A STUDY OF THE EFFICIENCY OF SMALL MODELS IN THE PROJECTION OF REGIONAL POPULATIONS

J.-M. Gambrelle

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Preface

The work described in this paper arose out of an ongoing research project, carried out at IIASA and the Centre for Environmental Studies, London, which aims at a more complete understanding of the dynamics of population movements and regional economic growth. This general study has two main themes. One deals substantively with interurban migration within a system of post-industrial cities, and aims to recast migration from the traditional economic push-pull theory into a more dynamic multicausal theory in which job turnover in the local labour market plays an important part. The second theme is methodological and describes a structured research strategy for the dynamic analysis of complex systems.

The study argues that, while it is important to recognize the usefulness of simple models at the early stages of an enquiry, those same simple models should be improved by hypothesis testing during the course of the work; the study argues further that a hierarchy of models of national settlement systems should be developed at varying levels of approximation. At the simplest level, one should be able to perform calculations on the back of an envelope that describe the broad qualitative directions of change in a way that is of interest to policy makers in the short term. In policy analysis, as in everything else, one has to begin in order to begin. But it is equally important to recognize the need for change when the inadequacy of the simpler methods has been demonstrated. Thus policy analysis becomes an iterative, structured learning process.

Within this general context, this paper by Jean-Marie Gambrelle aims to illustrate and test some simple models for calculating differential rates of population change which require little data or time to construct, but which may be useful in preliminary explorations of policy. The paper focuses on the regional population distributions of France; a companion paper by David Gleave entitled "The Utility and Compatibility of Simple Migration Models" [6] considers the application of similar methods in the UK, Italy, the Federal Republic of Germany and France.

Martyn Cordey-Hayes
London

1. Regional Projections for France: A Comparison of Methods

1.1 Aims

To forecast the size of the population in the regions of a country, scholars normally build a large model with a large amount of data--if, of course, they are aiming at a multi-regional forecast and not a solely regional one. Sometimes, the model is based on net migration alone, but in recent years the use of Markovian methods has become more frequent. Markovian methods need a large amount of data, an amount which increases with the square of the number of regions. Analysis with these methods is usually based on five-year cohorts, with birth- and death rates for each age group; this also implies voluminous data. Ultimately, decision makers in both public and private administration have a very sophisticated tool with these methods: that is they can produce a model that gives results with a fair degree of accuracy. However, there are problems with these methods.

First, the input data are always outdated, sometimes seriously. Second, comparative statistics often mislead by obscuring interesting and important intertemporal fluctuations. Further, even dynamic models artifically smooth the naturally stochastic nature of regional vital statistics.

A model in which data and equations can be changed with ease would therefore be useful, making it possible to allow for new trends. We shall attempt to demonstrate that a small model can give results not too different from those of the larger, more sophisticated, and less flexible models.

1.2 Approach

First we shall compare three methods of treating migration trends: the Markovian method, Feeney's method, and the method of the Kinematic models. Next, we look at the model of the Institut National de la Statistique et des Etudes Economiques (INSEE) whose results suggest some modifications are needed. Finally, we focus on a small model which looks at

1) changes in the national birthrate,

2) changes in national migration; and

3) interruptions of foreign immigation to France.

However, before this is undertaken, a presentation of the French migration system will give a better understanding of the following work.

2. A Presentation of the French Migration System

The following presentation of the French regions may be of interest in illustrating the French migration system. France is divided into twenty-two administrative regions each of which has some individual characteristics, and these characteristics can explain movements of the population (see Figures 1 and 2).

2.1 Region of Paris

This first region is well-known; it consists of Paris itself and the functionally adjacent new towns. With more than nine million inhabitants in 1968, this region held 19% of the French population (but 2% of the area), and one-third of the value of global national salaries. In the city there is a major concentration of centers of decision making in public or private administration, and 80% of all French research workers. Since the mid-fifties, the French policy of decentralization has attempted to discourage industry in this region and encourage the growth of administration and research centers.[1]

The Paris region's growth remained large during the period of the 1968 census (1962-1968); a global increase of 9% gave it the fourth fastest rate of growth of the twenty-two regions of France. However, this performance is less if we consider the region as a city, because at least seventy French cities have shown faster growth. This relatively lesser performance can be explained perhaps by the spread of this region into the Bassin Parisien, and by the total satellitization of cities such as Rouen, Amiens, Orleans, and Reims. Finally, we must say that the 1962-1968 population increase of the Paris region is not due to a high positive net migration but to natural growth plus strong foreign immigration.[2] Natural growth is large because immigration has brought more younger than older people.

2.2 The Bassin Parisien

The Bassin Parisien consists of six regions: in the East, Champagne-Ardennes (Reims); in the North, Picardie (Amiens); in the West, Haute Normandie (Rouen and Le Havre), and Basse Normandie (Caen); in the Southwest, the Centre (Tours and Orleans); and in the Southeast, Bourgogne (Dijon).

Except for Haute Normandie, which is an old urban and

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[1] The government decision of April 16, 1975 now encourages a different policy: conservation of existing industry in the Région Parisienne, strong reduction of office growth, strong growth of the region's new cities, and finally governmental decentralization by shifting ministeries to other cities in France.

[2] More than one-third of the foreigners living in France were in Paris in 1975.

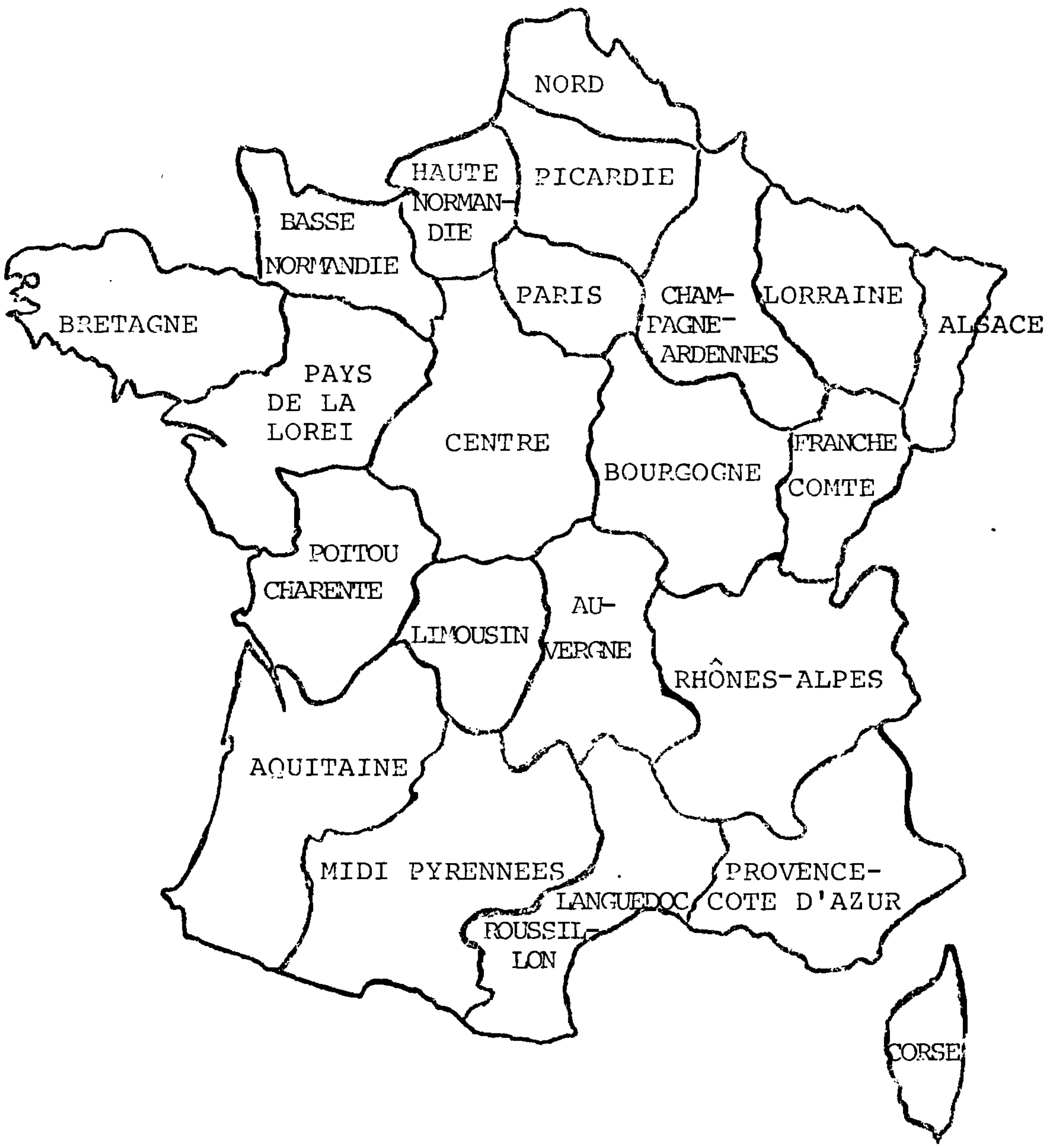
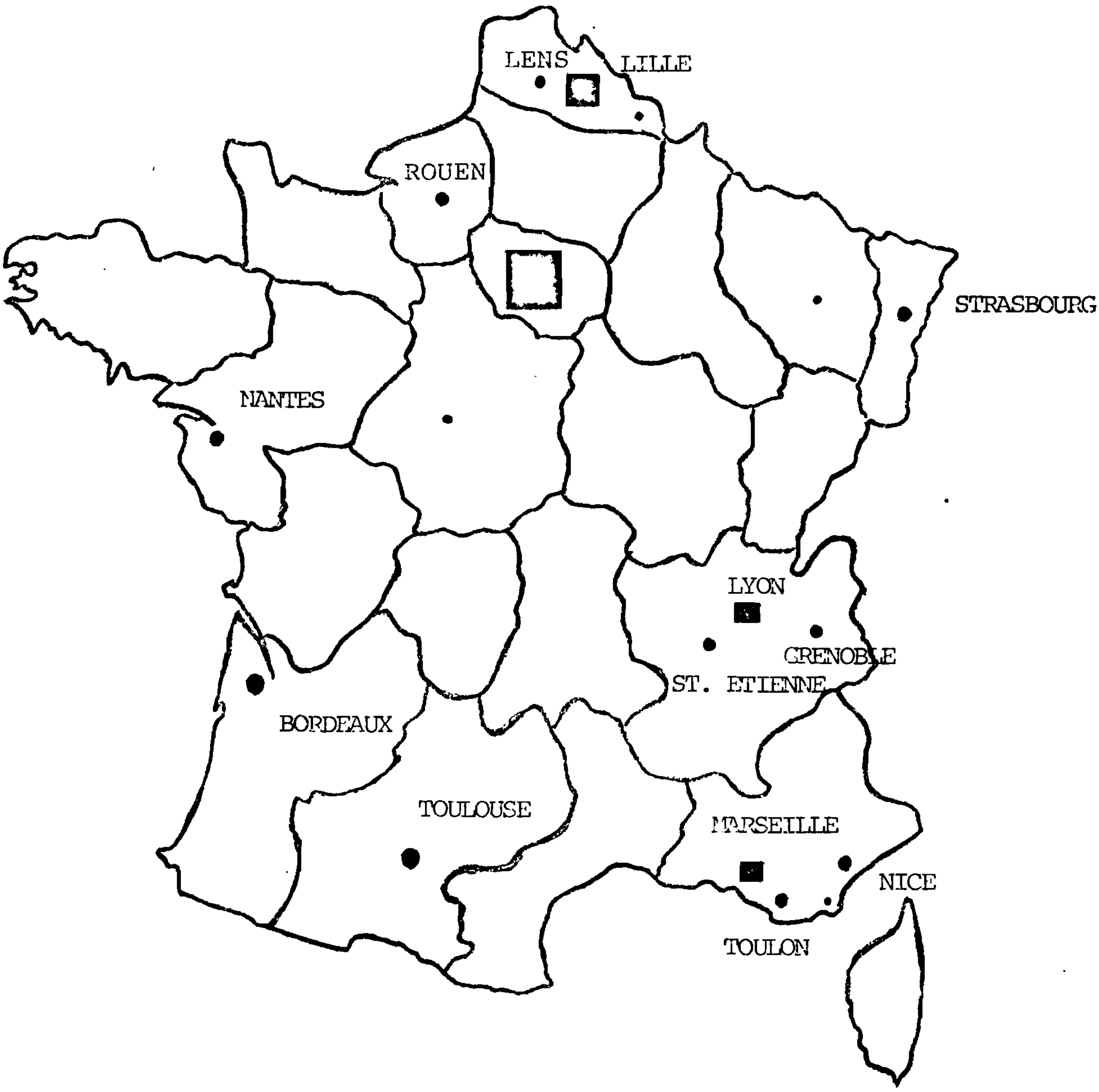


Figure 1. The French regions.



