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Quantitative, demographic, and geographic approaches to internal migration

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Abstract. The mainly temporal viewpoint adopted by the demographer allows him to analyse internal migration either by comparing consecutive periods (epoch analysis) or by following the life span of an individual (cohort analysis). This analysis leads to models of migration that are based on Markov processes. The principally spatial viewpoint taken by the geographer enables him to see how migration affects the distribution of the population in an area (spatial-differentiation analysis), and to study the flows between zones (spatial-interaction analysis). In fact only a combined spatial and temporal approach can throw fresh light on migration analysis.

1 Introduction

Demography and population geography are concerned with the same topic: the study of human populations. Basically, they are quantitative disciplines that mainly use statistical data, but they also employ qualitative approaches. The main difference between the two sciences is the fact that the demographer places his emphasis on time whereas the geographer places his emphasis on space.

In the demographic approach two basic concepts of analysis can be distinguished: First is period or *epoch analysis*. This is the study of changes that may occur to the population of a given area during a period; for example, the study of its natural change and the analysis of differences between subpopulations with respect to one demographic phenomenon, an example of which might be the study of differential mortality according to age. The temporal emphasis appears in comparing successive epochs for the same area. Second is generation or *cohort analysis*. This involves the study of one cohort through time and the occurrence of one or more demographic phenomena. The method leads to a *model approach*, for example, fertility models, that may include firstly internal causes (other demographic phenomena), and then external causes (nondemographic ones).

The geographical approach also comprises two basic concepts of analysis: first is *spatial-differentiation analysis*, which is the study of changes that may occur in the populations of different areas during a period, without connecting them; for example, the study of the spatial aspects of death in a country. A study of this type can make use of some demographic approaches, such as the reference to standard populations with a given structure, which permit comparisons between different population structures. The second concept is *spatial-interaction analysis*, which is the study of flows from one area to other areas during a given period. Examples arise in the study of geographic traffic fields: goods traffic, diffusion of information traffic, and so on. These two basic concepts may be explained by a more general *systems analysis*, and the geographer will try to relate locational patterns to human decisions through stochastic processes.

This brief survey of demographic and geographic methods shows their complementary approach to the same problem. Migration will be studied here from this double point of view. First, it is necessary to define the terms that will be used in this paper: a *migration* involves a change of residence from a place of origin to a place of arrival,

a *migrant* is a person whose place of residence changes during a given interval[1],
an *in-migration* is a migration into an area from a point outside it,
an *out-migration* is a migration out of a given area,
an *in-migrant* is a migrant who enters a given area during one interval,
an *out-migrant* is a migrant who leaves a given area during one interval,
the *net migration* for an area is the balance of movements in opposite directions,
the *net interchange* of migration between two areas is the difference between migrations from the second area to the first and the migrations from the first area to the second.

We can now proceed to see in more detail how the demographic and geographic methods approach migration.

2 The demographic approach

2.1 *Epoch analysis*

2.1.1 *Net migration.* Migratory movement is the component of total population movement which is due to migration: it is referred to as net migration[2]. Let us first consider its links with the other demographic phenomena. If $P(t_1)$ and $P(t_2)$ are the populations of an area at time t_1 and t_2, $B(t_1, t_2)$ the births in this area during the period (t_1, t_2), and $D(t_1, t_2)$ the deaths in this area in the period (t_1, t_2), then net migration $M(t_1, t_2)$ is given by

$$M(t_1, t_2) = P(t_2)-P(t_1)-B(t_1, t_2)+D(t_1, t_2) .$$

This formula allows us to calculate the net migration of an area without knowing all the migrations to and from it.

We can next see how net migration changes when the period of observation is modified. The net migration of a period (t_1, t_3) is the sum of the net migrations of the intermediate periods (t_1, t_2) and (t_2, t_3). This property allows the comparison of net migrations of different periods[3], with the same base period. For the demographer, however, such a comparison is not yet satisfactory. Net migration may be related to a base population to give a crude rate, like a crude birth rate. We cannot take as a base the population that could have migrated during the given interval, as such a population may be the population of the area for the out-migrations, and the population of the remainder of the earth for the in-migrations.

