Spatial Distribution of Population by Age in France over the Past 150 years

Florian Bonnet

Spatial Distribution of Population by Age in France over the Past 150 years

Florian Bonnet

Spatial Distribution of Population by Age in France over the Past 150 years

Florian Bonnet*

March 13, 2019

*Ecole Normale Supérieure de Paris-Saclay. 61 Avenue du Président Wilson. 94230 Cachan. Tel: 33147402307. Email: florian.bonnet@ens-cachan.fr

Spatial Distribution of Population by Age in France over the Past 150 years

Abstract

This paper analyzes the spatial distribution of population in the French departments since 1851, using a new demographic dataset presented in Bonnet (2018b). This evolution can be described as the sequence of three phases called “hyper-centralization”, “hyper-centralization thwarted”, “multipolarization”. I analyze this process by disentangling intrinsic growth and migrations and point out some geographical regions which cumulate impairments. Moreover, the age profile of inequalities has changed along the 150 years: today, it has an inverted U-shape and is maximum for young workers. Finally, age structures are more and more differentiated: the spatial specialization according to age has increased since 1950.

JEL Codes: J11, N93, N94, R23.

Keywords: French departments, Distribution of population, Historical demography, Spatial inequalities.

1 Introduction

The question of the location of both economic activities and population is one of the main point of spatial planning public policies for a long time. In France, in the 19th and 20th centuries, the population flows due to the rural exodus were massive. The urban population increased, leading to public health problems due to the easier dissemination of infectious diseases. The rural population decreased too, leading to destruction of real estate capital and difficulties in ensuring the survival of public services. Today, these population flows continue, but their nature has partially changed. The population living in Paris is gradually decreasing, unlike the population of both the suburbs and major regional cities. In the countryside, retirees are coming in specific regions, while population is still decreasing in others since the youngers adults leave.

Despite the importance of this issue, the spatial distribution of population has been little studied in an historical perspective. However, hysteresis effects can explain today's territorial evolutions. This absence is partly explained by the scarcity of data. Combes et al. (2011) explored the case of French metropolitan departments for five years (1860, 1896, 1930, 1982, 2000). Ayuda et al. (2010) explored the question for 9 European countries including France at two dates (1850 and 2000). Other papers have studied this issue only in the recent period (see in particular Breton et al., 2017). Talandier et al. (2016) propose a cartographic analysis since 1806 within the framework of French cities for the total population since 1806 (see Le Mée, 1989, for a presentation of the raw data used), but do not use a readable quantitative analysis by indicators.

The contribution of this paper is threefold. First, I get population of French departments since 1851 using a new database (Bonnet, 2018b) as well as old census. Consequently, I can analyze the evolution of the population spatial distribution for more than 150 years. This issue is particularly relevant in France since the "yellow vests" movement appeared in Novembre 2018; one potential mechanism explaining this movement may be the depopulation and abandonment of rural territories. This paper participates to the literature on "Shrinking Regions (Oswalt and Reniets, 2006; Bontje et al., 2012; Fol, 2012; Galjaard et al., 2012).

Second, I get populations by age; I can conduct the same analysis for the youngest and the oldest, and see who are the most unevenly distributed on the French territory. Moreover, I can analyze the age structures of the territories and see how they have evolved too. As far as I know, this issue has never been treated in the literature, but deserves further consideration. Indeed, if age structures are increasingly differentiated, territories are increasingly interdependent too: the French social system results in significant transfers of income, from the workers to the youngest and the oldest. Here, we meet the distinction between productive and residential economies (Blanc, 2007; Davezies, 2008; Beyers and Nelson 2008). Furthermore, ressources for local budgets are strongly constrained by age structure, since the income age-profile is not flat. As a result, if age structures are increasingly differentiated, decentralization must be conducted with the utmost caution.

The third contribution is methodogical. I propose an analysis that goes beyond the monitoring of indicators such as standard deviation, Gini or Theil used by Combes et al. (2011) and Ayuda et al. (2010) to analyze the spatial distribution of population. These indicators may hide evolutions in specific parts of the departmental distribution. For example, the Gini index may decrease while the share of the less populated departments decreases. This occurs if this phenomenon is more than offset by a population transfer from the most populated departments to the "a-little-less" populated departments.

This paper brings a number of new results. First, I show that the population is more and more unevenly spread. In broad outline, this process can be described with three phases. For example, the increase of inequalities from 1851 to 1901 is the result of the concentration of population in the most densely populated territories to the detriment of all others. Indicators also show that the increase in inequality from 1968 onwards hides a drop in the share of the most densely populated departments. Second, I reveal that departments which cumulated imbalances according to both intrinsic growth and migratory movement changed between the first and the second half of the 20th century. They were mainly in the central and western parts of the country between 1901 and 1968, while they were in the North-East and the south of Massif Central between 1968 and 2014. Third, the analysis of the spatial distribution of population according to age shows an inverted U-shaped profile today: the "20–39" age group is the most unevenly distributed. This profile has changed over time: in the second half of the 19th century, the elderly were the most unevenly distributed. Forth, departmental age structures are increasingly differentiated since the end of the Second World War. This process is mainly explained by an overrepresentation of young adults in urban departments, while retirees are overrepresented in South-West rural departments.

The rest of the paper is organized as follows. Section 2 presents the data as well as the methods used. Section 3 presents the results. Section 4 concludes.

2 Data and Method

I analyze the dynamics of the spatial distribution of the French population since 1851. The indicator most commonly used in the litterature (Ayuda et al., 2010) is the population density, defined as the ratio of the population to the total of km^2: it eliminates the differences of department sizes. In this article, I use population densities at the departmental level. I do not analyze inequalities of densities within *départements* but focus on inequalities between *départements*. So population densities show the number of persons on an average km^2 in a given *département*. In a first stage, I present the density differences for the total population. However, my analysis goes further than most of the current works: I analyze in a second stage inequalities for each major age group.

2.1 Data Sources

For the period 1901–2014, populations by age come from Bonnet (2018b)'s database and are exploited for the first time. This companion paper explains in detail the methodology used. It relies mainly on the protocol of the Human Mortality Database developed by Wilmoth et al. (2007). The raw data used consist of censuses, vital statistics as well as military deaths and deportees during the two World Wars. In this paper, I use deaths and populations by age as well as births, for each department and year.

For the period 1851–1900, populations by age group are available every 5 years, by quinquennial age group, sex and department. They were collected on the INSEE website, on February 5th, 2018. As revealed by Bonneuil (1997), these data are not as reliable as the 1901–2014 ones, because of the quality of censuses in the 19th century. Most of the biases come from respondents' poor specification of age (attractiveness for round ages), lack of internal consistency in tabulations and bad transcription of the data in tabulations. The impact of these biases is limited because the study focuses on populations by broad age group. In order to get populations on January 1st of each year, I assume that the population at the date of the censuses is equal to the population on January 1st of the census year, and interpolate linearly populations by age group during intercensal periods.

2.2 Geographical scope

This article examines inequalities population densities between French metropolitan departments. The overseas departments have not been included because their demographic statistics are much more recent and cannot be extrapolated backwards. Consequently, I use the term "national" to describe the situation in metropolitan France.

The number and boundaries of the French departments have generally varied little since they were created in 1790. What few modifications there have been are due to changes in France's eastern border and a recent reorganization of the Paris region. In order to have a consistent comparison over time, I have applied the classification of 90 departments valid in 1967 (see map in Appendix A1). This required reconstituting the populations by age for some departments that were absent in certain census years.

Three main territorial modifications took place during the period 1851–1900. Firstly, *Savoie, Haute-Savoie* and *Alpes-Maritimes* were created in 1860. Second, *Territoire de Belfort* and *Meurthe-et-Moselle* were created in 1871 after the war against Prussia and remained under French administration. Third, *Moselle, Bas-Rhin* and *Haut-Rhin* were created at the same date and passed under German administration. In order to re-estimate the missing populations by age, I used an adjacent department, called a reference department. The population by age of the reference departments were used to re-estimate those of the missing departments. The fit between the population of each pair of departments was analyzed for the closest year for which the data are available. Then specific ratios were calculated and applied to the populations of the reference department for the missing years.

According to the period 1901–1968, I use the same method with Bonnet (2018)'s database in order to estimate yearly deaths, births and population by age of *Bas-Rhin, Haut-Rhin* and *Moselle* up to 1920. Finally, as a result of their large populations, the two departments of the Paris region (*Seine* and *Seine-et-Oise*) were divided into seven in 1968. Statistics in the new departments were allocated to the old departments in the proportions observed in 1968, the year for which both sets of data are available. This ensures consistency in the data since the totals do not change.

Appendix A2 recap these departmental issues and the reference departments used.

2.3 Indicators of Inequality

There are a large number of indicators to capture inequalities. These indicators can also be used to analyze the spatial distribution of the population. Mackenbach and Kunst (1997) in the field of health studies, or Cowell (2011) more generally, show that each indicator provides different informations. Indicators based on extreme points or an interquantile range differ from indicators that use the entire distribution such as the Gini coefficient. Dissimilarity indices show how much would need to be redistributed among groups for densities to be the same for all. Moreover, inequalities can be analyzed in absolute or relative terms: a density difference of 10 inhabitants per km^2 represents 20% of the average density when the mean is equal to 50, but only 10% for a value of 100.

In this article, two types of indicators are used. One simple indicator is the Gini coefficient. Other series of indicators are used : these indicators target specific sections of the department densities distribution. By aggregating all the department densities, weighted by the number of km^2, I can calculate the share of population living in the more or the less densely populated. I split the distribution in six parts in order to obtain the share of the 10% most densely populated km^2 (namely P90–100), but also the shares of all other deciles of km^2 ranked by density and grouped by pair.

To study the differences of departmental age structures, I use the Kullback-Leibler Divergence (Kullback and Leibler, 1951), based on Shannon's entropy (1948). I am in line with d'Albis et al. (2014) who analyzed the international dissimilarities of age-specific mortality rates. KLD between two distributions of population according to age, namely P and Q, is calculated as follows:

$$\text{KLD} = \sum_{a=0}^{\Omega} \log\left(\frac{P(a)}{Q(a)}\right) P(a), \tag{1}$$

with a the age and Ω the maximum age. To get an index summarizing departmental dissimilarities, I calculate the national KLD (KLD_{Nat}):

$$\text{KLD}_{\text{Nat}} = \sum_{i=1}^{N} \sum_{a=0}^{\Omega} \log\left(\frac{P_i(a)}{P_{Nat}(a)}\right) P_i(a), \tag{2}$$

with i the department and N the total of departments.

KLD_{Nat} is an aggregate indicator for all distributions. I also calculate distortion indices (ID) which highlight the departmental distortions according to age structure. Thus:

$$\text{ID}_i(a) = \frac{\frac{P_i(a)}{P_i}}{\frac{P_{Nat}(a)}{P_{Nat}}}. \tag{3}$$

3 Results

3.1 Evolutions of Departmental Densities of Population

I start with the evolution of the French population by sex between 1851 and 2014 (Table 1). Between 1851 and 1946, the population increased only by 10% for both sexes (Line 3) and by 5% for men (Line 2). Two causes can explain this evolution. Due to a very early demographic transition, the birth rate in France in the beginning of the 20th century already reached low levels compared to its European neighbors. Coale (2017, p.38) showed that the fertility index dropped sharply since 1820 while this phenomenon appeared rather around 1900 in other developed countries (1890 in Germany, 1913 in Italy). In addition, the mortality increased dramatically during the war against Prussia and the two World Wars. These wars impacted strongly the sex ratio: in 1946, the male population is 10% lower than the female population while this difference was only 1 % in 1851 (Line 4). The period 1946–2014 is radically different. In 70 years, the population increased by 60%. This is due to three causes. First, the baby boom of the post-war years created much larger cohorts than cohorts born before 1946: according to Bonnet (2018b)'s database, the crude birth rate increased from 66 to 90 births per thousand of women between 1936 and 1946. Second, the sharp rise in life expectancy during the second half of the 20th century allows older people to live longer, which increases the population: according to Bonnet (2018b)'s database, female life expectancy at birth increased from 65 years in 1946 to 85 years in 2014. Finally, international migrations contribute to increase the population.