■ More than 800,000 inhabitants
● More than 300,000 inhabitants
Unlabeled points are cities having between 200,000 and 300,000 inhabitants.

Figure 2. Principal cities of France.

industrial region with the two large harbors of Rouen and Le Havre, the region is traditionally rural with a low population density (between forty-nine and eighty-one inhabitants per sq. km; France has an average overall density of ninety-one inhabitants per sq. km). The cities of this region are increasing in size very rapidly, some of them becoming more and more a part of the Parisian agglomeration: Haute Normandie is becoming the industrial region along the Seine River, and the Centre region is becoming the recreational area along the Loire Valley. Not one city in these regions is comparable to Paris in size or power. The largest city is Rouen with 370,000 inhabitants in 1968, making it the ninth largest French city.

2.3 The Southeast

We shall next consider four regions:

1) Rhônes-Alpes. This region is very industrial, powerful enough to counterbalance the Bassin Parissien. The city of Lyon has more than one million inhabitants, and it is attempting to become a European city capable of competing with Munich, Turin, or Zurich. Grenoble is the only French city (except Paris) with a real research center around the university. And as for the advantages of this region, the Alps attract tourism, and the proximity of Switzerland and the North of Italy aids the economy (Geneva is 150 kilometers from Lyon and Grenoble). This is a region with a strong positive net migration.

2) Auvergne. A little on the periphery of Rhônes-Alpes, Auvergne's economic situation is not good. Indeed, it is a region of traditional emmigration just as Limousin (which is the other mountainous region of the Massif Central), and these regions have past trends of decreasing population (their density decreased between 1936 and 1962). At present this trend has ceased but the natural increase remains weak. The first city of the region, Clermont-Ferran, is not very large (around 200,000 inhabitants) but has a strong expansion capability, probably owing to the presence of the factories and headquarters of the well-known Michelin corporation.

3) and 4) The Mediterranean regions Provence-Côte d'Azur and Languedoc Roussillon. Here the characteristics are changing, particularly because both regions are increasing rapidly in population. As in the Rhônes-Alpes, the urban network here is strong enough with Marseille (one million inhabitants), Nice (400,000 inhabitants), and Toulon-Avignon in the eastern part (Provence-Côte d'Azur); and with Montpellier, Nimes, Beziers Perpignan, Narbonne, etc. in the western part (Languedoc Roussillon). A better division of these regions might be to separate a Marseille region from the rest. The Marseille region itself is industrial: it is a petrochemical center and possibly the first harbor of the Mediterranean Sea, if we consider Etang de Berre and the new industrial complex of Fos as part of the Marseille region.

The remainder of the Mediterranean region has very few industries. But the expansion in the region is occurring because more people are coming to live here. This, along with the building of secondary residences, is providing employment, and in turn the new expansion makes the region attractive for certain factories. The cities of this region are growing rapidly, the fastest growing city being Montpellier, having increased by 37% in six years.

2.4 The Major Mining Regions and the East

The major mining regions of France are Nord (in the coal basin of Europe, running from Britain to the Ruhr) and Lorraine (continuing in the Saar). Almost all the steel factories of France and a large part of the textile industry have long been located here. Now Fos in the Marseille region has changed this pattern because of its large new steel works. Both Marseille and the two northern mining regions are in a state of crisis because of structural-industrial obsolescence and environmental catch-up. The crisis, though, seems strongest in Nord, perhaps for environmental reasons (French opinion rates this region as being unattractive). The Nord region, too, has a very high population density similar to that of Belgium and the Netherlands, and very close to that of Britain and Northern Europe. It also contains very large cities, for example, Lille (the fourth largest French city) and Dunkerque, the latter having a large harbor and the largest French steel producer, USINOR. It is perhaps because of this region's size that the crisis seems more spectacular than in Lorraine.

Lorraine, in its turn, has some advantages too: high urbanization with Nancy and Metz, a better natural environment with the Vosges, proximity to the FRG in which many people of this region do their daily work. Daily out-commuting is worse in Alsace, in the direction of the FRG and Switzerland, but we must point out here that the region's mother tongue is German. This is a region for weekend tourism from the FRG because of the many attractive cities, Strasbourg not the least, and especially because of the excellent reputation of Alsacian cooking. Next, in many respects the economic aspect of the Franche Comté region is not good and resembles that of Auvergne; net migration in favor of Alsace and Rhônes-Alpes; mountains for tourism; a small urban network (Besançon has only 116,000 inhabitants); some industrial specializations such as clock-making and the Peugeot car industry. But, like the other eastern regions, daily out-commuting to Switzerland takes place for the higher salaries paid there.

2.5 The West of France

France has six regions in the West, of which three are in fact in the West and three are in the Southwest. The six are:

a) Bretagne, with Rennes and Brest;

b) Pays de la Loire, with Nantes and Angers;

c) Poitou-Charente, with Poitiers and La Rochelle;

d) Limousin, with Limoges;

e) Aquitaine, with Bordeaux; and

f) Midi Pyrénnées, with Toulouse.

A common point of these regions is a very high level of agricultural workers, with, of course, a high rural emmigration and a weak industrial base. But there are also differences among the regions: the West consists mainly of young people where a traditionally high birthrate compensates emmigration unlike the regions of the Southwest. The policy of decentralization from the Paris region has sent some work to the West, but it has sent very little to the South except for Toulouse.

The urban networks are very different too. In the West there are many cities ranging from 50,000 to 200,000 inhabitants. Nantes is the only truly large city, with around 400,000 inhabitants. In the South, the metropolitan phenomenon comes into play: Bordeaux has 550,000 inhabitants and Toulouse 440,000, with the next city of this region having only around 100,000. And finally the net migration is always negative in the West whereas it is positive in the Southwest. The densities are also different, the South having a very low density.

3. Calculation of Migration Comparisons

These initial comparisons are made at constant populations: that is, the global population remains constant, but migration movements change regional populations.

3.1 The Markovian Model

The census is given in the form of a square matrix. Suppose this matrix is called M, with n lines and n columns:

$$M = \left\{M_{ij} \middle| i \in \{1,\ldots,n\} \quad , \quad j \in \{1,\ldots,n\}\right\}$$

where

M_{ij} is the number of people in the region i at the beginning of the period between the censuses and in the region j at the moment of the census if i is unequal to j; and

M_{ii} is the population which was in i at both times.

M_{ij} is the emmigration from i to j, or the immigration from j to i. We can say:

$$M_{i*} = \sum_{j \neq i} M_{ij}$$

and

$$M_{*j} = \sum_{i \neq j} M_{ij} \quad .$$

M_{i*} is the gross emmigration from i and M_{*j} is the gross immigration to j. The square matrix M^1 is the following:

$$M^1_{ij} = \frac{M_{ij}}{M_{ii} + M_{i*}} \quad .$$

$$M^1_{i*} = \sum_{j \neq i} M^1_{ij}$$

is the propensity to emmigrate from i during the period.

The expression of the matrix M could be:

$$\begin{bmatrix} 1 - M^1_{i*} & M^1_{12}, \ldots, M^1_{1n} & \\ M^1_{21} & 1 - M^1_{2*} & \\ & & 1 - M^1_{n*} \end{bmatrix} .$$

The population in the regions at the end of the census would be

$$P_i \quad , \quad i = 1, \ldots ,$$

where P is a line vector.

The Markovian projection of the population at the t-th period would then be

$$P \cdot (M^1)^t \quad .$$

There are two criticisms of the Markovian method:

1) It supposes steady rates of emmigration from each region i to each region j. But at the same time, the regions have no influence over their immigration. Thus, a region of decay near a region of expansion can have decreasing emmigration (constant rate on lessening number of people) and increasing immigration from the expanding region. This seems a little illogical, and hardly realistic; indeed, if we consider the expanding cities, the contrary seems truer over a long period of time: the city seems more and more attractive for the people living in the proximity, and the emmigration rate of the declining region can increase during the decreasing of the immigration rate. After some time it can reverse, of course, but it is perhaps a general movement. For example, the increase of the Région Parisienne occurred at the expense of the Bassin Parisien during the nineteenth and twentieth centuries until the 1960's; it is now true that the trends are reversed, but this occurred only after more than 150 years had elapsed. The impact of the fast increase in the size of the city of Lyon on the region of Auvergne is perhaps similar.

2) The second problem of this method is the need for such a large amount of data.

3.2 The Kinematic Model of M. Cordey-Hayes and D. Gleave

This model (see Cordey-Hayes [3]) is based on the equation:

$$n_i(t) = n_i^f \,(1 - e^{-E_i t}) + n_i^o \, e^{-E_i t}$$

where $n_i^f = (U_i/E_i)/\sum_i (U_i/E_i)$.

This model supposes a steady propensity to emmigrate from each region, and a steady propensity to immigrate to each region, for the emmigrating people. The proximity problem does not concern this method; essentially, the greatest advantages of this method are:

- continuity of time, since we are not concerned with the period;

- ease of calculation since it is possible to do the calculations for a country divided into twenty-two regions with a pocket calculator.

3.3 The Feeney Model

The Feeney model (see Feeney [5]) may be expressed by the following equations:

$$m_{ij}(t) = P_{ji}(t)\ c_{ji}\ x_i(t) \qquad i \neq j \qquad (1)$$

$$P_{ji}(t) = \sum_{k \neq i} \frac{x_j(t)}{x_k(t)} \qquad i \neq j \qquad (2)$$

$$c_{ji} = \frac{m_{ij}(to)}{P_{ji}(to)x_i(to)} \qquad i \neq j \qquad (3)$$

where

m_{ij} denotes the number of persons in region i at the beginning of the t^{th} time period who are in region j at the end of the t^{th} period;

$x_j(t)$ is the population of the region at the beginning of the t^{th} period;

P_{ij} is the number of persons in region i as a proportion of the total population of all regions excluding j; and

c_{ij} denotes the characteristics of the migrations from j to i, depending on the two regions.

It is clear that the population of region i at time t + 1 (end of the t^{th} period) is:

$$x_i(t + 1) = x_i(t) + \sum_{j \neq i} m_{ji}(t) - \sum_{j \neq i} m_{ij}(t) \qquad (4)$$

which expresses that the magnitude of population in region i at the end of the period is the magnitude at the beginning of the period plus immigration, less emmigration.

3.3.a Comments on the Emmigration Rate

We first must notice that the emmigration rate is changing with t:

$$\frac{\sum_{i\neq j} m_{ji}(t)}{xj(t)} = \frac{\sum_{i\neq j} P_{ij}(t)\cdot c_{ij}\cdot x_j(t)}{xj(t)}$$

$$= \sum_{i\neq j} \frac{x_i(t)\cdot c_{ij}}{P - x_j(t)}$$

where

$$P = \sum_e x_e(t) \quad .$$

It is really important because it is possible to have a growing rate of emmigration and a decrease of regional population.

