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MIGRATION IMPACT ON POPULATION GROWTH IN BELGIUM : A MULTIREGIONAL INVESTIGATION WITH DETAILED PROJECTION RESULTS FOR THE PERIOD 1976-2001

Stanley Wijewickrema

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I. INTRODUCTION

Population projections are very often done on the basis of scenarios that leave the migration factor out of count. Such a procedure has its uses : it gives an idea of the contribution to population growth flowing solely from the interplay of mortality and fertility : and this evaluation of how a population grows "naturally" is invaluable as a first step to further investigation. The picture thus obtained is however inadequate when the projections effected concern :

a) a country subject to non-negligible international migration streams; or
b) a part of a country (i.e. a region) which is exposed to substantial internal and/or international migration.

While an awareness of this inadequacy has never been completely absent, common demographic practice in the past has tended to shy away from incorporating the migration factor in the machinery of population projections.[1] And reasons for this tendency are not far to seek! There are, to start with, methodological difficulties stemming from the very nature of the migration process. Whereas rates (and corresponding probabilities) are easily envisaged, calculated and handled in the case of mortality and fertility, the same is no longer true as regards a process, like migration, which affects two groups of persons simultaneously[2] - the population (of

(1) The efforts of A. Rogers and his associates in the International Institute for Applied Systems Analysis in Austria have helped considerably to change this situation in recent times (cfr. infra).

(2) A similar difficulty is encountered when attempts are made to deal with nuptiality as a two-sex problem (cf. S.M. Wijewickrema "Weak ergodicity and the two-sex problem in demography" (unpublished doctoral dissertation, Vrije Universiteit Brussel, 1980).

departure) from which a migration stream takes its rise and the population (of arrival) which is at the receiving end of the process in question. Apart from theoretical difficulties regarding the conceptual elaboration of such rates, the prohibitive volume of the number of computations involved when the rates involved are both age specific and region (of departure and arrival) specific have rendered an adequate handling of migration computations practically impossible before the arrival of the computer : finally, when the above difficulties are overcome to some extent, the demographer is confronted with difficulties of another kind - the problem of the non-availability of adequate data.

The contributions to population change in Belgium due to the migration factor are certainly small in comparison to what is effected through mortality and fertility : they are not for that reason negligible. As shown in Table 1, over the decade preceding the starting point of the projections presented in the present text, migration could be held to account for at least 30% of the volume of movement directed towards population increase and for at least 27% of the movement in the opposite direction. If therefore migration has to be taken count of at the national level, it has a fortiori to find a place in any projection machinery destined to work at a sub-national level (i.e. at the level of a system of regions into which Belgium could be divided) where the importance of the migration factor is enhanced because of the presence of internal migrations.

The first set of projections of Belgium by sex and age in which an attempt was made to take account of the migration factor both at the national and sub-national level was authored by C. Wattelar and H. Dumas[(1)] : and their computations were accomplished through a handling of the volume of the migration flows involved.[(2)] An alternative methodology using migration rates has however been developed by A. Rogers and his colleagues[(3)] over the

(1) C. Wattelar et H. Damas : "Royaume de Belgique : perspectives de population par arrondissement, par sexe et par âge (1971-1985)". Centre d'Etude de la Population et de la Famille, Bruxelles.

(2) The recent N.I.S. projections (cf. Bulletin de Statistique, 1980, No. 3. Institut National de la Statistique, Bruxelles) do not introduce any methodological innovations as regards the migration factor.

(3) - A. Rogers : "Introduction to Multiregional Mathematical Demography". John Wiley & Sons, 1975.
- F. Willekens and A. Rogers : "Spatial Population Analysis : Methods and Computer programs". I.I.A.S.A., Laxenburg, Austria, 1978.

Table 1 Contributors to population growth (births, deaths and international migrations) in Belgium, 1966-78

Year	Births	Immigration	% contribution of immigration to population increase	Deaths	Emigrations	% contribution of emigration to population decrease
1966-70[x]	143946	61860	30	117720	54169	32
1971	139104	62708	31	118853	43341	27
1972	134437	62474	32	116743	54791	32
1973	129425	64250	33	118313	52603	31
1974	123155	71866	37	116039	52670	31
1975	119273	69886	37	119273	53739	31
1976	120472	58724	33	118765	56921	32
1977	121523	55298	31	112208	55076	33
1978	121983	52594	30	115060	58495	34

x Entries in this row are annual average values

N.B. : $\text{col } (4) = \dfrac{\text{col } (3)}{\text{col } (2) + \text{col } (3)} \times 100$

$\text{col } (7) = \dfrac{\text{col } (6)}{\text{col } (5) + \text{col } (6)} \times 100$

last ten to fifteen years. Whatever be its merits and demerits, this approach - commonly referred to as "Multi-regional Demography", and more recently generalised into "Multi-state Demography" - needs to be tried out with a view

a) to facilitating future efforts at analysing problems in which the same methodology would come in useful (e.g. projections involving transitions between marriage-specific states); and

b) to providing an instrument with which the plausibility of results obtained through other methodologies could be tested.

The research work presented in the present text makes use of the above mentionned "Multiregional" methodology in an effort at finding out how the migration factor would affect the evolution of the Belgian population. The projections effected in order to achieve this end have the following characteristics :

1) The 1st Jan. 1976 was taken as the starting time point of the projection process. This choice of a base data needs explanation. The habitual use of the date of the last census for this purpose follows the fact that the distribution of population by sex, age, and region of residence is known through direct observation at such a date. However granted

   a) the approximations allowed when five year age groups are used in the projection process, as well as the different assumptions consented to in the use of multiregional demography (cf. infra);

   b) the importance placed, in the present exercise, on finding the effect of the migration factor for which the apparatus of multi-regional demography is fairly well suited, and

   c) the availability of data needed for this purpose in 1976 (cf. infra)

   it was felt that the N.I.S. estimation of the population by sex, age and region for 1-1-76 was good enough for the purpose at hand.

2) The mortality of each region worked with was, throughout the period of projection, kept at what it was in 1976.[1]

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(1) The low level of mortality experienced in Belgium in 1976 will not in all likelihood be altered in any significant way in the near future.

3) The fertility experienced in each region was similarly kept constant throughout at its 1976 level.[1]

4) The following cases were experimented with as regards the migration factor.

 α) Total absence of migration : i.e. Belgium as well as each sub-national region was taken as closed to migration.

 β) Absence only of international migration : i.e. Belgium was taken as a closed population while internal migration between the sub-national regions was allowed.

 γ) Presence of both international and internal migration.

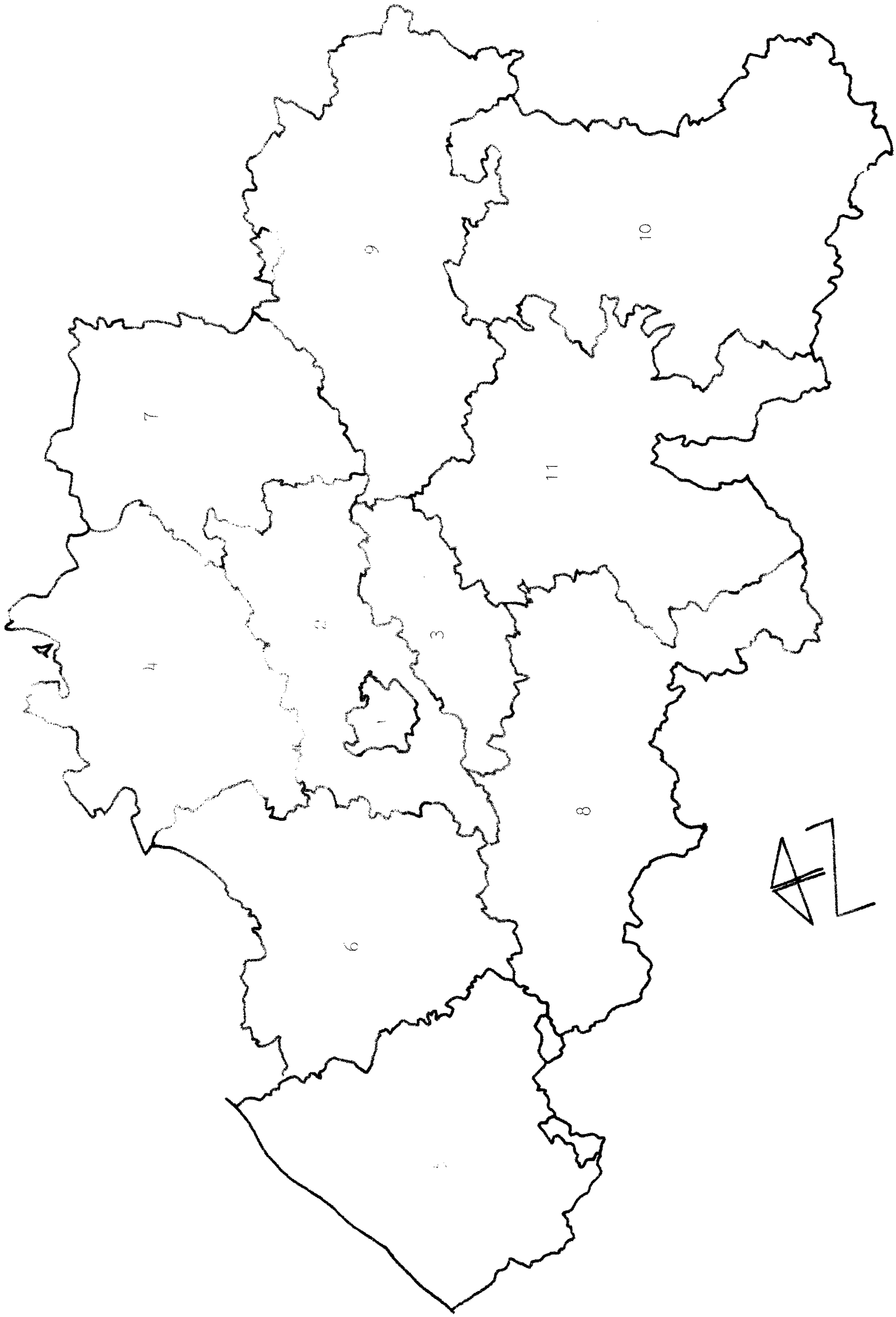
Three different distributions of Belgium into regions were used with each of the scenarios described above. The following schema shows the three levels of distribution, A (3 regions), B (5 regions) and C (11 regions), employed (see Figure 1).

	A	B	C
Belgium	1) Brabant	1) Brussels 2) Flemish Brabant 3) Walloon Brabant	1) Brussels 2) Flemish Brabant 3) Walloon Brabant
	2) Rest of Flanders	4) Rest of Flanders	4) Province of Antwerp 5) " " West Flanders 6) " " East Flanders 7) " " Limburg
	3) Rest of Wallonia	5) Rest of Wallonia	8) " " Hainaut 9) " " Liège 10) " " Luxemburg 11) " " Namur

A word about the regional distributions worked with is necessary.
The Use of the linguistic factor only (to the exclusion of other considerations)

(1) The uninterrupted downwards trend of fertility experienced in Belgium since 1964 had already reached such low levels in 1976 that it would have been incautious to extrapolate still further downwards.

Figure 1 : Regional distribution of Belgium (the numerotation follows the level of distribution C in the text)



as a distribution criterion runs into difficulties because of the presence of Brussels which does not fall into either the Flemish or the Walloon category. Hence distribution A keeps Brussels and the surrounding territory together as one whole i.e. Brabant. Distribution B merely ventilates the inner distribution of Brabant; Flemish Brabant consisting of Halle-Vilvoorde and Leuven, and Wallon Brabant of Nivelles. An effort aimed at arriving at a distribution of Belgium other than what is purely administrative (through the use of cluster analysis) failed to produce any significantly advantegeous division; and a return to administrative units was perforce necessitated. Thus the last of the distributions exploited, that is C, merely breaks down the two units, Rest of Flanders and Rest of Wallonia into their component provinces. The simultaneous presentation of results following distributions A, B and C helps to estimate the net effect of mere redistribution of territory in the projection process.

The usefullness of a population projection grows with every increase of detail found in the results it generates : and the user will find these detailed results at the end of the present text. The text itself will limit itself to :

1) an explanation of the methodology used;
2) a description of the type of information available (both as regards the data used as input, and the projected population related figures) in the detailed results presented; and
3) a brief commentary concerning some aspects of the contribution made by the migration factor in the dynamics of population growth in Belgium (as seen through the projection generated results).

To facilitate reading, the section entitled "Methodology" has been made as simple as possible, leaving complicated details to the Appendices that follow the present text.

II. METHODOLOGY

Each of our projections concerned a population (of one sex) distributed by age groups of five years (except the last open - ended age group : 80+) and was executed by projection intervals of five years. For any given migration scenario and subnational regional distribution, the computations entering into play made use of a population growth matrix (cf. Appendix I) and a corresponding population vector (cf. Appendix I). Work was carried out first with respect to the female sex, and the region specific female births thus evaluated were used as inputs for the projections of the male sex (*via* the sex ratio at birth of 105 to 100).[1]

Since computations concerning the male population are based on those proper to females, the explanatory notes which follow concern the female population projections. Appropriate remarks dealing with their male counterparts will be made later.

The detailed mechanics of the multiregional projection machinery used are explained in Appendix I, section A. It would be sufficient at this point to merely note that the operation of this machinery necessary for moving a population (distributed by sub-national region and age group), closed to international migration,[2] over any one projection interval presupposes the presence of

a) region specific fertility schedules; and
b) a multiregional life table[3]

characteristic of the fertility, mortality and internal migration prevailing over the projection interval.

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(1) The classic female dominance in the projection of births is thus maintained.

(2) The case of a population open to international migration is discussed further on in the text (*cf. infra*)

(3) The multiregional life table necessary for our projection engine would carry a description of how a fictive birth cohort, initially distributed among the different sub-national regions present, fares throughout life when exposed to both the mortality and migration risks characteristic of the interval during which the projection takes place. Age specific probabilities of dying in any one of the given regions, as well as probabilities of moving (as also of not moving) from one specified region to another (also specified) while escaping death are part of the information made available in such a table.

