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Daniel Courgeau

Migrants and Migrations

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Introduction

The journal Population *was launched in 1946 by the National Institute for Population Studies (INED), established immediately after World War II by the French Government. During these last 32 years, there have been 160 issues of* Population *under the guidance of Alfred Sauvy, who was the Director of INED from 1946 to 1962 and who remained editor of the journal until 1975;* Population *acquired international fame, not only in the field of population studies and demographic analysis, but also in social sciences related to demography such as history, sociology, economics, geography, public health and genetics.*

Currently, 5 000 copies are printed, half of which are circulated outside France and one third outside Europe. The articles are frequently quoted in bibliographies in other journals as well as in university text books. Unfortunately, since they are published in French, they present difficulties for those readers who are not familiar with this language.

That is the reason why INED has decided to translate and publish in various languages, under separate cover, the major articles that have been issued in the already long history of Population, *these texts being unabriged. The language most often selected for the translations will be English, but if this experiment proves successful, translation into other languages will be considered.*

Any suggestion concerning the selection of the articles to be translated and their circulation would be welcome.

We thank you in advance for your assistance.

The Director of INED,
Gérard CALOT.

Selected Papers n° 3, translated from POPULATION n° 1, 1973.

MIGRANTS AND MIGRATIONS

Censuses may give only partial indications of internal (or external) migrations, in particular, they mention only one migration for a migrant who experienced several migrations between two consecutive censuses.

In order to complete these data, special surveys of a longitudinal nature are required. With the help of these surveys, it is possible to study, in particular, the relations between the changes in residences of the migrants.

Mr. Daniel COURGEAU, *research fellow of INED, analyses in this article the results of some surveys and completes them with a theoretical analysis of the phemenon* [1].

According to the U.N. definition [4] *, a migrant is a person who moves at least once during a given period of time. The total number of internal migrations [2] of a population is therefore always greater than or equal to the total number of migrants. Equality will be observed only when the period of observation is very short. The difference observed between the two totals is mostly very important : in the U.S.A., for a 5-year period, there are approximately twice as many migrations as there are migrants.

This article analyses the relations between the number of migrations and the number of migrants : it is first of all a research on multiple migrations. Moreover, in order to relate the total number of mi-

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(1) See also the same author : « Les champs migratoires en France » *Travaux et Documents,* Issue n° 58, Paris, INED/PUF, 1970, X + 158 p.

(2) We have intentionally not defined the territory inside which migrations are not counted. Another article deals with this subject : « Migrations et découpages du territoire », *Population,* 3, 1973, pp. 511-537.

(*) The figures between brackets refer to the notes of the bibliography, p. 31.

grants to the estimation from census data [3], it is necessary to study the number of migrants returning to their place of residence at the previous census; we would need to know the number of deaths among the migrants and the number of departures out of the country before the census or survey, but this seems to be rather impossible [4].

This type of study will also help to improve the comparison of the census data concerning periods of different length. The French census gives the total migrants for two periods : 1954-1962, and 1962-1968 : to compare these totals, one has to refer to a comparable period of time. Therefore, it is necessary to know the distribution in time of the first emigrations and the total of returns to the initial place of residence.

Data in this form are rarely found because one has to enumerate all the migrations of each person of the sample.

The data we will use are : a survey conducted in France in 1967, some American data collected from the Social Security files and data from a Swedish study.

The French Data [5] The presentation of the sample has been made in an article by A. Girard and E. Zucker [1] : the data on migration was collected during a survey on birth control. Only 2464 responses out of a total of 2692 which gave correct information on migration wese used.

The respondents were asked to give all their places of residence since their 15th birthday, indicating addresses and dates of arrival. As these events are important in a person's life, we consider omissions to have been rare. In particular, the last place of residence must have been indicated more correctly, since people moved recently. Another survey for the people living outside town will be used [7].

(3) The total number of migrants is often estimated through a question about the place of residence at a previous date. This estimation is not satisfactory because :
- a dead migrant or a migrant leaving the country before the census will not be enumerated;
- some migrants who may have returned to their place of origin after one or more migrations will not be enumerated as migrants.

(4) As far as we know, only one research completed in Sweden could give all these totals for a cohort born between 1896 and 1905 in a village called Arnas. Unfortunately, the figures presented in the corresponding Cahier [9] do not allow us to study the fluctuations in time of these totals.

(5) M.A. Hersch has programmed and computerized these data.

The American Data P. A. Morrisson [5] [6] presents some figures obtained in the U.S.A. from the Social Security registers during the period 1957-1966. These figures cover only the economically active population which therefore means that an individual is not necessarily included in the files during the whole ten-year period. Therefore, Morrisson has considered the migrants within the longest continuous period during which a person is a member of the Social Security Organisation. Not all the migrants from one county to another are mentioned : only the county where a member had his highest income during one special year is indicated.

In fact, the sample is not fully satisfactory :

1. persons starting their active life or retiring could migrate without having it mentioned;

2. the migrations observed during the first three years [7] are correctly enumerated. Migrations of people under observation for more than three years are underestimated, the probability of moving is higher in the non-observed population than in the sample. Later we will correct this underestimation.

The Swedish Data. The data presented by B. Wendel [10] correspond to the total migrations of the members of a cohort born in the same village. These data, though very good for a longitudinal analysis, unfortunately are not representative of the total Swedish population.

I. Multiple migrations

1. Analysis of the Phenomenon. First, we shall introduce the variables and the relations we shall use subsequently :

- time (t) counted in years starting from an initial date ($t = 0$),
- the population of the country at time t, $P(t)$,
- the total number of internal migrations $m(t)$ for a given subdivision of the national terrirory [8] in the interval $(0,t)$ with a distinction between the rank of the migrations ($m_n(t)$ for migrations of rank n).

(6) See Annex 1.

(7) Only the people observed during at least 3 years have been included in the sample.

(8) Zoning into separate districts covering the whole territory.

a) Probability of annual migrations.

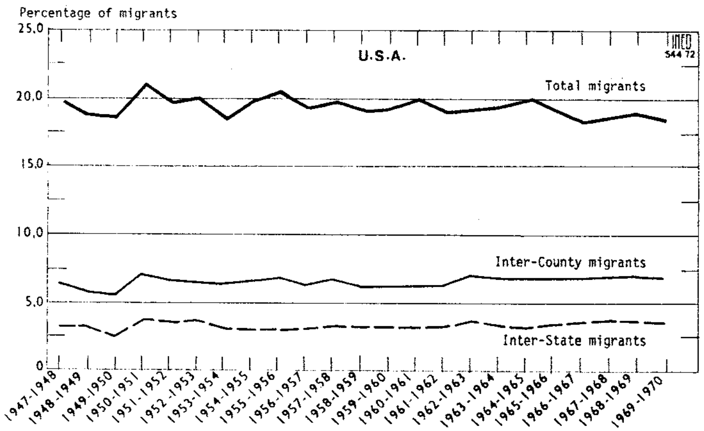
During the year (a), the population has a total number of migrations, noted $\Delta m(a)$ and we will first find out if the migration rate $P = \Delta m(a)/P(a)$ varies significantly with time.

The Swedish population registers present this rate for the migrations between parishes over a period of 50 years.

TABLE I

Period	Annual migration Rate (p. 1 000)	Period	Annual migration Rate (p. 1 000)
1911-1915	78	1930-1940	88
1916-1920	83	1941-1945	81
1921-1925	75	1946-1950	86
1926-1930	79	1951-1955	74
1931-1935	78	1956-1960	72

Annual surveys in the U.S.A. since 1947 estimate the number of people who, a year prior to the survey, had lived at a different place of usual residence [4] (graph 1). The total obtained concerns the migrants for a period of one year, not the migrations. But the period of observation is short and constant, so the underestimation must be small and constant from one year to the next.