3.3.b The Equilibrium

The equilibrium will be:

$$\sum_{i\neq j} m_{ji}(t) = \sum_{e\neq j} m_{ej}(t) \quad .$$

It expresses the equality between immigration and emmigration for each region. It can be expressed by:

$$\forall j : \sum_{i\neq j} p_{ij}(t) c_{ij} x_j(t) = \sum_{e\neq j} p_{je}(t) c_{je} x_e(t)$$

$$\forall j : \sum_{i\neq j} \frac{x_i(t)}{P - x_j(t)} c_{ij} x_j(t) = \sum_{e\neq j} \frac{x_j(t)}{P - x_e(t)} c_{je} x_e(t) \quad .$$

We have two cases:

1) $x_j(t) = 0$, where we reach an equilibrium with an empty region, and

2) $x_j(t) \neq 0$.

Then we have:

$$\sum_{i \neq j} \frac{x_i(t)}{P - x_j(t)} = c_{ij} = \sum_{e \neq j} \frac{c_{je} x_e(t)}{P - x_e(t)}$$

Both these expressions are strictly positive numbers by definition of c_{ij} and x:

$$x_j(t) = \frac{P - \sum_{i \neq j} x_i(t) c_{ij}}{\sum_{e \neq j} \frac{c_{je} x_e(t)}{P - x_e(t)}}$$

and,

$$c_{ij} = \frac{m_{ji}(to)}{p_{ij}(to) x_j(to)}$$

$$\frac{c_{ij}}{c_{ji}} = \frac{m_{ji}(to)}{m_{ij}(to)} * \frac{p_{ji}(to)}{p_{ij}(to)} * \frac{x_i(to)}{x_j(to)}$$

$$\frac{c_{ij}}{c_{ji}} = \frac{m_{ji}(to)}{m_{ij}(to)} * \frac{P - x_j(to)}{P - x_i(to)} = K_{ji}$$

$$x_j(t) = \frac{1}{\sum_{e \neq j} \frac{c_{je} x_e(t)}{P - x_e(t)}}$$

$$= \sum_{e \neq j} \left[\frac{c_{je} x_e(t)}{P - x_e(t)} \left(P - K_{je} P - K_{je} x_e(t) \right) \right]$$

if we have:

$$x_e(t) \leq P \frac{(K_{je} - 1)}{K_{je}} \quad \forall_e \; , \; e \neq j$$

then

$$x_j(t) \leq 0 \quad .$$

We are now in the same position as in case 1) because our calculation is true only in the case where $x_j \geq 0$ by definition of x_j, and then $x_j(t) = 0$. We must demonstrate that it is possible to obtain $x_j(t) = 0$. The following case with three regions

$$x_1(to) = x_2(to) = x_3(to) = \frac{P}{3}$$

$$\frac{m_{13}}{m_{31}} = 2 + \varepsilon \quad ,$$

$$\frac{m_{23}}{m_{32}} = 2 + \varepsilon \quad ,$$

gives equilibrium if $x_3(t) = 0$.

It is interesting to note that if a region is empty, there is an equality between immigration and emmigration:

$$\sum_{i \neq j} m_{ji}(t) = \sum_{i \neq j} \frac{x_i(t)}{P - x_j(t)} c_{ij} x_j(t) = 0 \quad ,$$

if

$$x_j(t) = 0 \quad ;$$

$$\sum_{i \neq j} m_{ij}(t) = \sum_{i \neq j} \frac{x_j(t)}{P - x_i(t)} c_{ij} x_i(t) = 0 \quad .$$

The probability of having empty regions grows with the number of regions: indeed, it is more probable that we shall have strongly decaying regions when we consider many small regions.

3.4 Comparison of Markov and Kinematic Forecasts

We shall first make a comparison between the Markov and the Kinematic forecasts of migrations. We are working with data of the 25% sample made during the 1968 census in France, giving the migrations of the people of the twenty-two French regions during the period between the 1962 and 1968 census.

We continue the tendencies of the migrations of this period from 1968 until 1986, using both the Markov and Kinematic methods. The results are given in Table 1. The first two columns are the projected net migrations between 1968 and 1986 using Markovian and Kinematic methods. The third column is the ratio of the regional 1986 populations found by the two calculations.

The regional differences in migration flows are quite significant, differing by up to 30%, particularly in regions with a low net migration. Still the total regional population is practically the same at the end of the eighteen years, with a range of over five per thousand.

It must be noted that the regions which are underestimated by the Kinematic method as opposed to the Markov method are generally those of the Centre East and the Southeast. These regions strongly exchange their migrations between themselves. The net migration figure for the Kinematic model results in the emmigrations of these regions being in proportion to their size, but the sharing of national immigration is more evenly distributed. If we make a partition between the Southeast and the rest of France, we find the Kinematic method gives a growing emmigration from the South to the rest of France and a decreasing immigration from the rest of France to the South. The Markov method gives another figure: a growth of emmigration from the Southeast, a gradual decrease of immigration from the rest of France to the Southeast, and a very strong growth of migration between the regions of the South.

The Kinematic model gives us a figure such as Figure 3.

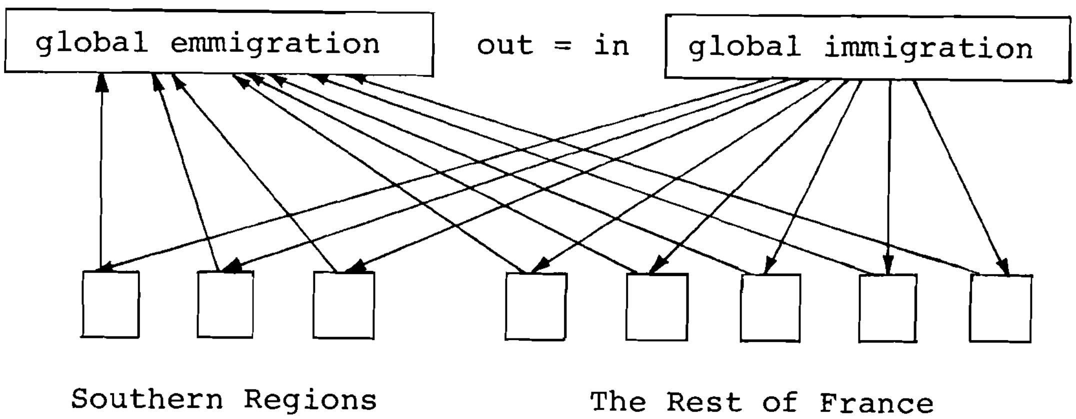
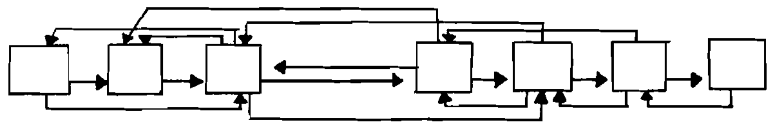


Figure 3.

Table 1. Net migrations 1968-1986.

Region		Markov	Kinematic	$\frac{P_{i,86,Kin}}{P_{i,86,Mark}}$
Région Parisienne	(RP)	89,410	84,450	.999
Champagne-Ardennes	(C-A)	-30,800	-29,220	1.001
Picardie	(Pic)	-2,900	-2,030	1.001
Haute Normandie	(HN)	-9,780	-9,730	1.000
Centre	(C)	97,690	93,860	.998
Basse Normandie	(BN)	-52,830	-51,370	1.001
Bourgogne	(Bo)	-240	-3,570	.998
Nord	(N)	-195,650	-192,890	1.001
Lorraine	(L)	-116,370	-114,130	1.001
Alsace	(Al)	33,510	33,730	1.000
Franche Comté	(FC)	-10,615	-10,872	1.000
Pays de la Loire	(PDL)	-78,680	-72,060	1.003
Bretagne	(B)	-53,830	-57,620	.998
Poitou Charente	(PC)	-77,450	-76,060	1.001
Aquitaine	(Aq)	19,220	18,320	1.000
Midi Pyrénnées	(MP)	-25,720	-27,970	.999
Limousin	(Lim)	-8,415	-8,560	1.000
Rhônes-Alpes	(R-A)	219,320	208,690	.998
Auvergne	(Auv)	-22,510	-24,620	.998
Languedoc Roussillon	(LR)	7,200	1,610	.996
Provence-Côte d'Azur	(PCA)	222,720	211,540	.996
Corse	(Cor)	-4,501	-5,501	.995

But the Markov model shows a different figure (see Figure 4).



Southern Regions The Rest of France

Figure 4.

The direction of the arrows gives the direction of the flow of migration.

We see here very clearly that in the Kinematic model one growing region increases the share of its emmigration over the global moving population, but nothing changes in its share of the immigration. This is not true of the Markov model: indeed, in this case, region i has no power to increase its share over the immigration, but the other regions can emmigrate more people globally, and if one increasing region has emmigrations into region i, the immigration in i increases proportionally to the size of region j. Then, with the Markov model, the growth of each region in the Southeast increases the emmigration of these regions, but the exchange of people is strong, and therefore the immigration to these regions grows accordingly.

3.5 Comparison of Kinematic and Feeney Forecasts

With the data of the 1954-1962 census (see [1]) a calculation was made using both methods. The results (see Table 2) are not greatly different; they differ rather more from the Markov-Kinematic projections because the differences in the global regional population can be more than 1% (for example, Bretagne or Alsace in 1980). To be fair we must indicate that we do not use a real Feeney model because Feeney used six age classes. But we use Feeney's principle for the study of migrational trends.

4. Comparison with An INSEE Extrapolation

The INSEE (see [4]) makes its extrapolation on the basis of a 25% sample of the 1968 census (see [2]).

The method proceeds as follows:

a) calculation of the population of each zone in 1974, with the hypothesis of constant fertility but not taking migration into account;

b) calculations, thereafter, of migration and induced births; and

Table 2. Percentages of French population in each region.

	1962	1974 Kin.	1974 Feeney	1980 Kin.	1980 Feeney	1986 Kin.	1986 Feeney	1998 Kin.	1998 Feeney
RP	17.90	19.16	19.02	19.72	19.58	20.24	20.13	21.16	21.22
C-A	2.63	2.55	2.56	2.51	2.52	2.47	2.48	2.41	2.40
Pic	3.26	3.20	3.21	3.18	3.18	3.16	3.16	3.11	3.10
HN	3.08	3.07	3.07	3.06	3.06	3.06	3.05	3.04	3.03
C	4.06	4.05	4.05	4.04	4.04	4.04	4.03	4.03	4.02
BN	2.68	2.49	2.50	2.40	2.42	2.33	2.33	2.20	2.16
Bo	3.14	3.08	3.08	3.05	3.06	3.03	3.03	2.98	2.98
N	8.05	7.86	7.98	7.77	7.80	7.68	7.72	7.51	7.55
L	4.64	4.61	4.61	4.60	4.60	4.59	4.58	4.56	4.55
Al	2.85	2.84	2.85	2.83	2.86	2.83	2.86	2.82	2.86
FC	2.02	2.01	2.01	2.01	2.01	2.01	2.01	2.00	2.00
PDL	5.46	5.24	5.26	5.14	5.17	5.05	5.07	4.88	4.88
B	5.30	4.94	4.99	4.77	4.83	4.62	4.68	4.35	4.38
PC	3.19	3.05	3.07	2.99	3.00	2.93	2.94	2.83	2.82
Aq	4.98	4.94	4.94	4.92	4.92	4.90	4.90	4.87	4.85
MP	4.42	4.31	4.32	4.25	4.26	4.20	4.21	4.11	4.10
Lim	1.62	1.56	1.56	1.53	1.53	1.50	1.50	1.45	1.44
R-A	8.58	8.82	8.78	8.94	8.88	9.05	8.98	9.25	9.18
Auv	2.79	2.72	2.72	2.68	2.69	2.65	2.65	2.59	2.58
LR	3.25	3.16	3.17	3.11	3.12	3.07	3.08	3.00	2.99
PCA	5.70	6.04	6.01	6.19	6.17	6.34	6.33	6.60	6.67
Cor	0.37	0.32	0.32	0.29	0.30	0.27	0.27	0.24	0.24

c) calculation of migrations with foreign countries by zone.