Data giving population (female) size by age and sub-national region together with information concerning the distribution of annual births cross tabulated by region of occurrance and age of mother go into the construction of the fertility schedules in question. For the construction of the requisite multiregional life table, region-age specific population size data has to be supplemented with information concerning region and age specific annual deaths (female) and annual internal migrations (female), the latter (i.e. migrations) carrying simultaneous specification as regards region of origin and region of destination.

Whereas data concerning population size, births and deaths were found at the N.I.S., the available information concerning internal migration did not meet the specifications called for. A sophisticated fudging procedure was therefore adopted to generate this information. Details of the methodology employed in this case are given in Appendix I, Section B. It would suffice, here, to note that the procedure in question consisted of three steps :

1) a "Pro Rata" operation correcting for inconsistencies (in the data) regarding the age specific volume of internal migration;
2) a "R.A.S." modification(1) which brings the data (already pro rata modified, as in (1) in line with available information concerning both age specific internal migration which is only region of origin specific on the one hand, and age specific internal migration which is (only) region of destination specific on the other.
3) an "entropy" transformation(2) which enables the "R.A.S." modified data (-the result of step 2-) to be simultaneously specified by region of origin and origin of destination.

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(1) A "R.A.S." modification (cf. Appendix I, section B; and Fig. A) adjusts a given matrix through an iterative process which generates a new matrix whose elements retain the cross-product ratios of the original matrix while obeying new marginal (exogeneous) constraints.

(2) An entropy transformation (cf. Appendix I, section B; and Fig. A) is identical to a R.A.S. modification which operates on an initial matrix whose elements are all equal to unity.

The case (α) mentionned above in the text (i.e. where both internal and international migration are left out of count) reduces the multiregional projection machinery to the well-known classical single region model. As such, it hardly needs special comment.

An attempt at a completely multiregional handling of the projection engine when both internal and international migration are accounted for - as in case (γ) - runs into difficulties of its own. In such an attempt the rest of the world would have to be treated as one of the many intercommunicating regions (the others being the sub-national regions of Belgium) which together form a closed system. Since this is well-nigh impossible for both practical and theoretical reasons, the following expedients were resorted to (cf. Appendix I, section C)

1) Emigration (i.e. migration out of Belgium) was treated as a form of "death" involving a loss to the multiregional system. In this fashion it finds a place in the usual multiregional machinery. An emigrant is thus considered as experiencing "death" in the sub-national region from which he moves out : and this removes the need for any knowledge as regards his place of arrival.
2) Since immigration (i.e. migration into Belgium) could not be dealt with in similar fashion, it was treated as a factor exogenous to the multiregional system used. This was done by apportioning immigration to the different subnational regions and distributing it age-wise according to an already observed pattern (of distribution by region and age).

As stated above, region specific projected values of female births serve as part of the input for male population projections. The summary details of the mechanics involved found in Appendix I, section D suffice by way of explanation in this connection.

Following the procedure explained above, regional fertility schedules as well as a multiregional life table characteristic of conditions in 1976 (in Belgium) were constructed from available data. Immigration data of the necessary type were also available for 1976. Finally, conditions as regards fertility, mortality and migration characteristic of 1976 were presumed to be constant thereafter i.e. over the total projection interval of twenty-five years.

In view of the fact that the present text makes frequent reference to the recent N.I.S. projections,[1] it is useful at this point to list the differences in hypotheses (as regards mortality, fertility and migration) used by the N.I.S. projections on the one hand and by ours on the other.

a) Re mortality

- The N.I.S. projections assume that a gradual amelioration sets in so that the mortality related situation in Belgium in the year 2000 would approximately be that of the Netherlands in 1971-75.
- The stationary nature of mortality (from 1976 to 2001) hypothesised in our projections would very probably only result in a slight long term attenuation of the importance of the older age groups (approximately 70+) in the population pyramid.[2]

b) Re fertility

- The N.I.S. projections work on the basis of a changing fertility schedule; this change being brought about by modifications in the mean age at maternity, the total fertility rate (TFR) and the variance of the schedule in question. In particular, the TFR is made to continue its trajectory of descent (observed since 1965 approx.) up to the year 1980, when its value is set around 1.5. After 1980, gradually increasing values are assigned the TFR which in the year 2000 reaches a value of 1.9 (approx.).
- In our projections the fertility related situation of 1976 (which is characterised by a TFR of 1.7 (approx.) is maintained constant throughout the projection exercise. The rapidity of fall of observed TFR values in Belgium has certainly diminished from 1975 to 1978, the last year for which the relevant data are available. Whereas the early seventies witnessed a fall from 2.25 (in 1970) to 1.95 (in 1973), the value of 1.73 recorded in 1975 moved down

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(1) They cover the period 1975-2000. Cf. Bulletin de Statistique (Op. cit.)

(2) Granted the low level of infant and child mortality characteristic of Belgium in 1976, future improvements of the life expectancy at birth will probably be largely due to higher survival probabilities in the older ages.

merely to 1.69 in 1978.(1) Though the estimations made by G. Calot(2) bring it further down to 1.66 in 1981, it would not be incautious to expect Belgium to follow her neighbours, the Netherlands and Luxembourg (where a small increase in TFR has shown up in 1979)(3) some time in the very near future. However, since the possibility of remarkable increases in future TFR values seems to be ruled out - the growing prevalence of new life styles goes in the contrary direction - there appears to be enough justification for our hypothesis in which Belgian fertility was kept stationary at its 1976 level.

c) Re internal migration

- The N.I.S. has maintained a constant sex and age specific distribution (averagely characteristic of 1976) of entries to, and exits from, the 43 arrondissements during the entire projection period.
- Our projections have kept inter-regional sex and age specific migration probabilities characteristic of conditions in 1976 constant throughout the projection period. The non-availability of relevant data precluded the possibility of taking into account any prevailing migration trends.

d) Re international migration

- The N.I.S. projections retain constant volume and distribution (by sex, age and region) of both immigration and emigration.
- Immigration was dealt with in similar fashion by us. Emigration however was handled through constant sex, age and region specific probabilities of loss to the system. Both volume and distribution of immigration as well as probabilities of emigration used were those proper to the year 1976.

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(1) Cf. P. Willems, S. Wijewickrema and R. Lesthaeghe : "L'Evolution de la fécondité en Belgique 1950-1980". Population et Famille 1981-1, 52, pp. 115-151.

(2) Cf. G. Calot and C. Blayo : "Recent course of fertility in Western Europe". Population Studies, 1982, No. 3, pp. 349-372.

(3) Cf. S. Wijewickrema : "Reproductive performance over the last decade in the Council of Europe states". Provisional Report DE-FT (82) 2, Council of Europe 1982, Strasbourg.

III. RESULTS AND COMMENTS

1) Presentation and contents of results[1]

Details of the projections under discussion are given in increasing order of the number of sub-national units (i.e. regions) used, but in decreasing complexity as regards the migration scenarios concerned. Results for females are followed by corresponding results for males. The order of presentation is thus : 3F3, 3F2, 3F1; 3M3, 3M2, 3M1, followed by 5F3, 5F2, 5F1; 5M3, 5M2, 5M1, which precedes 11F3, 11F2, 11F1; 11M3, 11M2, 11M1; where aFb (aMb) stands, in general, for a female (male) projection involving 'a' regions (i.e. a = 3, 5 or 11) and using migration scenario 'b' (i.e. b = 1 for the complete absence of any type of migration; b = 2 when only internal migrations are present; and b = 3 for the presence of internal and international migration).

Population figures (under the heading "MULTIREGIONAL POPULATION PROJECTION") are given at five year intervals of time starting on 1-1-1976 (the base data) and ending on 1-1-2001. Population figures are followed by information :

a) concerning age structure with accompanying explanations given as marginal notes to the results.

b) concerning events. The "BIRTHS", "DEATHS", "EMIG" (standing for migrational departures from Belgium to other countries) and "MIGRATION FLOWS" (giving internal migration)[2] computed carry estimations of the respective events that would be experienced in one year by the current population ($N_{(t)}$, say)[3] under the action of the age specific rates (of fertility, mortality, emigration, and internal migration) used. As such they may, in each case, be considered as an estimation of the relevent events occurring in the year just before, or immediately

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(1) Cf. also GLOSSARY (arranged in alphabetical order) for supplementary notes.

(2) The item "MIGRATION FLOWS" has been suppressed for certain cases, where its print-out would be reduncant.

(3) (t) stands for the 1st January of the year printed just above the display of population figures.

following time point (t). They do not necessarily give the average annual number of events occurring in the five years immediately preceding or following (t). "IMMIG" gives the annual number of immigrants to Belgium (or to the relevant region), which is presumed to be constant and forms part of the input. "IN BIR" gives the average annual number of female births occurring in the five year projection interval preceding (t) in the whole of Belgium (or in the relevant region). The corresponding value for males is obtained by multiplying "IN BIR" by 105/100, and forms part of the input for the projection of males

c) <u>concerning rates</u>. The rates in question are crude annual rates obtained by dividing the events (computed as just explained in (b)) by the appropriate population size. "OUTMIGRATION RATES" carry rates related to the internal migration detailed in "MIGRATION FLOWS". "SUMMARY TABLE" gives a résumé of the various crude rates involved.

Details of input data[1] are found at the beginning of each set of projection results (i.e. preceding 3F3, 3M3; 5F3, 5M3; and 11F3, 11M3). They are immediately followed :

a) in the 3F3 case, by a print-out of the "AGE SPECIFIC RATES of fertility, mortality and migration computed[2] from the input data. These rates are used in time-invariant fashion throughout the projection period. The same mortality and fertility rates hold good for 3F2 and 3F1, whereas emigration rates (but not internal migration rates) equal zero for 3F2 and all migration rates equal zero in the case of 3F1. (Since the same simple computational procedure is used in all other cases (of aFb and aMb) the print-out of the corresponding rates, in these instances, has been suppressed). One notes that the fertility rates in question give the number of female children per woman per year for the age-group specified, and that five times their sum - i.e. the Gross Reproduction Rate, G.R.R. - is the last entry of the "FERTILITY" column (i.e. in row "TOT"). Each other entry of "TOT" is similarly five times the sum of the respective column entries : giving rise to

(1) The results of the operations (Pro rata, "RAS", and entropy) constitute the internal migration input.

(2) The computation gives the ratio of events to population. The population used for migration rates is always the population of origin (i.e. of departure).

1) GMR, the "Gross Migraproduction Rate" in the case of internal migration;
2) GER, in the case of emigration; and
3) GDR in the case of mortality[1].

b) in all cases by :

1) "DEMOGRAPHIC PARAMETERS" which tabulates all the summary indices just discussed, and also carries "GOIMR", the annual number of immigrations to Belgium (or to a region).

2) "LIFE EXPECTANCIES", "FERTILITY EXPECTANCIES" and "MOBILITY EXPECTANCIES" which have been computed from the "AGE SPECIFIC RATES" explained in (a). The interpretation of the matrices carrying the different "EXPECTANCIES" is presented, in what follows, through the use of examples taken from 3F3.

1) A girl born in Brabant is expected (cf item "LIFE EXPECTANCIES") to live a total of 53.7 years in Belgium, of which 35.2 years will be spent in Brabant, 9.4 years in the Rest of Flanders and 9.1 years in the Rest of Wallonia. The astonishingly low value of

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(1) The terminology used and the similarity of the computational procedure (cf Willekens and Rogers, 1978, op. cit., pp. 77-78 and 99-105) should not lead the reader to extend any parallelism involved too far. GRR is obtained from age specific fertility rates, which are different in nature from the age specific migration rates that give rise to GMR and GER. In the first case we have "reduced events" where the denominator consists of a mixture of persons who may or may not have experienced the event concerned : in the second (as also in the case of rates leading to GDR), we are confronted rather with exposure rates where the denominators in play are composed only of persons who have not experienced the relevant event. (For the distinction between "reduced events" and "exposure rates" cf G. Wunsch and M. Termote "Introduction to demographic analysis : principles and methods"; Plenum Press, 1978, pp. 22-28 and 33-47).

53.7 arises from the handling of emigration as a form of death (cf text supra) - thus the figure 53.7 is not to be taken as an unqualified life expectancy at birth : it is rather a life expectancy which depends on the migration behaviour experienced.[1]

2) 1000 women born in Brabant (cf "FERTILITY EXPECTANCIES")[2] will give birth to 602 female children in Belgium. Of these, 400 will be born in Brabant, 103 in the Rest of Flanders and 99 in the Rest of Wallonia. These values are obtained through calculations which take into account the presence of mortality and migration : they have thus a significance analogous to the classical Net Reproduction Rate.

3) 1000 women born in Brabant (cf "MOBILITY EXPECTANCIES")[3] are expected to make a total of 286 interregional moves in Belgium in their lifetime. Of these, 239 have their origin in Brabant, 19 in the Rest of Flanders and 28 in the Rest of Wallonia. Here too, the risk of moving (internal to Belgium) is experienced in the presence of the competing risk of mortality (which includes emigration in certain cases).

In short, a maximum of detail is given in the three-region female projections (and, of these, especially in 3F3) so that the methodology used can be better followed; whereas for the remaining projections, apart from details of data used as input and useful information concerning "expectancies" etc., only population figures are printed .

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(1) cf Willekens and Rogers (1978) op. cit., p. 40 for the mathematical formulation concerned.

(2) cf Willekens and Rogers (1978) op. cit., 83 for the relevant mathematics.

(3) Cf. Willekens and Rogers (1978) op. cit., p. 105.

2) Comments

Of the results presented, the aF3 and aM3 projections (which take account of all forms of migration) come closest to being forecasts. The reader is however reminded that beyond ten to fifteen projection years the forecastive nature of the results begins to be open to serious doubt.(1) It is also important to note that with every further degree of disaggregation (i.e. of further subdivision of the whole - here, Belgium), the risk of using random - erratic age schedules of the relevant demographic processes involved increases. From this point of view, the three projections are to be considered the safest.

Various aspects of the impact of migration on population growth in Belgium can be seen by comparing the detailed results of a given projection with the corresponding results yielded by other projections for the same sex and same regional sub-division (Thus, for example, 3F1, 3F2 and 3F3 could be compared with each other). A comparison for the same sex and migration scenario, but across different region sub-divisions helps to get at any effect produced by mere disaggregation.