Graph 1. — Migrants according to their mobility type in the U.S.A. (April 1948 - March 1970).

The observed stability for all age groups confirms the bias of Morrison's data. It is necessary to straighten the data. There is no apparent reason to think that the migrations omitted are of a specific rank, so we made the hypothesis that all migrations, whatever their rank, have been underestimated. With this hypothesis, the table given in Annex 1 becomes (totals in p. 1 000) :

TABLE II

Year of observation	Number of previous moves									
	0	1	2	3	4	5	6	7	8	Total
1	180									180
2	105	75								180
3	76	71	33							180
4	58	65	41	16						180
5	44	59	44	24	9					180
6	37	50	43	31	14	5				180
7	33	44	37	31	21	10	4			180
8	29	40	36(1)	31	24	12	6	2		180
9	28	35	29	29	24	22	8	4	1	180

(1) *Example.* Within the observed population, 36 p. 1 000 experienced 2 moves during the last 8 years and moved again during the next year.

The INED survey gives a satisfactory estimation of the migration rate for France : because it concerns a period very close to the survey. For the other periods, the rate $p(a)$ is overestimated because the observed population $P'(a)$ is underestimated (9) (because of the non-observed deceased people).

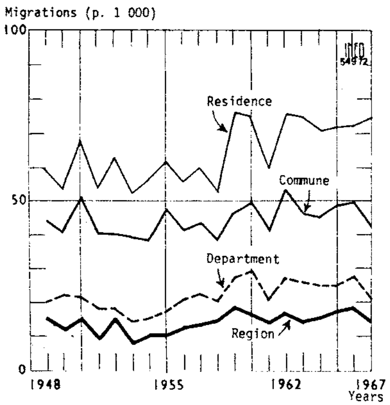
The probability for these old people to move was small : so the total number of migrants observed is closer to the real number, than $P'(a)$ is close to $P(a)$ and as a consequence, there is an overestimation of the ratio $p(a)$. The non-corrected rates are presented in table III.

Table IV gives the estimations of the mean annual migration rate p. for different geographical subdivisions during the period 1958-1967.

The dispersion test of the annual migration rate (10) permits our making an assumption that the migration rates for a change of commune, department or region are constant. With respect to changes of residence,

(9) It is possible to obtain a correct estimation of the total rate when calculating the rates for the age groups combined with a constant age distribution.

(10) The values of χ^2 with 8 degrees of freedom are respectively 18.68, 9.25, 8.84, 4.33.



Graph 2. — Annual migration rates of the different geographical subdivisions.

there is a small probability of about 2 % to get a bigger value than 18.68. Yet, in leaving the year 1958 out, the χ^2 with 7 degrees of freedom is equal to 8.96, showing that the hypothesis may be maintained for the changes of residence.

The analysis of these data from various origins shows that the hypothesis of a constant rate *p*(*a*) through time si verified for Sweden for a period of 50 years and for the U.S.A. for a period of 20 years. The French data show an increase of the changes of residence during the last 20 years (11). This upward trend, though difficult

TABLE III

Year	Changes of			
	Residence (p. 10 000)	Communes (p. 10 000)	Department (p. 10 000)	Region (p. 10 000)
1967	743	422	211	138
1966	719	488	280	178
1965	713	481	248	171
1964	703	453	253	151
1963	747	464	258	139
1962	758	529	271	158
1961	594	405	206	133
1960	747	489	289	164
1959	659	458	265	178
1958	521	380	197	136
1957	598	431	220	129
1956	556	408	211	118
1955	612	466	170	100
1954	558	384	153	102
1953	522	386	135	78
1952	632	396	182	150
1951	538	401	175	87
1950	681	506	208	146
1949	531	414	216	116
1948	595	444	204	150

TABLE IV

	Changes of			
	Residence	Commune	Department	Region
$\hat{p}$	0,0693	0,0458	0,0249	0,0155

to be specified by this method (12), is slow enough over the time period to permit the application of the hypothesis of constant rate *p*(*a*) over the ten-year period.

b) Probability of a new migration.

Let us take a person who already experienced a migration at a certain time; a priori, his attitude must depend on the rank of his migration. But, if his attitude would depend only a little, or not at all, on the rank of his migration, the problem would be greatly simplified. In order to ascertain on which factor his attitude depends, a longitudinal analysis would be necessary.

• *Probability of a supplementary move.*

Let us for the moment neglect the timing of supplementary moves and examine if the probability of a new move of rank *n* depends more or less on the rank of that move.

The Swedish data [10] show that the probability of making a second move is the same as the probability of migrating for the third time (13) (0.66 and 0.67 respectively).

A survey conducted in the U.S.A. [8] gives us general approximations of the probability of undertaking a move of rank (n + 1) after having already made a move of rank n (K_n) (table V).

(11) The important activity in the building sector and the rapid growth of the population have contributed to increase mobility in France. The USA and Sweden did not have the same evolution : in the USA, the population growth has been going on for some time now, while in France it is a new phenomenon.

(12) A longitudinal analysis of mobility will show this growth much more clearly (see an article from D. Courgeau, « Les premières migrations de Français dans la période contemporaine », *Population*, special issue, March 1974).

(13) These probabilities have been calculated with 2 hypotheses : First, the disturbing phenomena such as mortality and international migration have not been modified by the internal migration [72]; Secondly, there is an underestimation, both of the population susceptible to make a migration of rank *n* and the population really migrating, due to the fact that these people are under 50 years of age. The probability to migrate after the age of 50 is very small, so we think the error is rather small.

TABLE V. — PROBABILITY OF A SUPPLEMENTARY MOVE (in p. 1 000)

Generation	K_1	K_2	K_3	K_4	Observed totals
1893 and before	642	576	586	603	14 609
1894-1903	617	554	583	587	14 893
1904-1913	629	591	597	621	19 796

It is clear that this probability depends very little on the rank of the move; the figures decrease from K_1 to K_2 and they increase slightly for the next probabilities (these probabilities are subject to the same errors as the preceding ones).

Likewise, two surveys conducted in France [7] and [1] give the same probabilities. The results, by generation, of the first survey are comparable to those of the U.S.A. [14].

TABLE VI. —
PROBABILITY OF A SUPPLEMENTARY MOVE BEFORE THE AGE OF 70 YEARS
(in %)

Generation	K_1	K_2	K_3	K_4	Totals
1890 and before	65	70	55	48	139
1891-1995	56	66	66	69	138
1896-1900	68	64	48	63	142
1901-1905	67	65	61	54	156
1906-1910	60	62	54	61	220
Average	63	65	57	59	

As before, these probabilities show little variation as the rank of move changes. The second survey collects the probabilities for people aged 50 and above, and 70 and above, for different types of migrations [15] (table VII).

The lowering of these probabilities as the rank of migration increases partly explains the effect of age: people having their fifth migration will, on the average, be older than those having their first migration. The time elapsed since the last migration is not very important and some

(14) The results presented here are slightly different from those of the article referred to: they have been recalculated on the basis of the migration distribution because some misprints had been included in the probability table.
(15) This table will take into account all the migrations made before the survey by the sample population in order to reduce the non-observed migrations.

TABLE VII. — PROBABILITY OF A SUPPLEMENTARY MIGRATION

Changes of	People of 50 years and over (in %)								Observed numbers
	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	
Residence	73	68	63	57	61	53	56	58	740
Commune	61	61	59	57	64	40			467
Department	59	50	54	42					307
Region	56	48	38	52					227
	People of 70 years and over (in %)								
Residence	78	68	70						107
Commune	71	63	78						74
Department	69	58							51
Region	63	57							38

supplementary migrations are not indicated by the results of the survey, especially where the rank of this migration is high. On the other hand, one observes a decreasing probability for a rank when examining data on the changes of residence, the changes of commune, of department or region.