The zones are founded on ZPIU or "zones de peuplements industriel urbains." Taking certain regroupings into account and, for each region, all the communities outside ZPIU gives a total of 181 migration zones. INSEE includes data on the population by age and sex and data on foreign migrants for each zone. The calculations of migration between the zones estimate the immigrations, the emmigrations, and the steady population in each zone by cohort ages of five years. But a more general table estimating the migrations of yearly age groups between the five large groups of zones (Paris; ZPIU of more than 60,000 inhabitants; ZPIU between 20,000 and 60,000 inhabitants, ZPIU of less than 20,000 inhabitants; and non-ZPIU) gives an estimate of the population by yearly age group.

Several calculations were made with the aim of approximating the regional results of INSEE. We estimated the migrations by the Kinematic model only; the result, as we have seen, was not far off from the result of the Markov model, and the estimate was more easily reached using the Kinematic method. Our calculations were made in the following order:

1) migration alone, kinematic;

2) natural growth by region;

3) migration and natural growth;

4) migration, natural growth, and estimates of the change in the natural growth of regional population;

5) foreign net-migration; and

6) items 1) - 5) plus an attempt to integrate the changing age structure due to migrations.

4.1 Migration Alone, Kinematic

We used the data of the 25% sample of the 1968 census. But, different from INSEE, we worked only at the aggregated level of the twenty-two French regions. This calculation is made by using the Kinematic method the same way as reported in Section 3.4 above.

The only difference with regard to the previous computation is that to compare INSEE's regional population to the national population, the national population cannot be, in itself, too dissimilar. In fact, the INSEE computation leads to an increase in the French population of more than 18%, whereas our migration calculations are made at constant national population. Then we shall simply multiply each regional population by approximately 1.18, thus implicitly assuming that there are no spatial variations in fertility.

For input data we need:

$P_{i,68}$:	population of each region i in the year 1968	22
	global emmigration for each region i between 1962-1968	22
	global immigration for each region i between 1962-1968	22
	an estimate of the French population in 1986	1
	Total number of data entries	67.

The results are summarized in Table 3.

4.1.a Remarks

This calculation particularly favors the regions of old population with a low birthrate; in fact, our calculation attributes to each region a natural and uniform annual growth of 0.94%. One estimate of this type lacks exactness since the error in the 1968 population forecast can reach and exceed 10%. It is therefore necessary to include some approximate measure of the spatial variations in fertility.

But we can see, however, by this result that the regions with high natural growth are the Northeast quarter of France plus the Lyon-Grenoble region. The three other quarters have (or will have during this period) a lower natural growth rate than the rest of France. It is of course the more economically powerful and more urbanized regions that have a high natural growth rate owing to the migration pressure of young people. But this is not incompatible with the fact that in the case of France the fecundity of women decreases with the size of the city. It is clear that the migrations give a bad estimate of the regional population and we shall compare this with the case where only the natural growth is taken into consideration.

4.2 Natural Growth by Region

For input data we need:

d_i:	the natural growth in 1971 in each region	2 × 22
$P_{i,68}$		22
$P_{F,86}$:	the population of France in 1986	1
	Total number of data entries	67 .

Table 3. Kinematic versus INSEE projections.

	Percent of increase: Kinematic projection, 1968-1986	Percent of increase: INSEE projection, 1968-1986	Regional projection $\frac{P_{i,86,Kin.}}{P_{i,86,INSEE}}$	Ratio of change $\frac{\text{Kinematic}}{\text{INSEE}}$
RP	19	29	.92	.65
C-A	16	19	.98	.84
Pic	19	22	.97	.85
HN	18	22	.97	.83
C	25	20	1.03	1.23
BN	14	11	1.02	1.23
Bo	19	12	1.06	1.50
N	13	16	.97	.76
L	12	18	.92	.68
Al	22	23	.99	.96
FC	17	20	.98	.88
PDL	16	14	1.01	1.10
B	16	9	1.06	1.71
PC	13	4	1.08	2.97
Aq	19	11	1.09	1.70
MP	17	7	1.09	2.38
Lim	19	-1	1.19	-1.38
R-A	24	26	.98	.92
Auv	16	6	1.10	2.83
LR	17	13	1.04	1.38
PCA	25	19	1.05	1.32
Cor	14	10	1.03	1.40

4.2.a Calculation

$$P_{it} = P_{i,86} \, (1 + d_i)^t$$

and

$$P_{i,86} = P_{i,86} \left[\frac{P_{F,86}}{\sum_i P_{i,86}} \right]$$

which is the normalization of the population of France by INSEE.

4.2.b Remarks

The following computation (see Table 4) excludes the growth or decline of regions due to net migration. It is interesting to note that this estimate is globally more exact than those based only on migrations. This occurs because eighteen years is a relatively short time period and migrations do not generally change the demographic structure of a country in this short a period of time.

But it is surprising to note that some of the regions are underestimated and others overestimated by both calculations. At the same time, the total French population is underestimated in comparison to INSEE in 1986. This is probably so because the "baby boom" of 1946-1950 has not really affected the birthrate of 1971, and the increase in the birthrate must in reality be greater than simple extrapolation of the 1962-1968 trend would allow. (The reality is different because since 1973 France has been following a strongly decreasing birthrate curve similar to the FRG, but having begun several years later.)

At this time it is normal that the regions which cumulate a strong birthrate and immigration of young people (Paris for example) are underestimated. But the interpretation of the difference between INSEE's results and our calculation is more difficult than in the previous case.

4.3 Migration and Natural Growth

This calculation combines the two preceding calculations, migrations and natural growth, in the following way: for a three year period we

- calculate the migrations,

- calculate the natural growth of the population after migration,

Table 4.

	Percent of change Natural increase 1968-1986	INSEE 1968-1986	$\frac{P_{i,86}}{P_{i,86,INSEE}}$	Natural increase INSEE
RP	22	29	.95	.76
C-A	22	19	1.03	1.18
Pic	22	22	1.00	.98
HN	24	22	1.02	1.10
C	16	20	.97	.82
BN	21	11	1.08	1.82
Bo	13	12	.99	1.05
N	23	16	1.06	1.39
L	23	18	1.04	1.27
Al	17	23	.96	.77
FC	23	20	1.02	1.15
PDL	24	14	1.08	1.66
B	16	9	1.06	1.74
PC	16	4	1.11	3.66
Aq	12	11	1.00	1.04
MP	11	7	1.04	1.54
Lim	4	-1	1.05	-2.80
R-A	20	26	.95	.76
Auv	10	6	1.04	1.75
LR	10	13	.98	.79
PCA	12	19	.94	.64
Cor	8	10	.98	.40

Result: Population of France: 55,460 (INSEE: 58,843)

- iterate (and we iterate six times), and we
- multiply by a coefficient to obtain the population of $P_{i,86}$.

For this we need:	Number of Data Entries
for the regional population	22
for migrations	44
for natural growth	44
for the French population	1
Total number of data entries	111 .

The results are shown in Table 5.

4.3.a Remarks

We have reduced the difference between our projection and the INSEE population of the global population to ≃ + 6%. It is not a good result, but for nine regions the differences of the populations of the change are less than 10%. It is clear that one improvement must eventuate with a better appreciation of the natural increase of the population because the French population in 1986 seems badly projected. We have already explained why this is so, and we shall calculate now one adjustment in the natural growth taking into account the expected increase of the birthrate beginning with the second generation after World War II.

4.4 Migration, Natural Growth, and Estimates of the Change in the Natural Growth of Regional Population

The projected natural growth in France will increase if the fertility stays steady. The calculation made by INSEE [1] gives increasing birthrates until 1980 and thereafter the rates decrease (see Table 6).

Table 6.

	1968	1970	1975	1980	1985	1990
birthrate %	16.7	17.1	18.2	18.5	18.1	17.6
death rate %	10.8	10.7	10.5	10.3	10.1	10.0

Table 5.

	Percent of change 1962-1986 by Calculation	INSEE	$\frac{P_{i,86}}{P_{i,86,INSEE}}$	$\frac{\text{Calculated variation}}{\text{Variation INSEE}}$
RP	23	29	.95	.78
C-A	20	19	1.01	1.04
Pic	22	22	.99	.99
HN	23	22	1.01	1.07
C	23	20	1.02	1.14
BN	17	11	1.04	1.43
Bo	14	12	1.01	1.11
N	17	16	1.00	1.01
L	21	21	.99	.92
Al	21	21	.98	.92
FC	21	20	1.01	1.08
PDL	20	14	1.05	1.43
B	15	9	1.05	1.53
PC	11	4	1.06	2.47
Aq	13	11	1.02	1.16
MP	10	7	1.03	1.39
Lim	4	-1	1.06	-3.20
R-A	26	26	1.00	.98
Auv	9	6	1.03	1.55
LR	10	13	.98	.78
PCA	19	19	1.00	1.01
Cor	5	10	.95	.45

Result: Population of France: 55,400 (INSEE: 58,843)

It is useless to establish that this projection is wrongly specified because since 1973 the birthrate has been decreasing strongly. The INSEE projection, which we try to approximate, incorporates the principle that all trends in the 1962-1968 period are the same in the future.

We must note that the global population of France, given by extrapolation at the aggregate level of the French population following the aggregate level of the French population following the aggregate trends of the natural growth (Table 5), is 56.8 million people, whereas the calculations that we perform give a population of 58.8 million. INSEE explains this difference of two million by the foreign migrations, and, secondarily, by the hypothesis of constant fertility at one disaggregate level.

4.4.a The Calculations

We perform the previous calculations, but at each period of three years we change both birth- and death rates by one coefficient which is the ratio between national birth- and death rates of the period over that of the previous period. The results are found in Table 7.

4.4.b Remarks

We can see that the results are dismayingly near to those of the previous calculation. This is amazing because the approximation of the global French population is now better, and we could have expected a big change in the results at the regional level. But, in fact, we reduced the death rate and increased the brithrate in similar proportion; if we note that the regions with a low birthrate have a high death rate and vice versa, we can understand that the result of the change in both birth- and death rates induced small changes in the size of the regional populations. Now we shall try to improve our regional assumptions by the integration of the foreign migrations which must add again around 2% of the population to the French territory.

4.5 Adjustment for Foreign Migration

Two hypothetical situations will now be examined: annual growth of the number of foreigners at 140,000 and at 110,000. The actual growth rate of the number of foreigners during the last decade is 140,000. The number 110,000 takes into account that if the number of immigrations can be considered constant, the number of emmigrations is related to the number of foreigners living in France. Thus the number of emmigrations would increase, and this could involve an average yearly growth of 110,000 over the next few decades (see Table 8).

Table 7.