Table 1: French population and distribution of department densities, 1851–2013

		1851	1872	1901	1921	1946	1975	1999	2013
Population (in thousands)	Men	18,112	18,727	19,750	18,455	18,906	25,726	28,443	30,847
	Women	18,295	18,894	20,338	20,405	21,014	26,840	30,171	32,852
	Total	36,407	37,621	40,088	38,860	39,920	52,566	58,614	63,699
	Sex-ratio	99,0%	99,1%	97,1%	90,4%	90,0%	95,8%	94,3%	93,9%
Densities of population	Min	22	20	17	13	12	15	14	15
	25%	49	49	47	42	41	45	48	48
	Median	63	60	58	53	53	67	71	75
	75%	76	73	75	71	73	104	130	140
	Max	2,963	4,625	7,486	9,033	9,579	13,374	14,358	15,655
	National	67	69	74	71	73	97	108	117

Notes: Sample includes 90 departments. Computations of densities based on the total population. 25% means that 25% of *departements* have a density below this level.

Next I analyze the evolution of population density at national and departmental levels. The national density of population in 1851 and 2013 was 67 and 117 inhabitants by km^2, respectively. This global increase hides local specificities. Density was multiplied by more than a factor 5 in the most densely populated department (namely, *Seine*), while it decreased by 30% in the less densely populated department (*Basses-Alpes* in 1851, *Lozère* in 2013). These variations are mainly due to the rural exodus, already highlighted by Ariès (1948). These evolutions have not been similar for all departments during these 150 years. The maximum density increased continuously between 1851 and 2013, but this is not the case for the others, whose density followed a U-shaped curve: it decreased from 1851 to 1946, then increased from 1946 onwards.

To better understand the changes of these departmental densities, Appendix A3 maps the population densities in 1851 and 2014. Northern France was in 1851 more densely populated: the Channel coasts, the German borders as well as Paris and *Lyon* regions had a density of more than 80 inhabitants per km^2. These densities were less than 20 inhabitants per km^2 in the Alpine departments, *Lozère* and *Landes*. Overall, this finding continues today. One can add the Atlantic and Mediterranean coasts as well as the Swiss border in the densely populated regions. The difference between the two maps is mainly in relation to the relative positions: the second revealed a broad band sparsely populated from *Meuse* in the North-East to *Aveyron* in the South-West. This band is called the "empty diagonal" in Oliveau and Doigneau (2016). In 1851, it was not so marked.

Appendix A3 maps the variations of density between 1851–1946 and 1946–2014 too. The previous statements are confirmed. Between 1851 and 1946, the small increase in density was due to the North of France, Paris and *Lyon* regions and the Mediterranean coast, in which densities have increased by more than 30%. Elsewhere, the population fell or stagnated. The largest decreases are recorded in the Alps or in the North-East. From 1946 to 2014, population densities fell in a large region around the *Massif Central*, while it increased sharply in a large South-East and in the departments which host large metropolises (*Haute-Garonne* for *Toulouse*, *Loire-Atlantique* for *Nante*s etc.).

3.2 The Three Phases in the Evolution of Spatial Distribution of Population

In the remaining of the paper, I analyze the evolution of the spatial distribution of the women. This choice is explained by two main reasons. Thanks to Bonneuil (1997)'s work, I get female lifetables for the 1851–1900 period. Moreover, France experienced three major wars during this period, and men were more widely affected than women by their consequences: forced migration and excess mortality make long-term developments less readable.

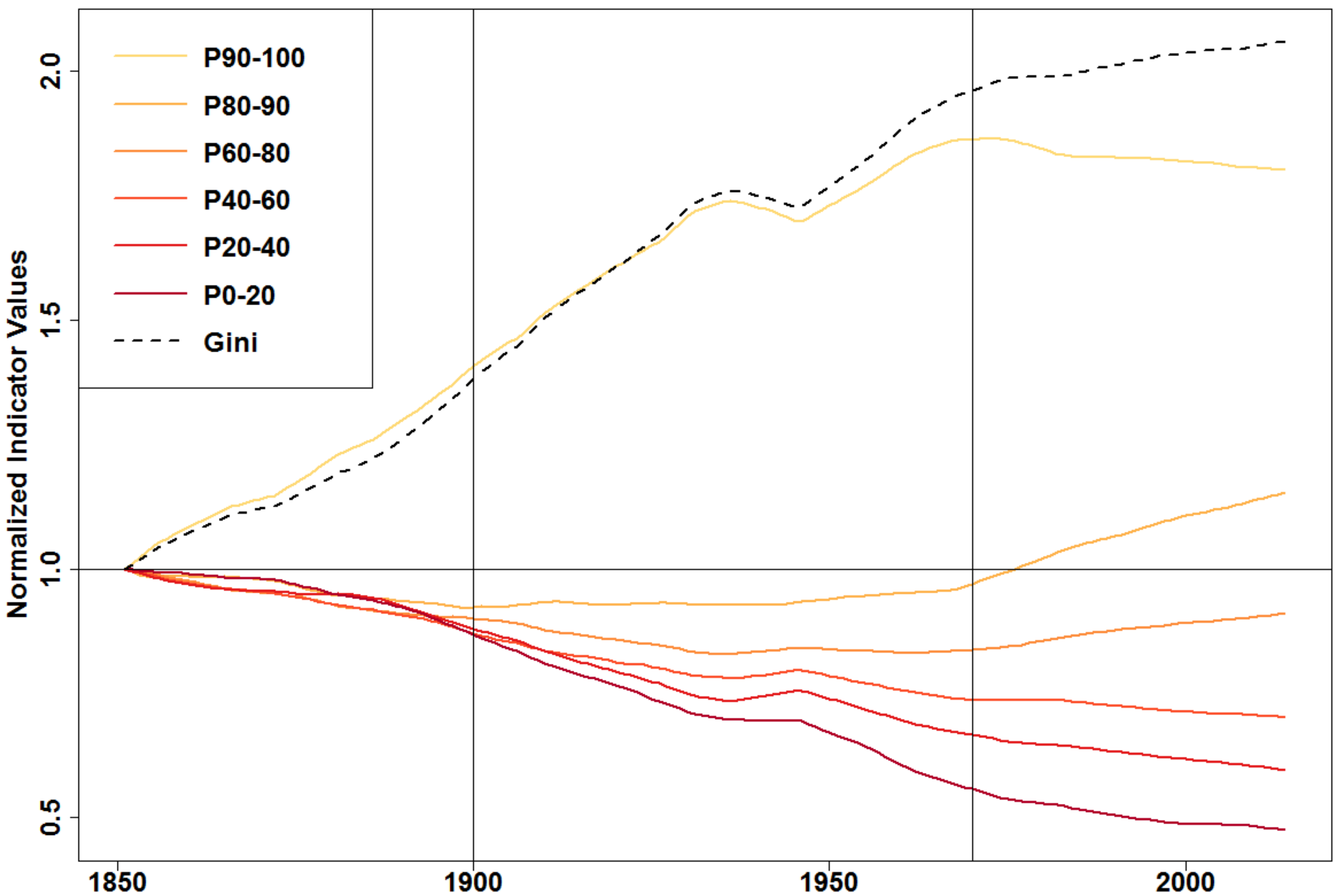
First the spatial inequality indicators are analyzed. Figure 1 presents the evolution of these indicators since 1851. There was a sharp increase in inequality of population densities: the Gini index has more than doubled over the period, from 0.232 in 1851 to 0.478 in 2014. While Combes et al. (2011) found a stagnation of the Theil index between 1982 and 2000, the Gini index was still increasing along this period. This can be explained in two ways. Combes et al. (2011) did not weight departments by their area, and the Gini and Theil indices do not weight equally each part of the distribution. Furthermore, my indicators highlight three phases in the increase of inequalities, which were hidden in Combes et al. (2011)'s analysis.

I name the period 1851–1900 "hyper-centralization" since the 10% most densely populated km^2 expanded to the detriment of all the others. Its share in the total population increased from 21.5% to 30.2%. Inside this decile, one can analyze *Seine*'s share: this department – which includes Paris and its surrondings – has an area about 0.01% of the national one. Its share doubled (9.1% in 1900) while the one of the remaining decile increased by only 20%. In contrast, the share of all other territories declined. These dynamics highlight the rural exodus, whose beginning dated back to the 18th century (Ariès, 1948). The spatial distribution of the French population can no longer be explained by "first-nature" advantages as in pre-industrial societies, as shown by Beeson et al. (2001) and Michaels et al. (2012) in the case of the US. At that date, agglomeration effects became the main force explaining the changes at work. Thereby, the development of railway during the second half of the 19th century could have favored this process for two reasons. First, the train facilitated migrations of rural people to cities and therefore spatial concentration. Mojica and Marti-Hennberg (2011) revealed that in 1880, 90% of agglomerations were connected to the railways. Second, lower transport costs at the national level led to the importation of cheaper US wheats (Fletcher, 1961; Schwartz et al., 2011). Consequently, the French agricultural sector was plunged into crises between 1870 and 1900. Figure 1 shows that the share of the least densely populated km^2 strongly decreased from 1870 too: P0-20 decreased by only 2% between 1850 and 1870, compared to 11% between 1870 and 1900.

Between 1900 and 1968, the 10% most densely populated km^2 were still concentrating the population: its share in the total population went from 30.2% to 40%. Unlike the previous period, this hyper-centralization was no longer at the expense of all other territories: the share of the second decile, which comprise second-tier cities, increased as quickly as the national population. On the other hand, the share of the less populated departments were still declining. Since 1851, this decrease fell between –20% and –50% according to the deciles. While the rural exodus affected all territories except the most densely populated between 1851 and 1900, the decline was over in fairly densely populated departments. Consequently, I call this second phase "hyper-centralization thwarted". An interesting issue concerns the World War Two, which was a temporary break in the hyper-centralization process. Bonnet (2018a) showed that internal migrations during this conflict were strong, especially from the North of the country (occupied by the Germans) to the South (in the free zone until 1942). The scars left by the conflict were deep: the refugees who fled densely populated regions did not fully come back.

Finally, I name the period 1968–2014 "multipolarization". This can be explained by two reasons. First, the share of the first decile in the total population decreased from 40% to 38.8%. The decline is a little more sharp for *Seine*. While the share of this department in the total population had increased three-fold in a little more than 100 years, the cumulative process stopped for the capital and its suburbs. The second-nature advantage (Krugman, 1993) was no longer enough to attract the national population. This is probably due to congestion costs in the Paris region, in line with the results of Puga (1999), Graham (2007) or Combes et al. (2012). Second, the share of the second to fourth deciles increased quite strongly. The share of the population living in the second decile went up from 12.3% in 1968 to 14.8% in 2014. The share of lower deciles continued to decrease, even if the pace was less sustained. Overall, the rise in global inequalities hides a decrease in the share of the most densely populated departments (pushing down inequalities), and a decrease in the share of the least densely populated departments (pushing up inequalities). One had to note that the multipolarization presented here is geographical and not statistical: departments belonging to the second, third and fourth deciles (for example *Haute-Garonne, Loire-Inférieure, Gironde*) are scattered throughout the landscape and contain the second-tier cities such as *Toulouse, Nantes, Bordeaux*. At that date, “Paris and the French desert” (Gravier, 1947), gradually loses its importance: the policy pursued by DATAR since the 1960s succeeded. It allowed the displacement of the most mobile jobs towards regions where mass unemployment threatened at the end of the “30 glorious”.