The results of the three countries show a very similar attitude of the migrants, although depending slightly on the cohorts considered: *the probability of making a supplementary move is almost independent of the rank of the previous move.* The results must be tested on several examples before they are held to be general. From now on, we may consider, on first approximation, that the probability of supplementary move is constant.

• *Distribution in time of the new migrations.*

In order to be able to study this distribution, it is necessary to know what part of the population is subject to the risk of undertaking a new migration a certain number of years after a former migration of rank n. We noted earlier that a fractional part K_n of the population which made n migrations will migrate once more $(n + 1)$. The population at risk of making a migration during the t^{th} year will then be a fraction of the total with those who migrated for the $(n + 1)^{th}$ time until the $(t - 1)^{th}$ year (inclusive) being excluded [16].

(16) Some writers [6] put as an implicit hypothesis that all the people who migrated n times will migrate $(n + 1)$ times; the consequence of this is that the probability of having an $(n + 1)$ th migration decreases with time; whereas, our hypothesis considers the probability as independent of time, as will appear later.

TABLE VIII. — QUOTIENTS OF NEW MIGRATION ACCORDING TO THE DURATION OF RESIDENCE FOR DIFFERENT TYPES OF MIGRATIONS (COHORT BORN IN 1917 AND BEFORE)

Changes of		Duration of stay	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15(1)	16 and more
Residence	Moves of rank 2	Numbers	49	45	33	32	30	24	22	16	17	7	4	9	8	3	3	61
		Pop. at risk	393	344	299	266	233	201	171	147	125	109	92	85	81	72	64	
		Quotient (p. 1 000)	125	131	110	124	137	149	140	150	128	156	76	47	111	111	47	
	Moves over rank 2	Numbers	56	46	31	29	16	19	17	7	9	11	9	10	3	7	4	34
		Pop. at risk	308	252	206	175	146	130	111	94	87	78	67	58	48	45	38	
		Quotient (p. 1 000)	182	182	150	165	110	146	153	74	103	141	134	172	62	155	105	
Commune	Migrations of rank 2	Numbers	35	32	25	21	25	23	17	14	16	12	6	5	7	4	5	44
		Pop. at risk	291	256	224	199	178	153	130	113	99	83	71	65	60	53	49	
		Quotient (p. 1 000)	120	125	112	106	140	150	131	124	162	145	85	77	117	75	102	
	Migrations over rank 2	Numbers	32	33	11	19	15	11	12	7	5	7	7	6	2	5	5	16
		Pop. at risk	193	161	128	117	98	83	72	60	53	48	41	34	28	26	21	
		Quotient (p. 1 000)	166	205	86	162	153	132	167	117	94	146	171	176	71	192	238	
Department	All ranks	Numbers	32	36	15	12	15	11	11	6	10	8	6	4	6	5	5	36
		Pop. at risk	218	186	150	135	123	108	97	86	80	70	62	56	52	46	41	
		Quotient (p. 1 000)	147	193	100	89	122	102	113	70	125	114	97	71	115	109	122	
Region	All ranks	Numbers	16	22	10	8	9	6	6	6	6	1	1	4	5	3	4	21
		Pop. at risk	128	112	90	80	72	63	57	51	45	39	38	37	33	28	25	
		Quotient (p. 1 000)	125	196	111	100	125	95	105	118	133	26	26	108	152	107	160	

(1) The numbers annually observed after 15 years are too low ; they were not taken into account.

Unfortunately, in a retrospective survey, it is nearly impossible to enumerate all the migrations of rank n and $(n + 1)$ of the observed population; the only information one gets is on the migrations before a certain age for each cohort. The population at risk and the real migrants are underestimated.

First, let us study the particular case when underestimation is low : let us in effect find the distribution over time of the migrations of rank$(n + 1)$ among the migrations of rank n of people under 25 years belonging to the cohorts born in 1917 and before. The population at risk is then observed at least 25 years after the previous migration : the number of people migrating once again after that long time must be small.

Table VIII that shows that the quotients of new migrations are more or less independent of the duration of residence.

The whole series of data have permitted an estimation of this quotient. The following table gives the results according to the types of migration (table IX).

In supposing that this quotient is independent of the duration of stay, we obtain theoretical estimations of the number of migrants within the population at risk. The comparison of the theoretical numbers with the real numbers [17] allows us to maintain the hypothesis of a quotient being independent of the duration of stay.

TABLE IX

	Changes of					
	Residence		Commune		Depart-ment	Region
	Moves of rank 2	Moves over rank 2	Migrations of rank 2	Migrations over rank 2	All ranks	All ranks
Quotient (p. 1 000)	124	147	122	145	149	125

We will now see if this quotient is independent of the migration rank : the sample is too small, so we will only take into account the migrations of rank 2 and above for the changes of residence and com-

[17] The values of χ^2 with 12, 11, 10, 8, 10,7 degrees of freedom respectively are: 12.89, 13.48, 5.92, 9.93, 16.00, 12.15 for the various types of migrations.

TABLE X. — QUOTIENTS OF NEW MIGRATION (CHANGES OF RESIDENCE) ACCORDING TO THE DURATION OF STAY FOR MIGRATIONS OF VARIOUS RANKS

Rank of migration	Duration of stay (in years)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16 and more
2	Numbers	75	63	46	42	44	31	30	19	15	15	10	13	11	17	5	92
	Pop. at risk	528	453	390	344	302	258	227	197	178	163	148	138	125	114	97	
	Quotient k_2 (p. 1 000)	142	139	118	122	166	120	132	96	84	92	68	94	88	149	52	
3	Numbers	45	49	34	27	18	9	18	9	12	20	10	11	9	8	12	67
	Pop. at risk	361	316	267	233	206	188	176	158	149	137	117	107	96	87	79	
	Quotient k_3 (p. 1 000)	125	155	127	116	87	64	102	57	81	146	85	102	94	92	152	
4	Numbers	25	27	21	16	20	12	8	10	5	4	8	7	6	3	4	44
	Pop. at risk	220	195	168	147	131	111	99	91	81	76	72	64	57	51	48	
	Quotient k_4 (p. 1 000)	114	138	125	109	153	108	81	110	62	53	111	109	105	59	33	
5	Numbers	12	15	14	14	9	11	3	10	3	5	11 and more 28					
	Pop. at risk	124	112	98	83	69	60	49	46	37	33						
	Quotient k_5 (p. 1 000)	97	134	143	169	130	183	61	217	81	152						

mune. We will use the same procedure as for the duration of stay. The estimated values for all ranks are :

$$\hat{k} = 134 \text{ p. } 1\,000 \text{ (changes of residence)}$$

$$\hat{k} = 133 \text{ p. } 1\,000 \text{ (changes of commune)}$$

We may still maintain [18] our hypothesis of independence of the two quotients according to the rank of the migrations.

Finally, the different values of k obtained for different geographical subdivisions are so close to each other that we will consider them independent of these subdivisions [19].

Considering the total number of observed migrations within a same cohort, the results are very close to those found before.
This indicates :

a) that the underestimation of the population at risk and the migrants is small (this may be explained by the the fact that most of the migrations are made during the young ages of the migrant);

b) that the age at the previous migration has nearly no influence on the results.