	Percent of change 1962-1963 Our calculation	INSEE	$\frac{P_{i,86}}{P_{i,86,INSEE}}$	$\frac{\text{Calculated variation}}{\text{INSEE variations}}$
RP	23	29	.95	.77
C-A	20	19	1.01	1.04
Pic	22	22	.94	1.00
HN	23	22	1.01	1.06
C	23	20	1.02	1.15
BN	17	11	1.04	1.44
Bo	14	12	1.01	1.12
N	17	16	1.00	1.03
L	17	18	.99	.92
Al	21	21	.98	.92
FC	21	20	1.01	1.08
PDL	20	14	1.05	1.41
B	15	9	1.05	1.59
PC	11	4	1.06	2.47
Aq	13	11	1.02	1.16
MP	10	7	1.03	1.39
Lim	5	-1	1.06	-3.78
R-A	26	26	1.00	.98
Auv	9	6	1.03	1.56
LR	10	13	.98	.79
PCA	19	19	1.00	1.00
Cor	5	10	.95	.50

Result: Population of France: 56,831 (INSEE: 58,843)

Table 8. Annual foreign immigrations of 110,000.

	Percent of Change: Our calculation	Percent of Change: INSEE	$\frac{P_{i,86}}{P_{i,86,INSEE}}$	$\frac{(1986-1968)}{(1986-1968)\ INSEE}$
RP	28	29	.97	.87
Ç-A	19	19	1.00	1.01
Pic	21	22	.99	.92
HN	21	22	.99	.96
C	22	20	1.01	1.07
BN	13	11	1.02	1.16
Bo	13	12	1.01	1.07
N	16	16	1.00	.97
L	17	18	.99	.96
Al	20	23	.99	.90
FC	21	20	1.01	1.08
PDL	17	14	1.02	1.20
B	11	9	1.02	1.19
PC	8	4	1.03	1.81
Aq	12	11	1.01	1.06
MP	9	7	1.02	1.31
Lim	3	-1	1.04	-2.00
R-A	27	26	1.01	1.03
Auv	8	6	1.02	1.43
LR	11	13	.98	.85
PCA	21	19	1.02	1.11
Cor	12	10	1.02	1.25

Result: Population of France: 58,821 (INSEE: 58,843)

For input data we need:

$P_{i,68}$	22
$Emmig._{i,62-68}$	22
$Immig._{i,62-68}$	22
Birthrate	22
Death rate	22
Foreign population in 1968 in each region	22
French population in 1986	1
National birth- and death rate in six periods of time	12
Increase of the foreign population	1
Total number of data entries	146 .

By this computation we have eleven regions within a range of 10% calculated on the growth of population from 1968 to 1986. However, two out of four of the more populated regions are situated outside this margin: la Provence and the Région Parisienne.

Only five regions have a difference with the INSEE calculation of more than 20%; they are Limousin, Poitou Charente, Auvergne, Midi Pyrénnées, and Corse. These are the regions located in the Southwest and Central South of France and they are characterized by a very low rate of demographic growth and negative migrations, particularly due to the negative net migrations of working populations.

Next, only four regions are more poorly estimated than the above five: Picardie, Alsace, Rhônes-Alpes, and Provence-Côte d'Azur. These are regions that are strongly increasing economically, and it is possible that they take a growing share in the foreign immigration; our estimate is founded on the foreign population by region at the beginning of 1973. Thus the regions with traditional trends of foreign immigration are overestimated (Région Parisienne, Lorraine, and Nord), and the newly economically powerful regions are underestimated. But if the global foreign population depends on political constraints, the trends of the movement of these people must be less stable in time than the national trend, and so the extrapolation of trends becomes less relevant. It is worth knowing that since 1973 the Région Parisienne has had a decreasing foreign population because industry is decreasing here. Finally, we must note the very good approximation of the French population: the difference is only 0.022 million of inhabitants, less than four in 10,000. If we take a foreign yearly immigration of 140,000 persons the result is very much the same, but the approximation to the national population is worse.

4.6 An Attempt to Integrate the Changing Structure of the Regional Population

To the last computation we add an attempt to change the structure of the regional population. It is obvious that migrations change the age-sex structure of the population. Our hypothesis takes into account the direct change by migration in birthrate but not the change in the second generation. We have no data on the age structure, only birth- and death rates.

We know also the net migration by regions of the working population (people between the ages of sixteen and sixty-five). It is clear that this is a bad indication, because the sixteen year olds are too young to affect the birthrate and the sixty-five year olds are too old. We really need the migrations of the people between the ages of twenty and forty to be able to build an efficient hypothesis. But, since "it is better to try and fail than to not try at all," we try to approximate the population with the following equation:

$$1 - \frac{\text{net migration of region i}}{\text{population of region i}} - \frac{\text{net migration of working pop.}}{\text{working population}} \cdot$$

This gives the coefficient of change of the birthrate in each three year period. We use exp $(-E_i T)$ because the Kinematic method uses this to slow the migration in time.

This equation means that if the working population grows faster than the general population, the region's birthrate should grow and vice versa. One must note that since we use three year periods, and that since the migrations are given over a six year period, our coefficients multiply the effect of a simple rate difference by two.

This hypothesis can be criticized strongly; for example, the Région Parisienne which has seen a positive and large working immigration population, mainly for those of childbearing age, should show a growth in its birthrate. It is, however, possible that this is an erroneous movement, erroneous because the Région Parisienne has benefited from the immigration of a very strong, active population for quite some time with a birthrate probably due to this. This equation itself is only an attempt, and it is easy to argue against. It would be interesting to look for a better equation, but our aim is to show only that it is possible to improve the model by integrating a hypothesis of structural change by age due to migration. We have no idea what hypothesis could be exact and logical with the data available.

If we study the result in Table 9, we see a small difference (10% margin) of the estimated change between the eighteen year period by both methods (our own and that of INSEE), and this for sixteen regions. But four regions remain outside this 10% margin. The regional populations in 1986 are roughly the same, but Languedoc Roussillon shows a strong difference.

This difference can be due to the very high migration rate of this region, a few migration modifications then having important consequences. This region has seen, in recent decades, an important emmigration of the rural population toward the urban centers of the region and also toward Marseilles and Lyon. Another reason for the difference can stem from the effects of the closeness of the Rhônes-Alpes and the Marseille regions, both of which have a marked growth. A final reason for the difference could be an error in the estimate of the foreign population which is particularly numerous in this region (over 10%). This error is due to our data on foreign population; for INSEE, data were for the period 1962-1968, but we extrapolated to the period 1963-1973. The trends here could be very different.

The differences between Limousin, Poitou Charente, and Auvergne can be of another order: the growth of these regions is weak, and so we can produce a good estimate of their growth; for these regions, the sudden inflow of 10,000 people involves a sensitive reevaluation of the growth estimate, but a reevaluation which is negligible on the total population itself. Next, we see that the estimate for Corse is relatively correct. This leads us to suppose that the hypothesis of the aging of the population due to migrations is perhaps not sufficient. One must also note the weak rate of urbanization in these regions.

4.7 Comparison of Estimates for 1975 and 1980

We have made the final calculation for 1975 and 1980, this to see if the relative accuracy of our 1986 estimate (compared to that of INSEE) was due to coincidence. This was not likely considering the number of regions correctly reached, though it was possible. However, as Table 10 shows, this was not so. One must note that there is a relatively strong modification in the growths of 1980 and 1986, due most probably to the considerable growth of the birthrate for the 1980's. Table 10 gives our and INSEE's ratio of calculated change during the time period between 1975, 1980, 1986, and for the year 1968.

It is not reasonable, with the data used, to try to approximate a stated extrapolation made with a large amount of data and many calculations. It is time to remind ourselves of the goal of this study, to find an easy method to allow testing of

Table 9. Immigration of 110,000 foreigners per year.

	Percent of change Δ	Δ INSEE	$\frac{P_{i,86}}{P_{i,86,INSEE}}$	$\frac{\Delta}{\Delta\ INSEE}$
RP	30	29	1.01	1.03
C-A	19	19	1.00	.98
Pic	19	22	.98	.87
HN	21	22	.99	.96
C	20	20	.99	.97
BN	12	11	1.00	1.00
Bo	12	12	1.00	.96
N	15	16	.99	.94
L	17	18	.99	.96
Al	21	23	.99	.92
FC	21	20	1.01	1.06
PDL	16	14	1.01	1.11
B	9	9	1.00	.95
PC	6	4	1.02	1.41
Aq	10	11	.99	.91
MP	7	7	1.00	1.03
Lim	1	-1	1.02	-.90
R-A	27	26	1.01	1.03
Auv	7	6	1.01	1.24
LR	9	13	.96	.67
PCA	20	19	1.01	1.06
Cor	10	10	1.00	1.00

Table 10.

	(75) / (75) INSEE	(80) / (80) INSEE	(86) / (86) INSEE
RP	.93	.95	1.03
C-A	.98	.97	.98
Pic	.95	.92	.87
HN	.96	.96	.96
C	1.07	1.06	.97
BN	1.06	1.03	1.00
Bo	1.03	1.02	.96
N	.99	.94	.94
L	.98	.94	.96
Al	.95	.95	.92
FC	1.07	1.07	1.06
PDL	1.13	1.10	1.11
B	1.12	1.09	.95
PC	1.56	1.45	1.41
Aq	.99	.99	.91
MP	1.12	1.13	1.03
Lim	--	-1.04	-.90
R-A	1.04	1.05	1.03
Auv	1.32	1.29	1.24
LR	.74	.76	.67
PCA	1.09	1.12	1.06
Cor	1.00	1.08	1.00

alternative policies using little data and few calculations. From this point of view the goal is achieved, since the computer used is a Hewlett Packard 9803, one of the smallest of computers, situated half-way between modern pocket calculators and full-size computers.

The amount of data is negligible:

- 22 data entries on the 1968 regional population;
- 44 data entries on the migration of population;
- 44 data entries on the migration of working population;
- 44 data entries on natural growth; and
- 22 data entries on the location of foreign population.

The method, however, is simple, easy to use, and the results are accurate for a large number of regions, only one being estimated badly. It is very easy to change the method and the facts slightly to test different hypotheses.

It is possible to say that our goal for this study has been achieved, despite reservations over the weaknesses of hypotheses on aging due to migrations; still, something more satisfactory must be done in this area.

5. Test of the Hypotheses

We have built a model of very simple usage, and with it we shall be able to test our hypotheses. Now we shall demonstrate how this is possible, and the results obtained.

5.1.a Hypothesis of the Trends of Immigration

This hypothesis has two sources for input data:

a) extrapolation from 1968 regional population and migratory currents noted during the 1954-1962 period; and

b) extrapolation from 1968 regional population and migratory currents that will exist if the perceived evolution between the census of 1962 and 1968 proceeds in similar fashion.