In the discussion which follows all references made to NIS projections concern those described in the Bulletin de Statistique 1983, No. 3 already cited earlier in this text(2) They are labelled "N.I.S." in the graphs presented here. Our own multiregional projections are captioned "OUR". When no explicit indication to the contrary is in evidence, dotted lines found in the graphs correspond to the migration scenario where both internal and international migration are taken into account. Unbroken lines on the other hand take care of the case where all forms of migration are left out of count, whereas lines formed of dashes cover the scenario which allows only internal migration. The evolution of size of population or of age groups as well as the evolution of the various ratios presented are for the period 1976-2001.

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(1) Cf. the remarks of L. Henry in "Perspectives Démographiques", Editions de l'Institut National d'Etudes Démographiques, 1973, p. 10.

(2) The results of this latest set of N.I.S. projections are found in detail in "Bevolkingsvooruitzichten 1976-2000" (Nationaal Instituut voor de Statistiek, 1979) in four brochures dealing separately with Belgium as a whole, and the regions Brussels-Capital, Flanders and Wallonia.

A) The Case of Belgium treated as a whole

In all our projections, population size (of both males and females) in Belgium increases somewhat at the start, but decreases towards the end of the projection period. The resulting maximum values of the corresponding curves shown in Fig. 2(1) are found either in the mid-eighties or the early nineties. International migration is seen (in Fig. 2) to account for :

1) the displacement of the maximum characterising the female curve from the mid-eighties to the early nineties; and

2) the lessening of population loss, which shows itself towards the end of the century, in the case of both males and females.

The evolution of population size according to the results of the N.I.S. projections is also portrayed in Fig. 2. Here too the positive action of international migration as regards population increase is in evidence.(2) Note that except in the case of females where, in the absence of international migration (NISF1, NISF2), a maximum value shows itself, the NIS curves display uninterrupted population increase during the projection period. The progressive flattening of these curves, however, tends to suggest

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(1) Only values generated by our three-region projections are presented, the differences between these values and the values generated by our five or eleven-region projections being insignificant. The initial increase in population size, which is seen to occur when no migration whatsoever is present (see 3F1 results) is the result of the increasing positive difference between the occurrance of births and deaths. The fall in annual births between 1965 and 1975, as recorded in the published statistics of the N.I.S., gives way to a rise (in 3F1) - a consequence of the progressive entrance of women born during the baby boom of the late fifties to early sixties into ages characterised by high reproduction. As these heavily packed cohorts age annual birth occurrance drops. This decrease being more important than the accompanying decrease of annual deaths, the population size falls : which is what happens after the early nineties!

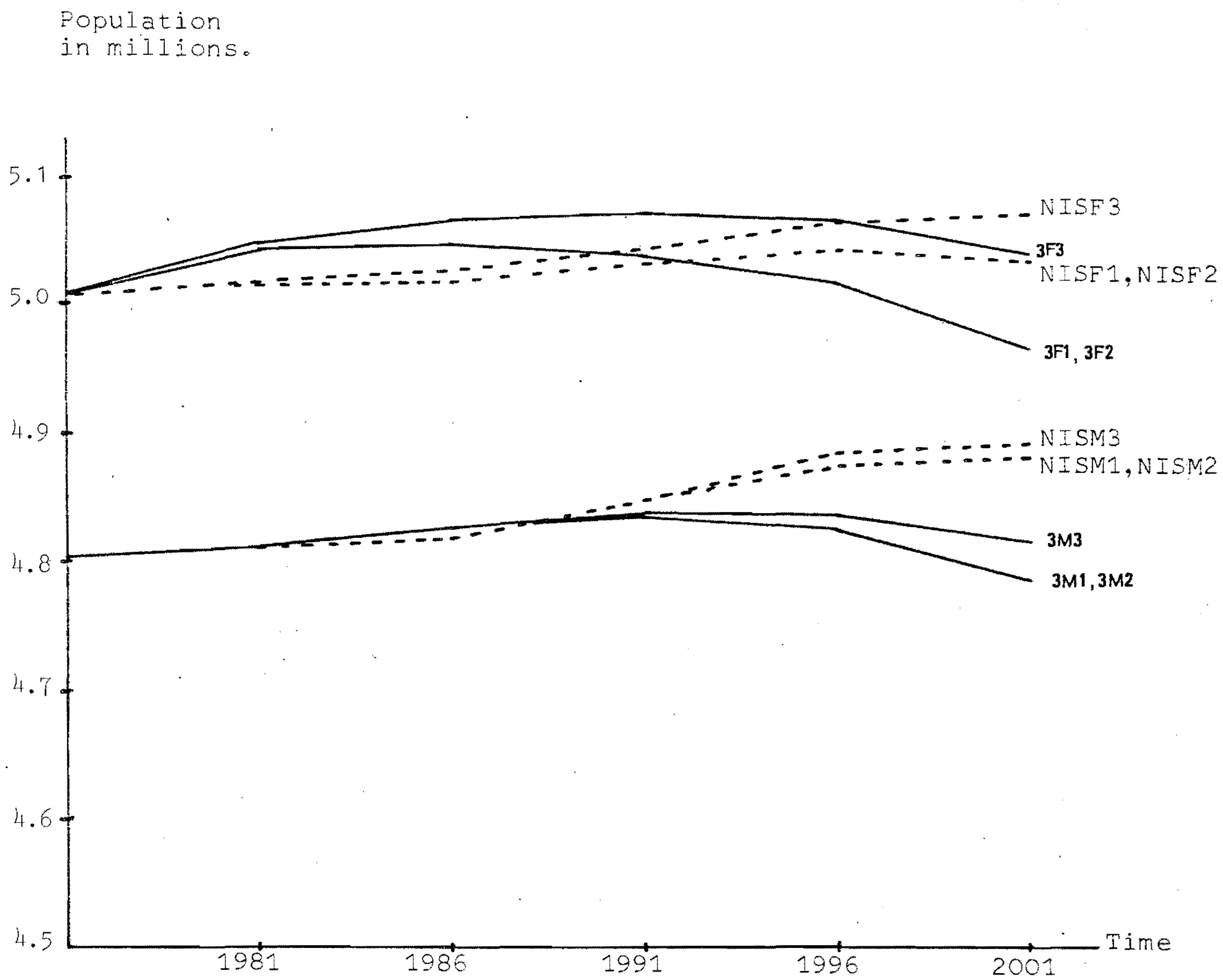
(2) Over twenty-five projection years, international migration has been instrumental in preventing a loss of population size amounting to :

a) 18 000 (males) and 36 000 (females) in the N.I.S. projections

b) 28 000 (males) and 75 000 (females) in our projections.

Cf. - Bulletin de Statistique (Op. cit.)

Figure 2: Evolution of the Belgian population (1976-2001) by sex, according to different migration scenarios. Comparison of NIS and OUR results.



Note:

N.I.S. projections

- female NISFb (b= 1,2, or 3 as for 3Fb)
- male NISMb (b= 1,2, or 3 as for 3Mb)

Our projections (taken from the 3-region case)

female 3F1, 3F2, 3F3
male 3M1, 3M2, 3M3

oncoming turning points which will probably occur soon after the turn of the century. Thus in spite of the differences in the hypotheses used (as regards mortality, fertility and migration)(1) both the N.I.S. projections and our own point to an absolute decrease in population size occurring in the not too distant future. Over the twenty five years of projection however, the following differences in results concerning net population increase (or decrease) are to be noted :

a) Re projections without international migrations :

1) In the case of females :

- NIS values result in a net gain of 21 000 (approx.)
- Our projections result in a net loss of 39 000 (approx.)

2) In the case of males :

- NIS values give rise to a net gain of 75 000 (approx.)
- Our projections end up with a net loss of 16 000 (approx.)

b) Re projections with international migrations :

1) Case of females :

- NIS values give rise to a net gain of 57 000 (approx.)
- Our values give rise to a net gain of 36 000 (approx.)

2) Case of males :

- NIS values give rise to a net gain of 94 000 (approx.)
- Our values give rise to a net gain of 12 000 (approx.)

Thus even in the absence of international migration, the NIS hypotheses concerning mortality and fertility are sufficient to bring about a net population increase (for each of the two sexes) over the twenty-five year projection period. In our projections however a net increase is made possible only through the action of international migration; its positive contributive action growing more important as population size becomes smaller(2) - which is

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(1) These differences have already been outlined in the section entitled Methodology.

(2) This is a consequence of maintaining constant annual immigration flow on the one hand and emigration probabilities on the other : while immigration flow remains thus absolutely invariant, the out-going annual migration flow increases (decreases) by and large as population size increases (decreases).

what happens after the arrival of the maxima found in Fig. 2 i.e. towards the end of the projection period.

Of the many interesting features of population evolution a few have been singled out for comment in the present text as they are of particular interest for planning purposes.

Granted the tendency in Belgium to extend the years of schooling beyond the legal minimum, the age group 20-64 has been considered here as constituting the active segment of the population. Fig. 3 shows the changes experienced by the population segments comprised of persons (both sexes together) who have just entered (age group 20-24) "active life" and those who are about to leave it (age group 60-64) through retirement together with the evolution of the total active population (20-64). Here as in many of the other graphs that follow, the corresponding evolution as seen in the results of the recent NIS projections has been graphed for purposes of comparison. The drastic fall of the 20-24 curve from 1986 reflects the fall in annual births registered since 1964 whereas the pronounced dip in the 60-64 curve[1] can be attributed to the disturbances of the birth function experienced around the period of the first world war. The first pannels of Fig. 4 (Ratio A is the ratio of age group 20-24 to age group 60-64)[1][2] compare the exits and entries into "active" life. The ratio in question never goes below unity though it gets fairly close to it at the end of the present century thus calling a halt to the rapid rise (Fig. 3) of the active population experienced up to mid eighties. The balance between entries and exits is however seen to be incapable of presenting a slight dip in the 20-64 curve (Fig. 3)[1] at the end of the century due to the prevailing effect of mortality over the whole range of the "active" ages. The curves composed of dots show to what extent international migration decreases the exits and increases both the entries and the total active population itself.

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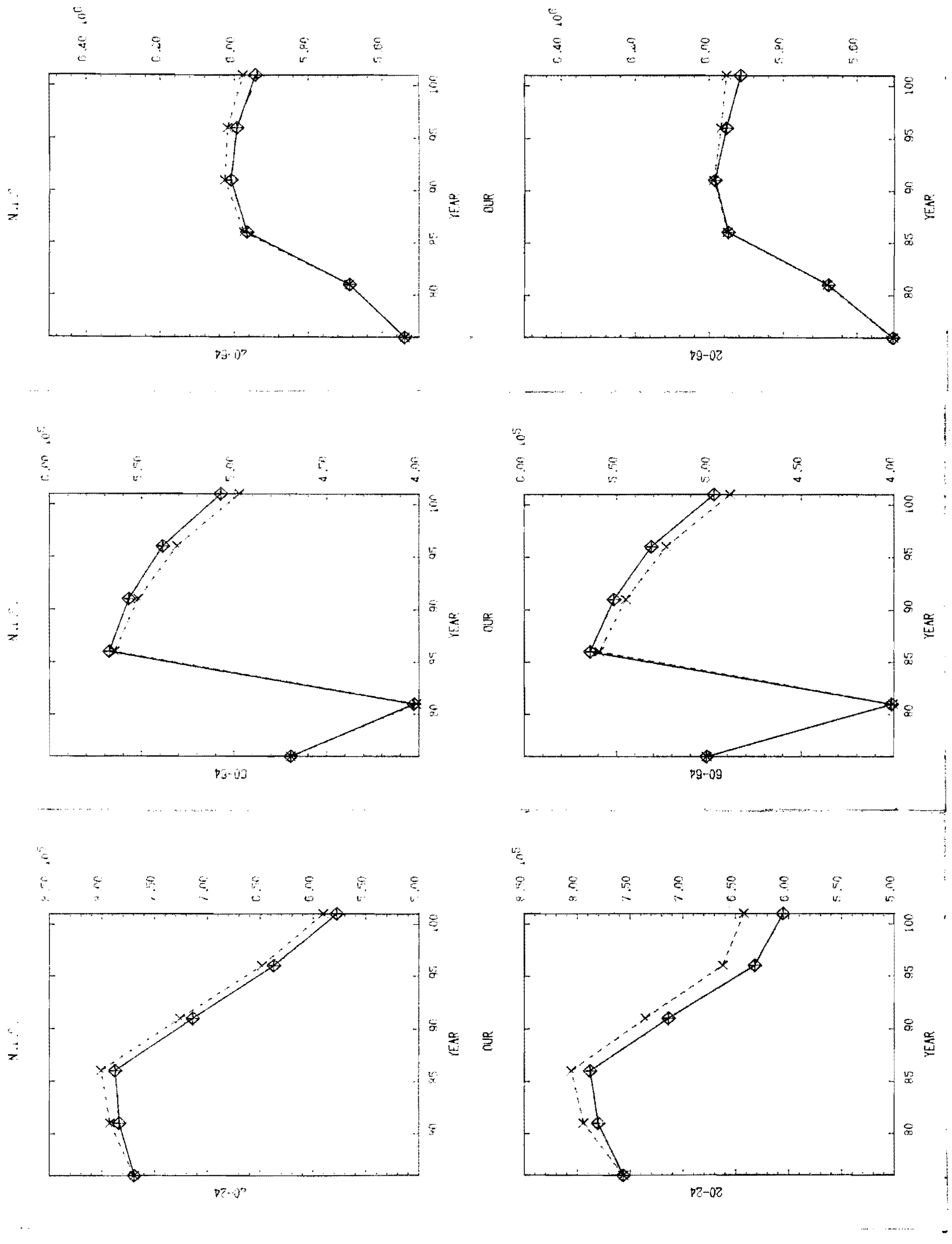
(1) Reference is made to the unbroken line covering the two scenarios - they overlap here - which leave out international migration.

(2) Ratio B in Fig. 4 (Age group 75+ as a proportion of those who are aged 65+) draws attention to that portion of the retired population needing special care because of advanced old age.

Fig. 3 : Evolution of age groups 20-24, 60-64 and 20-64 in Belgium (1976-2001) according to different migration scenarios. Comparison of NIS and OUR results.