Table X shows first the effect of the rank of the migration for the changes of residence [20]. If we suppose the quotient of new migration is independent of this rank, we obtain : $\hat{k} = 0.116$. Comparing the theoretical numbers observed with this value and the observed numbers leads us to maintain our hypothesis of a quotient independent of the rank of the migration [21].

A close examination of table X reveals, however, that for periods of less than 7 years, the quotient is more or less constant, a notable decrease appears between 7 and 13 years (especially for migrations of rank 2 – the most frequent ones). We show in Annex 2 that this decrease does not contradict the hypothesis that the quotient of new migrations is constant.

We do not want to use the totals corresponding to long stays in the computation of k, so we will consider only the durations of less than 7 years : k will of course be overestimated but this overestimation will not vary significantly.

Let us take the data of table X; a new estimation of k will be : $\hat{k} = 0.127$. The theoretical numbers compared with the real numbers

[18] The values of χ^2 with 25 and 21 degrees of freedom respectively are 33.02 and 24.68.

[19] The value of χ^2 with 49 degrees of freedom is in fact 51.92.

[20] k_n is the probability of migrating for the n^{th} time after having already done $(n-1)$ migrations, whatever the duration of stay.

[21] The value of χ^2 with 48 degrees of freedom is 61.98. The probability to obtain a higher value is 9 %.

TABLE XI. — QUOTIENTS OF A NEW MIGRATION FOR 3 GIVEN COHORTS ACCORDING TO THE DIFFERENT GEOGRAPHICAL SUBDIVISIONS

Cohorts		1917 and before						1918-1927						1928-1937					
Duration of stay		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Changes of Residence	Numbers	178	170	136	122	103	77	100	71	57	44	50	30	97	86	52	54	46	43
	Pop. at risk	1 408	1 230	1060	924	822	699	523	423	352	295	251	201	465	368	282	230	176	130
	Quotient (p. 1 000)	126	138	128	132	128	110	191	168	162	149	199	149	209	234	184	235	261	331
Changes of Commune	Numbers	104	106	68	69	74	49	67	39	92	33	30	17	51	47	37	28	28	22
	Pop. at risk	850	746	640	572	503	429	320	253	214	172	139	109	278	227	180	143	115	82
	Quotient (p. 1 000)	122	142	106	121	147	114	209	154	196	192	216	156	183	207	206	196	287	268
Changes of Department	Numbers	46	51	32	24	31	21	36	21	17	19	18	4	29	19	18	8	15	11
	Pop. at risk	399	353	302	270	246	215	155	119	98	81	62	44	126	97	78	60	52	37
	Quotient (p. 1 000)	115	144	106	89	126	98	232	176	173	235	290	91	230	196	231	133	288	297
Changes of Region	Numbers	24	33	21	17	21	17	20	15	10	10	10	5	16	12	13	0	4	5
	Pop. at risk	256	232	199	178	161	140	94	74	59	49	39	29	65	49	37	24	24	20
	Quotient (p. 1 000)	94	142	106	96	130	121	213	203	169	204	256	172	246	245	351	0	167	250

give a value of χ^2 with 22 degrees of freedom equal to 21.78. So, we will from now on consider the migrations from all ranks together.

Let us take a look at the effect of the geographical subdivisions. Table XI shows the results for three cohorts: 1917 and before, 1918-1927, and 1928-1937. The value of k has been estimated as follows:

TABLE XII

Cohort	1917 and before	1918-1927	1928-1937
$\hat{k}$ p. 1 000	124	184	223

It is clear that, for each cohort, the value of $\hat{k}$ is independent of the geographical subdivision [22].

On the other hand, one may consider that an increase of $\hat{k}$ indicates an increase of the real coefficient k with more recent cohorts. Annex 2 shows that the estimation depends on the age at which the persons are observed: the data concerning the cohort born in 1917 and before indicate how this estimation varies when the cohort is observed up to different ages:

TABLE XIII

Observation before	50 years	40 years	30 years
$\hat{k}$ p. 1 000	211	250	336

When the observation period becomes shorter, $\hat{k}$ increases. This is to be compared with the estimation of the cohorts 1918-1927 (observation before 50 years of age) and the cohorts of 1928-1937 (observed before 40 years of age). The coefficient k varies only a little with the observed generations.

Finally, the French data lead to the conclusion that *the probability to migrate a certain number of years after making a migration of a given rank depends little on the duration of stay, the rank of the previous migration, the geographical subdivision where the migrations are measured or on the particular generation considered.*

The Swedish data [23] confirm some of the preceeding results.

(22) χ^2 with 22, 21 and 20 degrees of freedom respectively is 23.03, 23.95 and 27.22.

(23) The French data are different from the Swedish data because, for the former, only the year of migration was collected.

TABLE XIV. — QUOTIENTS OF A NEW MIGRATION (SWEDEN)

Ranks of migrations	Duration of stay (in years)	Less than one year	1	2	3	4	5	6	7	8	9 and more
2	Numbers	64	75	53	34	30	26	24	12	10	58
	Pop. at risk	386	322	247	194	160	130	104	80	68	
	Quotient (p. 1 000)	166	233	214	175	187	200	230	150	147	
3	Numbers	61	46	35	29	21	18	13	9	5	21
	Pop. at risk	258	197	151	116	87	66	48	35	26	
	Quotient (p. 1 000)	236	234	231	250	241	273	302	257	192	

Table XIV shows that the quotient of a new migration is independent of the period elapsed and the rank of the migration. The coefficient k is estimated to be $\hat{k} = 0.211$.

The comparison of the theoretical and the observed totals confirm the French results [24].

- *Probability of a new migration; period analysis.*

The longitudinal analysis has indicated that the behaviour of the members of a cohort is characterized by a small number of indices depending very little on the considered cohort. The period analysis will confirm these findings.

The French survey enables this type of analysis under certain hypotheses. First, in order to observe a period of at least 6 years after the preceding migration, the only useful data will concern the previous migrations that happened 6 years before the survey.

On the other hand, since we cannot observe the entire history of these migrants we cannot tell, a priori, what percentage will migrate again at a future date : successive approximations have determined this percentage so that we obtain an annual probability of new migration independent of the duration of stay and the geographical subdivision, as we saw before.

[24] χ^2 with 17 degrees of freedom is 18.37.

TABLE XV

Changes of		Duration of stay (in years) 1	2	3	4	5	6
Residence	Migrants	130	117	89	78	74	65
	Population at risk	882	752	635	546	468	403
	Quotient (p. 1 000)	147	155	140	142	158	161
Commune	Migrants	90	76	64	43	44	36
	Population at risk	586	496	420	356	313	269
	Quotient (p. 1 000)	154	153	152	120	140	134
Department	Migrants	59	45	44	27	23	19
	Population at risk	331	272	227	183	156	133
	Quotient (p. 1 000)	178	165	194	147	147	142
Region	Migrants	29	28	28	8	9	8
	Population at risk	174	145	117	89	81	72
	Quotient (p. 1 000)	167	193	239	90	111	111

Table XV concerns the migrations between 1961 and 1954 (8 years). The values of K, the proportion of migrants who run the risk of migrating again, have been estimated at 0.75 for the changes of residence, 0.70 for the changes of commune, 0.70 for the changes of department, and 0.65 for the changes of region. With the help of those results, we may estimate k close to 0.15 for all types of migrations, which is coherent with the results of the longitudinal analysis.

Table XV allows us to generalize the results of the longitudinal analysis to the case of a transversal analysis [25].

[25] χ^2 with 4 degrees of freedom have the following values : 1.59 for the changes of residence, 2.88 for the changes of commune and 2.50 for the changes of department. The small number of migrants changing of region give less clear results : with 2 degrees of freedom χ^2 is 4.12 with a probability of 10 % to get a higher value.