5.2 Comparison of 1962 and 1968 Census

The 1962 census measured changes which came between 1954 and 1962. The period between these censuses was eight years, while the period between the 1962 and 1968 censuses was only six years (see Figure 5). The comparison of these censuses is,

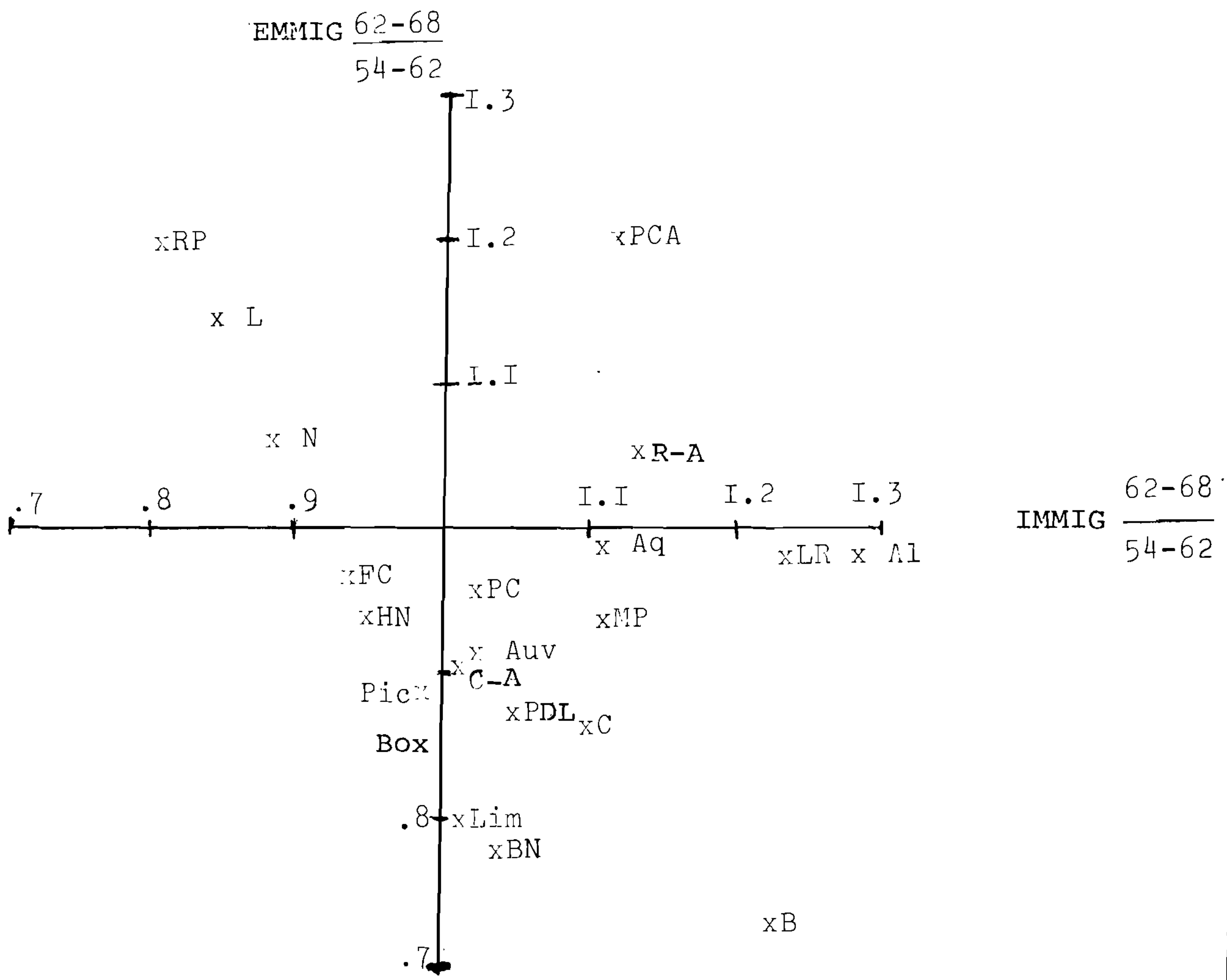


Figure 5. Change in the migrations between the census of 1962 and 1968. Plot of the ratios of immigration and emmigration.

however, facilitated by the fact that the global volume of migrations is comparable: slightly less than 3.3 million people in the two censuses.

From the comparison between these censuses, Nord, Lorraine, and the Région Parisienne emerge as being in a period of reconversion to deconcentration (their emmigration grew and their immigration declined), contrary to a large majority of predominantly rural regions and Alsace, where the emmigration declined and the immigration grew.

This can be explained by the rapid urbanization of these regions. The rural exodus can no longer be viewed in terms of national migratory currents; rather it must be in terms of regional currents (departure toward the neighboring medium-sized or larger city), these cities also being large enough to be attractive outside the region. Immigration is to grow from this fact (however, all these regions, except Alsace, have negative net migrations).

An interesting problem would be to try to discover if the migratory currents between neighboring regions grew more rapidly than the other migratory exchanges. The regions where the immigration and emmigration decreased simultaneously are those peripheral, not largely urbanized (except for the Haute Normandie region) regions of Paris. As rural regions, their emmigration decreased due to larger attraction of regional cities localized in neighboring regions.

On the one hand, deprived of large cities, they must have suffered from the Parisian deconcentration policy toward stable metropolises; on the other hand, they must have profited from the first wave of deconcentration toward the cities of the Bassin Parisien in the previous period.

The last two regions are those of Lyon and Marseille, dotted with attractive cities in a region of strong expansion. However, it must be noted that if immigration and emmigration have grown absolutely, the immigration and emmigration per capita have remained stable; indeed they follow the increasing size of the population.

5.3 Extrapolation of Tendencies Due to our Model

By the extrapolation of the changing trends between the two censuses, we have built a hypothetical census with new trends (see Table 11 and Figures 6, 7, and 8). The change in the noted migrations is favorable to demographic regional growth except for the four missing regions which are all (the Région Parisienne included) traditionally urbanized French regions. For the other three urban regions (Rhônes-Alpes, Midi Pyrénnées, and Alsace), the evolution can only be felt in Alsace.

Table 11.

1968 Regional population	Percent of change 1962 Census	1968 Census	Theoretical census Percent of Change
RP	41	30	18
C-A	14	19	21
Pic	16	19	23
HN	20	21	21
C	14	20	27
BN	3	12	20
Bo	9	12	15
N	17	15	12
L	22	17	16
Al	16	21	25
FC	21	21	20
PDL	11	15	19
B	-1	10	20
PC	5	6	6
Aq	8	10	13
MP	5	7	10
Lim	-3	1	6
R-A	26	27	29
Auv	5	7	9
LR	4	9	14
PCA	21	20	22
Cor	-12	10	33

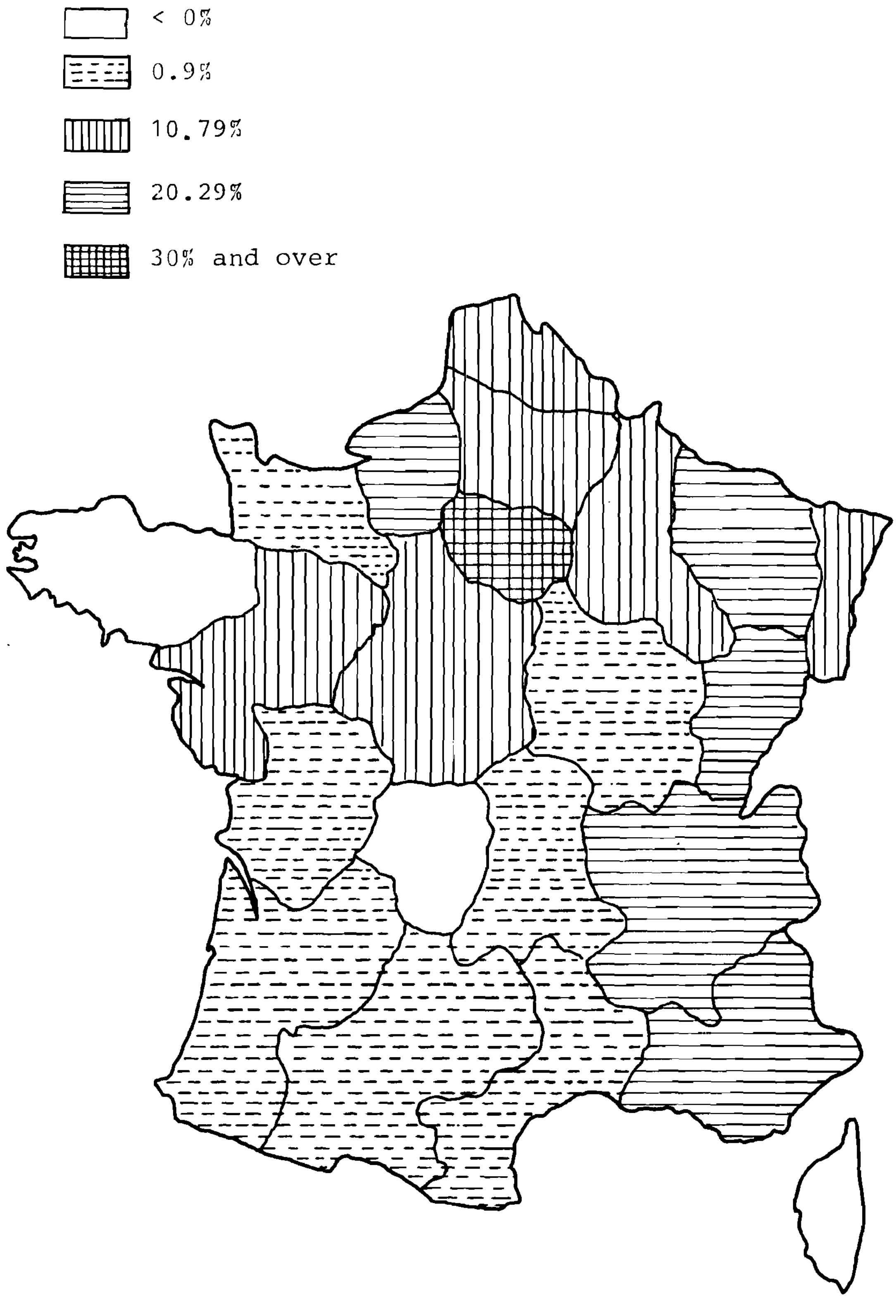


Figure 6. Regional growth between 1968 and 1986.
Trends of the 1962 census.

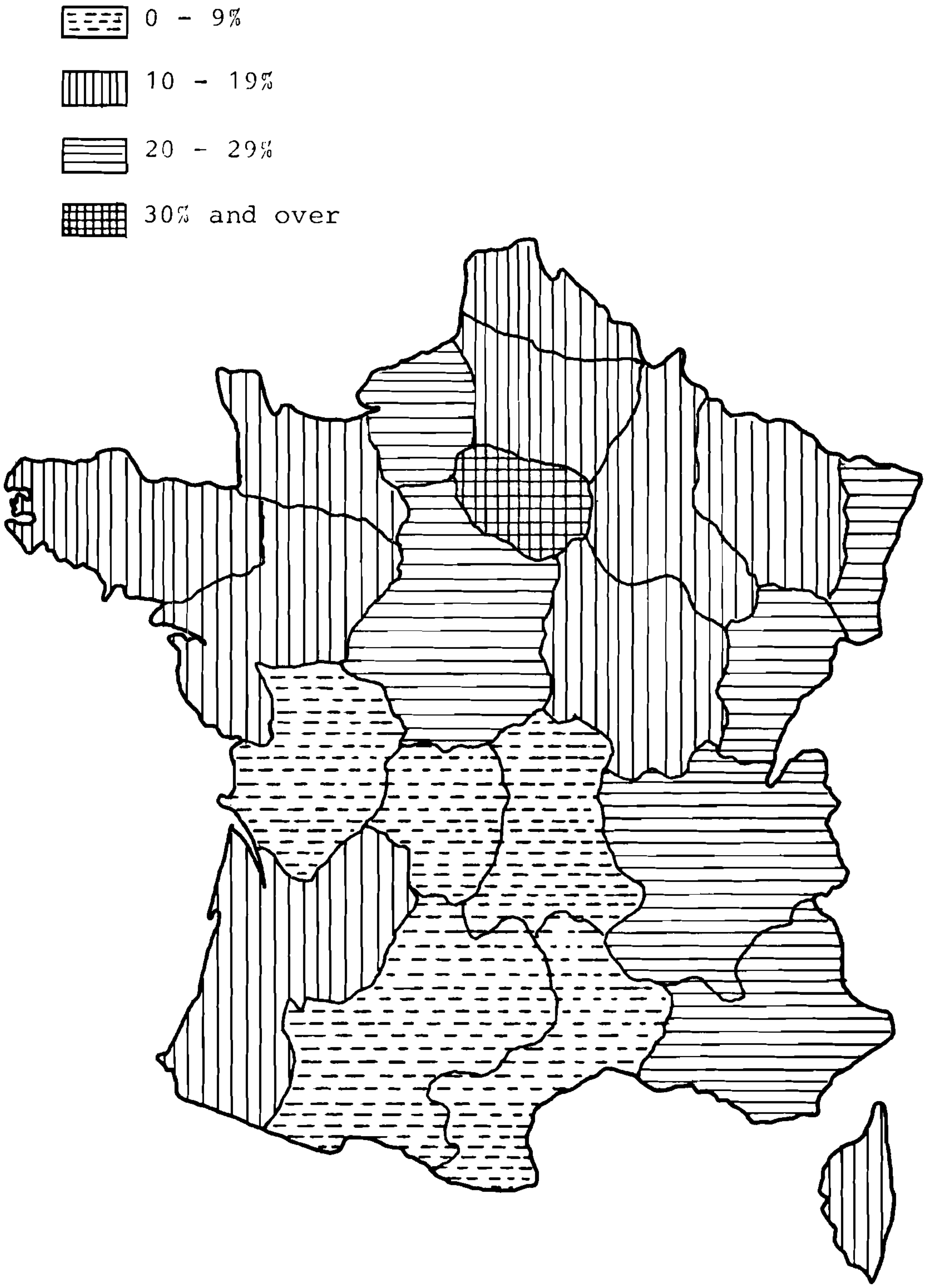


Figure 7. Regional growth between 1968 and 1986. Trends of the 1968 census.

