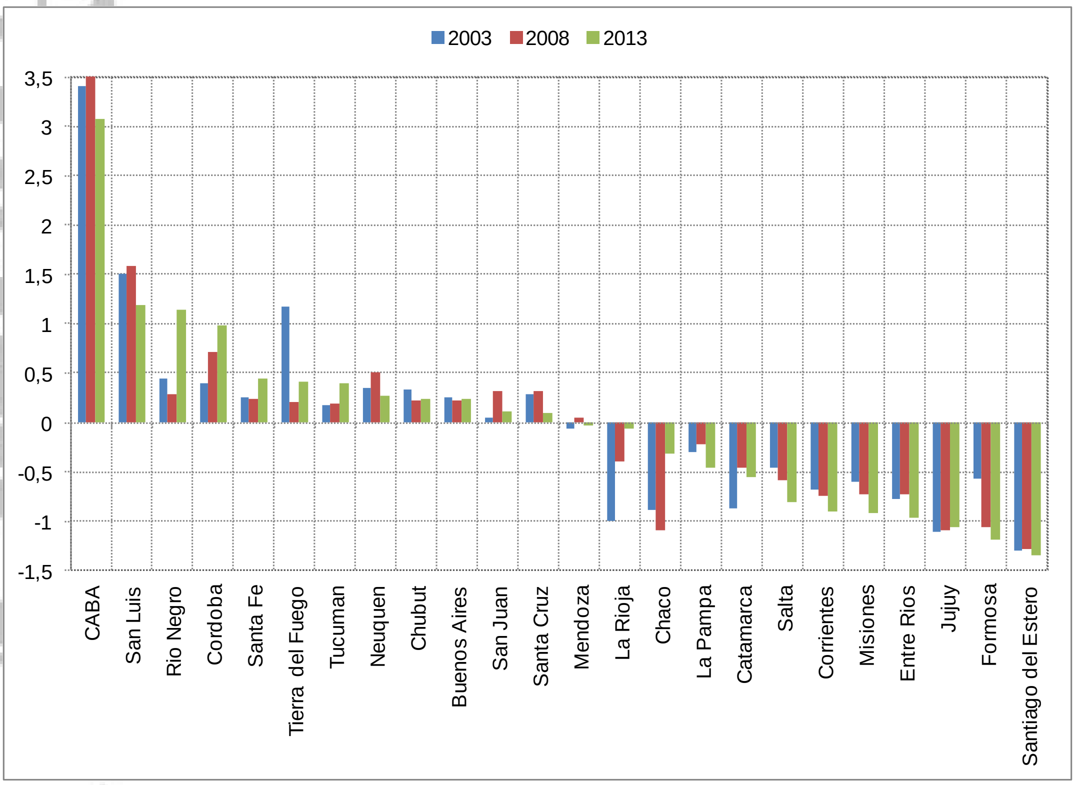
iii. Infrastructure



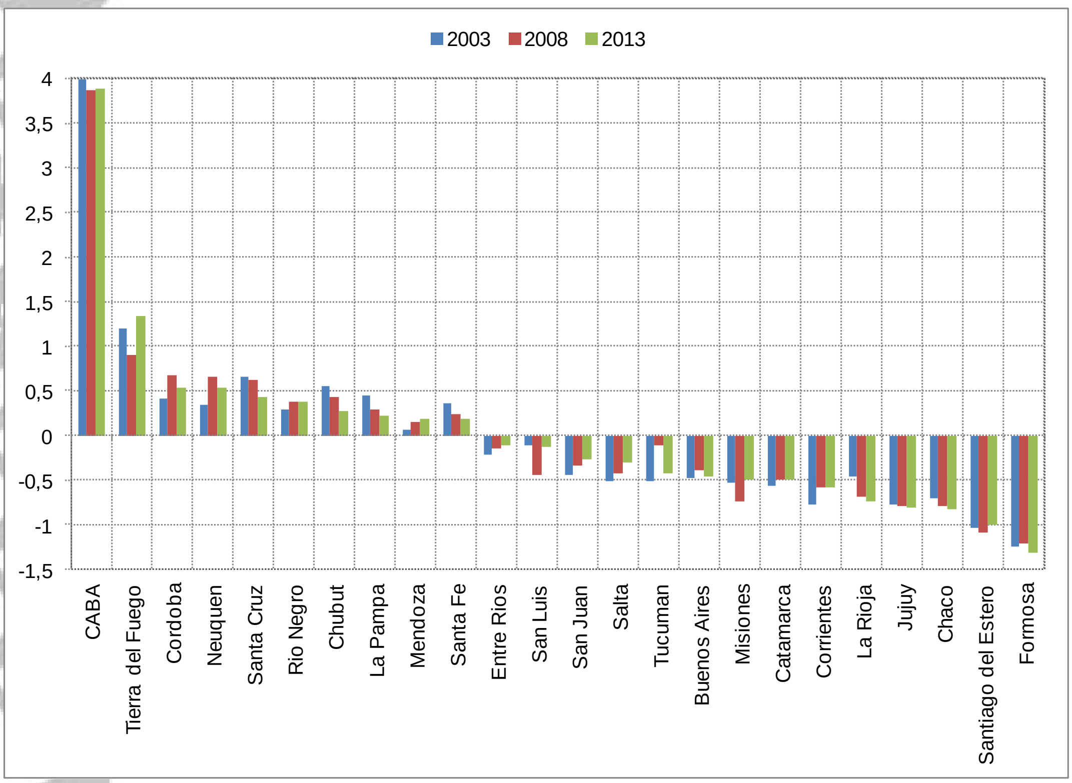
iv. ICT



v. STI



vi. Private and business development



vii. Finantial system