The data for the U.S.A. [5] could be analysed in a similar manner under certain hypotheses. We are interested only in the population observed during 10 years and we suppose that all members of the sub-populations that migrated for the last time some years before 1966 have the same patterns of behaviour. Considering this hypothesis, the tables in Annex 1 may be transformed into a table of the total number of new migrants during the periods following a migration. After 9 years, those totals are nearly equal to zero (9 p. 1000) : so we deduct a coefficient K (proportion of people making another migration) equal to 810 p. 1 000. From this, we obtain the next table :

TABLE XVI

Duration of stay	Migrants (p. 1 000)	Population at risk (p. 1 000)	Quotient of migration (p. 1 000)
Less than 1 year	404	810	499
1	139	406	342
2	87	267	326
3	61	180	339
4	39	119	328
5	25	80	313
6	20	55	361
7	13	35	371
8	9	22	409

If we do not take into account the duration of stay of less than one year, the other durations give a probability of migrating to be fairly constant.

2. *The model.* We will deal with this model as a continuous process over the course of time.

In order to make the computations easier, we will suppose the studied population remains constant in time (stationary population), but this hypothesis may be changed into another (stable population, for instance). Since our analysis is over a short period, this assumption is not too unrealistic.

If p is the annual probability of migrating, a population composed with P members will make, over a short time interval $(\theta, \theta + d\theta)$, $Ppd\theta$ migrations. Some of these migrants will migrate once again after this first time, this concerns a proportion $PpKd\theta$ where K is the probability of new migration in the future.

How are these supplementary migrations distributed over time? Suppose an infinitely small interval of time $(t, t + dt)$ posterior to θ.

The new migrations occurring in this interval of time $[d\mu(t)]$ are proportional to the population at risk, let $PpKd\theta - \mu(t)$ be these new migrations, k is the coefficient of proportionality [26].

$$d\mu(t) = k[PpKd\theta - \mu(t)]\,dt$$

so that $$PpKd\theta - \mu(t) = ce^{-kt}$$

The conditions at the limits for $t = \theta$ are,

$$PpKd\theta = ce^{-kt}$$

where $$c = PpKe^{k\theta}\,d\theta$$

and $$\mu(t) = PpKd\theta\,[1 - e^{-k(t-\theta)}]$$

When θ varies between an initial moment $(\theta = 0)$ and a final moment $(\theta = t)$, we may enumerate all the migrations of a rank superior to one by calculating the integral :

$$\int_{\theta=0}^{\theta=t} PpKd\theta\,[1 - e^{-k(t-\theta)}] = PpK\left[t - \frac{1}{k}(1 - e^{-kt})\right]$$

On calculating the difference between the total migrations during that period (Ppt) and those of a rank superior to one, we obtain the total migrations of rank one [27].

$$m_1(t) = Pp\left[(1 - K)\,t + \frac{K}{k}(1 - e^{-kt})\right]$$

3. *Application to the data.* The French and American data are retrospective : starting with a population at a given date, one goes back in time to determine the number of migrations of various ranks. The model presented is prospective, but with our hypothesis in mind, it is easily proved that the model is also valid for retrospective data.

Another problem arises when one considers that the observed population is not constant over time : we then express the hypothesis that the non-observed population (in the case of France, the migrants who left the country) would have had the same attitude as the observed population if they had remained under observation.

(26) k is slightly different from the one calculated before for a period of one year (k') : it is possible to demonstrate that $k' = 1 - e^{-k}$.

(27) The total migrants can be calculated for each rank (tables XVII and XIX).

TABLE XVII

Year	Residence: Moves of rank 1 observed	Residence: Moves of rank 1 theoretical	Residence: Moves of rank 2 observed	Residence: Moves of rank 2 theoretical	Commune: Migrations of rank 1 observed	Commune: Migrations of rank 1 theoretical	Commune: Migrations of rank 2 observed	Commune: Migrations of rank 2 theoretical	Department: Migrations of rank 1 observed	Department: Migrations of rank 1 theoretical	Department: Migrations of rank 2 observed	Department: Migrations of rank 2 theoretical	Region: Migrations of rank 1 observed	Region: Migrations of rank 1 theoretical	Region: Migrations of rank 2 observed	Region: Migrations of rank 2 theoretical
1967	169	160,72	14	9,73	93	105,11	11	7,30	48	56,88	4	4,20	31	35,25	3	2,76
1966	138	142,51	38	25,53	89	91,40	31	18,97	52	48,97	17	10,88	32	30,03	12	7,12
1965	120	127,11	41	36,73	80	79,82	32	27,02	40	42,29	19	15,41	27	25,64	13	10,03
1964	119	114,25	38	44,45	74	70,17	26	32,34	42	36,73	14	18,34	26	21,98	10	11,86
1963	104	103,39	51	49,46	60	62,05	35	35,56	31	32,05	20	20,04	15	18,91	11	12,88
1962	87	93,27	50	51,90	58	54,66	34	36,86	24	27,84	16	20,63	12	16,16	11	13,16
1961	77	83,33	37	51,92	49	47,67	25	36,39	22	23,93	11	20,22	13	13,65	6	12,80
1960	89	75,12	51	50,97	53	41,95	37	35,23	25	20,74	26	19,42	12	11,62	15	12,19
1959	66	68,41	47	49,48	40	37,32	35	33,70	21	18,16	21	18,42	14	9,98	13	11,46
1958	53	63,00	35	47,75	35	33,60	26	32,04	10	16,10	15	17,36	7	8,67	12	10,69
χ^2	23,64				21,78				19,07				14,55			
Degrees of freedom	17				16				16				16			

a) The French data.

The principal problem of the adjustment of the model to the French data is related to the estimation of the parameters because the model is not linear. Whereas the coefficient p is already determined as the probability of migrating during a given year, the coefficients k and K were estimated on an experimental basis as coefficients giving the minimal value of χ^2 under the following conditions :

— only migrations of rank 1 and 2 are considered, because only a few migrated more than twice;

— the coefficient k is supposed to be independent of the geographical subdivision;

— the coefficient K may be influenced by the geographical subdivision, but for a given geographical subdivision, K is independent of the rank of migration.

Table XVII shows the theoretical distributions compared with the observed ones, for the minimal value of χ^2 under the conditions already mentioned.