Hence the best choice for such a base population is that which generates a rate that may be compared to the crude rate of natural increase. This is generally the mean population of the period, but occasionally such a rate may be computed by using the population at the beginning of the period. Further, the demographer may compute more comparative net migration indices by reference to a standard population with a given structure. Later on we shall see how they are used by geographers. The comparison of net migration rates of an area for consecutive periods is important, for it enables the demographer to assess the validity of population projections that have a constant net migration rate. It seems that, if the net migration rate shows important variations in short-term periods, then long-term variations may be more valid. The following example taken from Shryock (1964) confirms this observation for the United States. Table 1 gives the annual net migration, calculated by geographic division for the periods 1940–1950 and 1949–1950, and shows the danger of extending annual results to a longer period.

(1) This definition corresponds to a measure at the end of the interval (census) by a question on the place of residence at a fixed prior date; it is different from the definition given in the UN handbook *Methods of Measuring Internal Migrations* (1970).

(2) Net migration is an algebraic number.

(3) In France this problem is important because the censuses are not periodic: 1954–1962 (8 years), 1962–1968 (6 years), and 1968–1975 (7 years).

Table 2 gives the correlation of 'averaged' estimates of net migration by states for the decades from 1880 to 1950, and shows that net migration has been a continuous process that follows a persistent pattern, except for the first decade, 1880–1890. So net migration can be a useful instrument for throwing light on migration patterns, but it is inadequate for explaining this phenomenon.

Table 1. Annual net migration (in thousands) by geographic division for the United States, 1940–1950 (source: Shryock, 1964, table 5.13).

Geographic division	1940–1950	1949–1950[a]	Geographic division	1940–1950	1949–1950[a]
New England	−2	−34	East South Central	−108	−29
Middle Atlantic	−43	−101	West South Central	−99	+59
East North Central	+52	−33	Mountain	+10	+29
West North Central	−95	−19	Pacific	+278	+47
South Atlantic	+7	+81			

[a] The correlation between the two sets of data is 0·29.

Table 2. Correlation of averaged estimates of net migration by states, for the United States, 1880–1950 (source: Shryock, 1964, table 5.17).

Decade	1930–1940	1920–1930	1910–1920	1900–1910	1890–1900	1880–1890
1940–1950	+0·84	+0·84	+0·80	+0·46	+0·11	+0·20
1930–1940		+0·85	+0·68	+0·35	+0·08	+0·04
1920–1930			+0·79	+0·46	+0·24	+0·07
1910–1920				+0·54	+0·32	+0·09
1900–1910					+0·69	+0·53
1890–1900						+0·04

2.1.2 *Migration.* To obtain the components of net migration the demographer should incorporate some special questions in censuses (relating to migrants) or obtain data from population registers or special inquiries (relating to migrations). Even if migration data are always additive with respect to time, the numbers of migrants are not necessarily so. For example, a person who is a migrant during the first period may return during the second period, and will not be counted as a migrant during the joint period.

We have already seen the difficulties in finding a base population for net migration rates. For migration or out-migration from an area, the population exposed to risk is the population of this area and so it can be taken as its mean population during the period. For out-migrants from an area it is better to take the survivors at time t_2 of the population residing in the area at time t_1. Conversely, when we look at migration to an area, the population exposed to risk is the world population, but such a rate does not have any analytical value. This is the reason why demographers work mainly on migration or on out-migration between territorial units within a country. However, when they use an in-migration rate, they keep in mind that it constitutes "a relative frequency statement, which must be handled with caution and whose range of permissible inferences is restricted" (Haenzel, 1967). The comparison of migration rates for consecutive periods shows a very great stability of the phenomenon: for fifty years the annual out-migration rate between parishes in Sweden remained between 7·2% and 8·8%; for more than twenty years the annual migration rate in the United States remained between 18% and 21%.

2.1.3 *Migration differentials.* Migration is not an isolated phenomenon. The demographer wishes to show the ties between migration and other demographic or nondemographic phenomena. Migration differentials may be measured in a number of ways, but we shall choose here a method not quoted in the UN handbook *Methods of Measuring Internal Migration*. Let

M represent the number of migrants whose distribution with respect to some characteristics is $M_1, M_2, ..., M_n$, and let

P represent the total population whose distribution with respect to the same characteristic is $P_1, P_2, ..., P_n$.

A measure of migration differential is then given by the following index:

$$\frac{M_i P}{M P_i} - 1 .$$

This index is zero when there is no difference between the subpopulation i and the total population. Its range of variation is between -1, when $M_i = 0$, and $P/M - 1$, when $M_i = P_i$. Such an index will depend on the territorial units within which migrants are not counted; hence its demographic interest will be lessened. But, when this index is fairly independent of the territorial units, it will be useful for comparisons[(4)]. This can be seen in the case of the age pattern of population redistribution. For example, table 3 gives the indices of migration differentials for France for the period 1954-1962.