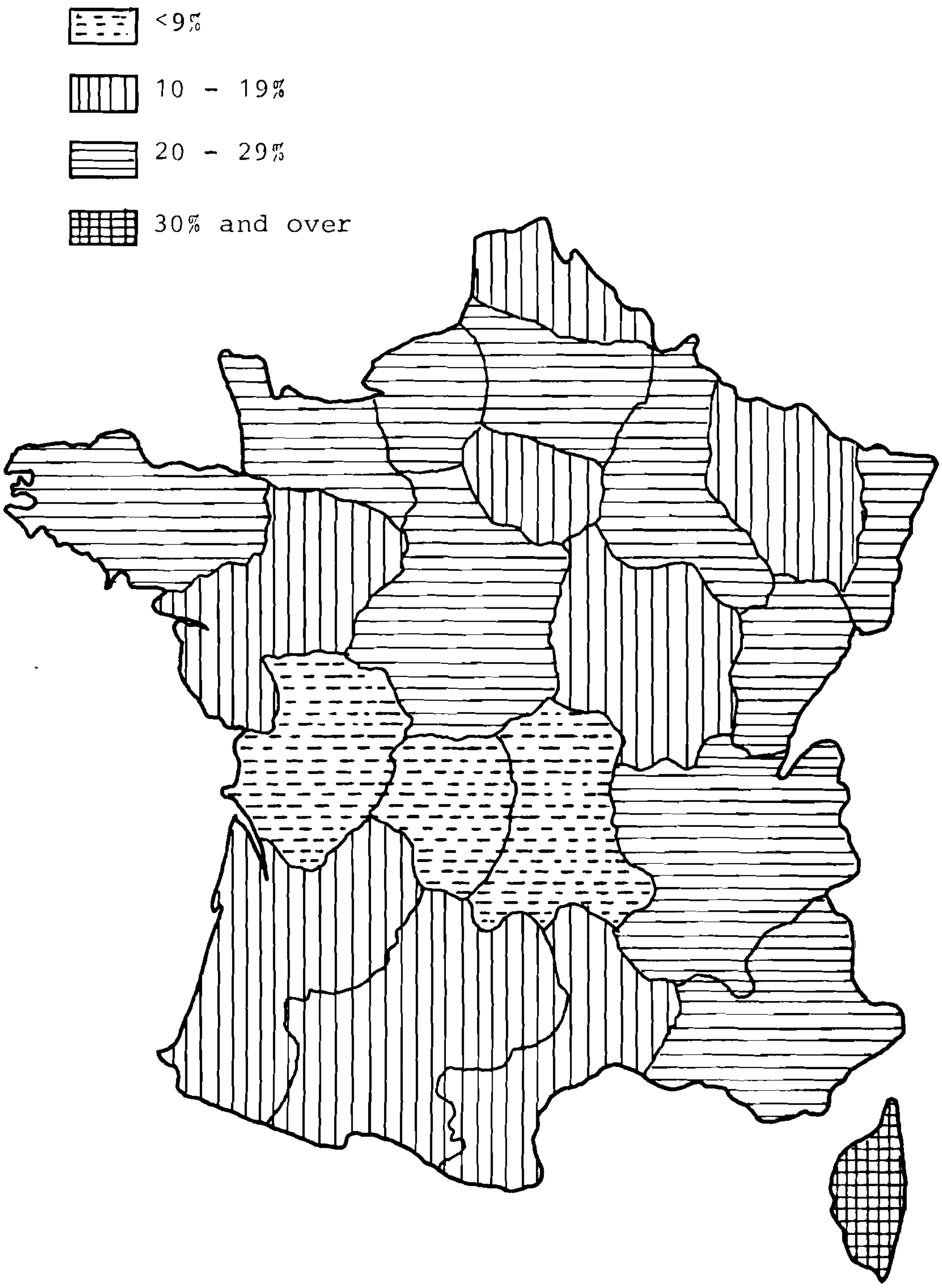


Figure 8. Regional growth between 1968 and 1986 with a hypothesis of trends of theoretical censuses.

One sees on the other hand, a more marked growth than the other regions, a growth that must be put on a parallel with the growth of cities in these regions, which causes them to swing little by little to urbanized regions. One must note the strong similarity in growth rates: some parts of the Southwest alone remain greatly below the national average. This calculation shows the great modification of French Eastern migrations. However, we must also note here that this is only a hypothesis from a prolongation of the change in trends.

5.4 Test of the Consequences of Two events

The above calculations attempted to discover the consequences of various evolutions in internal migrations in France. Here we shall see what could be the new figures for the French regional populations in the year 1986, if two new events, a decreasing birthrate and a steady foreign population, are stable trends.

The first calculations will be made with a foreign population ever growing at the same rate, and a national birthrate holding steady at 14.5 per thousand from 1974 to 1986. The birthrate is from 1973 and it is likely that this will be a higher rate than in reality. Fourteen and one-half percent is an average rate, of course, and each region has a rate calculated as follows:

$$\text{rate of region i in 1974} = \frac{(\text{rate of region i in 1971}) \cdot 14.5}{\text{National rate in 1971}} .$$

With a foreign immigration of 110,000 persons per year, and with these birthrates, the French population will be 2.6 million people fewer in 1986 than in 1968. If the foreign population remains at the same level between 1968 and 1986, the French population will then be 4.6 million fewer, or 4.5 million fewer than the extrapolation made by INSEE and studied above.[3]

This second hypothesis is quite possible. Indeed the foreign population of France in 1974 was 8% of the global population, and 9% of the people with French nationality. This

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[3]In this case, the decision of the Government (April 16, 1975) to reduce the growth of Paris between 1968 and 1986 by around two million inhabitants (giving a total of eleven million inhabitants in 1986) is not as good as it seems because the increase in this region would be the half of the national growth. In comparison, our calculations give a growth of less than 1.5 million for the Région Parisienne.

could result in strong limitations on the increase in the number of foreigners in France. Another reason this second hypothesis is possible is that the strong economic growth of France during the 1960's could be much slower during the following decades, and then the need for foreigners would be smaller.

A third reason supporting this hypothesis resides in the following: we say that the foreigners accept employment where the French would not, but this assertion is not totally true; indeed, foreigners accept employment that the French would not accept in some places, but accept in others. For example, at the Renault factory in Boulogne-Billancourt (Région Parisienne) approximately 20% to 30% of the workforce is made up of foreigners if we are to believe the newspapers, but at the Renault factory in Le Mans (Pays de la Loire) less than 1% of the workforce is made up of foreigners. Thus the economic crisis and national settlement policies can perhaps strongly reduce the need for foreign workers. Table 12 gives the percentage of population change between 1968 and 1986:

1) as projected by INSEE;

2) resulting from a reduced birthrate; and

3) the same as 2) plus steady foreign population.

It is interesting to note that with this low birthrate the demographic growth of some regions is not assured. It is thus possible that the struggle over national settlement policies will increase in the future because this policy was built in the past on the basis of a growing national population and economy. Both the population and the economy seem less likely to grow in the future (cf. Figures 9 and 10).

6. Conclusion

We shall not give a finer analysis of the results, as one can study this oneself and follow one's own interests. The prospect here was not to think specifically about France; rather it was to demonstrate that it is possible to build a very small, accurate model with easily changeable data in the program.

The model's accuracy was shown in Section 3. We found results very close to those obtained by INSEE, results which required a much larger amount of data (fine zonal division, a likely heavily structured program, and great amount of time and money, etc.).

The ease in changing some data and then the testing of different hypotheses was shown above. There, we tested four hypotheses; however, many more are possible. It is worth noting

Table 12.

	Percent of change		
	Hypotheses INSEE	Birthrate = 14.5	Birthrate = 14.5 Foreign = steady
RP	30	23	16
C-A	19	13	10
Pic	19	14	12
HN	21	15	13
C	20	15	13
BN	12	7	6
Bo	12	8	5
N	15	10	7
L	17	12	7
Al	21	15	12
FC	21	15	11
PDL	15	10	10
B	10	5	5
PC	6	2	1
Aq	10	7	4
MP	7	4	1
Lim	1	-2	-3
R-A	27	21	16
Auv	7	3	1
LR	9	6	1
PCA	20	16	10
Cor	10	7	-4