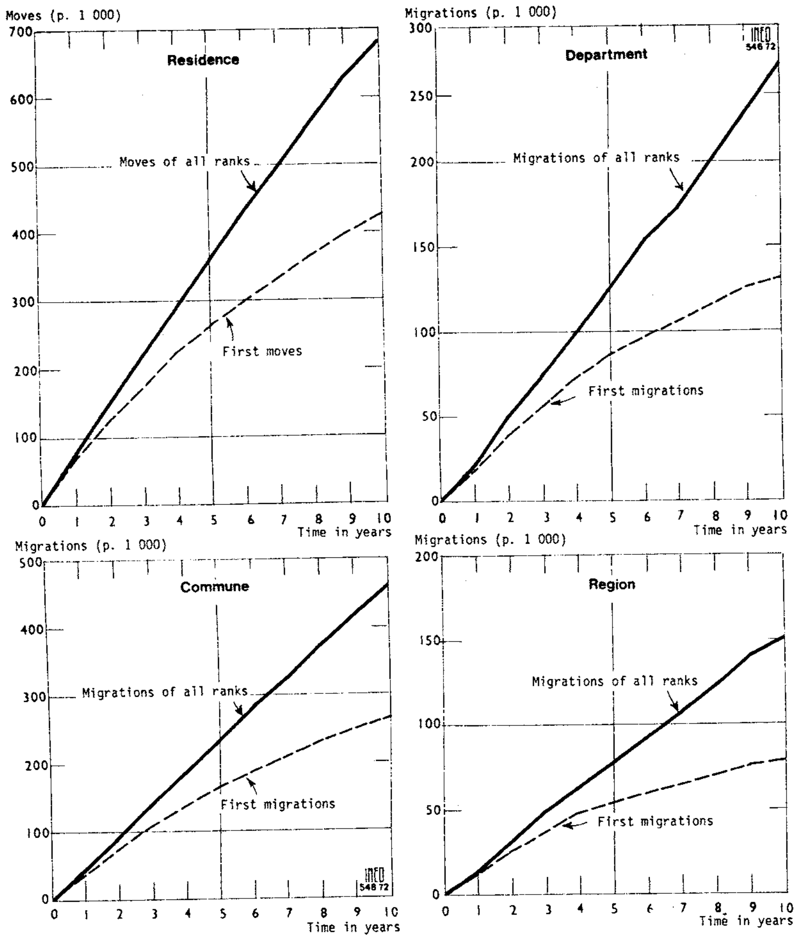
Except for K, the coefficients [28] in table XVIII are coherent with those found in the analysis of the problem : we observed a decrease of this coefficient in case of the changes of residence to changes of commune while in the present cases, we observed the opposite trend. The variations are, however, very small.

TABLE XVIII

	Changes of: Residence	Changes of: Commune	Changes of: Department	Changes of: Region
k	0,18	0,18	0,18	0,18
p	0,0694	0,0458	0,0249	0,0155
K	0,70	0,80	0,85	0,90

Graphs 3 to 6 show the distribution of the first migrations and the migrations of all ranks starting from 1967. The theoretical distribution which is very close to the one observed has not been included in the graphs.

[28] The definition of k is different in the two types of analysis : the value found here (0.18) corresponds to a lower value of the annual coefficient (0.16); this last value is close to the one found in the transversal analysis (0.15).



Graphs 3 to 6. — Time distribution of first migrations and migrations of all ranks combined, by type of migration or move.

b) The American data.

The way the data have been collected is different than for the French data : the multiple migrations occurring during one year cannot be discerned; the model is theoretically not applicable to these data.

We will have to assume that the table, when complete, is not very different from the one obtained.

In table II, m_1 is nearly stationary after 8 years : so the high value of the coefficient k will nullify the term with e^{-kt}. With the hypothesis that m_1 stabilized around 25 p. 1000, the estimate of the product will be : $p\,(1 - K) = 25$ p. 1000.

This means the whole model may be written more simply :

$$\Delta m_1 - p\,(1 - K) = p\,\frac{K}{k}(e^k - 1)\,e^{-kt}$$

Using the logarithms, a linear model appears, of which we estimate the coefficients as :

$k = 0.491$ $\quad$ $K = 0.88$ $\quad$ $p = 0.207$

We can now estimate the migrations of all ranks.

TABLE XIX

Duration	m_1(p.1 000)		m_2(p.1000)		m_3(p.1 000)		m_4(p.1000)		m_5(p.1000)		m_6(p.1000)	
	theoretical	observed	theoretical	observed	theoretical	observed	theoretical	observed	theoretical	observed	theoretical	observed
1	169	180	33	–	4	–	1	–	–	–	--	–
2	113	105	67	75	21	–	5	–	1	–	–	–
3	78	76	72	71	38	33	14	–	4	–	1	–
4	58	58	67	65	48	41	23	16	8	–	3	–
5	45	44	59	48	44	44	31	24	14	9	6	–
6	38	37	50	50	43	43	36	31	20	14	10	5
7	32	33	42	44	37	37	37	31	26	21	13	10
8	30	29	36	40	36	36	36	31	27	24	17	12
9	28	28	32	35	38	29	36	29	30	24	23	22

Table XIX shows the percentage of migrations not appearing because only one migration per year is registered. The importance of these migrations prove that, for a study of this type, it is necessary to enumerate all migrations. On the other hand, the model is more or less coherent with the observed data : however, migrations of rank 1 occuring after one year are underestimated while these migrations are overestimated when occurring after two years. This is related to the high value of the probability of migrating less than one year after the previous one. For the other ranks, the model seems to overestimate the migrations.

II. Return migrations

Let us now introduce the movement back to the place of origin $[r(t)]$ within the interval (o, t).

1. *Analysis of the phenomenon.* Only the French data are used in this case. One would think that the return migrations would represent a constant part of the migrations of a rank superior to one [29] during one year. This part is very small, so we rather use the cumulative totals. The hypothesis becomes :

$$r(t) = l \sum_{i=2}^{\infty} m_i(t)$$

Table XX shows the results for the French data. We see that the hypothesis is possible and that the coefficient (l) increases when going from the changes of commune to the changes of region.

TABLE XX

Duration of stay (in years)	Changes of								
	Commune			Department			Region		
	$r(t)$ p. 1 000	$\Sigma m_i(t)$ p. 1 000	l %	$r(t)$ p. 1 000	$\Sigma m_i(t)$ p. 1 000	l %	$r(t)$ p. 1 000	$\Sigma m_i(t)$ p. 1 000	l %
2	1	17	6	1	9	11	1	6	17
3	3	33	9	3	17	18	3	12	25
4	4	48	8	4	25	16	5	17	29
5	5	70	7	5	38	13	6	25	24
6	8	98	8	9	55	16	8	35	23
7	9	118	8	11	67	16	11	43	26
8	11	143	8	14	85	16	13	54	24
9	12	171	7	17	101	17	16	65	25
10	13	192	7	18	116	16	17	76	22

2. *The model.* If the return migrations are proportional to the migrations of a rank greater than one, the number of migrants in a census between the dates 0 and $t\,[m^*(t)]$ is calculated easily :

$$m^*(t) = m_1(t) - r(t) = m_1(t) - l \sum_{n=2}^{\infty} m_n(t)$$

and, as seen on page 20 :

$$m^*(t) = \mathrm{P}p\left[\{1 - \mathrm{K}(1+l)\}\,t + \frac{\mathrm{K}}{k}(1+l)(1-e^{-kt})\right]$$

This expression is different from $m_1(t)$ because K has been replaced by $\mathrm{K}(1+l)$.

3. *Application to the data.* Instead of checking if the model is applicable to the French data [30] we will try to find an index independent of the geographical subdivision.

TABLE XXI

	Changes of			
	Residence	Commune	Department	Region
K(*)	0,78	0,71	0,69	0,63
l(**)	0,00	0,07	0,16	0,22
$\mathrm{K}(1+l)$	0,78	0,76	0,80	0,77

* We used the values of K from the population of 70 years and over (table VII).

** The estimation of l in this case corresponds with the maximum of the observed returns, for a duration of stay of more than 10 years.

We have seen that only the coefficient k is independent of the geographical subdivision. The coefficient K decreases when we go from a refined subdivision to a more rough one : l changes inversely in the same circumstances. The French data show in table XXI, that there must be a compensatory effect.

Under this condition, $m^*(t_1)/m^*(t_2)$ becomes independent of any geographical subdivision. These results may be confirmed during censuses when the respondents are asked to state their places of residence at two different dates before the census. The results for France, England and the U.S.A., given in table XXII show that the compensation hypothesis is demonstrated for the 3 countries and that the ratio considered is independent of any geographical subdivision.

(29) We will not consider the multiple returns, assuming they are not very important.

(30) This application is similar to the one for $m_1(t)$, only, one more coefficient is used.