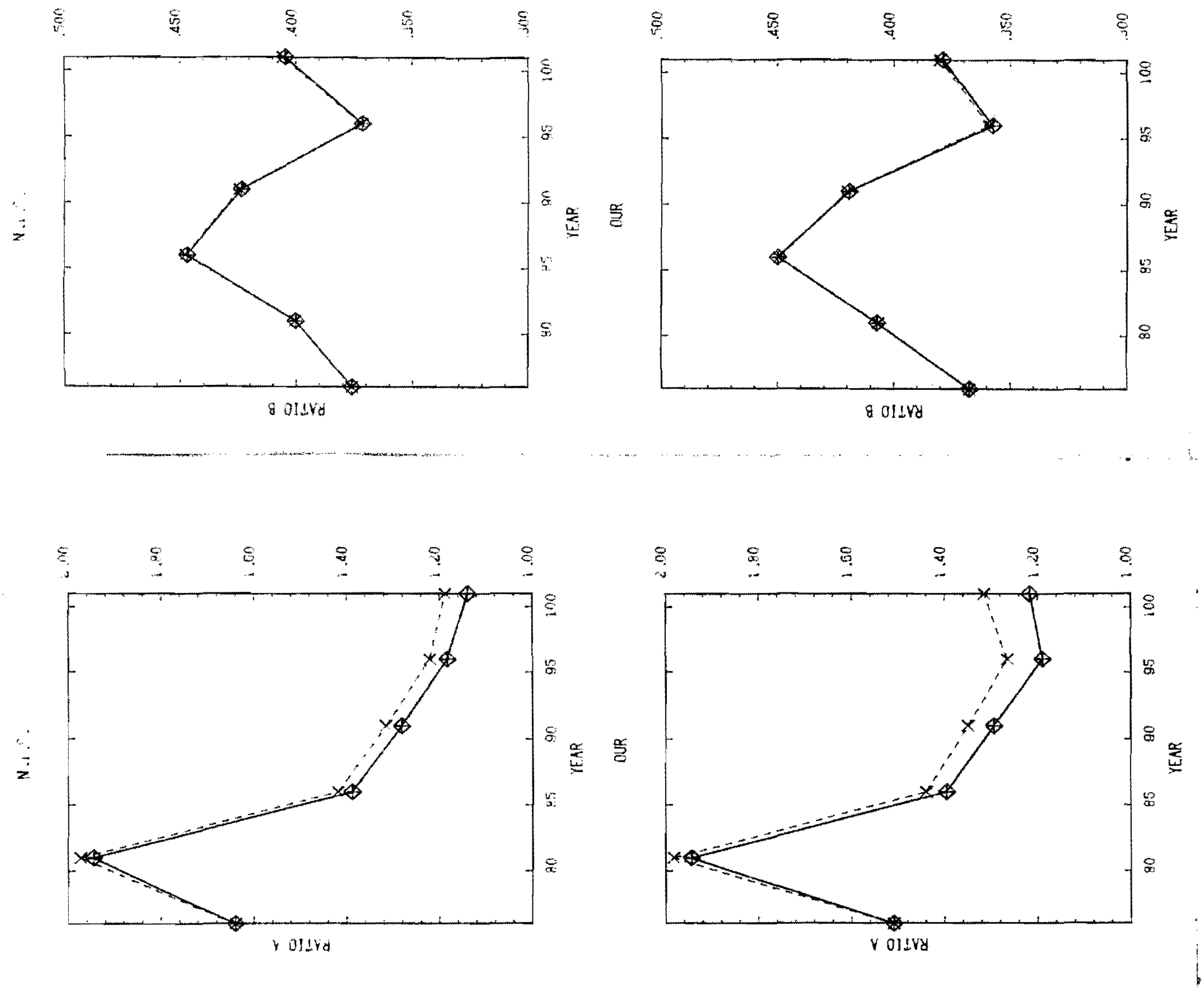
—— No migration --- Only internal migration ... Also international migration



Note : All graphs refer to the two sexes taken together.

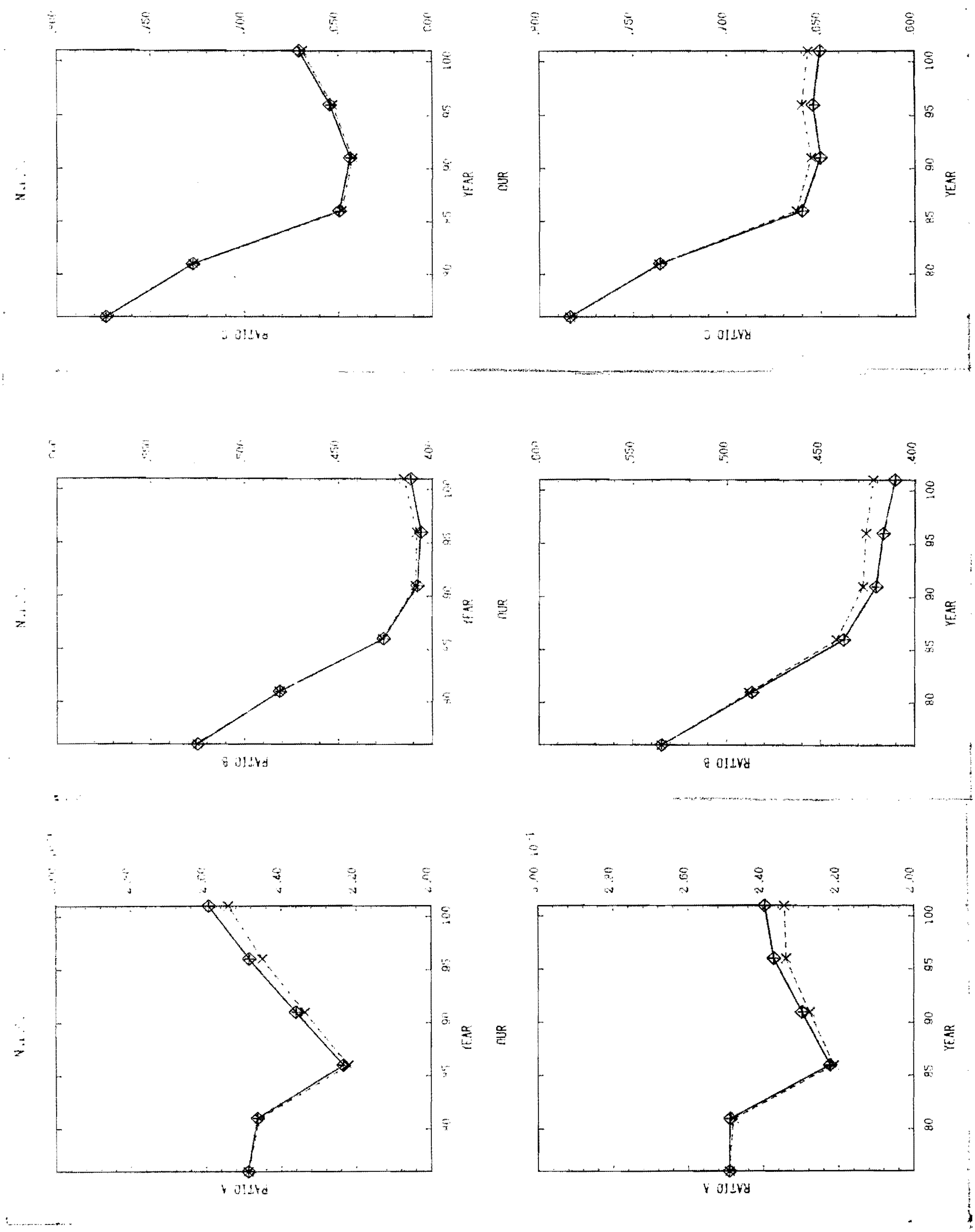
Fig. 4 : Evolution of chosen ratios (A = 20-24/60-64; B = 75+/65+) in Belgium (1976-2001) according to different migration scenarios. Comparison of NIS and OUR results.

—— No migration --- Only internal migration ... Also international migration



Note : All graphs refer to the two sexes taken together.

Fig. 5 : Evolution of chosen ratios (A = (65+)/20-64; B = 0-19/20-64; C = ((65+) + (0-19))/20-64) in Belgium (1976-2001) according to different migration scenarios. Comparison of NIS and OUR results.
—— No migration --- Only internal migration ... Also international migration



Note : All graphs refer to the two sexes taken together.

Fig. 5 shows the evolution of the relation existing between the active population and the two "inactive" population segments - age groups 0-19 and 65+ - as seen through three dependency ratios (Ratios A, B and C) which are formed by dividing the age groups 65+, 0-19 and their sum respectively by age group 20-64. Whereas the burden on the active population due to the age groups in retirement (Ratio A) goes through a minimum, the marked fall of Ratio B shows how the burden carried by the active population vis-a-vis those who have not yet finished schooling has decreased. The initial velocity of fall (Ratio B, Fig. 5) is the result both of falling annual births since the mid-sixties and the rising numerical importance of the active population(1) estimated as occurring up to the early nineties (Fig. 3). The pronounced similarity in the evolution of the Ratios B and C point to the very important part played by the lower age segment 0-19 in the evolution of the total burden. That the action of international migration in causing a small rise (less than 0.01) of the total dependency ratio over twenty-five years (compare the dotted and unbroken lines representing Ratio C) is largely due to effect of net migration at the bottom of the population pyramid (i.e. at early ages) is seen through a comparison of the Ratios A, B and C in Fig. 5.

A word about the significance of the different age ratios hitherto used. Whether the evolution of a given ratio is judged advantageous or not depends on the particular point of view in relation to which such a judgement is made. The sustained decrease of ratio A (20-24/60-64) in Fig. 4(2) is, *ceteris paribus*, particularly disadvantageous for the well-being of the social security system related to old-age pensions since it increases the burden of the active population caused by the ages 65+ (Cf. Ratio A, Fig. 5, which increases from 1986). The pronounced rise of the numerical importance of the active population (Cf. Fig. 3) - its acquired size is not lessened in any substantial fashion before the end of the century - helps, on the contrary,

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(1) Post World War II birth cohorts have remained heavily packed up to the late sixties. Even though the baby boom of 153 000 births in 1946 was brought down to 142 000 in 1951, this was followed by an almost uninterrupted rise of annual births up to 1964 when its value reached 161 000. This increase of the annual birth function is what brings about the rapid rise of the active population in the early part of the projection period.

(2) Its initial rise is short-lived.

to ease the burden caused by the ages 0-19 (Ratio B, Fig. 5). Increasing size of the active population can however be a mixed blessing. It is advantageous only in the presence of correspondingly advantageous employment possibilities. That the high level of unemployment currently existing points to a gloomy future in this regard can hardly be denied!

B) Population movement in Brabant, the Rest of Flanders and the Rest of Wallonia

The evolution of population size in Belgium taken as a whole depends on the evolution of each of its sub-national regions. Fig. 6 shows the evolution of population size in each of these regions in our three region projections. In the absence of all types of migration (cf. the 3F1 and 3M1 curves), Brabant and the Rest of Wallonia are seen to witness a net population loss, whereas the contrary is evidenced by the Rest of Flanders. Internal migration however helps to diminish the ensuing divergence by attenuating both the extent of loss in Brabant and in the Rest of Wallonia as also the gain (or increase) in the Rest of Flanders (see curves 3F2 and 3M2). International migration, like internal migration, lessens population loss for both sexes in Brabant and the Rest of Wallonia. Brabant even succeeds in registering a net population gain through the instrumentality of international migration. All this can be seen in the similar positioning of the different curves for Brabant and the Rest of Wallonia - 3F3 (3M3) is above 3F2 (3M2), which in turn is above 3F1 (3M1). Note that population gain, via internal migration, experienced by Brabant and Rest of Wallonia. is nothing other than population loss in the Rest of Flanders. International migration increases this loss for males but has the contrary effect in the case of females.

The evolution of the population features already commented on in the case of Belgium as a whole are graphed for Brabant, the Rest of Flanders and the Rest of Wallonia in Figures 7 through 10. Figure 11 shows what proportion of the total population in each of the three regions is formed of the two "inactive" population segments during the projection period. The following points are noteworthy.

- the influence of international migration (seen through the dotted lines) in increasing the size of the age group 20-24 and lowering that of the 60-64 olds (cf. Fig. 7) is mostly felt in Brabant, where it reinforces

Figure 6 : Evolution of population (the three region case)[x] in 1976-2001 by sex and migration scenario. —— No migration --- Only internal migration ... Also international migration
x Brabant, Rest of Flanders and the Rest of Wallonia.