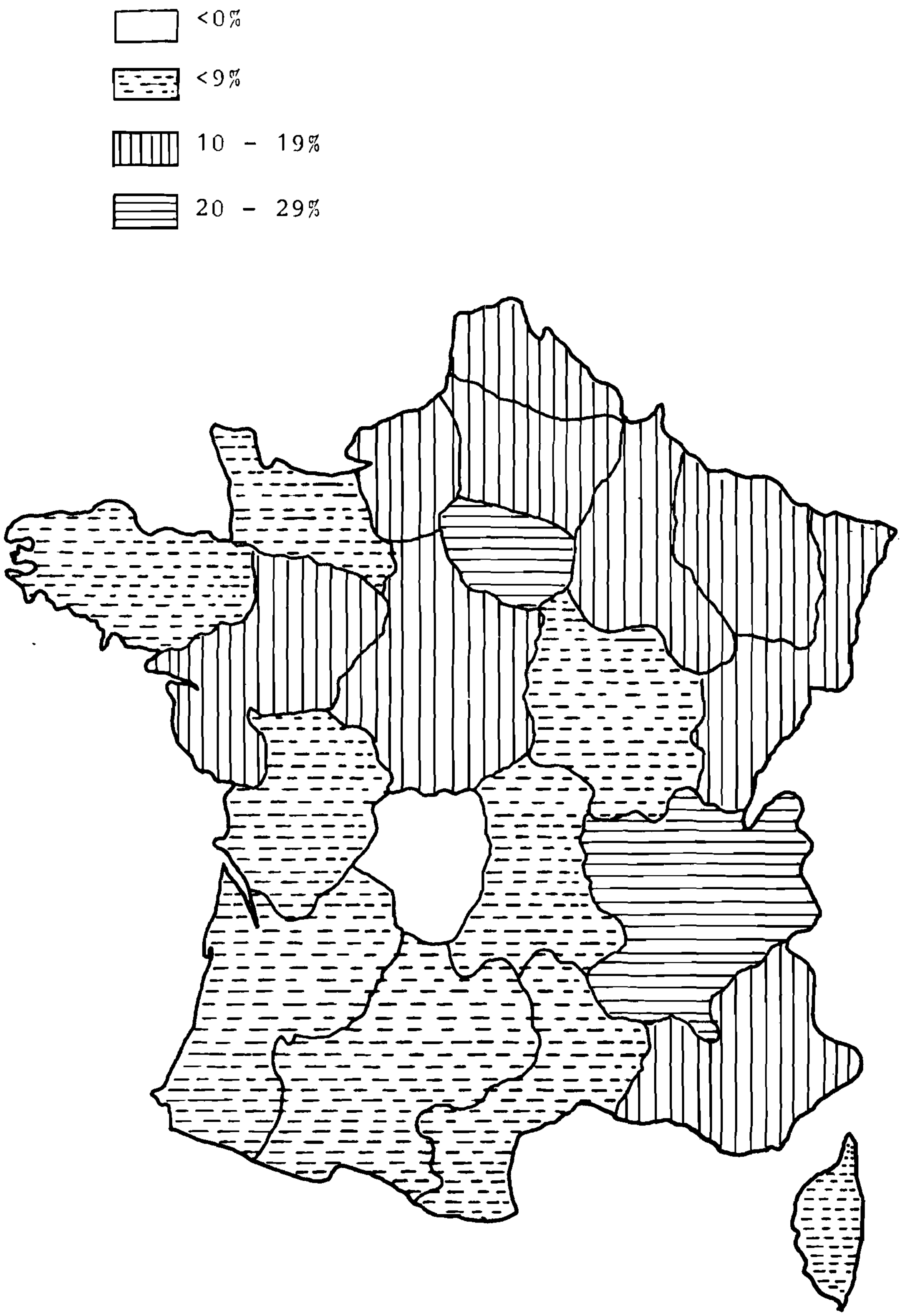

Figure 9. Regional growth between 1968 and 1986 with a 14.5% birthrate and a growing foreign population.

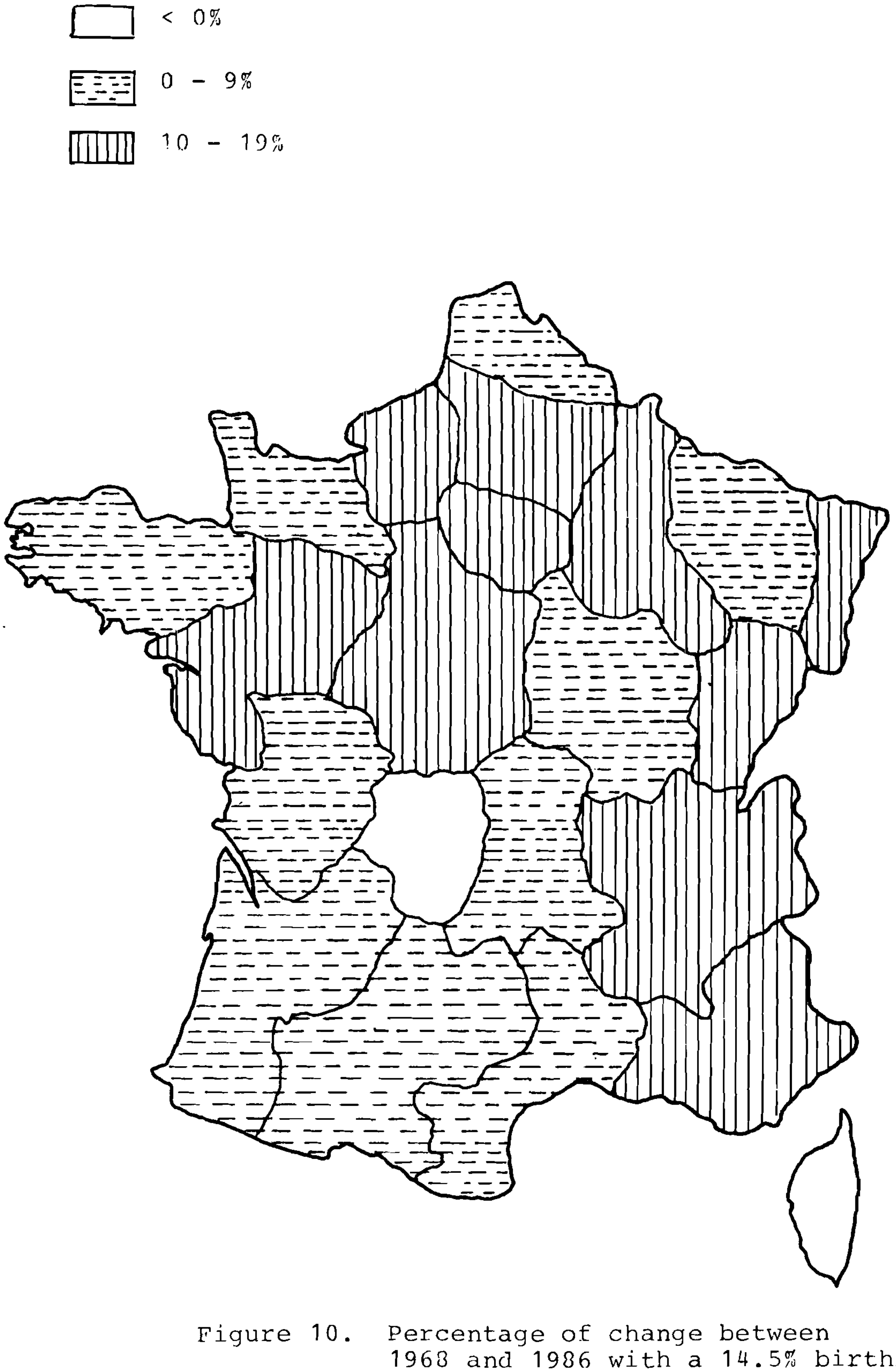

Figure 10. Percentage of change between 1968 and 1986 with a 14.5% birthrate and a stable foreign population.

that calculations for each hypothesis took, on the whole, less than half an hour using a Hewlett Packard 9308. Both the data and statement change and the running time are included in this half hour, demonstrating that the study of each of these hypotheses is quite simple.

APPENDIX

Flow Chart

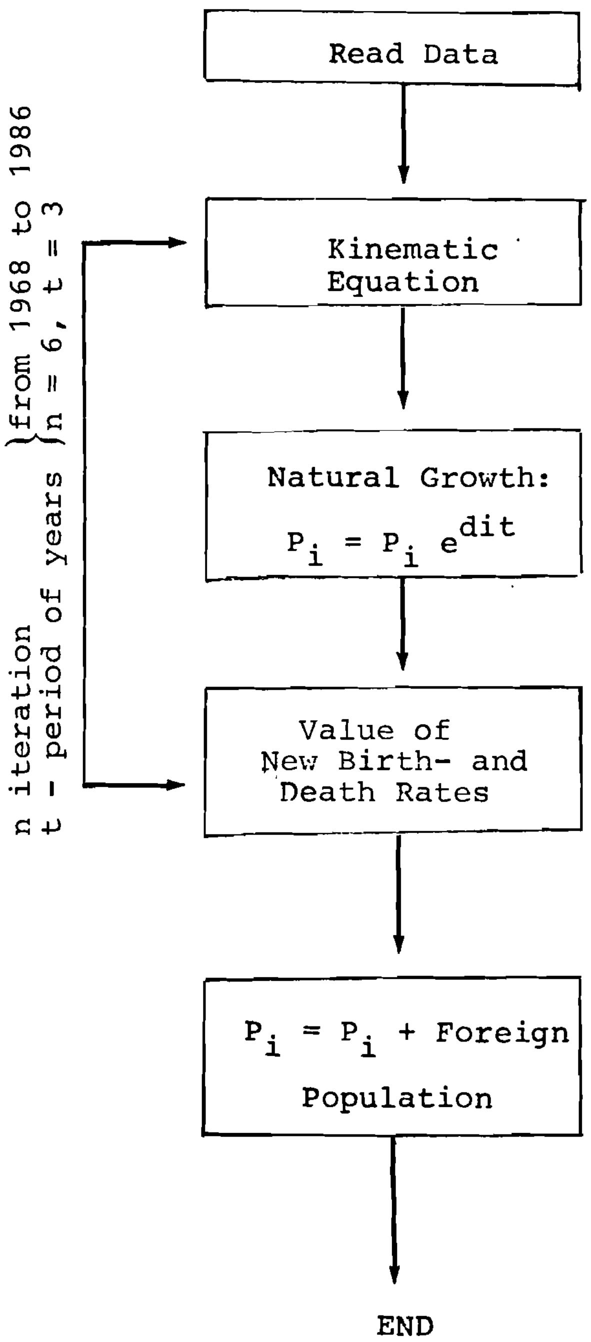

Table 13. Migrations.

	Million inhabitants (1968)	Million inhabitants (1986) INSEE	Census 1962 - 1963 (Total population)	
			IMMIG	EMMIG
RP	9.248	11.967	.722	.684
C-A	1.280	1.523	.093	.105
Pic	1.575	1.925	.132	.132
HN	1.497	1.823	.101	.104
C	1.988	2.387	.195	.155
BN	1.262	1.407	.090	.111
BO	1.504	1.691	.122	.123
N	3.824	4.455	.093	.164
L	2.278	2.692	.101	.146
Al	1.411	1.728	.067	.054
FC	.994	1.191	.063	.067
PDL	2.590	2.958	.141	.169
B	2.472	2.706	.131	.153
PC	1.479	1.543	.099	.130
Aq	2.461	2.741	.163	.155
MP	2.186	2.339	.127	.137
Lim	.738	.729	.054	.057
R-A	4.418	5.579	.256	.177
Auv	1.314	1.391	.080	.089
LR	1.707	1.921	.126	.124
PCA	3.288	3.917	.271	.186
Cor	.209	.229	.015	.017

Sources: INSEE, "Dictionnaire des Projections 1985 et 2000, Travaux et Recherches de Prospectives" [4]; and "Annuaire Statistique 1972" [2].

Table 14. Census data.

	Census 1962 - 1968 (Working population)		Ratio $\frac{\text{(Working population)}}{\text{(Total population)}}$	
	IMMIG	EMMIG	IMMIG	EMMIG
RP	.386	.232	.53	.34
C-A	.036	.042	.39	.40
Pic	.049	.055	.37	.42
HN	.040	.043	.40	.41
C	.079	.069	.38	.45
BN	.034	.052	.38	.47
Bo	.044	.052	.36	.42
N	.035	.067	.38	.41
L	.039	.056	.39	.38
Al	.027	.021	.40	.39
FC	.024	.028	.38	.42
PDL	.053	.076	.38	.45
B	.045	.071	.34	.46
PC	.035	.057	.35	.44
Aq	.056	.068	.34	.44
MP	.043	.062	.34	.45
Lim	.020	.026	.37	.46
R-A	.103	.070	.40	.40
Auv	.030	.039	.38	.44
LR	.042	.053	.33	.43
PCA	.096	.072	.35	.39
Cor	.005	.007	.33	.41

FRANCE: .41

References

[1] "Annuaire Statistique, 1967." Collection INSEE, Serie D, No. 4.

[2] "Annuaire Statistique, 1972." Collection INSEE.

[3] Cordey-Hayes, Martyn. "Dynamic Frameworks for Spatial Models." CES WP-76. Centre for Environmental Studies, London, 1971.

[4] "Dictionnaire des Projections 1985 et 2000, Travaux et Recherches de Prospectives." Schéma Général d' Aménagement de la France, No. 4.

[5] Feeney, G. "Two Models for Multiregional Population Dynamics." Environment and Planning, 5 (1973) No. 1, 31-43.

[6] Gleave, David. "The Utility and Compatibility of Simple Migration Models." IIASA RR-75-10. Laxenburg, Austria, (IIASA), 1975.