Figure 1: SPATIAL INEQUALITIES OF POPULATION DENSITY, 1851–2014



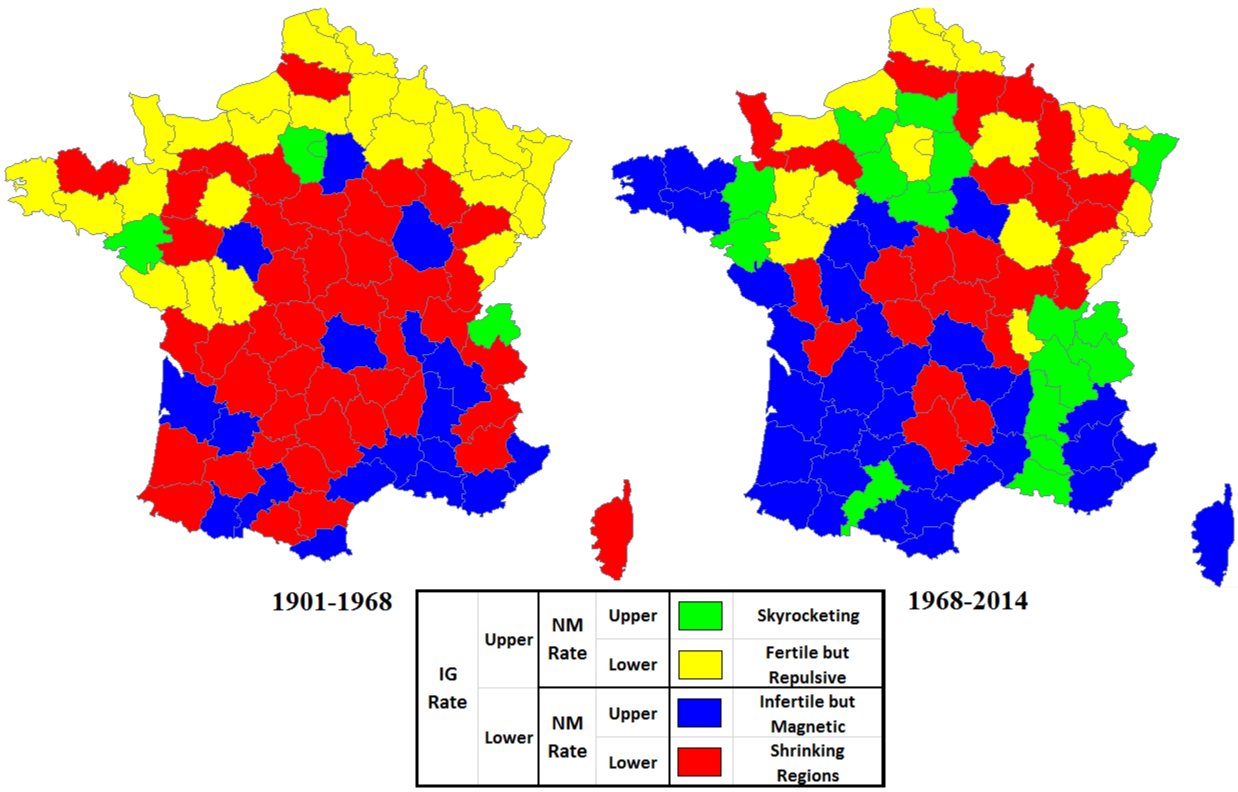
Notes: Computations based on the population of women. P90-100 refers to the share of national population who lived in the 10% of km^2 with the highest density values. All inequality indicators are weighted by km^2 and normalized by 1851 values. Sample includes 90 departments.

The share of the less densely populated departments declined since 1851. This evolution is explained by a population growth rate below the national average and can come from two factors. The first is intrinsic growth rate, the second net migration rate. Departments can be classified in four categories. "Shrinking departments" are those with both rates below the national average. "Skyrocketing" departments are those with both rates above the national average. "Infertile-magnetic" departments are those with net migration rate upper the national average and intrinsic growth rate below. "Fertile-Repulsive" are the opposite. Data from the period 1851–1900 do not allow for this classification since they do not include the total births and deaths of each department. I used Bonnet (2018b)'s database to perform this classification. Figure 2 presents the classification for periods 1901–1968 and 1968–2014. These two phases correspond to what I have called "hyper-centralization thwarted" and "multipolarization".

Concerning period 1901–1968, Figure 2 reveals a deep difference between the North and the South according to the intrinsic growth. In the North the growth rate of population due to the intrinsic growth is higher than the national average. This region was named *"croissant fertile"* (Francart, 1983) and was visible since World War Two. This phenomenon compensated a net migration rate lower than the national average: these regions were not attractive for migrations, whether internal or coming from abroad. In the South, departments along the Mediterranean coast, the Rhone Valley and those which host major cities compensated this impairment by a strong attractiveness: net migration rates are higher than the national average. For others, their shares fell because of a weak intrinsic growth and a lack of attractiveness on the migratory side.

The situation changed during the period 1968–2014. The first striking result concerns *Seine* and *Seine-et-Oise* and feeds the conclusions already stated above. Migration rates fell below the national ones, which explains the decline in the share of the first decile. This statement is supported by the fact that the neighboring departments became "Skyrocketing" ones: they draw a green belt around *Seine* and *Seine-et-Oise*. These departments, more efficiently linked by transport to the capital, became attractive for migrations. I name it the "wide belt of attractiveness". This belt cannot be seen in the litterature since researchers have studied migration flows at the regional level (Baccaïni, 2001; Baccaïni and Lévy, 2009; Baccaïni and Dutreuilh (2007)). The second stiking result concerns the North-South gradient according to intrinsic growth, which globally disappears. Intrisinc growth rate became stronger than the national average in the South-East. The opposite occurred in *Bretagne* and in departments like *Meuse* and *Ardennes*. The North-West and the North-East differed on the migratory side: the former was attractive, which was not the case of the latter. These results support the idea that *Aisne*, *Ardennes*, *Meuse* or *Somme* constitute a "shrinking region" in the sense of Oswalt and Rieniets (1984). This region, which enjoyed a first-nature advantage with mines and steel plants, is still facing difficulties in converting its productive capital. Finally, the South-West became attractive for migratory flows: *Dordogne* is an example of departments that switched from "Shrinking Regions" to "Infertile-but-Magnetic" class. Baccaïni and Dutreuilh (2007) noted this attraction for the South-West from the 1960s, which contributed to the spatial redistribution of the population. Nevertheless, one can see on Figure 2 that some departments remained on the margins of this process (south of *Massif Central*, *and Deux-Sèvres/Charente,* too far from the amenities of Atlantic coast).

Figure 2: CLASSIFICATION OF FRENCH DEPARTMENTS, 1901–1968 AND 1968–2014



Notes: Computations based on the population of women. "NM" means "Net Migration". "IG" means "Intrinsic Growth". "Upper" means "upper the national value". Sample includes 90 departments. All the maps were made with the software Philcarto (http://philcarto.free.fr/).

3.3 The Uneven Spatial Distribution of Population According to Age

With Bonnet (2018)'s database, I can analyze differentiated trends in the spatial distribution of the population by age group. The data did not allow so far to perform this analysis. Overall, I find that the trends of population aged 0 to 19, 40 to 49 and 50 to 64 are the same as the global trends. On the other hand, they are significantly different for population aged 20-29, 30-39, 65-79, and 80 and over. Appendix A4 reveals inequality indicators for women aged 30 to 39 and 65 to 79.

According to women aged 30 to 39, the main difference with national trends comes from the period 1990–2014: the share of the first decile increased while the share of the third and fourth deciles stagnated. The evolution of the first decile was almost completely due to the increase of *Seine*'s share. Consequently, France is facing a new phase of "hyper-centralization thwarted" concerning this age group. It gathers individuals at the heart of their working lives, usually with high salaries and stable work situations. This result supports Combes et al. (2011), which shows that the spatial distribution of tertiary value-added followed an inverted U-shape from 1860 to 1982 and increased from 1982 to 2000. The end of the aggressive spatial planning policy counducted during the 1960s could explain this process. Following works on endogenous growth, economists and politicians were aware of how strong regions have to be supported first, in order to redistribute income to poorer geographic areas in a second time (Jayet et al, 2006; Davezies, 2008).

For the older ones, changes are different. Overall, the Gini index increased only by 60% over the period 1851–2014, compared to 110% for the whole population. From 1851 to 1910, this index remained stable, hiding contrary evolutions: both the share of the first decile and the share of the less densely populated departments expand to the detriment of the second to fourth deciles. Thus, there was a deconcentration of the elderly population in France from 1851 to 1900, unique in my statistics of population by age. Between 1900 and 1968, the hyper-centralization thwarted was at work: the share of the 80% least densely populated km^2 fell, while the share of the first decile increased and that of the second stagnated. Finally, between 1968 and 2014, the multipolarization appeared: the share of the most densely populated territories decreased, while the one of the departments of the second to fourth deciles increased.

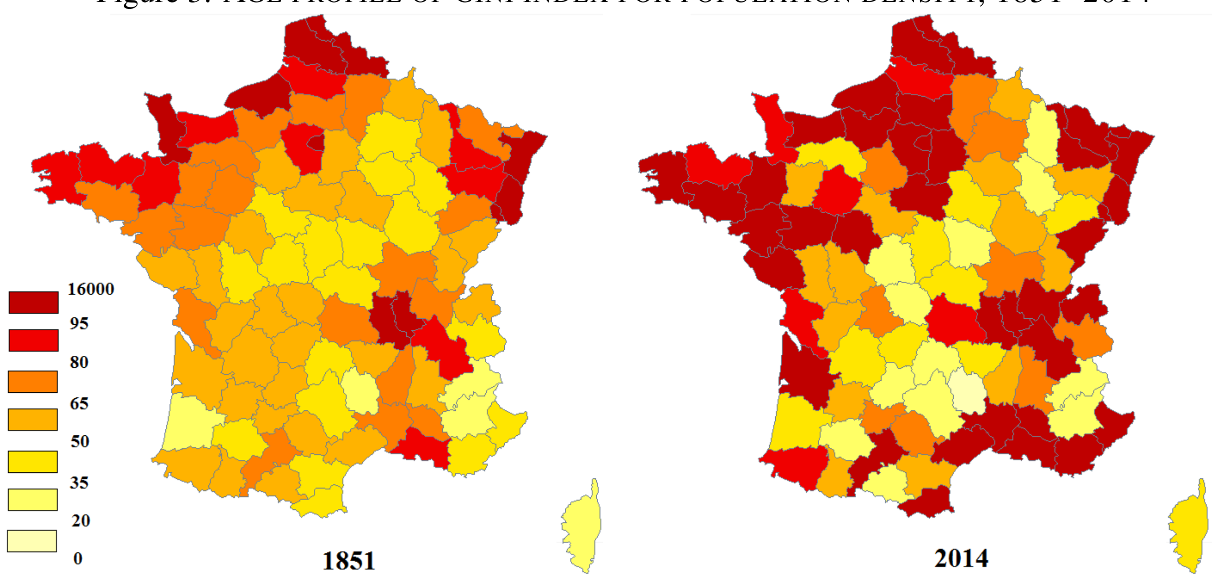
Beyond the evolution of the spatial distribution of population by age, one want to know which are the most unevenly distributed populations, and whether these relative positions have evolved over time. Figure 3 presents the age profile of the Gini index at several dates along the 150 years of this study.

With regard to the age profile, Figure 3 reveals that the population density inequalities in 1851 were similar for all age groups between 0 and 64-year-olds, with a Gini value of about 0.25. Beyond these ages, the values were growing. In other words, population aged 65 and over were much more unequally spread than the others. This specificity of the oldest ages gradually disappeared during the end of the 19th century: inequalities observed for this age group became the weakest from 1901 onwards. Conversely, at this date, the flat profile between age 0 to 64 disappeared too. The profile reveals an inverted U-shape, more and more pronounced over time, where the most uneven age group is 20–29.

For the period 1851–1900, this profile can be explained as follows. Spatial inequalities of population density were the same from 0 to 64-year-olds since the working age groups remained in the territory where they were born. The strong inequalities concerning women aged 65 and over did not come from a choice of location but from spatial differences in mortality: there were fewer elderly people where their mortality rates were very high. This is the case for example in *Bretagne* and in the Alps, where life expectancy at birth was around 25 years between 1861 and 1865 according to Bonneuil (1997). Conversely, they were overrepresented in a broad band linking *Normandie* and *Meuse*, where life expectancy at birth was about 52 years. This phenomenon progressively disappeared: spatial mortality inequalities decreased strongly from 1881 according to Bonnet and d'Albis (2018). They name this phenomenon "Centennial Convergence". Overall, there was no rural counter-exodus: for these reasons, I name that differentiated spatial concentration of elderly people "undergone concentration".