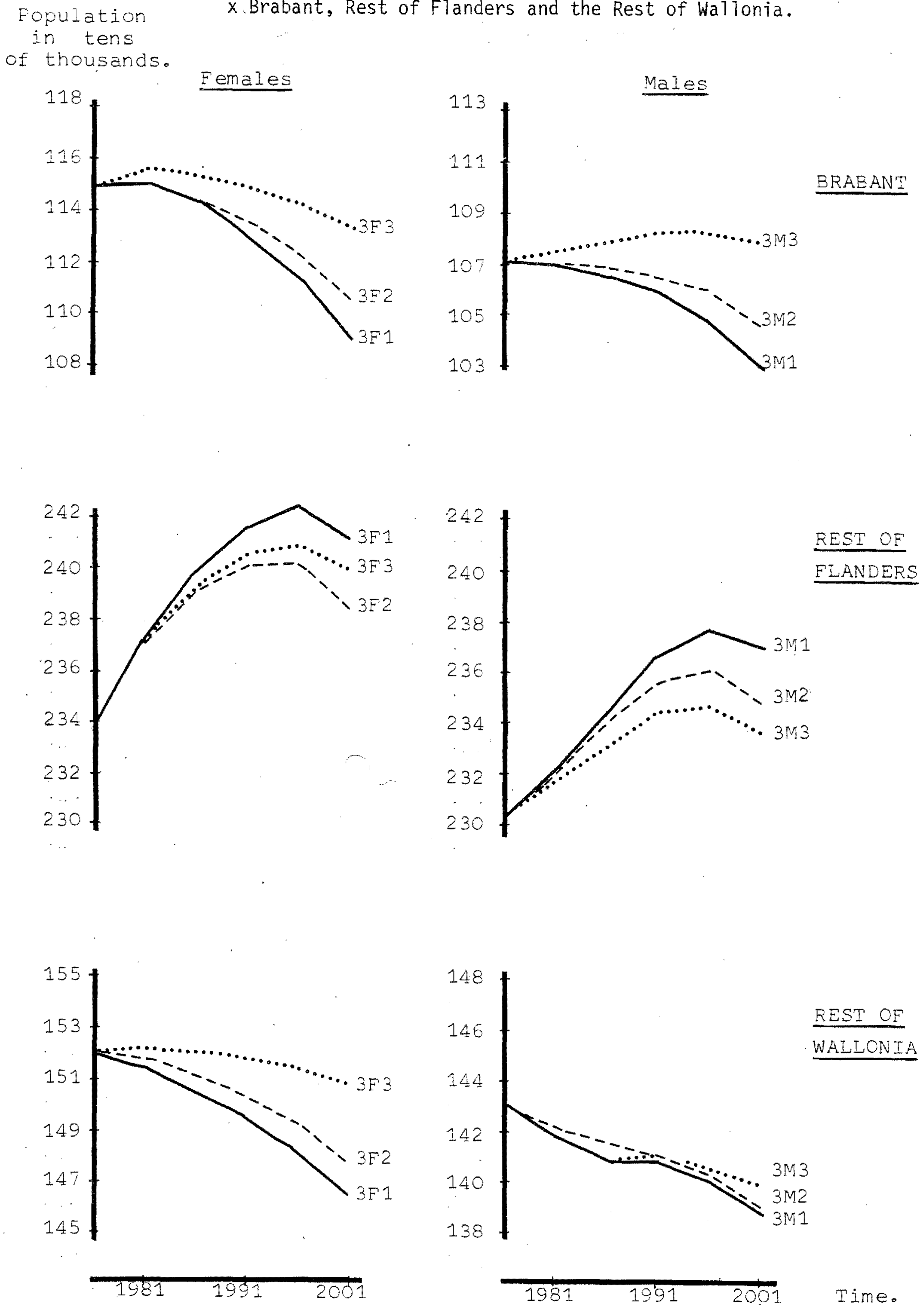
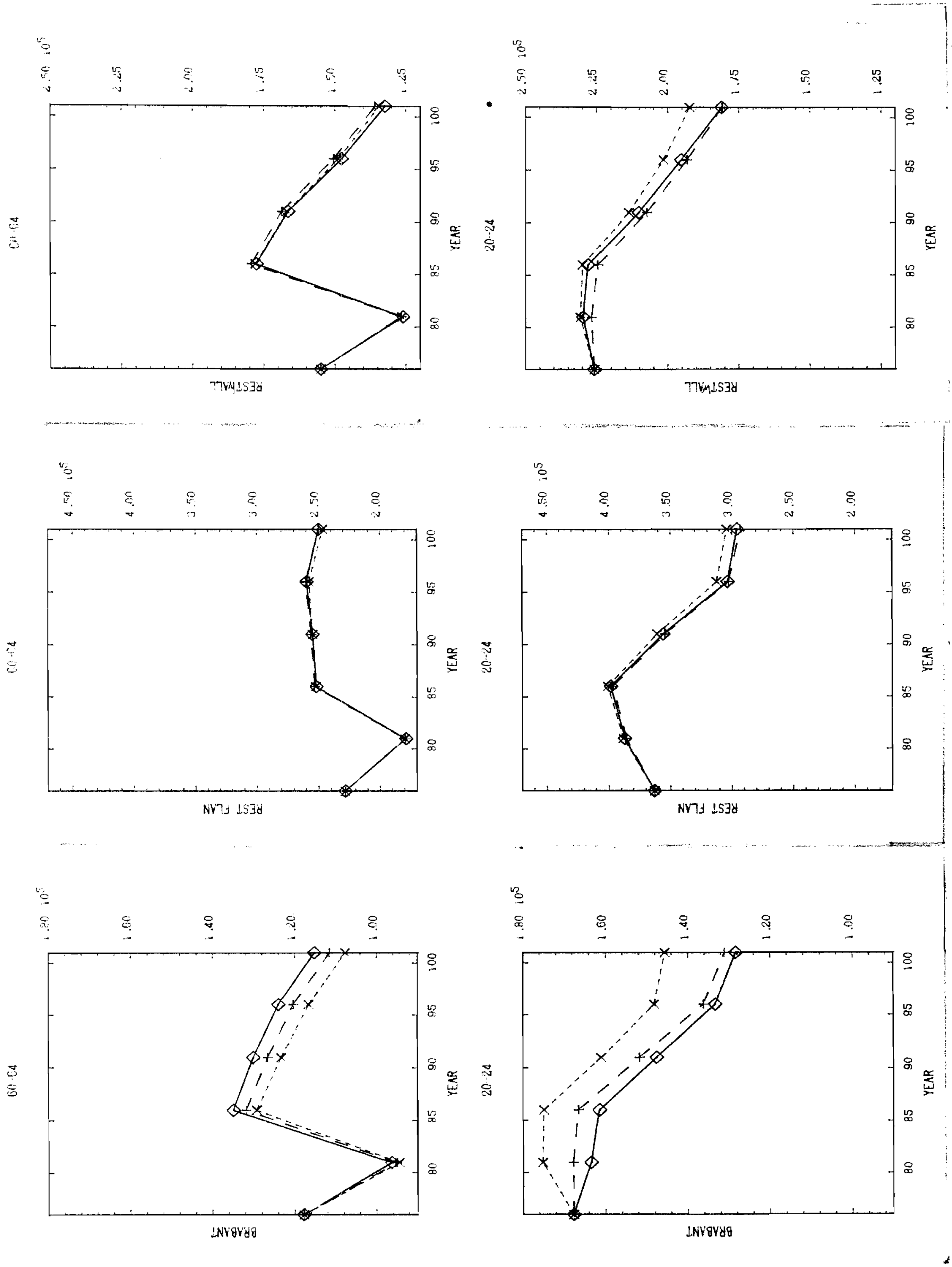
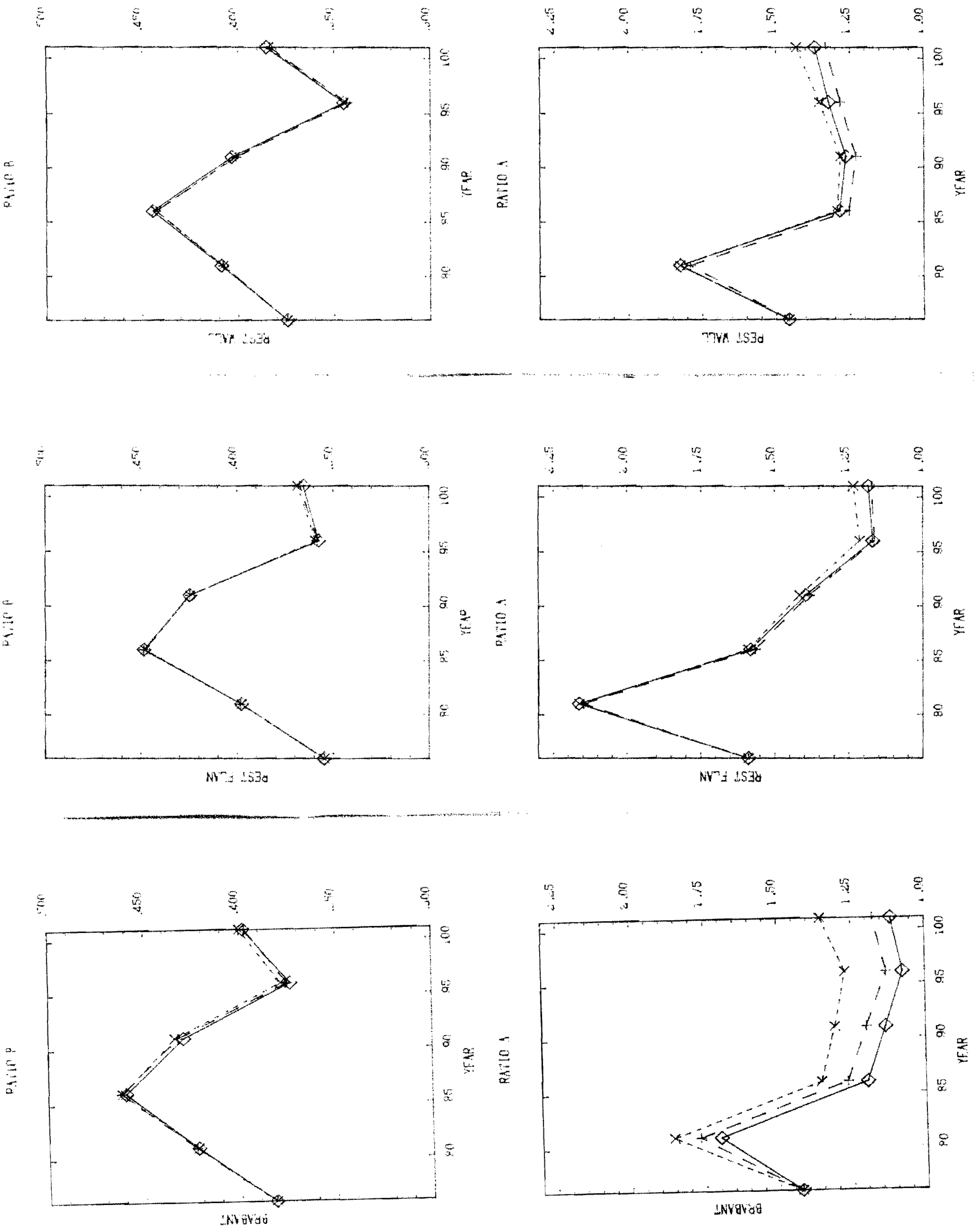


Fig. 7 : Evolution of age groups 20-24 and 60-64 in chosen regions[x] (1976-2001)
according to different migration scenarios.
—— No migration --- Only internal migration ... Also international migration
x Brabant, Rest of Flanders and the Rest of Wallonia.



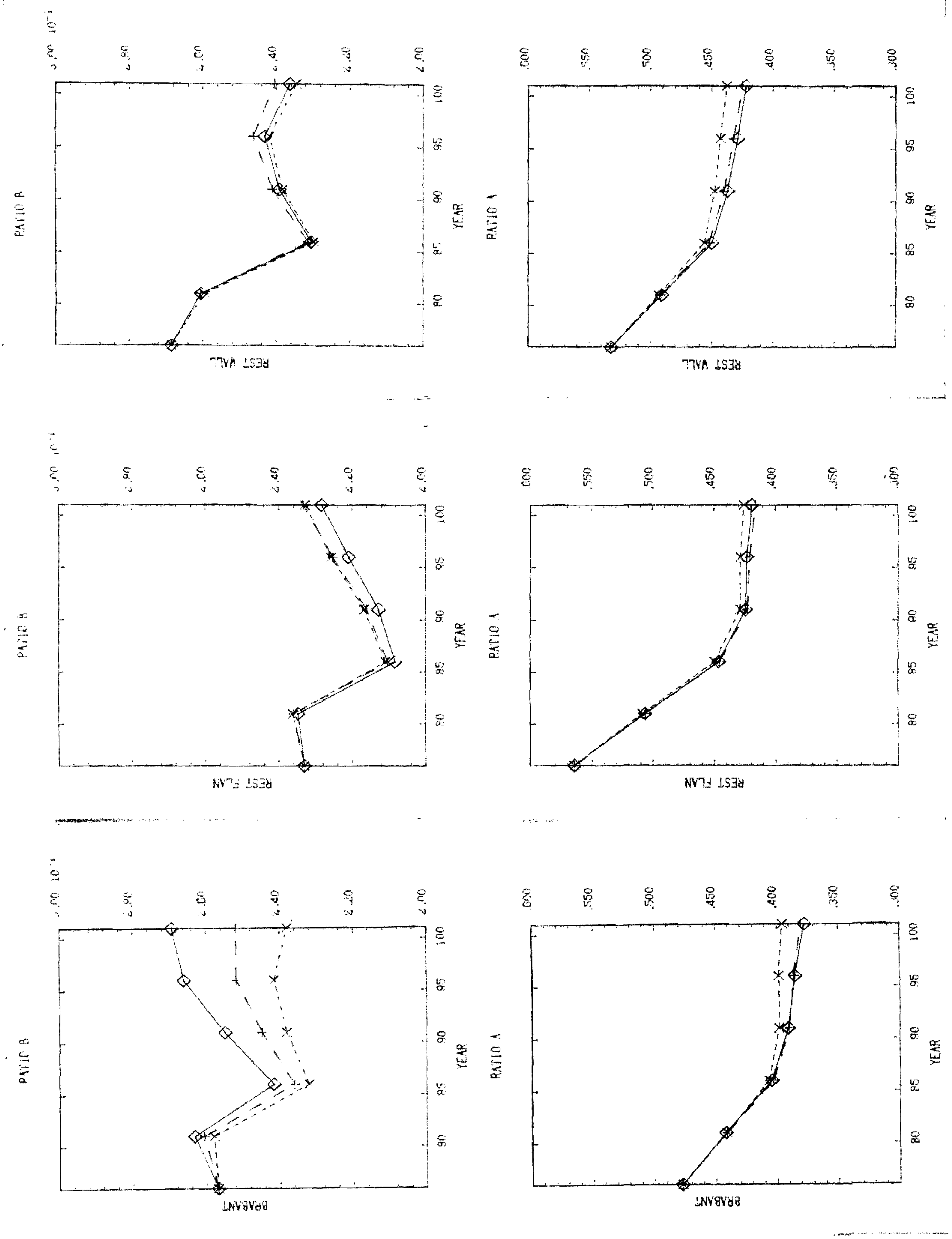
Note : All graphs refer to the two sexes taken together.

Fig. 8 : Evolution of chosen ratios (A = 20-24/60-64; B = 75+/65+) in chosen regions[x] (1976-2001), according to different migration scenarios.
—— No migration --- Only internal migration ... Also international migration
x Brabant, Rest of Flanders and the Rest of Wallonia.