Table 3. Indices of migration differentials for different territorial units (multiplied by a thousand).

Age in 1962	Parish	Canton	Department	Region
0- 8	+72	+67	+61	+57
9-24	+11	+11	+8	+9
25-34	+78	+81	+89	+96
35-44	+4	+6	+6	+1
45-54	−39	−39	−41	−43
55-64	−56	−57	−55	−54
65-74	−42	−42	−39	−37
75 and over	−26	−27	−29	−29

Hence an international comparison of these indices is possible, but age comparison is the only one permitted by this method because the other migration differential indices are dependent on territorial units. On the other hand, comparison of other migration differentials must take into account this age pattern, and so on: the number of people in each case will rapidly diminish, thereby making this method worthless. The demographer must find a new way of analysing such data; for example, by means of multivariate analysis.

2.2 *Cohort analysis*

2.2.1 *Net migration.* To follow the pattern of the net migration of a given cohort, the demographer may isolate all the territorial units that have a positive net migration during a period. Thus he can calculate a redistribution index by summing these net changes and relating them to the average population of this cohort. Such a method was used by Eldridge (1964) to show the effect of prosperous or depressed decades on this redistribution index. This index may be used to compare different periods for the same country, but is inapplicable to any international comparison.

(4) The indices given by the UN handbook do not permit this comparison.

2.2.2 *Migration.* The migrations made by an individual during his life can be distinguished by rank. Let us assume a retrospective observation[5]. The probability of a first migration is measured by the ratio of the number of first migrations to the total sedentary population of the cohort at the beginning of the period. Like other demographic phenomena, the distribution of these probabilities may be summarized by an intensity and a mean age at the first migration. Whereas epoch analysis of first migration in France shows great variations, depending on the period, cohort analysis shows a continuous variation of its intensity and mean age during the time (Courgeau, 1974). For out-migrations from parishes and departments, these two characteristics are variable, and so international comparisons are not yet possible. Under some other hypotheses, census data on place of birth may give an estimate of first migration that is very useful in the study of the evolution of past migration.

Repeated migrations can be studied in the same way as the first one. Their intensity seems fairly independent of their rank, as a study of the data for the United States and France shows (see table 4). Many US researchers define the probability of migration by duration of residence, relating the number of moves to the number of intervals during which the respondents in the sample lived in a given area. This probability declines as duration of residence increases, thereby showing a cumulative residential stability. But there is another way of defining such a probability: if we consider that the population at risk is not the entire population that had made a previous migration (of rank 1 for example) but only that part of the population that will make another migration (of rank 2), then we can define a new probability. With respect to France, such a probability seems fairly independent of the duration of residence, the rank of migration, and the territorial units that define an out-migration (Courgeau, 1973a). Some US and Swedish data show that some of these results may be generalized to other countries. Another phenomenon which may be studied, and which relates to out-migration from territorial units, concerns the returns to these units. The hypothesis that these returns are proportional to the number of migrations of rank greater than one seems confirmed for France.

Table 4. Intensity of migrations (%) calculated from surveys.

	Rank of previous migration			
	1	2	3	4
Cohort, 1904-1913 (USA)	63	59	60	62
Cohort, 1901-1910 (France)	63	63	57	59

2.2.3 *Migration models.* Such a demographic analysis leads to migration models that allow the entire phenomenon to be constructed with a small number of estimated coefficients. These models, which may be based on the theory of Markov or semi-Markov processes, will be essentially probabilistic. However, the technical complexity of the problem and the lack of data about individual mobility history with which they may be tested constrained their development. Another kind of model, which takes into account the results obtained from cohort analysis, has been developed for epoch analysis of migration. These models are interesting in that they explain the following census result: let M_1 be the number of migrants who, one year ago, lived in a given area; and let M_5 be the number of migrants who, five years ago, lived in a given area; then the ratio M_1/M_5 is found to be fairly independent of the territorial units (see table 5).

(5) When the observation is made by means of information from registers, it is necessary to calculate probabilities of first migration on the assumption that there is no mortality.