The inverted U-shaped profile that appeared in 1901 is different. From this date, the rural exodus was powerful: the 20 to 39-year-olds moved to the most densely populated areas – Paris and then second-tier cities – to find a job and left rural departments. On the opposite of the "undergone concentration", this inverted U-shape profile results from a chosen location. Concerning the elderly, their location choices were less constrained: their income stream is not conditioned by their location today, as it is the case for the youngers. They can settle everywhere, and especially in departments less densely populated, with attractive amenities. This age profile is accentuated nowadays due to a sharp rise in inequality among 20 to 29-year-olds. As such, the 10% most densely populated km^2 host 43% of women aged 20 to 29. For those aged 65 and over, this figure is only 32%.

Figure 3: AGE PROFILE OF GINI INDEX FOR POPULATION DENSITY, 1851–2014



Notes: Computations based on the population of women. "30–39" refers to age 30 to 39. Sample includes 90 departments.

By comparing Figure 1 and 3, one can see that the dynamics of density inequalities according to age followed both a common and a specific process.The population of the elderly is more unequally distributed in 2013, like all the other age groups, but the evolution was different than the evolution of the youngest. These differences can be explained by changes in age structures: if they remained the same, then the evolution of spatial inequalities would be the same for all age groups. In Appendix A5, I propose a method to disentangle the effect of the background process induced by the evolution of total population densities and the age-specific process explained by the evolution of population age structures. It reveals that the shares of the women aged 20 to 29 in the departmental populations are more and more differentiated, contrary to the shares of women aged 65 and over.

3.4 Differences in Departmental Age Structures

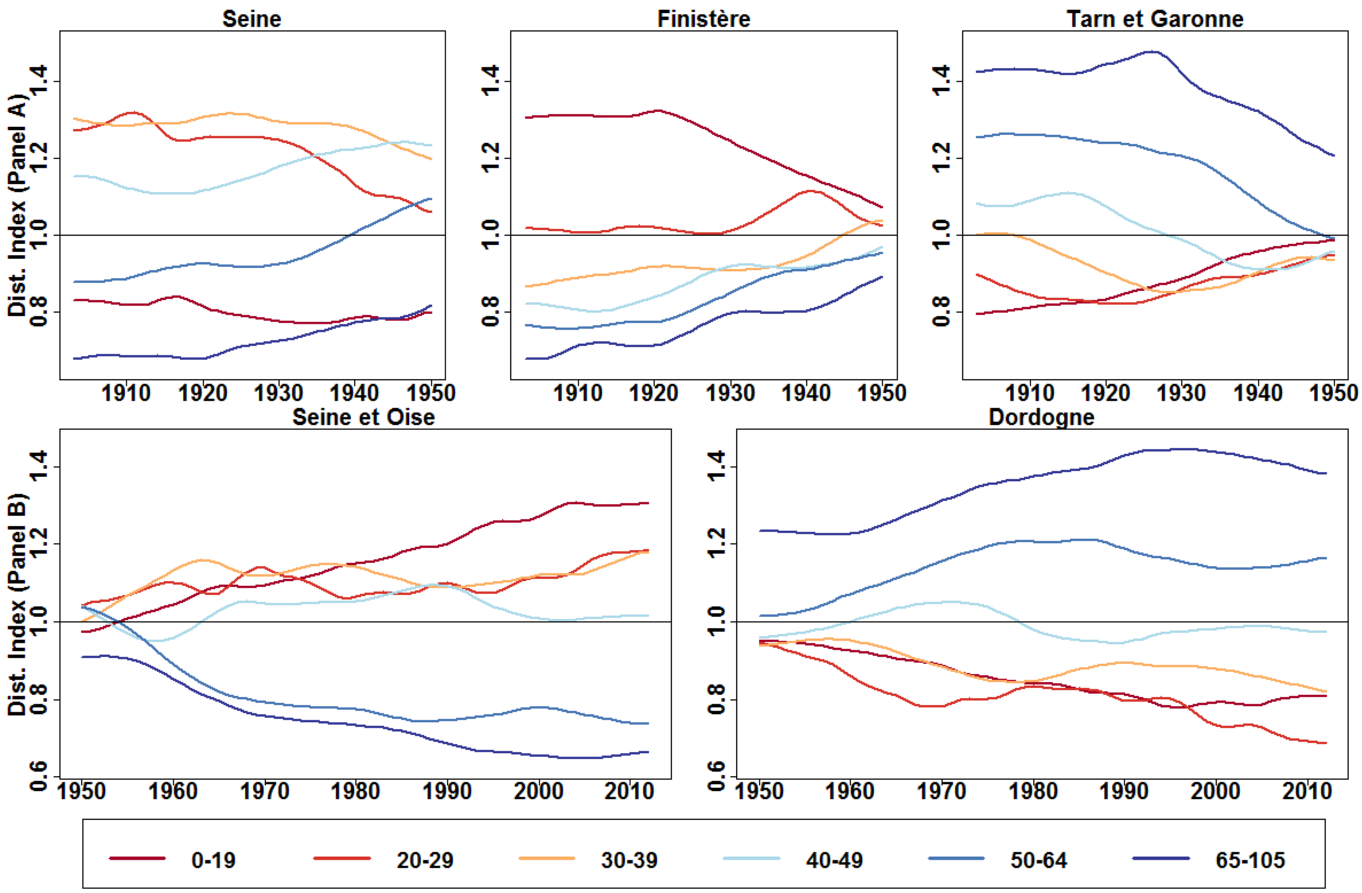
National age structures of population have changed since 1851: at that time, the women aged 65 and over accounted for only 7% of the female population, compared with 21% today. For those under 20, these shares are 35% and 23%, respectively. These results are different at the departmental level and have public policy implications. For example, the concentration of the elderly in rural areas requires a specific health policy, especially in France where the medical deserts are numerous.

At first I am interested in the overall dissimilarity of population age structures. I use KLD_{Nat}, presented in equation 2, not weighted by population. Appendix A6 presents the evolution of this indicator. To describe it, I define three subperiods: 1850–1930, where the index remained broadly stable, 1930–1950 when it declined sharply (70% of the 1851 value), and 1950–2014 when it increased by 85% and reached a 30% level higher than the 1850s one. In order to provide an explanation for these contrary variations over the past 80 years, I use the additivity property of KLD_{Nat}. One can break down this indicator in order to get the contribution of each department in its variation between two years. This was done for the two sub-periods 1930–1950 and 1950–2014. Appendix A6 maps the contribution of each department too.

Between 1930 and 1950, France experienced a territorial homogenization. Going into more detail, the departmental age structures homogenized due to four distinct geographical areas: *Seine*, *Bretagne*, departments around *Yonne*, the *Garonne* valley. To better understand what may have caused this homogenization, Figure 4 (Panel A) represents the distortion indices according to three representative departments. In order to avoid the issues of small numbers in the computations of departmental distortion indices, "65–79" and "80 and over" age groups have been gathered. Moreover, these distortion indices have been smoothed over 5 years.

Figure 4 reveals that the decline in dissimilarity between 1930 and 1950 is caused by two main factors. The first is the decrease of the overrepresentation of the oldest in Center-East and South-West (represented by *Tarn-et-Garonne*), coupled with the increase in the share of these age groups in *Bretagne* (represented by *Finistère*). This phenomenon is partly explained by the convergence process of health conditions, very powerful during the inter-war period (d'Albis and Bonnet, 2018). This phenomenon could be explained by migratory flows too. Bonnet (2018a) shows that migrations during World War Two occured from the the whole North to the South and more specifically to the South-West. It is likely that internal migrations during the war mainly concerned active age groups. Consequently, the overrepresented young people in *Bretagne* moved to the South-West where they were underrepresented. The second reason for the decline in overall dissimilarity is specific to *Seine*: the distorsion index of women aged 20 to 29 fell sharply. This decline began before the Second World War, which suggests that the conflict is not directly the cause.

Figure 4: DISTORSION INDICES, 1901–1950 (PANEL A) AND 1951–2014 (PANEL B)



Notes: Computations based on the population of women. Distorsion index for age x is the ratio between the population's share of age x in one department and the same share at the national level. These distorsion indices are smoothed over 5 years. "30–39" refers to age 30 to 39. Sample includes 90 departments.

Since 1950, France faced a spatial specialization process which is still on the rise. This sharp increase came from four distinct geographical areas, namely *Seine-et-Oise*, *Hautes-Pyrénées*, *Nièvre* and a large region around *Dordogne* in the South-West (Appendix A6). Figure 4 represents the distortion indices for two representative departments (Panel B). Age structures of the rural departments (represented by *Dordogne*) have diverged very strongly from the national average due to two parallel phenomena: the increasing overrepresentation of the elderly, and the growing underrepresentation of young workers and their children. In *Dordogne*, the share of women aged 65 and over was 40% higher than the same share at the national level: in 2014, this share was

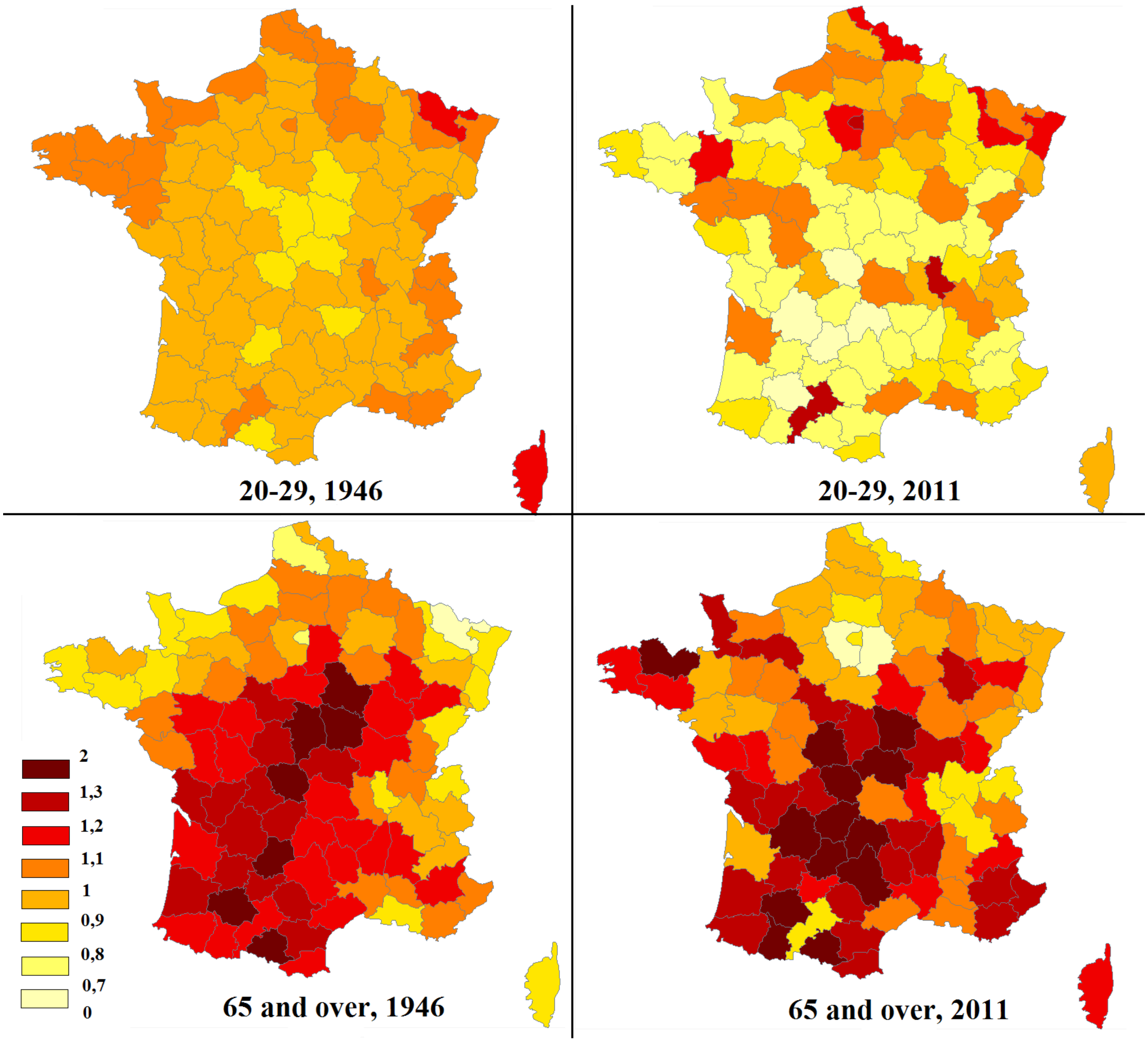
29.3% compared to 20.5%. The situation is opposite in *Seine-et-Oise*: the distortion indices, quite low at the beginning of the period, diverge continuously afterwards. The share of the elderly in the total population is nearly 40% lower than the national share, while the share of 20 to 39-year-olds is 20% higher. According to these results, France is differentiating more and more. It opposes a rural France in which pensioners are overrepresented, and an urban France where active age groups are overrepresented. This is in line with the new geographical economy, which postulates an agglomeration of service jobs in major cities, in parallel with an increase in wages and real estate prices. These developments are gradually chasing retirees with lower income. The elderly settle in less densely populated areas such as the South-West, the Center or the Atlantic coast, creating in these territories a residential economy focused on personal services or tourism (Davezies, 2008). Baccaïni and Dutreuilh (2007) showed that internal migrations were positive at all ages except 20 to 29 in *Bretagne*, *Pays de la Loire*, *Limousin*, *Aquitaine* and *Poitou-Charentes* between 1999 and 2004. On the other hand, these internal migrations were negative for all ages except the 20 to 29 age group in *Ile-de-France*.