Note : All graphs refer to the two sexes taken together.

Fig. 9 : Evolution of chosen ratios (A = 0-19/20-64; B = 65+/20-64) in chosen regions[x] (1976-2001), according to different migration scenarios.
—— No migration --- Only internal migration ... Also international migration
x Brabant, Rest of Flanders and the Rest of Wallonia.

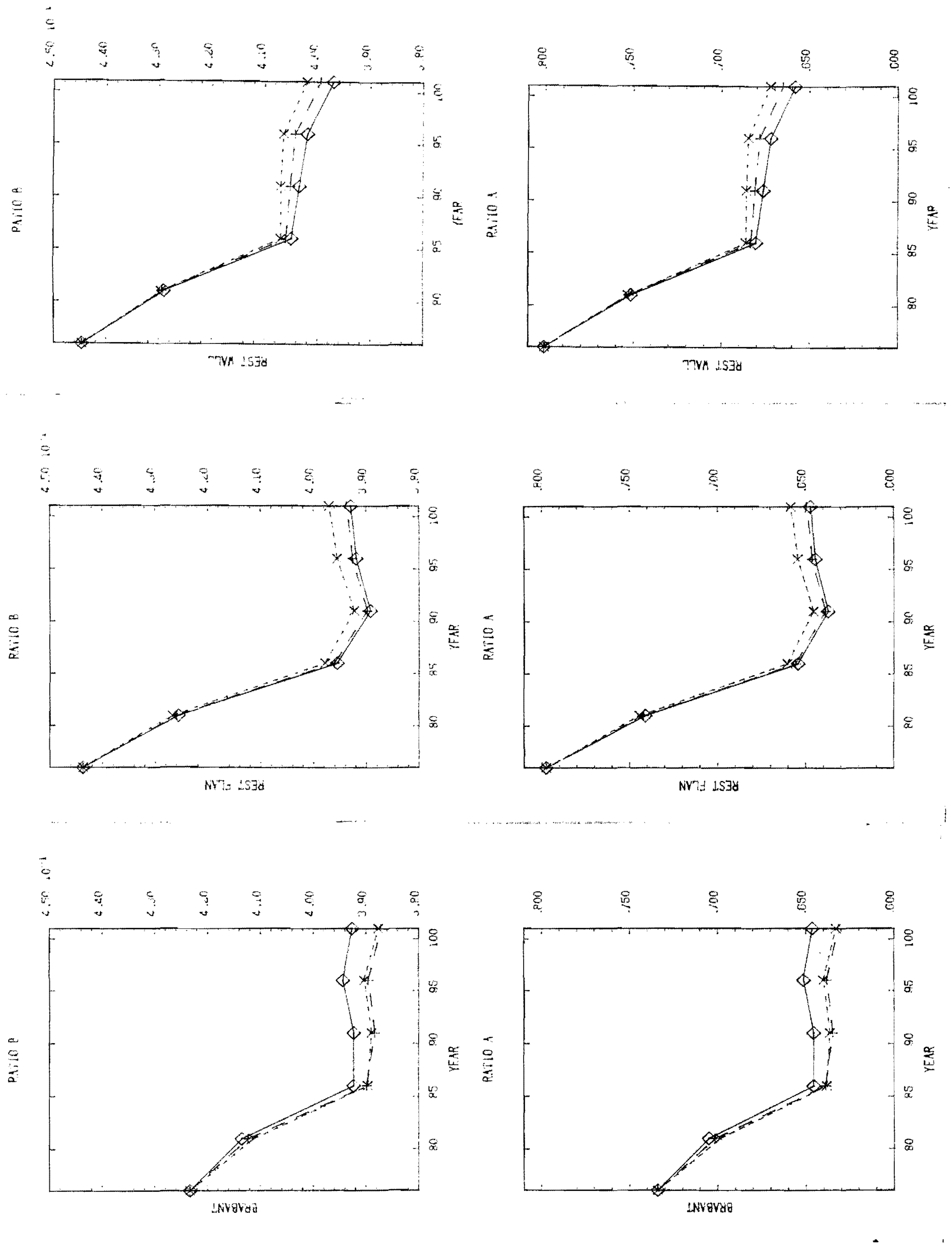


Note : All graphs refer to the two sexes taken together.

Fig. 10 : Evolution of chosen ratios (A = ((65+) + (0-19)/20-64; B = ((65+) + (0-19))/0+) in chosen regions[x] (1976-2001), according to different migration scenarios.

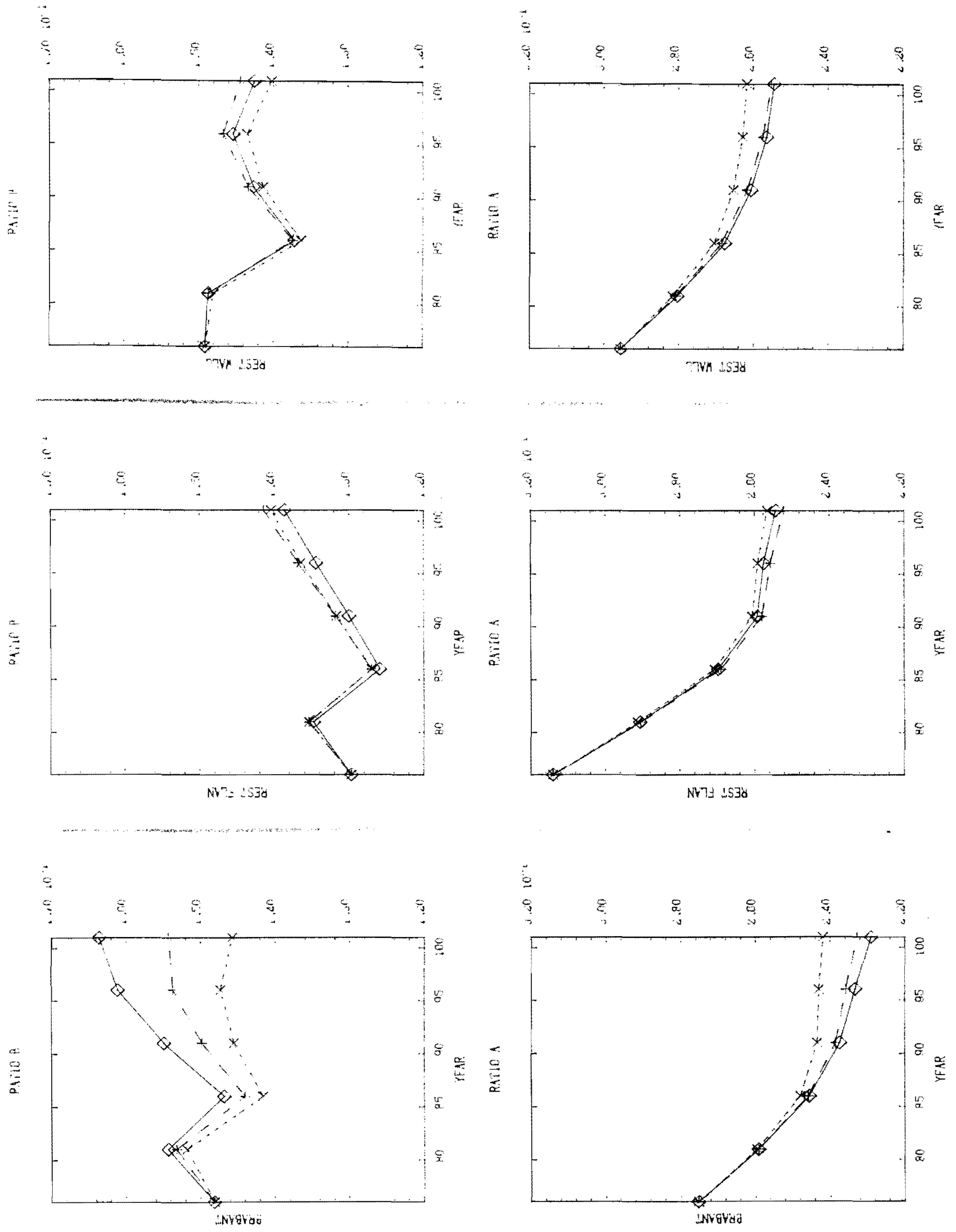
—— No migration --- Only internal migration ... Also international migration

x Brabant, Rest of Flanders and the Rest of Wallonia.



<u>Note</u> : All graphs refer to the two sexes taken together.

Fig. 11 : Evolution of chosen ratios^{x}(A = 0-19/0+; B = 65+/0+) in chosen regions (1976-2001), according to different migration scenarios.
—— No migration --- Only internal migration ... Also international migration
x Brabant, Rest of Flanders and the Rest of Wallonia.



<u>Note</u> : All graphs refer to the two sexes taken together.

the parallel action of internal migration (shown through the curves in dashes). In the Rest of Flanders, internal and international migration are seen to act in different directions. Fig. 8, which compares the two age groups in question (Ratio A) for the three regions, shows how international migration helps to keep the relevant ratio away from the value of unity.(1)

- While changes due to internal and international on the different dependancy ratios used(1) are found in all three regions, it is in Brabant that these effects are by and large most felt (cf. Figs. 9 and 10).
- The only beneficiary of a lowering of the total burden due to the sole action of internal migration is Brabant (cf. Fig. 10, Ratio A), this being brought about by changes introduced in ages 65+ (cf. Fig. 9 Ratio B and Fig. 11 Ratio B). International migration is seen to accentuate this effect. Its action on the burden caused by the 0-19 year olds is in the contrary direction : i.e. a rise in the dependency ratio 0-19/20-64 (Fig. 9 Ratio A).

C) Brussels, Flemish Brabant and Walloon Brabant

Granted the special position occupied by Brussels (formed of 19 communes) in the Belgian scene, the present text cannot be satisfactorily terminated without some comments in her regard. Figure 12 gives the evolution in population size of Brussels, Flemish Brabant and Walloon Brabant as it is obtained from our five-region projections. The diminishing size of Brussels stands out clearly. This loss, which is experienced in the absence of all forms of migration (curve 5F1, 5M1) is further intensified by migratory movements within Belgium (curves 5F2, 5M2). International migration however moderates the loss (curves 5F3, 5M3). The tables presented under the captions "MIGRATION FLOWS" and "OUTMIGRATION RATES"(2) show morevover that a good portion of the loss in question is due to migratory movements ending in Flemish Brabant (principally) and in Walloon Brabant (secondarily). This flight from

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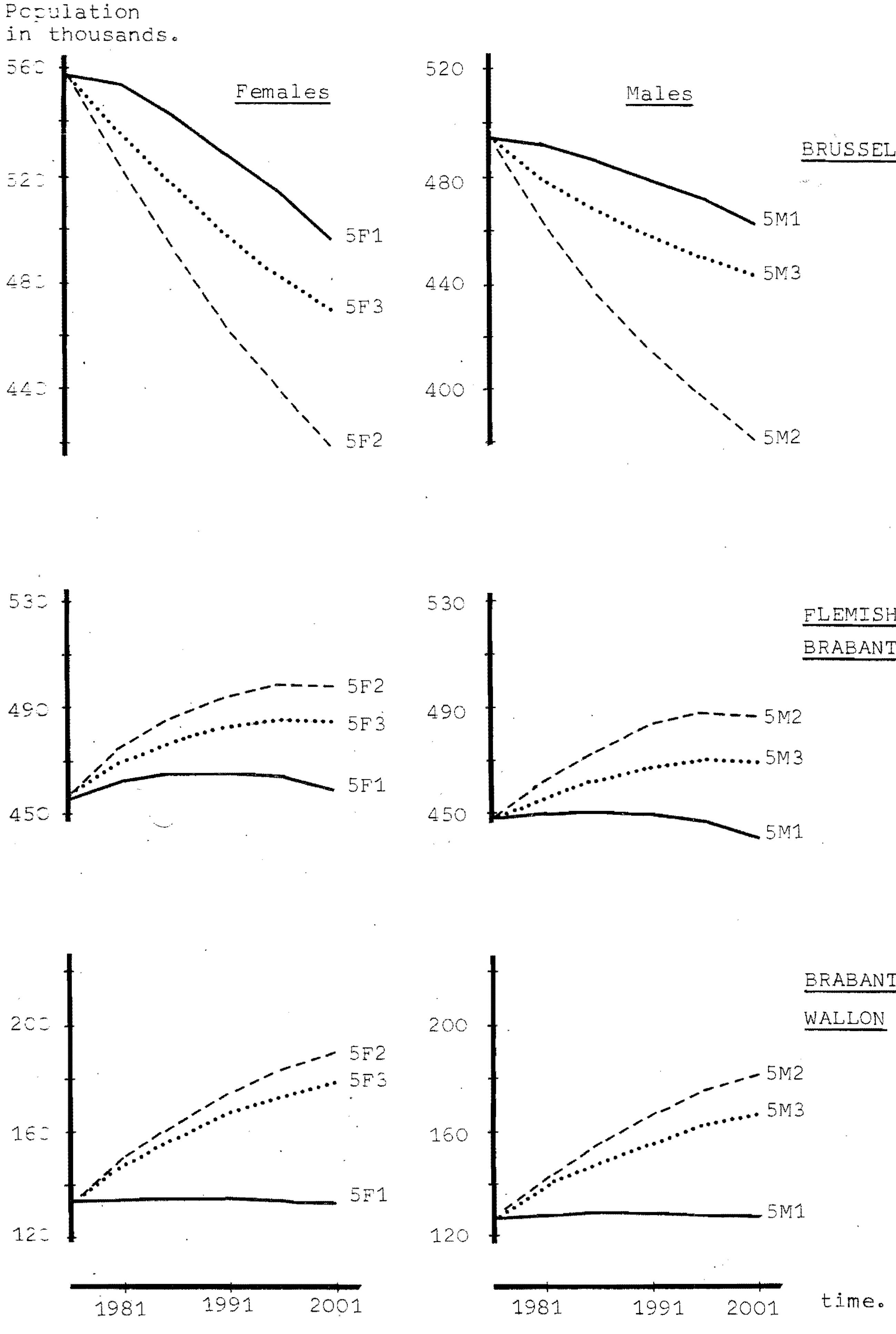
(1) Cf. supra for remarks concerning the significance of the ratio(s) question.