TABLE XXII

France 1967 Survey (1 year – 5 years)

	Changes of			
	Residence	Commune	Department	Region
$\frac{m^*(1)}{m^*(5)}$	0,257	0,234	0,224	0,208

U.S.A. (1960 census and current population survey)

	Changes of			
	Residence	County	State	Region
$\frac{m^*(1)}{m^*(5)}$	0,377	0,360	0,368	0,407

England (1966 census : 1/10 th sample survey)

	Changes of			
	Residence	Local area	County	Region
$\frac{m^*(1)}{m^*(5)}$	0,321	0,333	0,328	0,337

As mentioned earlier, this study makes it possible to compare the results of the 1962 and 1968 censuses, related to periods of different length (8.22 years and 6.21 years respectively). Because of some modifications in the departments between the two censuses we will only consider the changes of commune and region.

If we suppose that the variations in the 1967 survey are correct and are perfectly applicable to the 1968 census, we could calculate what they would be if conditions of the 1962 census were maintained (the population of 25 years and over is used to compare the censuses).

TABLE XXIII

Changes of	Period of 6.21 years (*a*)	Period of 8.22 years (*b*)	(*b*)/(*a*)
	(p. 1 000)	(p. 1 000)	
Commune	1 551	1 944	1.25
Region	580	633	1.13

* [9]

From the totals observed during the census, we will calculate the expected totals in 1962 with the 1968 migration rate. The results follow :

TABLE XXIV

Changes of	Census of		Theoretical value for 1962	$r = \frac{\text{theoretical value 1962}}{\text{observed value 1962}}$
	1968 (p. 10 000)	1962 (p. 10 000)	(p. 10 000)	
Commune	2 070	2 277	2 587	1.13
Region	588	675	700	1.04

The increase of the mobility of the population of 25 years and over is estimated, between the two dates, to be 4 % for the changes of region and 13 % for the changes of commune.

This increase is much smaller than what we would obtain supposing the annual probability of a first migration is independent of the duration of stay [9] : 16 % for the changes of region, 20 % for the changes of commune.

The survey estimates rather correctly the changes of region (580 p. 10 000 for the survey and 588 p. 10 000 for the 1968 census), but the changes of commune may have occurred within the same agglomeration and so they were omitted in the survey.

Table XXV shows the comparison for the two periods (1962-1967 and 1954-1961) of mean annual migration rates (all ranks) :

TABLE XXV

Changes of	Period		Ratio (*a*)/(*b*)
	1962-1967 (*a*) (p. 10 000)	1954-1961 (*b*) (p. 10 000)	
Residence	725	648	1.12
Commune	473	428	1.11
Department (1)	253	226	1.12
Region	156	134	1.16

(1) The definitions used for the 2 periods are those of the 1968 census.

Only the population of 15 years and more is considered. The increase observed for the communes is of the same magnitude as the one observed in the censuses. For the regions, the increase is much higher : it is to be underlined that the inaccuracy becomes greater when a survey of that type uses geographical subdivisions becoming much less clearly defined. In 1954, the rate of 134 p. 1000 corresponded to 26 inter-regional migrations.

So we may conclude that, although a certain level of inaccuracy was associated with the survey results, the increase in mobility between 1962 and 1968 is about 12 per cent.

Conclusion

This study on multiple migrations has taken us through to a detailed analysis of their distribution over time. The main results, applicable in the case of France and partly applicable to other countries, are summarized as follows :

In a first stage, to disentangle the factors involved, it is recommended to analyse the data in a longitudinal way. Only a certain proportion of the population that migrated for the n^{th} time will migrate once more in the future ($n + 1$). This proportion is largely independent of the rank of the migration and the generation, but it is a function of the geographical subdivision.

The annual migration rate of the population that runs the risk of migrating again is independent of : a) the period elapsed since the previous migration, b) the rank of the migration, c) the geographical subdivision. It is more difficult to put forward the effect of the age of the previous migration and the generation, but we showed this effect was not too important.

The description of the multiple migrations through a small number of indices may be used in the transversal analysis.

First, we showed that the annual migration rate (all ranks) depends little on the year in consideration, the fluctuations are certainly related to the economic situation. Then, as we observed all the migrations during one year, we noticed that the distribution in time of the next migration followed the same trend as in the longitudinal case.

A mathematical model using all these characteristics was constructed and its application to the data gives satisfactory results.

A last point to be considered before the model is applied to the census data relates to the return migrations. These migrations are proportional to the migrations of a rank geater than one occurring over the intercensal period. The coefficient of proportionality is a function of the geographical subdivision.

However, in the case of France, a compensation is observed between the probability of a new migration and the probability of a return migration. This compensation allows us to conclude that the ratio of the migrants between the censuses and two other dates is independent of the geographical subdivision used to define them. These results were observed for several countries and we may say that the compensatory effect is a more general phenomenon.

The application of these arguments to the French data of the 1962 and the 1968 census leads to much lower estimations of the mobility increase than when we set as a hypothesis the independance between the observed migrants and time.

This study is however deficient for several reasons :

— the French survey was conducted on too small a sample. The analysis is therefore limited because the population observed is too small to draw for reaching conclusions;

— the American data are not satisfactory. First, we do not know all the migrations of the sample; secondly, the observed population changes during the 10 years of observation, leading to errors difficult to estimate;

— the Swedish data concerns a non-representative sample of the population and, so, they are not really relevant.

Of course, we did not introduce variables such as the economic conjuncture. These variations will influence the number of migrants, but this influence will be of less importance than the permanent factors we have put forward. After having eliminated these factors, the study of the social and economic factors could be put in evidence.

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BIBLIOGRAPHY

[1] GIRARD A. and ZUCKER E. — « La conjoncture démographique : régulation des naissances, famille et natalité. Une enquête auprès du public » *Population*, 1968, n° 2, p. 225-264.

[2] HENRY L. — « D'un problème fondamental de l'analyse démographique » *Population*, 1959, n° 1, p. 9-32.

[3] JAKOBSSON A. — *Omflyttningen i Sverige*, 1950-1960. Monografiserie, Berlingska Goktryckeriet, Lund, 1969.

[4] « Method of measuring internal migration » *Population Studies*, n° 47, New York, 1970.

[5] MORRISON P. A. — « Chronic movers and the future redistribution of population : a longitudinal analysis » *The Rand Corporation*, 1970.

[6] MYERS G. C., MCGINNIS R., MASNICK G. — « The duration of residence approach to a dynamic stochastic model of internal migration : a test of the axiom of cumulative inertia ». *Eugenics quarterly*. vol. 14, n° 2, juin 1917, p. 121-126.

[7] POURCHER G. — « Un essai d'analyse par cohorte de la mobilité géographique et professionnelle », *Population*, 1966, n° 2, p. 357-378.

[8] TAUEBER K. E., CHIAZZE L., HAENSZEL W. — *Migration in the United States. An analysis of residence histories*. Public Health Monograph, n° 77.

[9] TUGAULT Y. — « La mesure de la mobilité », *Travaux et Documents* Cahier n° 67, Paris, INED, PUF, 1972.

[10] WENDEL B. — *A migration schema. Theories and observations*. Lund Studies in Geography, ser. B, n° 9, 1953.

ANNEX 1. — THE AMERICAN DATA [5]

PROPORTION OF MIGRANTS ACCORDING TO THE NUMBER OF PREVIOUS MIGRATIONS

Number of years of prior observation *i*	Proportion migrating during last year of observation (p. 1 000)										Observed sample
	Number of prior moves in exactly *i* preceding years									Total observed migrants (p. 1 000)	
	0	1	2	3	4	5	6	7	8		
1	180(2)									180	51 466
2	126	404								176	51 466
3	100	320	430							168	47 024
4	82	273	344	490						159	42 773
5	66	249	288	403	510					151	38 705
6	56	216	248	369	430	540				144	35 184
7	51	192	206(1)	321	400	470	590			137	32 022
8	46	168	188	265	360	410	520	600		130	28 929
9	42	135	158	234	290	370	440	570	700	124	26 414

(1) *Example* : Among the people who moved twice in the past 7 years, 20.6 % moved again during the next year.