Finally, I present a cartographic analysis of this territorial specialization. Figure 5 shows the departmental distortion indices in 1946 and 2011 for women aged 20 to 29, and those over 65. These years are the lowest and the highest point in the process of territorial specialization. Moreover, these two age groups are the most emblematic. Values in 1856, 1896, 1946 and 2011 are available in Appendix A7.

In 1946, the situation was homogeneous according to the youngest: indices fell between 0.9 and 1.1. The situation was different in 2011. They were overrepresented in departments with big cities (*Seine, Haute-Garonne*, *Rhône etc.)* where these indices are comprised between 1.2 and 1.4. Other departments appear with less pronounced situations: *Hérault (Montpellier)*, *Gironde (Bordeaux)* or *Loire-Atlantique (Nantes)*. Conversely, the proportion of young adults in the population was low in central France and in *Bretagne*. The minimum values are reached in South-West. The distortion indices show that this share was 35% lower than the national one, and has been steadily declining for 60 years. This region is becoming an exclusion lands for young adults.

According to women aged 65 and over, the situation in 1946 is different since it presents a clear spatial configuration. A large South-West showed high distortion indices, with peaks reached in *Creuse* or *Nièvre* (around 1.4). The shares in the whole Northern France as well as Eastern borders are lower than the national average. In 2011, the situation is globally similar in the South-West. This suggests that the geography of old age is deeply rooted in territories. However, mirroring the situation of the youngest, urban departments stand out: *Haute-Garonne, Gironde* or *Rhône* have lower distortion indices. Furthermore, one can notice a remarkable situation in *Ile-de-France*: the oldest are underrepresented in the distant suburbs – where the values were the lowest, around 0.6 – but indices are close to the average in the capital and its surroundings. This phenomenon could probably be explained by the housing market: since it is still on the rise, only the elderly who bought their flats before 1995 can stay in Paris and benefit from these amenities, while this population do not want to stay in the distant suburbs.

Figure 5: DISTORSION INDICES, 1946 AND 2011



Notes: Computations based on the population of women. Distorsion index for age *x* is the ratio between the population's share of age *x* in one department and the same share at the national level. These distorsion indices are smoothed over 5 years: 1946 is the mean over the 1944–1948 period. "20–29" refers to age 20 to 29. Sample includes 90 departments.

4 Conclusion

In this paper, I have presented populations by age contained in Bonnet (2018b)'s database and use them to analyze the spatial distribution of the French population for more than 150 years. I have showed that the population was more unevenly distributed in 2014 than it was in the mid 19$^{\text{th}}$ century. This increase in inequality occurred in three phases. "Hyper-centralization" (1851-1900) was due to the increase of population share living in the 10% most densely populated km^2, at the expense of all others. In particular, *Seine*'s share doubled in 50 years to reach 9.1%. During "hyper-centralization thwarted" (1901–1968), the population was increasingly concentrated in the 10% most densely populated km^2, but not at the expense of the second to fourth deciles. During "multipolarization" (1968–2014), the share of both the most and the less densely populated areas decreased, while the share of departments hosting second-tier cities increased. Meanwhile, the shrinking regions of the North-East were particularly vulnerable: the share of the population living there decreased both because of migrations and birth deficit.

My analysis conducted by age group reveals that "hyper-centralization thwarted" has resumed in recent years for those aged 20–29. It reveals a deconcentration phase of the elderly at the end of the 19$^{\text{th}}$ century too, due to the national homogenization of mortality conditions, in line with Bonnet et d'Albis (2018)'s results. Globally, the analysis of age structures reveals a growing and uninterrupted territorial specialization for 50 years: these age structures are increasingly different and reveal two competing France: urban departments that concentrate working-age populations, and rural departments where the elderly are overrepresented. My cartographic analysis deepens these results by showing that elderly are still overrepresented in the South-West, joined more recently by *Bretagne*.

To better understand the causes of population locations, and guide public authorities in their choices, it would be useful to couple this database with economic data according to the same spatial framework. To go even further, the simultaneous analysis of migrations by age group, income and employment statistics would be particularly accurate.

Acknowledgements

The author thanks H. d'Albis, M. Barbieri, L. Kezstenbaum, F. Toubal, E. Perdrix, S. Ligonnière, J. Monardo as well as participants of INED and ENS Paris-Saclay seminars for their comments.

Disclosure statement

The author declares that he has no relevant or material financial interests that relate to the research described in this paper.

References

Ariès, P. (1948). *Histoire des populations françaises et de leurs attitudes devant la vie depuis le XVIIIe siècle*. Éditions Self.

Ayuda, M. I., F. Collantes, and V. Pinilla (2010). Long-run Regional Population Disparities in Europe During Modern Economic Growth: a Case Study of Spain. *The Annals of Regional Science 44*(2), 273–295.

Baccaïni, B. (2001). Les migrations internes en France de 1990 à 1999 : l'appel de l'Ouest. *Économie et statistique 344*(1), 39–79.

Baccaïni, B. and C. Dutreuilh (2007). Inter-Regional Migration Flows in France over the Last Fifty Years. *Population (English Edition)*, 139–155.

Baccaïni, B. and D. Levy (2009). Recensement de la population de 2006. Les migrations entre départements: le Sud et l'Ouest toujours très attractifs. *Insee première* (1248), 4.

Beeson, P. E., D. N. DeJong, and W. Troesken (2001). Population Growth in US Counties, 1840–1990. *Regional Science and Urban Economics 31*(6), 669–699.

Beyers, W. B. and P. B. Nelson (2000). Contemporary Development Forces in the Nonmetropolitan West: New Insights from Rapidly Growing Communities. *Journal of Rural Studies 16*(4), 459–474.

Blanc, M., B. Schmitt, and E. Ambiaud (2007). Orientation économique et croissance locale de l'emploi dans les bassins de vie des bourgs et petites villes. *Economie et statistique 402*(1), 57–74.

Bonnet, F. (2018a). Beyond the Exodus of May-June 1940: Internal Migrations in France during the Second World War. *mimeo*.

Bonnet, F. (2018b). Computations of French Lifetables by Département. *PSE Working Papers 2018-57*.

Bonneuil, N. (1997). *Transformation of the French Demographic Landscape 1806–1906.* Oxford England Clarendon Press.

Bontje, M., S. Musterd, et al. (2012). *Understanding Shrinkage in European Regions*. Alexandrine Press.

Breton, D., M. Barbieri, H. d'Albis, and M. Mazuy (2017). L'évolution démographique récente de la France: de forts contrastes départementaux. *Population 72*(4), 583–651.

Coale, A. J. (2017). *The Decline of Fertility in Europe*. Princeton University Press.

Combes, P.-P., G. Duranton, and L. Gobillon (2012). The Costs of Agglomeration: Land Prices in French Cities. *CEPR Discussion Paper No. 9240*.

Combes, P.-P., M. Lafourcade, J.-F. Thisse, and J.-C. Toutain (2011). The Rise and Fall of Spatial Inequalities in France: A Long-Run Perspective. *Explorations in Economic History 48*(2), 243–271.

Cowell, F. (2011). *Measuring Inequality*. Oxford University Press.

d'Albis, H. and F. Bonnet (2018). Spatial Inequality in Mortality in France over the Past Two Centuries. *PSE Working Papers 2018-53*.

d'Albis, H., L. J. Esso, and H. Pifarré i Arolas (2014). Persistent Differences in Mortality Patterns across Industrialized Countries. *PloS One 9*(9), e106176.

Davezies, L. (2008). *La France et ses territoires, la circulation invisible des richesses*. Seuil.

Fletcher, T. W. (1961). The Great Depression of English Agriculture 1873–1896. *The Economic History Review 13*(3), 417–432.

Fol, S. (2012). Urban Shrinkage and Socio-Spatial Disparities: Are the Remedies Worse than the Disease? *Built Environment 38*(2), 259–275.

Francart, G. (1983). Le rééquilibrage démographique de la France. *Economie et statistique 153*(1), 35–46.

Galjaard, R., L. Van Wissen, and K. Van Dam (2012). European Regional Population Decline and Policy Responses: Three Case Studies. *Built Environment 38*(2), 293–302.

Graham, D. J. (2007). Variable Returns to Agglomeration and the Effect of Road Traffic Congestion. *Journal of Urban Economics 62*(1), 103–120.

Gravier, J.-F. (1947). *Paris et le désert français: décentralisation, équipement, population*. Flammarion.

Jayet, H., J.-P. Puig, and J.-F. Thisse (1996). Enjeux économiques de l'organisation du territoire. *Revue d'économie politique*, 127–158.

Krugman, P. (1993). First Nature, Second Nature, and Metropolitan Location. *Journal of Regional Science 33*(2), 129–144.

Kullback, S. and R. A. Leibler (1951). On Information and Sufficiency. *The Annals of Mathematical Statistics 22*(1), 79–86.

Mackenbach, J. P. and A. E. Kunst (1997). Measuring the Magnitude of Socio-economic Inequalities in Health: an Overview of Available Measures Illustrated with two Examples from Europe. *Social Science & Medicine 44*(6), 757–771.

Michaels, G., F. Rauch, and S. J. Redding (2012). Urbanization and Structural Transformation. *The Quarterly Journal of Economics 127*(2), 535–586.

Mojica, L. and J. Martí-Henneberg (2011). Railways and Population Distribution: France, Spain, and Portugal, 1870–2000. *Journal of Interdisciplinary History 42*(1), 15–28.

Oliveau, S. and Y. Doignon (2016). La diagonale se vide? Analyse spatiale exploratoire des décroissances démographiques en France métropolitaine depuis 50 ans. *Cybergeo: European Journal of Geography*.

Oswalt, P. and T. Rieniets (2006). *Atlas of Shrinking Cities*. Hatje Cantz.

Puga, D. (1999). The Rise and Fall of Regional Inequalities. *European Economic Review 43*(2), 303–334.

Schwartz, R., I. Gregory, and T. Thévenin (2011). Spatial History: Railways, Uneven Development, and Population Change in France and Great Britain, 1850–1914. *Journal of Interdisciplinary History 42*(1), 53–88.

Shannon, C. E. (1948). A Mathematical Theory of Communication. *Bell System Technical Journal 27*(3), 379–423.