(2) The tables in point carry migration figures with simultaneous specification of region of origin and region of destination.

Figure 12 : Evolution of population in chosen regions[xx] (1976-2001), by sex and migration scenario. —— No migration --- Only internal migration ... Also international migration.
xx Brussels, Flemish Brabant and Walloon Brabant as seen through OUR five-region projections.



Brussels thus seems to be one more exemplification of the phenomenon of suburbanisation.(1) The extent of the loss involved over twenty-five years (25 % according to the N.I.S. figures and 15 % according to ours)(2) merits underlining as, among other possible consequences, its repercussions on the use and non-use of available living space (in buildings) is bound to be substantial. The positioning of the curves in Fig. 12 (compare 5F1 with 5F2, and 5M1 with 5M2) shows that even though the migratory flow from Brussels is directed more towards Flemish Brabant than towards Walloon Brabant (as has already been pointed out earlier), it is Walloon Brabant and not Flemish Brabant which is the principle beneficiary of the total volume of Brabant directed internal migration in Belgium. This is seen through the greater separation between the curves 5F1 (5M1) and 5F2 (5M2) proper to Walloon Brabant as opposed to those characteristic of Flemish Brabant.

Figure 13 through 17 present the evolution of the same population features for Brussels, Flemish Brabant and Walloon Brabant as were given earlier for Brabant, the Rest of Flanders and the Rest of Wallonia.

The net attraction exercised by Brabant on young migrants (aged 20-24) coming into Belgium, commented on earlier, is clearly seen to be largely due to Brussels (cf. Fig. 13). This is however not the case as regards the internal migration of 20-24 year olds. They too are seen to join the flight from Brussels from around the mid-eighties.

The following points merit attention.

- that international migration is chiefly responsible for keeping the Ratio A in Fig. 14 above unity in Brussels.
- that the total burden imposed on the active population, in Brussels, is considerably lessened by international migration (cf. Fig. 16 Ratio A) thus enhancing the influence of internal migration which acts in the same direction as international migration . The part played separately by the two "inactive" population segments can be followed in Fig. 15.

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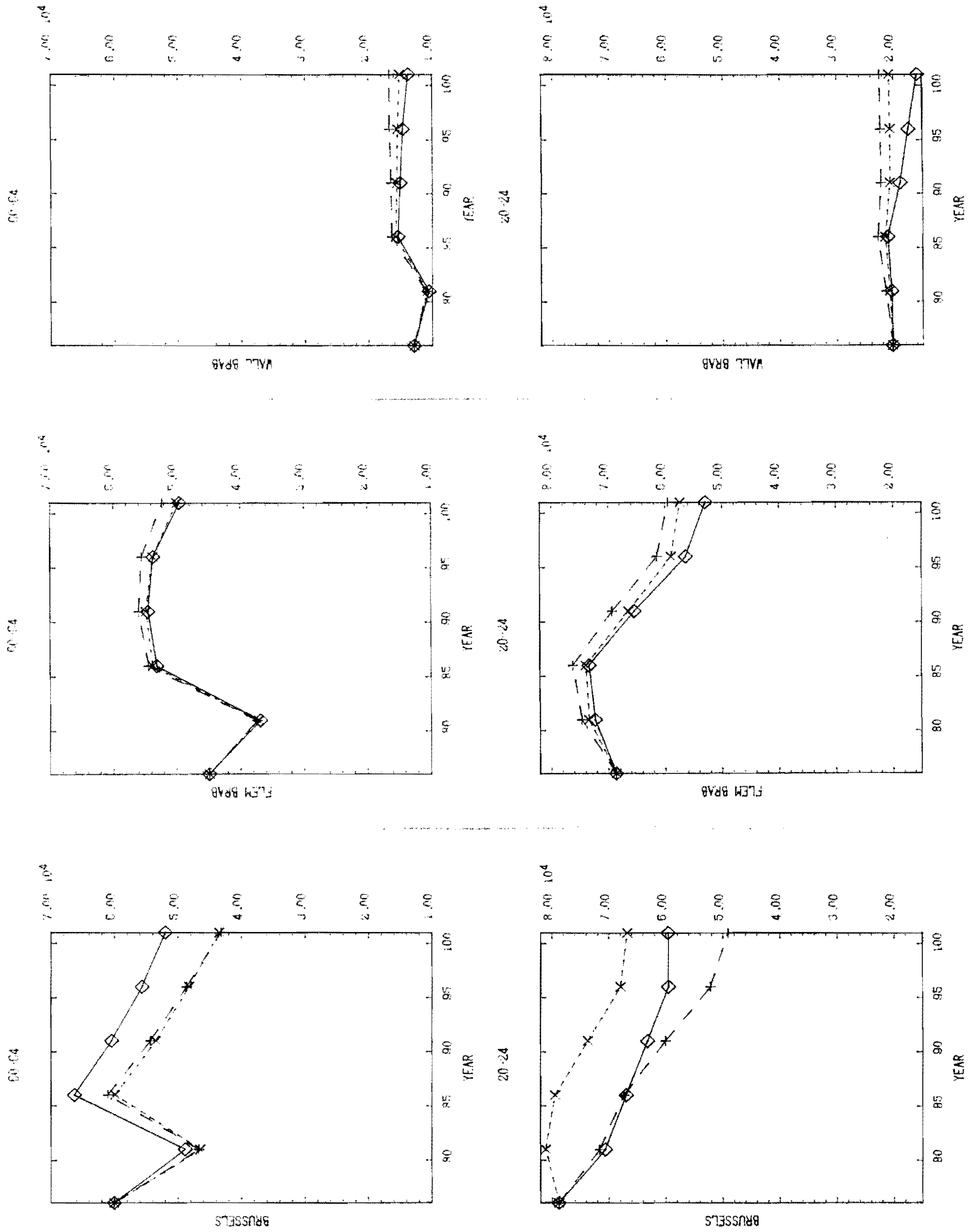
(1) Migration studies made in other countries speak not only of "suburbanisation" but also of "re-urbanisation" - the return to the big cities. This process is however not made manifest through our projection figures.

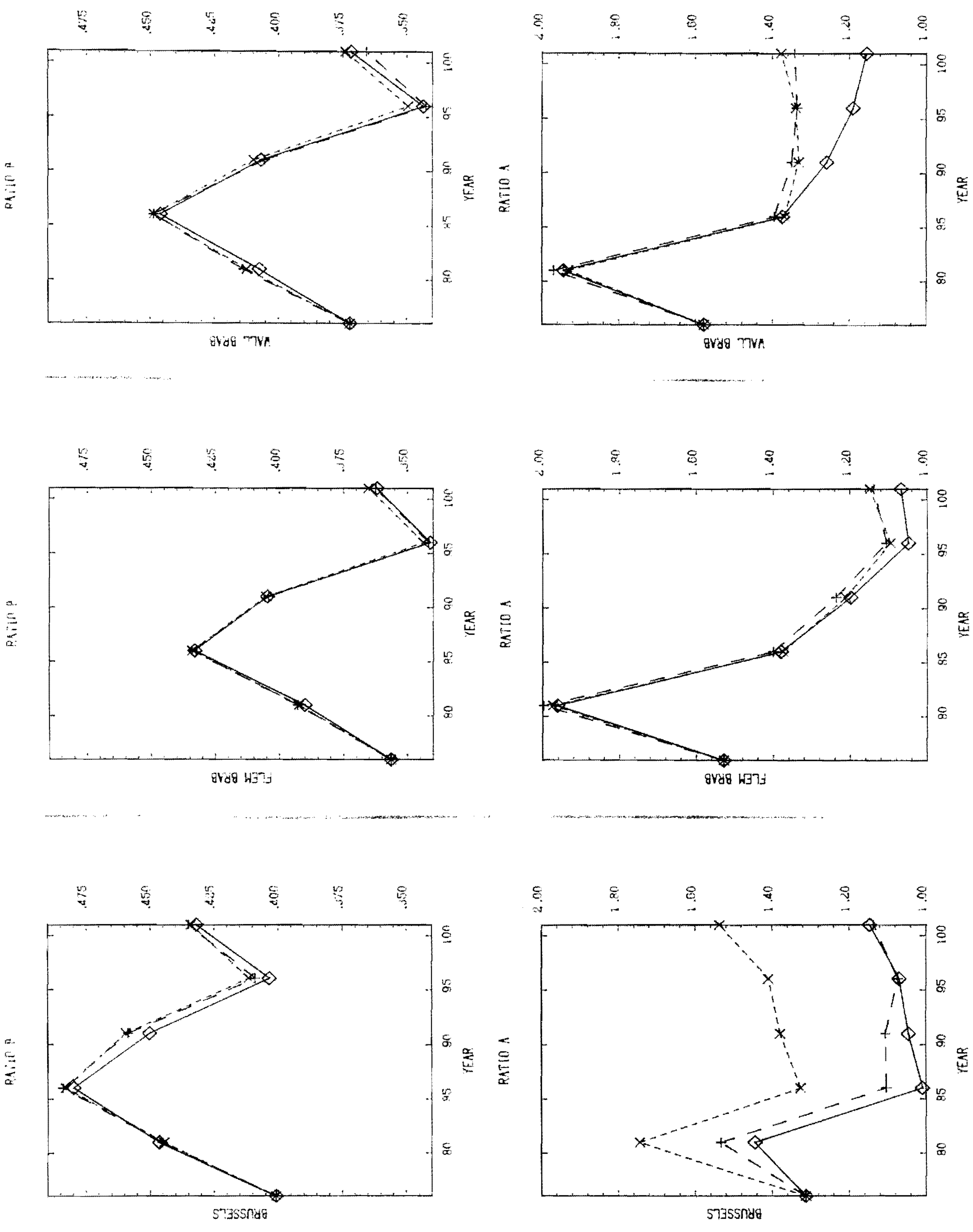
(2) The computed percentages refer to the scenario which takes count of both forms of migration.

Fig. 13 : Evolution of age groups 20-24 and 60-64 in chosen regions[xx] (1976-2001), according to different migration scenarios.
—— No migration --- Only internal migration ... Also international migration
xx Brussels, Flemish Brabant and Walloon Brabant.



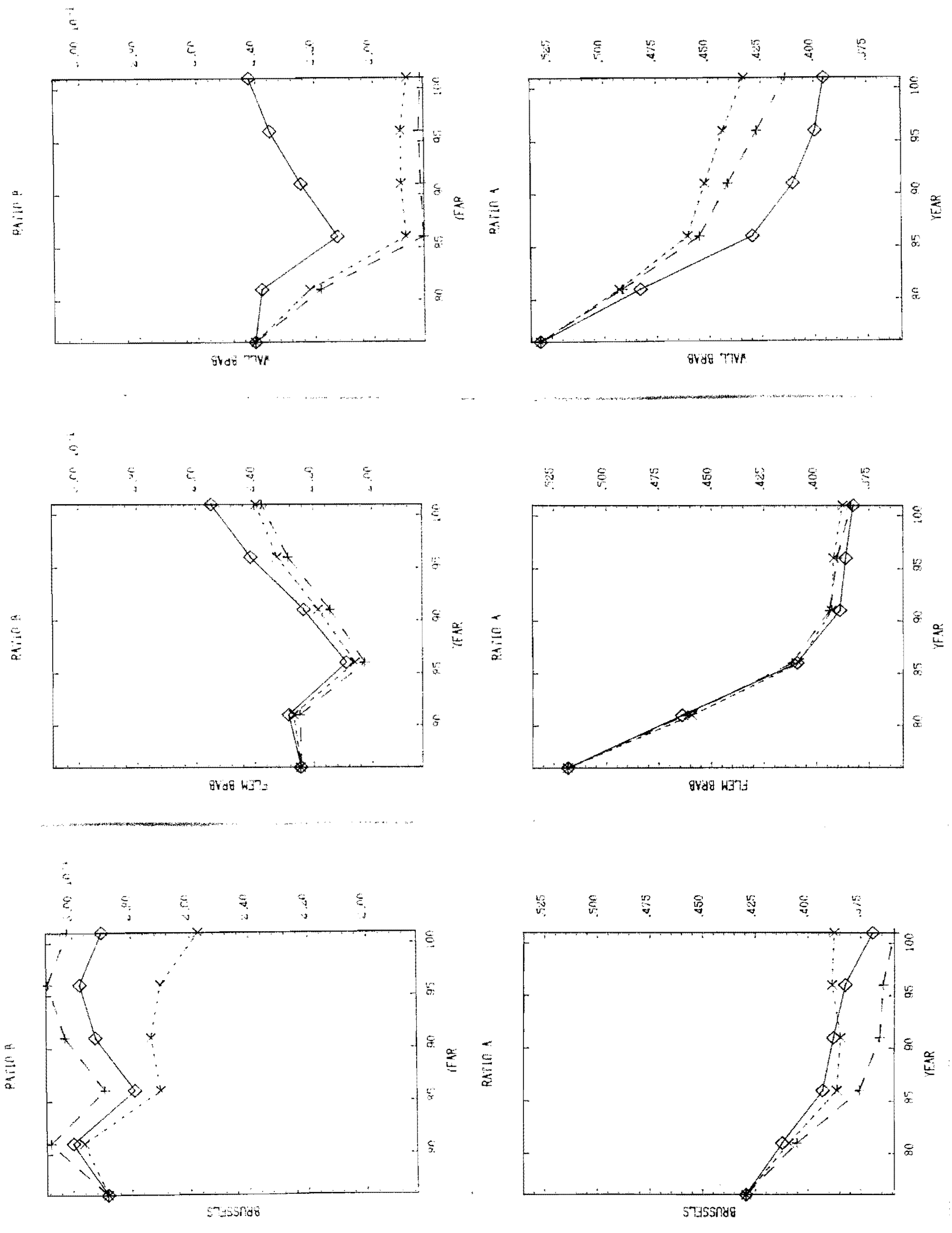
Note : All graphs refer to the two sexes taken together.

Fig. 14 : Evolution of chosen ratios (A = 20-24/60-64; B = 75+/65+) in chosen regions[xx] (1976-2001), according to different migration scenarios.
—— No migration --- Only internal migration ... Also international migration
xx Brussels, Flemish Brabant and Walloon Brabant.