Such a result is obtained if the product of the intensity of migration, K, and the number $(l+1)$, where l is the proportion of returns, is independent of the territorial units. Some French data (Courgeau, 1973a) verify this hypothesis (table 6). The last step in the use of models, which involves links with nondemographic variables, has not yet been attained.

Table 5. United Kingdom 1966 census: ratios of the number of migrants one year ago (M_1) to the number five years ago (M_5) for different territorial units.

	Change of			
	residence	local area	country	region
$\frac{M_1}{M_5}$	0·321	0·333	0·328	0·337

Table 6. French data on the intensity of migration, K, and the proportion of returns, l, for different territorial units.

	Change of			
	residence	parish	department	region
K	0·78	0·71	0·69	0·63
l	0·00	0·07	0·16	0·24
$K(l+1)$	0·78	0·76	0·80	0·78

3 Geographic approach

3.1 *Spatial-differentiation analysis*

3.1.1 *Net migration.* The geographer attempts to study the variations of net migration through space, during a given period. We can first see how net migration changes when the areas under observation are modified: the net migration for contiguous areas that are joined is the algebraic sum of the net migrations for each area. Hence the net migration rate used by the demographer will be useful to the geographer in comparing different areas. If the geographer wants to compare net migrations of areas with different age compositions, he may also use net migration indices by reference to a standard population. A study of net migration has been made on Finnish statistics (Ajo, 1957). It shows that net migration around cities follows a spatial pattern (table 7). Such a pattern may be decomposed into a linear variation and a sinusoidal variation.

Table 7. Net migration around Helsinki.

Central distance (km)	0	14	21	29	44	61	78	99	114
Net migration rate (‰)	+18·1	+77·1	+67·3	+56·3	+30·3	+5·7	−6·4	−12·8	−6·4

3.1.2 *Migration.* The sum of in-migration to, and out-migration from, an area in relation to its total population gives a mobility index. Such an index is correlated with the size of the area. This relationship was studied in Sweden (Wendel, 1953), and it may be summarized by the following equation:

$$\lg y = -0\cdot 13 \lg x + 2\cdot 43$$

where y is the mobility index and x the parish size in km^2. Kulldorff (1955) tried to relate the probability that a movement starts inside a region, will cross its border and end outside the region, to different migration distributions that depend on the length of the movement. Such a distribution will be seen later.

3.1.3 *Migration and other variables.* The geographer will now try to relate the previous migration variables to every other variable he wants to introduce into his spatial-differentiation analysis, and in the arrangement and association of these variables his aim is to distinguish one area from another. He may use some graphic methods, but multivariate analysis is now more likely to be used in analyzing such data.

3.2 *Spatial-interaction analysis*

3.2.1 *Net interchange of migration.* The study of the net interchange of migration between a given area and the surrounding ones reveals important traits in the flow of population. A good example is given by Hägerstrand's (1962) study of the city of Simirisham (see table 8). This table shows that up to a distance of about 60 km the net gain comes from rural areas, whereas an almost perfect balance exists between the two urban streams. On the other hand, the net loss in the exchange with other urban areas is located in zones further away, whereas a balance exists between the two rural streams of these distant areas.

Table 8. Net interchange between Simirisham and rural or urban areas around this town.

Distance to Simirisham (km)	0-10	10-20	20-30	30-40	40-50	50-60
Net interchange:						
from rural areas	+218	+128	+36	+5	+2	+20
from urban areas	0	0	+1	−5	0	+1
Distance to Simirisham (km)	60-70	70-80	80-90	90-100	100-110	110-120
Net interchange:						
from rural areas	−4	0	−3	−7	+6	+2
from urban areas	0	−41	−97	−5	−4	−4

3.2.2 *Migration.* To study the spatial distribution of in-migration to, or out-migration from, a given area it is necessary to use migration rates, because the interacting populations may be very different. In order to distinguish between the population, P_i, in the area from which the migrants start and the population, P_j, in the area of destination, we can define a rate, m_{ij}, such that:

$$m_{ij} = \frac{M_{ij}}{P_i P_j} ,$$

where M_{ij} is the number of migrants. The rationale behind the use of such a rate is that the total number of movements from i is proportional to P_i, and that the number of individuals who will go to j is proportional to P_j. To study the spatial distribution of migrations from an area it is useful to treat every movement as a vector and to give a common origin to all the vectors. But the population of the area of destination is obscure because movements which started from scattered points have been transferred to a common origin; hence the reduction factor is assumed to be the area rather than the population.