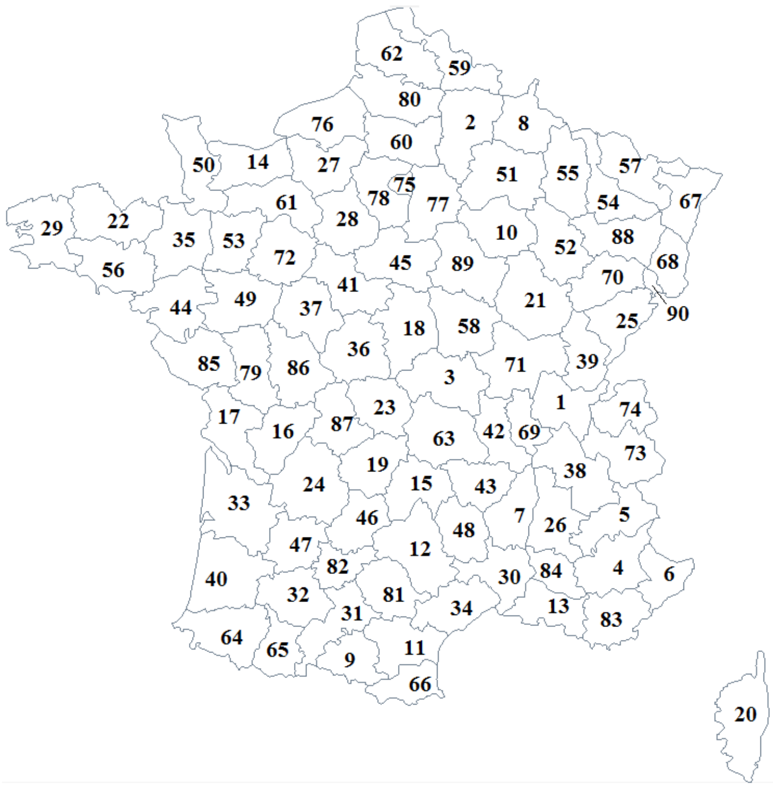
Talandier, M., V. Jousseaume, and B.-H. Nicot (2016). Two Centuries of Economic Territorial Dynamics: the Case of France. *Regional Studies, Regional Science 3*(1), 67–87.

Wilmoth, J. R., K. Andreev, D. Jdanov, D. A. Glei, C. Boe, M. Bubenheim, D. Philipov, V. Shkolnikov, and P. Vachon (2007). Methods Protocol for the Human Mortality Database. *University of California, Berkeley, and Max Planck Institute for Demographic Research, Rostock. URL: http://mortality. org [version 31/05/2007] 9*, 10–11.

Spatial Distribution of Population by Age in France by Age in France over the Past 150 years. Appendix

March 13, 2019

A1 Map of the 90 French Departments Used to Calculate Inequalities



1 Ain
2 Aisne
3 Allier
4 Alpes (Basses)
5 Alpes (Hautes)
6 Alpes Maritimes
7 Ardèche
8 Ardennes
9 Ariège
10 Aube
11 Aude
12 Aveyron
13 Bouches du Rhone
14 Calvados
15 Cantal
16 Charente
17 Charente Maritime
18 Cher
19 Corrèze
20 Corse
21 Côte d'Or
22 Côtes du Nord
23 Creuse
24 Dordogne
25 Doubs
26 Drôme
27 Eure
28 Eure et Loir
29 Finistère
30 Gard
31 Garonne (Haute)
32 Gers
33 Gironde
34 Hérault
35 Ille et Vilaine
36 Indre
37 Indre et Loire
38 Isère
39 Jura
40 Landes
41 Loir et Cher
42 Loire
43 Loire (Haute)
44 Loire Inférieure
45 Loiret
46 Lot
47 Lot et Garonne
48 Lozère
49 Maine et Loire
50 Manche
51 Marne
52 Marne (Haute)
53 Mayenne
54 Meurthe et Moselle
55 Meuse
56 Morbihan
57 Moselle
58 Nièvre
59 Nord
60 Oise
61 Orne
62 Pas de Calais
63 Puy de Dome
64 Pyrénées (Basses)
65 Pyrénées (Hautes)
66 Pyrénées Orientales
67 Rhin (Bas)
68 Rhin (Haut)
69 Rhône
70 Saône (Haute)
71 Saône et Loire
72 Sarthe
73 Savoie
74 Savoie (Haute)
75 Seine
76 Seine Inférieure
77 Seine et Marne
78 Seine et Oise
79 Sèvres (Deux)
80 Somme
81 Tarn
82 Tarn et Garonne
83 Var
84 Vaucluse
85 Vendée
86 Vienne
87 Vienne (Haute)
88 Vosges
89 Yonne
90 Territoire de Belfort

Notes : Numbers used in Bonnet (2018b)'s database. Corse is unified in this classification.

A2 Departments with missing data and reference departments

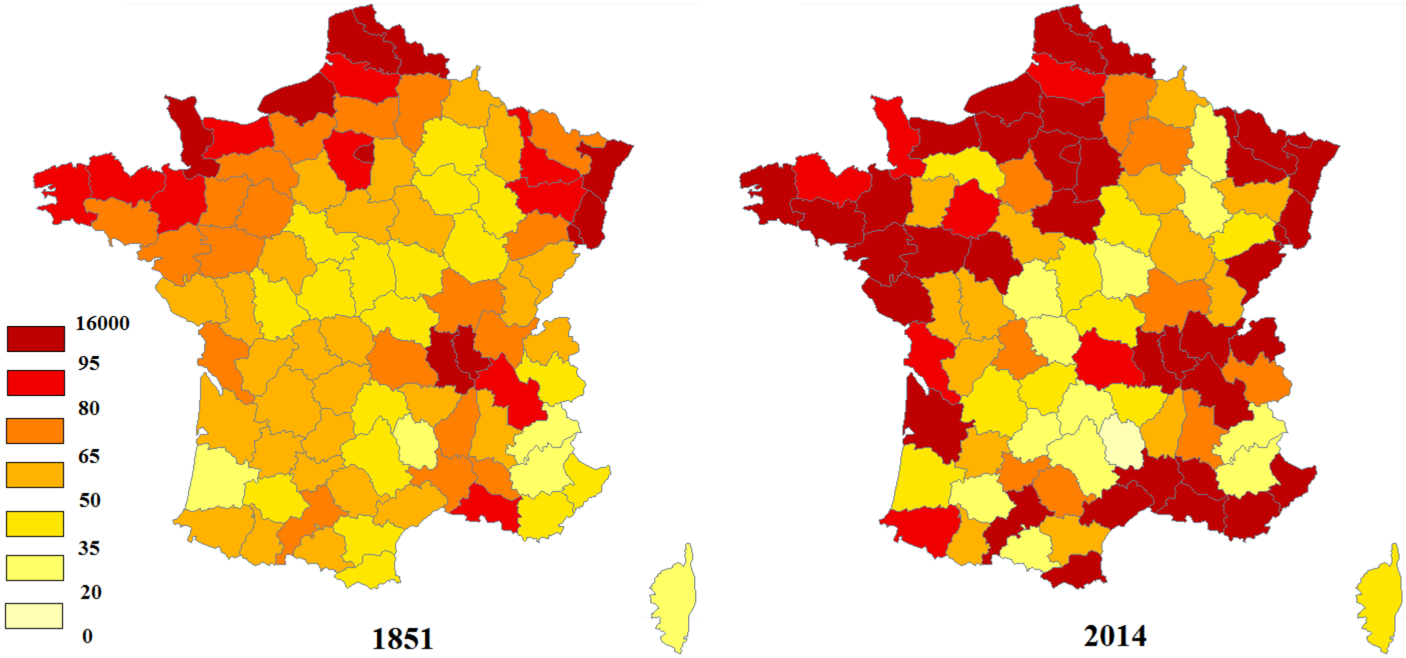
Table 1: DEPARTMENTS WITH MISSING DATA: 1851–2014

Departments	Period with missing data	Reference department
Alpes Maritimes; Var	1851–1856	*Bouches du Rhone*
Savoie; Savoie (Haute)	1851–1856	*Ain*
Vosges; Territoire de Belfort	1851–1866	*Saone (Haute)*
Meurthe et Moselle; Moselle	1851–1866	*Saone (Haute)*
Moselle; Rhin (Bas); Rhin (Haut)	1866–1900	*Saone (Haute)*
Seine	1969–2014	(*)
Seine et Oise	1969–2014	(*)

Notes: Periods are the first and the last year with missing data.
(*) Sum of *Essonne, Hauts-de-Seine, Seine-Saint-Denis, Val-de-Marne, Val d'Oise, Paris, Yvelines*.

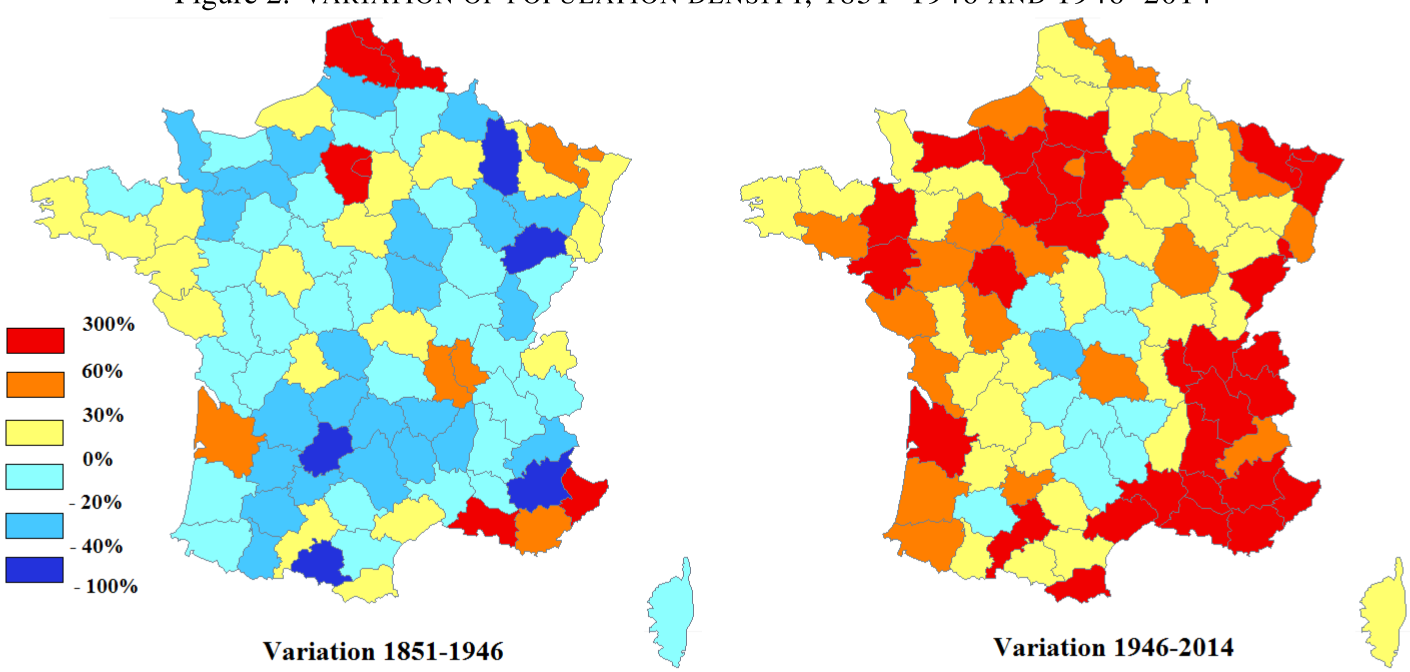
A3 Departmental Densities and Variations between 1851 and 2014

Figure 1: POPULATION DENSITY, 1851 AND 2014



Notes: Population densities based on the population of both sexes gathered. Sample includes 90 *départements*.