(2) This may be found using the second line of the table
$(1-x)\,0.126 + 0.404\ x = 0.176$ So $x = 0.180$.

PROPORTION OF MIGRANTS ACCORDING TO THEIR PREVIOUS DURATION OF RESIDENCE FOR PEOPLE OBSERVED DURING 10 YEARS

Proportion of migrants (p. 1 000)										Observed sample
Duration of prior residence									Total migrants (p. 1 000)	
Less than one year	1	2	3	4	5	6	7	8		
404	234 (1)	191	166	126	91	85	60	42	124	26 414

(1) *Example* : Among those having one year of previous residence, 234 p. 1 000 migrate the following year.

ANNEX 2

One would want to show that the estimation of the quotient of new migration, $\hat{k}$, may decrease as in table X without affecting the hypothesis that the quotient is constant.

Consider the part of a cohort that migrated $(n-1)$ times before age x. Let $m(\tau, t)$ [31] be the part of the population that migrated $(n-1)$ times at age τ (before age x) and migrated once more (rank n) t years later. But we observe this cohort up to age x so that some migrations of rank n will not appear.

The following hypotheses are made:

— the probability of a migration of rank n does not depend on the age at the $(n-1)^{\text{th}}$ migration but on the time elapsed since the $(n-1)^{\text{th}}$ migration;

— the quotient of a new migration, t years after the previous one, is independent of the duration t.

With those hypotheses, we set the estimation of the quotient of new migration (k) independent of t:

$$\hat{k} = \frac{m(.\,,t)}{m(.\,,.) - \sum_{\theta=1}^{\theta=t-1} m(.\,,\theta)}$$

As we observe this cohort up to age x, the estimation $\hat{k}(t)$ depends on t:

$$\hat{k}(t) = \frac{\sum_{\theta=1}^{x-t} m(\tau, t)}{\sum_{t=1}^{x-1}\sum_{\tau=1}^{x-t} m(\tau,t) - \sum_{\theta=1}^{\theta=t-1}\sum_{\tau=1}^{x-\theta} m(\tau,\theta)}$$

With our hypothesis, we may now write:

$$m(\tau, t) = m(\tau, .)\, k\, (1-k)^{t-1}$$

The quantity

$$\varphi(t) = \frac{1}{m(.\,,.)} \sum_{\tau=1}^{x-t} m(\tau, .)$$ represents the

total migrants of rank $(n-1)$ before age $(x-t)$ who migrate once more (n) related to the total number of migrations of rank n.

(31) When we sum for only one of the variables, the variable will be replaced by a point.

When t increases, $\varphi(t)$ is a decreasing or stationary function: as a matter of fact, $\varphi(t)$ is proportional to the number of migrations of rank $(n-1)$ before age $(x-t)$. The function is equal to zero and becomes stationary when $x = t$.

Under these conditions, the estimation of k becomes:

$$\hat{k}(t) = \frac{k(1-k)^{t-1}\varphi(t)}{\sum_{t=1}^{x-1} k(1-k)^{t-1}\varphi(t) - \sum_{\theta=1}^{t-1} k(1-k)^{\theta-1}\varphi(\theta)}$$

$$\hat{k}(t) = \frac{\varphi(t)}{\sum_{\theta=t}^{x-1}(1-k)^{\theta-t}\varphi(\theta)}$$

What happens with $k(1)$:

$$\hat{k}(1) = \frac{\varphi(1)}{\sum_{\theta=1}^{x-1}(1-k)^{\theta-1}\varphi(\theta)}$$

The sum from the denominator may be written:

$$\sum_{\theta=1}^{x-1}(1-k)^{\theta-1}\varphi(\theta) = \varphi(1)\sum_{\theta=1}^{x-1}\frac{\varphi(\theta)}{\varphi(1)}(1-k)^{\theta-1} < \varphi(1)\sum_{\theta=1}^{x-1}(1-k)^{\theta-1}$$

$$< \varphi(1)\sum_{\theta=1}^{\infty}(1-k)^{\theta-1} = \frac{\varphi(1)}{k}$$

so that

$$\hat{k}(1) > k \qquad \text{(I)}$$

The overestimation of k, for a stay of one year is increasing when the age x of the observed cohort is low.

It is easily proved that $\hat{k}(x-1) = 1$.

What we would like to know is if the function of $k(t)$ is necessarily increasing. Therefore we will compare $\hat{k}(t)$ with $\hat{k}(t+1)$:

$$\frac{\hat{k}(t)}{\hat{k}(t+1)} = \frac{\varphi(t)}{\varphi(t+1)} \cdot \frac{\sum_{\theta=t+1}^{x-1}(1-k)^{\theta-t-1}\varphi(\theta)}{\sum_{\theta=t+1}^{x-1}(1+k)^{\theta-t}\varphi(\theta)}$$

$$= \frac{\varphi(t)}{\varphi(t+1)} \cdot \frac{1}{1-k}\left[1 - \frac{\varphi(t)}{\sum_{\theta=t}^{x-1}(1-k)^{\theta-t}\varphi(\theta)}\right]$$

so that

$$\frac{\hat{k}(t)}{\hat{k}(t+1)} = \frac{\varphi(t)}{\varphi(t+1)} \times \frac{1-\hat{k}(t)}{1-k} \qquad \text{(II)}$$

We know that $\varphi(t)$ is decreasing, so that $\frac{\varphi(t)}{\varphi(t+1)} > 1$; on the other hand since $\hat{k}(t)$ is always greater (32) than k, $\frac{1-\hat{k}(t)}{1-k} < 1$.

Thus it is not impossible that $\hat{k}(t) > \hat{k}(t+1)$.

For instance, if the population migrates for the $(n-1)^{th}$ time in a short period, $k(t)$ may be decreasing in that period (33).

We have shown that the hypothesis of an increasing quotient of new migration with time is not contradictory with the decrease of the estimation of the quotient.

(32) If it were not like that, $\hat{k}(x)$ could not be equal to 1 : (II) shows that when $\hat{k}(t) = k$,

$$\frac{\hat{k}(t)}{\hat{k}(t+1)} > 1 \text{ ; so } \hat{k}(t+1) < k.$$

(33) In the theoretical case :

$k = 0.125 \qquad \hat{k}(t) = 0.150$

$\varphi(t) = 0.9 \quad \varphi(t+1) = 0.8$

So $\hat{k}(t+1) = 0.15 \times \frac{0.8}{0.9} \times \frac{0.875}{0.850} = 0.137$

COURGEAU Daniel. — **Migrants and migrations.**

This study on multiple migrations between two different dates and on returns to places of former residence is based on the data collected in special inquiries.

A longitudinal analysis of these inquiries makes it possible to study the relationships between the changes which have occured in the migrants' status, using a few indicators to measure this phenomenon which is analyzed in France and in the U.S.

COURGEAU Daniel. — **Migrantes y migraciones.**

Este estudio de las migraciones entrte dos fechas y de las migraciones de ritorno es posible utilizando encuestas especiales.

Un análisis longitudinal de estas encuesta permite estudiar las relaciones entre los cambios que han ocurrido en la situación de los migrantes. Estas relaciones se miden con pocos indices que permiten el análisis teórico del fenómeno en Francia y en los Estados Unidos.