3.2.3 *Migration models.* The dependence of migration on distance can be expressed mathematically. A first approach, based on physical distance, d_{ij}, may use a formula of the Pareto type, for example

$$m_{ij} = k d_{ij}^{-b} ,$$

where k and b are estimated constants, or some more elaborate formula.

A second approach based on some more 'social' distance, may use an expression such as Stouffer's (1940) formula

$$M_{ij} = k\frac{\Delta x}{x} ,$$

where Δx is the number of intervening opportunities in the area of destination, and x the number of intervening opportunities between the area of departure and the area of destination. When the intervening opportunities constitute a constant proportion of the population, and the population density in the particular country is constant, then Stouffer's formula is equivalent to the Pareto-type equation, with the exponent b equal to 2.

In a similar approach another migration formula gives a better 'prediction' than either of the preceding two:

$$M_{ij} = k\frac{\Delta x I_j}{P_j} ,$$

where I_j is the number of migrants from i to j during a previous period. A good discussion of these models is to be found in Hägerstrand (1957). To go further such models may include many other variables, and regression analysis is then used to calculate their parameters(6). Such models may be found, for example, in Lowry (1966) and in Olsson (1965). The last step in the geographic analysis is to synthesise the spatial-differentiation and spatial-interaction analysis.

4 Conclusion

This brief description of demographic and geographic analyses of migration enables us to see that the epoch is usually the basic approach of the geographer and that the cohort does not appear in his analysis. As for the demographer, he usually remains in a fixed spatial context and does not consider the spatial-interaction level. We can see the differences between these two approaches if we consider the following: let $p_{i\cdot}^{(x)}$ be the probability that an individual x, drawn from an area i, will migrate; and let $p_{\cdot j}^{(x)}$ be the probability that such a migrant will go to area j. Then

$$p_{ij}^{(x)} = p_{i\cdot}^{(x)} p_{\cdot j}^{(x)}$$

is the probability that an individual x drawn from an area i will be a migrant to j.

We can distinguish the following cases in demographic studies: the individual x is drawn from the whole population, P, and the area j will be the remainder of the territory. Therefore $p_{\cdot j}^{(x)} = 1$, and the demographer will study $p_P^{(x)}$ in relation to the cohort of the individual and other characteristics (age, rank of migration, socio-economic status, etc). A similar case is found when analyzing migrations from an area i: the demographer will study $p_{i\cdot}^{(x)}$. Alternatively, the individual is drawn from the whole population, and he originates in the area i: the area j where he can go as an out-migrant will be an area other than i. Therefore $p_{\cdot j}^{(x)} \neq 1$, and the demographer will study $\sum_{ij} p_{ij}^{(x)}$, for $j \neq i$, which depends on territorial units. In some cases, as in the study of migration differentials, we can define the following relation:

$$\frac{\sum_{ij} p_{ij}^{(x \in a)}}{\sum_{ij} p_{ij}^{(x)}} = \frac{p_P^{(x \in a)}}{p_P^{(x)}} , \qquad \text{for } j \neq i ,$$

(6) These models are in fact multiplicative, and a logarithmic transformation gives them the linear form. The estimation of their parameters is in a great number of cases performed on the transformed variables, and the problems involved in presenting results in the original variables are not generally discussed.

where a denotes a category of population, such as an age group. In such a case the result will be independent of the parcelling of the territory.

From another perspective the geographer works on migrations and tries to see their spatial distribution. Thus he takes $p_{i.}^{(x)} = 1$, and he will study $p_{.j}^{(x)}$ in relation to other variables (distance, population, etc). This probabilistic approach shows the interdependence between the demographic and geographic views of migration.

Finally, an example is given to show how a synthesis of the two approaches may be made. The problem is, say, to make an international comparison of internal migration. From the demographic point of view, census data on migration from different countries are not comparable because they are measured for different periods (one year, five years, six years, etc). Therefore in order to resolve this problem the demographer must first use a cohort analysis and then apply it to epoch data (Courgeau, 1973a). For the geographer, however, it is not possible to compare the results obtained for the same period, because they involve different territorial units (parishes, departments, regions, etc). Hence the geographer, by using a spatial-interaction analysis, must construct general models whose application to the different units may be summarized by a few numbers, independent of a particular mode of partition (Courgeau, 1973b). Therefore only a combined time and space approach will throw new light on migration problems.

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