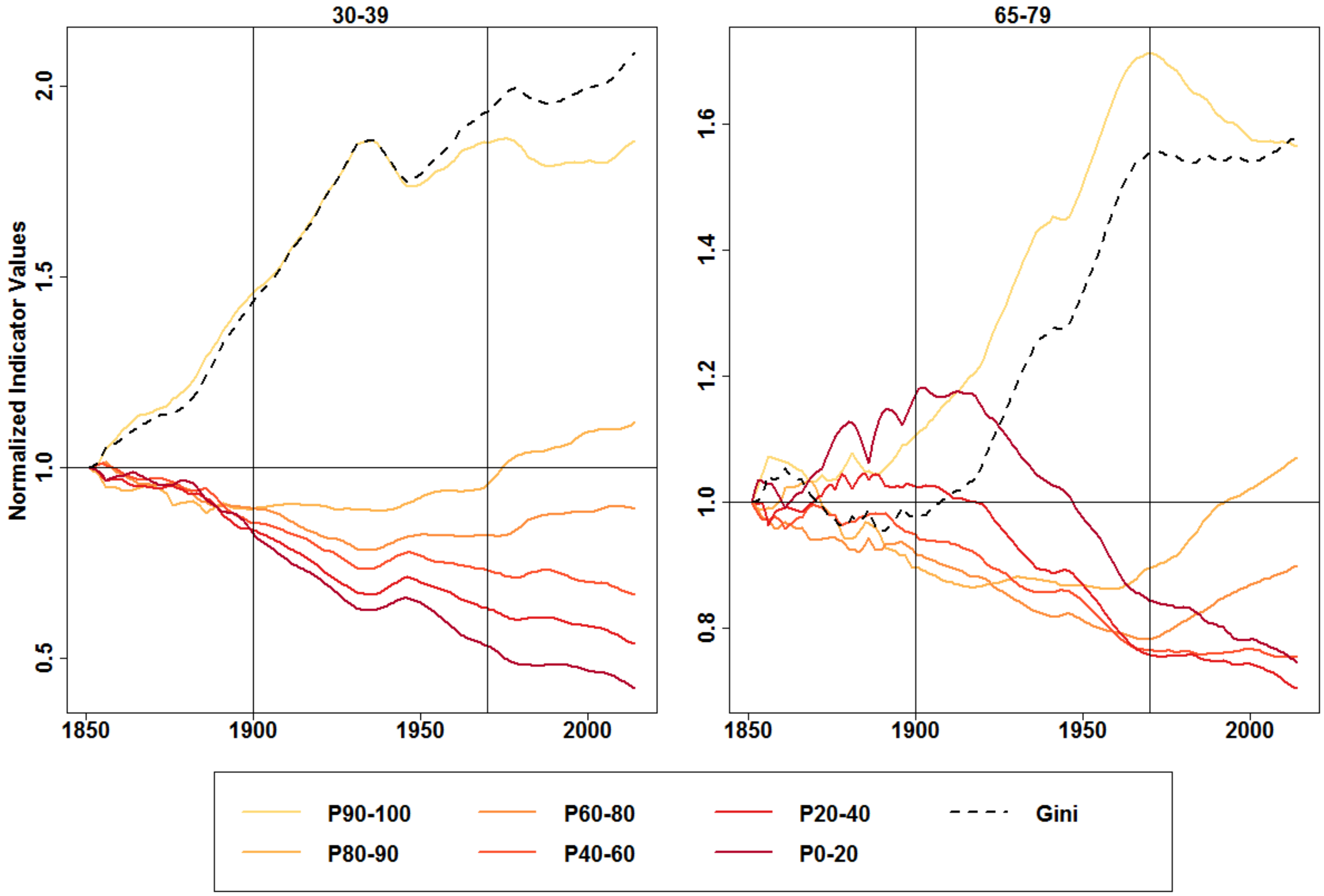
Figure 2: VARIATION OF POPULATION DENSITY, 1851–1946 AND 1946–2014



Notes: Variation of population density based on the population of both sexes gathered. Sample includes 90 *départements*.

A4 Spatial Distribution of Population According to Age

Figure 3: SPATIAL INEQUALITIES OF POPULATION DENSITY BY AGE GROUP, 1851–2014



Notes: Computations based on the population of women. P90-100 refers to the share of national population who lived in the 10% of km^{2}with the highest density values. All inequality indicators are weighted by km^{2}and normalized by 1851 values. "30–39" refers to age 30 to 39. Sample includes 90 departments.

A5 Spatial Distribution of Population and Departmental Age Structures

To show that departmental age structures matter in the evolution of spatial inequalities, I seek to disentangle two different effects. The first is the background process induced by the evolution of total population densities. The second is the specific process explained by the evolution of population age structures in departments. Formally, let call d_t^a the population density of age a at date t in one department, and S the area. One have:

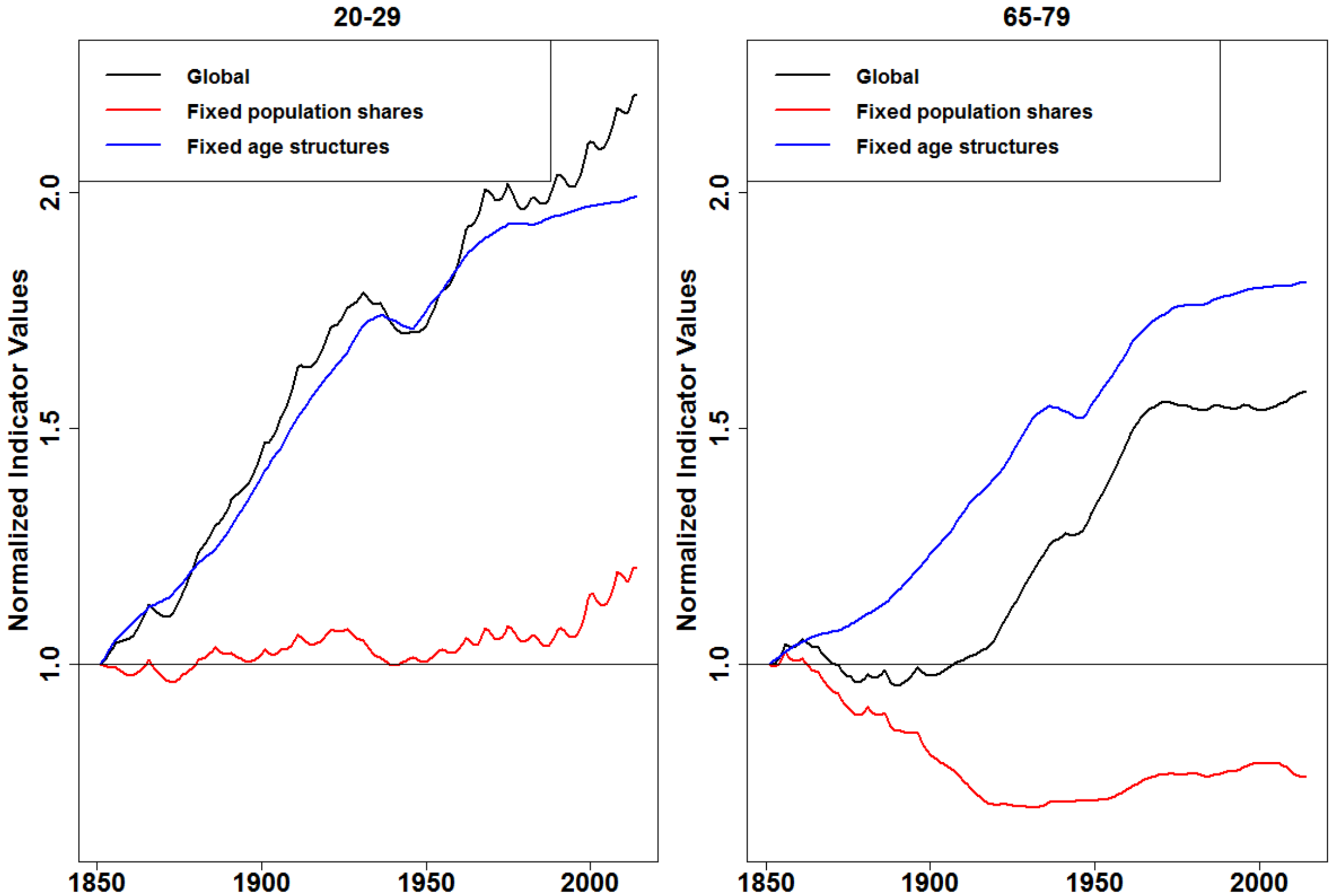
$$d_t^a = \frac{\theta_t^a P_t}{S}, \tag{1}$$

with θ_t^a the share of population aged a in the total of population P_t. The area is fixed regardless of age and year for a department. The sequence of the inequality index Θ^a relative to age a for the T years studied can be written as follows:

$$\Theta^a = \Theta^a(\theta^{\mathbf{a}}, \mathbf{P}), \tag{2}$$

where θ^a is the (N,T) matrix of departmental age structures for each year and $\mathbf{P}$ is the (N,T) matrix of the departmental total population for each year. The variation of Θ^a comes either from the evolution of θ_t^a, specific to the age group a, or from the evolution of P_t, common to all age groups. To assess whether departmental age structures contribute to the increase of inequalities, I fix in stage 1 departmental populations P_t at their initial level and allow age structures θ_t^a to vary. Then, in stage 2, I fix age structures at their initial level and allow departmental populations to vary.

Figure 4: SPATIAL INEQUALITIES OF POPULATION DENSITY BY AGE GROUP AND TYPE, 1851–2014



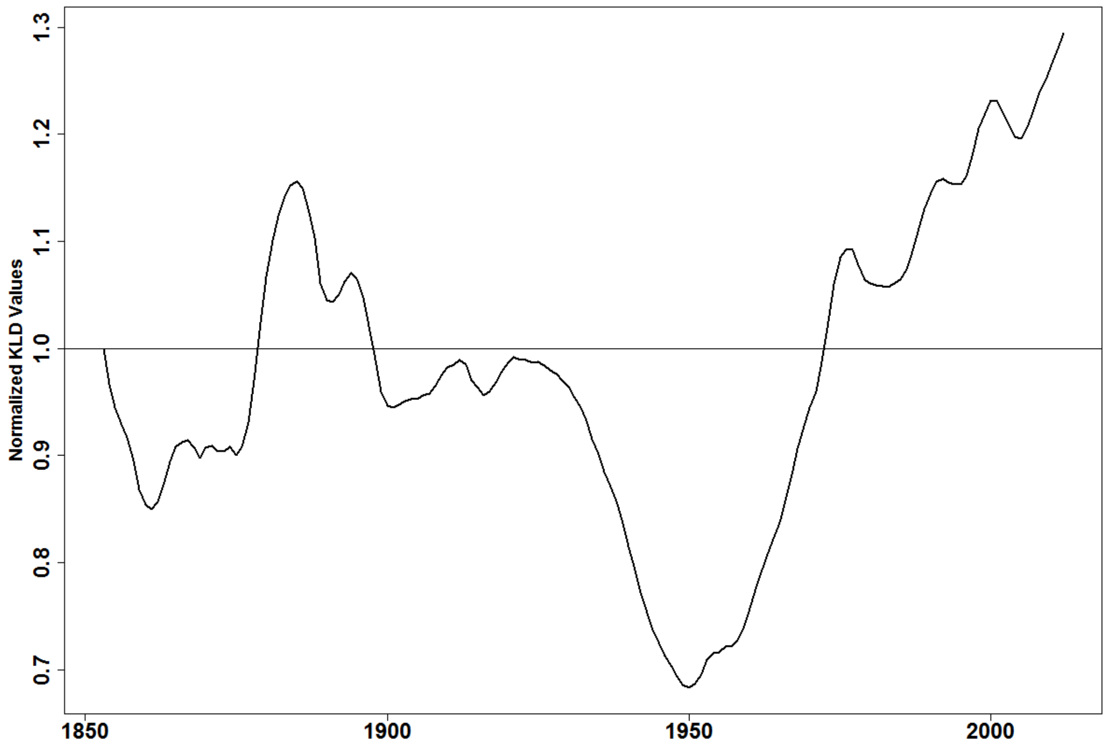
Notes: Computations based on the population of women. "Fixed population shares" means that the shares of departments are fixed at their 1851 levels. "Fixed age structure" means that the age structure of each department is fixed over the 1851–2014 period. "20–29" refers to age 20 to 29. Sample includes 90 departments.

Figure 4 presents the evolution of the Gini index for women aged 20 to 29 and 65 to 79. For the first age group, the red curve shows that the change in departmental population age structures contributed to the rise in spatial inequalities. They would have increased by 20% if the total departmental populations had remained stable. In other words, the 20 to 29-year-olds shares in departmental populations are more strongly differentiated than in 1851, and this differentiation has accelerated since 1990. On the other hand, the change in the departmental shares of the 65 to 79-year-olds has slowed the rise in inequality. The curve in red has a U-shape: until the 1930s, the 65 to 79-year-olds shares homogenized; they differentiated from 1930 onwards. More broadly, this profile is observed for all women aged 65 and over.

A6 Evolutions of KLD_{Nat} and Departmental Contributions

Figure 5 presents the evolution of KLD_{Nat}. One can use three subperiods to describe it: 1850–1930, where the index remained broadly stable, 1930–1950 where it declined sharply, and 1950–2014 when it increased dramatically.

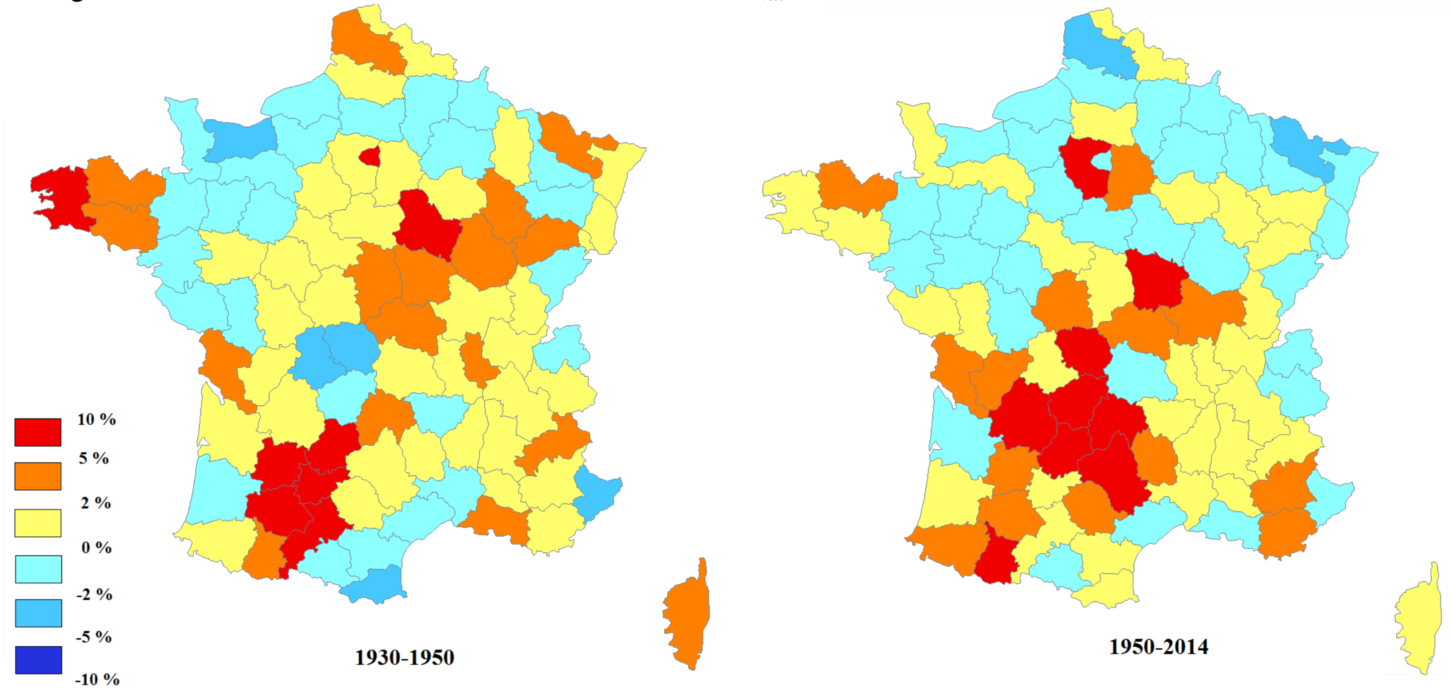
Figure 5: NORMALIZED KLD_{NAT}, 1851–2014



Notes: Computations based on the population of women.KLD_{NAT} is non-weighted by population. Sample includes 90 departments.

Thanks to its additivity property, KLD_{Nat} can be decomposed to know the weight of each department in its evolution between two dates. Figure 6 shows the result of this decomposition for the periods 1930–1950 (during which the indicator fell by 30%) and 1950–2014 (during which the indicator increased by 85%). For the first, I identify four geographical areas explaining the decline: *Seine*, *Bretagne*, *Yonne* and its neighboring departments, the South-West along the Garonne Valley. For the second, I identify four geographical zones explaining the rise: *Seine-et-Oise*, *Hautes-Pyrénées*, *Nièvre* and a large region around *Corrèze* in the South-West.

Figure 6: DEPARTEMENTAL CONTRIBUTIONS IN KLD_{Nat} VARIATIONS, 1930–1950 AND 1950–2014



Notes: Computations based on the population of women. Sample includes 90 departments.

A7 Distorsion indices of age structures in 1856, 1896, 1946 and 2011

	Women aged 20 to 29				Women aged 65 and over			
	1856	1896	1946	2011	1856	1896	1946	2011
Ain	98%	94%	96%	89%	84%	105%	108%	88%
Aisne	95%	91%	100%	92%	129%	125%	103%	100%
Allier	103%	100%	89%	74%	74%	95%	128%	137%
Alpes (Basses)	98%	90%	95%	75%	85%	103%	117%	125%
Alpes (Hautes)	98%	89%	102%	75%	64%	75%	95%	116%
Alpes Maritimes	106%	120%	94%	87%	94%	81%	108%	127%
Ardèche	102%	93%	92%	74%	103%	96%	114%	120%
Ardennes	94%	93%	96%	88%	127%	125%	105%	102%
Ariège	101%	89%	85%	71%	86%	129%	147%	131%
Aube	96%	88%	95%	91%	144%	145%	108%	108%
Aude	93%	98%	92%	76%	99%	108%	125%	125%
Aveyron	96%	90%	94%	70%	92%	103%	116%	141%
Bouches du Rhone	94%	114%	107%	102%	116%	79%	90%	101%
Calvados	93%	93%	104%	99%	160%	130%	87%	103%
Cantal	103%	94%	94%	70%	95%	113%	117%	143%
Charente	90%	90%	92%	77%	110%	135%	124%	125%
Charente Maritime	97%	93%	97%	76%	124%	126%	125%	130%
Cher	97%	92%	89%	78%	67%	94%	134%	125%
Corrèze	98%	95%	96%	73%	85%	87%	123%	141%
Corse	117%	111%	116%	92%	58%	66%	89%	116%
Côte d'Or	91%	89%	96%	110%	142%	140%	116%	102%
Côtes du Nord	99%	93%	102%	73%	88%	86%	94%	131%
Creuse	102%	96%	82%	65%	75%	114%	154%	154%
Dordogne	98%	96%	95%	69%	90%	100%	123%	139%
Doubs	100%	97%	104%	108%	90%	86%	87%	96%
Drôme	115%	101%	97%	86%	95%	103%	111%	107%
Eure	87%	88%	97%	90%	162%	144%	100%	91%
Eure et Loir	84%	89%	96%	89%	138%	129%	105%	97%
Finistère	105%	100%	106%	84%	63%	65%	85%	118%
Gard	101%	105%	96%	85%	96%	99%	108%	110%
Garonne (Haute)	101%	99%	102%	124%	101%	119%	114%	86%
Gers	90%	90%	92%	65%	125%	130%	130%	135%
Gironde	118%	111%	99%	107%	89%	111%	116%	98%
Hérault	105%	108%	98%	107%	99%	104%	117%	105%
Ille et Vilaine	97%	103%	105%	112%	63%	75%	86%	91%
Indre	105%	94%	90%	71%	68%	102%	125%	137%
Indre et Loire	91%	93%	95%	102%	118%	128%	110%	106%
Isère	105%	94%	99%	102%	64%	109%	98%	90%
Jura	94%	95%	97%	80%	102%	102%	108%	114%
Landes	96%	107%	90%	72%	96%	65%	128%	120%
Loir et Cher	93%	89%	90%	77%	99%	113%	121%	122%
Loire	104%	108%	96%	93%	66%	76%	101%	114%
Loire (Haute)	101%	95%	89%	72%	74%	93%	119%	120%
Loire Inférieure	98%	103%	100%	102%	94%	90%	101%	94%
Loiret	95%	90%	95%	97%	100%	114%	116%	99%

	Women aged 20 to 30				Women aged 65 and over			
	1856	1896	1946	2011	1856	1896	1946	2011
Lot	95%	110%	88%	62%	117%	136%	141%	142%
Lot et Garonne	96%	96%	95%	79%	131%	127%	122%	129%
Lozère	96%	86%	93%	77%	86%	85%	113%	127%
Maine et Loire	99%	98%	97%	101%	112%	110%	111%	98%
Manche	90%	96%	103%	79%	148%	101%	88%	123%
Marne	94%	95%	102%	109%	121%	118%	95%	94%
Marne (Haute)	93%	83%	95%	84%	135%	150%	113%	121%
Mayenne	97%	89%	99%	83%	104%	102%	94%	110%
Meurthe et Moselle	105%	99%	107%	113%	109%	102%	81%	98%
Meuse	89%	84%	97%	86%	130%	137%	108%	109%
Morbihan	112%	102%	101%	78%	67%	79%	87%	119%
Moselle	88%		111%	101%	93%		68%	97%
Nièvre	96%	87%	86%	72%	75%	107%	139%	143%
Nord	95%	111%	101%	115%	98%	77%	93%	86%
Oise	88%	95%	97%	99%	138%	121%	103%	80%
Orne	90%	90%	98%	80%	137%	141%	99%	124%
Pas de Calais	96%	98%	110%	99%	111%	77%	75%	94%
Puy de Dome	99%	98%	96%	100%	118%	113%	118%	109%
Pyrénées (Basses)	97%	100%	96%	84%	102%	106%	111%	123%
Pyrénées (Hautes)	97%	98%	97%	72%	98%	130%	119%	137%
Pyrénées Orientales	98%	104%	99%	82%	73%	80%	113%	127%
Rhin (Bas)	95%		103%	111%	73%		81%	90%
Rhin (Haut)	123%		97%	95%	66%		89%	95%
Rhône	121%	117%	102%	126%	73%	78%	90%	89%
Saône (Haute)	98%	85%	91%	80%	115%	126%	120%	107%
Saône et Loire	103%	106%	93%	76%	89%	82%	119%	126%
Sarthe	91%	89%	98%	88%	108%	132%	100%	108%
Savoie	99%	93%	100%	92%	63%	97%	98%	100%
Savoie (Haute)	101%	96%	107%	97%	66%	77%	87%	84%
Seine	132%	128%	110%	124%	75%	68%	78%	81%
Seine Inférieure	107%	99%	107%	105%	121%	96%	83%	98%
Seine et Marne	86%	91%	90%	109%	134%	125%	113%	69%
Seine et Oise	88%	100%	100%	119%	139%	102%	91%	65%
Sèvres (Deux)	95%	96%	95%	80%	97%	101%	110%	116%
Somme	92%	90%	97%	104%	123%	128%	110%	97%
Tarn	96%	97%	92%	75%	94%	118%	124%	128%
Tarn et Garonne	101%	94%	93%	78%	132%	138%	125%	113%
Var	104%	110%	100%	80%	110%	110%	105%	127%
Vaucluse	99%	98%	97%	89%	98%	117%	106%	107%
Vendée	100%	97%	95%	81%	74%	83%	106%	115%
Vienne	98%	95%	95%	107%	97%	107%	116%	107%
Vienne (Haute)	106%	100%	95%	94%	61%	80%	121%	122%
Vosges	101%	97%	96%	82%	92%	99%	100%	114%
Yonne	89%	81%	85%	80%	127%	154%	140%	118%
Belfort	125%	105%	98%	100%	80%	75%	92%	97%