Note : All graphs refer to the two sexes taken together.

Fig. 15 : Evolution of chosen ratios (A = 0-19/20-64; B = 65+/20-64) in chosen regions[xx] (1975-2001), according to different migration scenarios.
—— No migration --- Only internal migration ... Also international migration
xx Brussels, Flemish Brabant and Walloon Brabant.

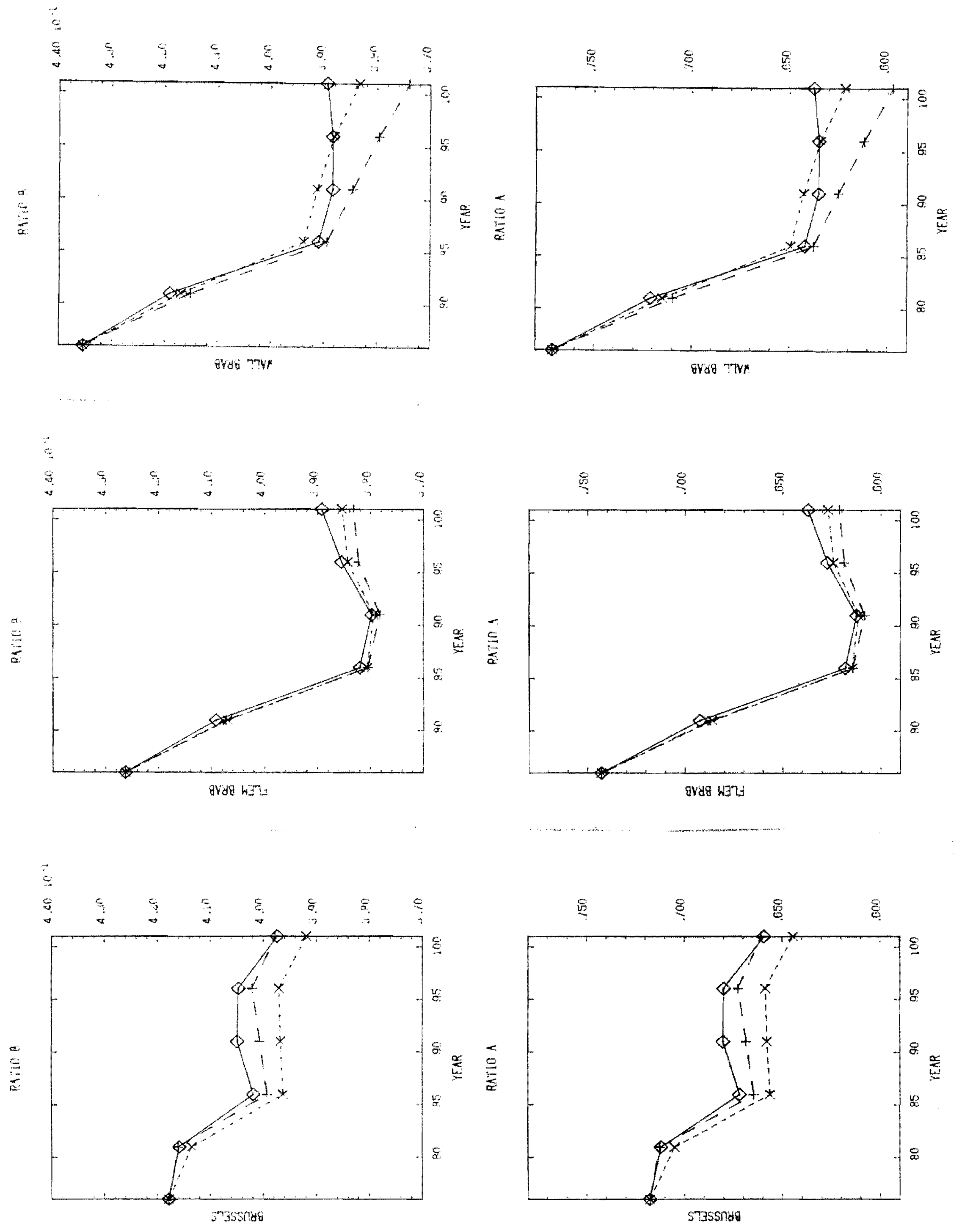


Note : All graphs refer to the two sexes taken together.

Fig. 16 : Evolution of chosen ratios (A = ((65+) + (0-19))/20-64; B = ((65+) + (0-19))/0+) in chosen regions, in 1976-2001, according to different migration scenarios.

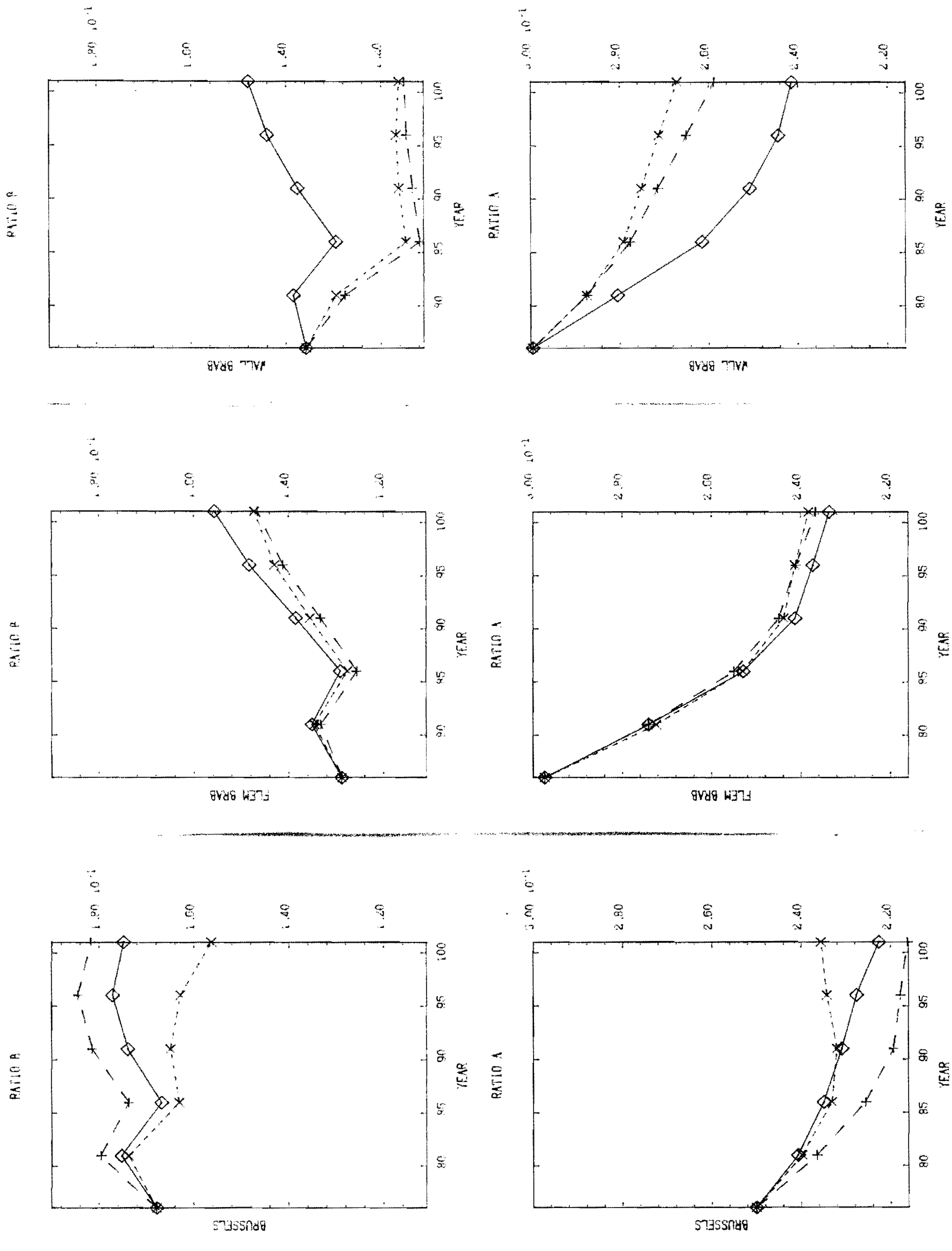
—— No migration --- Only internal migration ... Also international migration

xx Brussels, Flemish Brabant and Walloon Brabant.



Note : All graphs refer to the two sexes taken together.

Fig. 17 : Evolution of chosen rations (A = 0-19/0+; B = 65+/0+) in chosen regions, in 1976-2001, according to different migration scenarios.
—— No migration --- Only internal migration ... Also international migration
xx Brussels, Flemish Brabant and Walloon Brabant.



Note : All graphs refer to the two sexes taken together.

- That the changes in Brussels due to internal migration leads to an aging of population. Both the increased importance of her 65+ age group and the diminished importance of her 0-19 population segment (cf. Fig. 17 Ratios A and B)(1) play a part in this process brought about through the agency of internal migration. The reduced (increased) importance of 0-19 (65+) age group in Brussels, due to internal migration, is found to accompany a remarkable increase (decrease) in importance in Walloon Brabant. Brussels' loss (gain) appears thus to result largely in the gain (loss) of Walloon Brabant.(2)

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(1) Compare the unbroken curve and the curve formed of dashes in each case.

(2) This is particularly true of the population segment 0-19. Brussels' loss as regards the importance of the 0-19 year olds mainly benefits Brabant (cf. Fig. 11, Ratio A), since the Rest of Flanders witnesses a loss and the Rest of Wallonia registers an almost negligible gain.

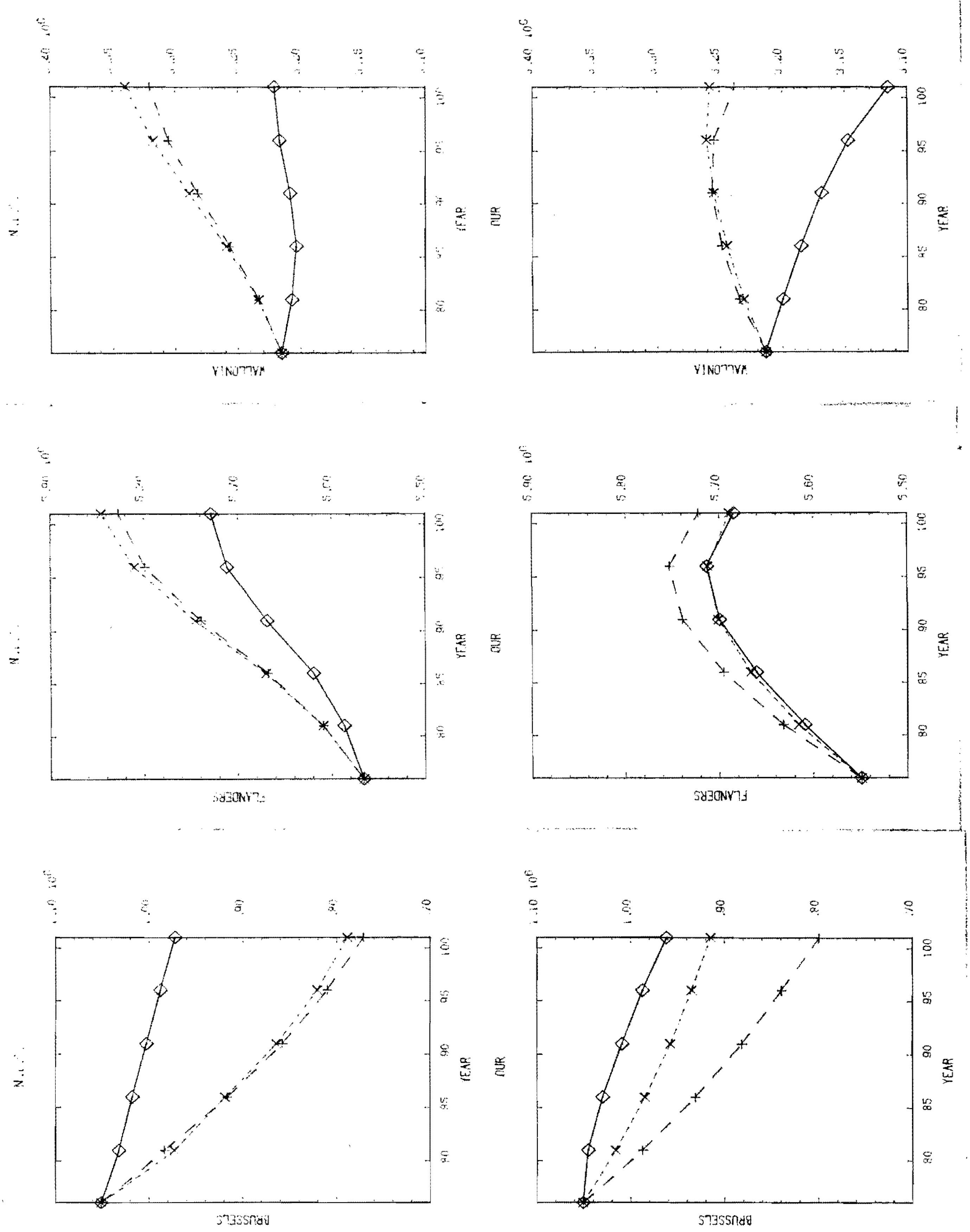
IV. FINAL REMARKS

Belgium, like the rest of Western Europe has experienced a pronounced drop in fertility levels which started off in the mid-sixties and has continued right up to the present. The value reached (by the Total Fertility Rate) at this stage is unprecedented in Belgian history. Published fertility related statistics which cover the period ending in 1979 show that while the drop in question has levelled off somewhat there is no clear sign of a significant rise appearing on the scene. Many, if not most, observers incline to the view that low fertility (with minor cyclic variations) will very probably characterise future reproductive effort in Western Europe.

Our projections spell out the impact on population evolution of maintaining fertility at a constantly low level, the effect of possible variations in the mortality related scene in Belgium over the projection period of twenty-five years being presumably small in comparison. The three migration scenarios used help to bring the effect of spatial mobility (both international, and internal to Belgium) into the picture. It is hoped that the detailed numerical results, together with the comments found in this text which also contains a fair number of graphs related to certain aspects of population movement, presented here will be of use especially to :

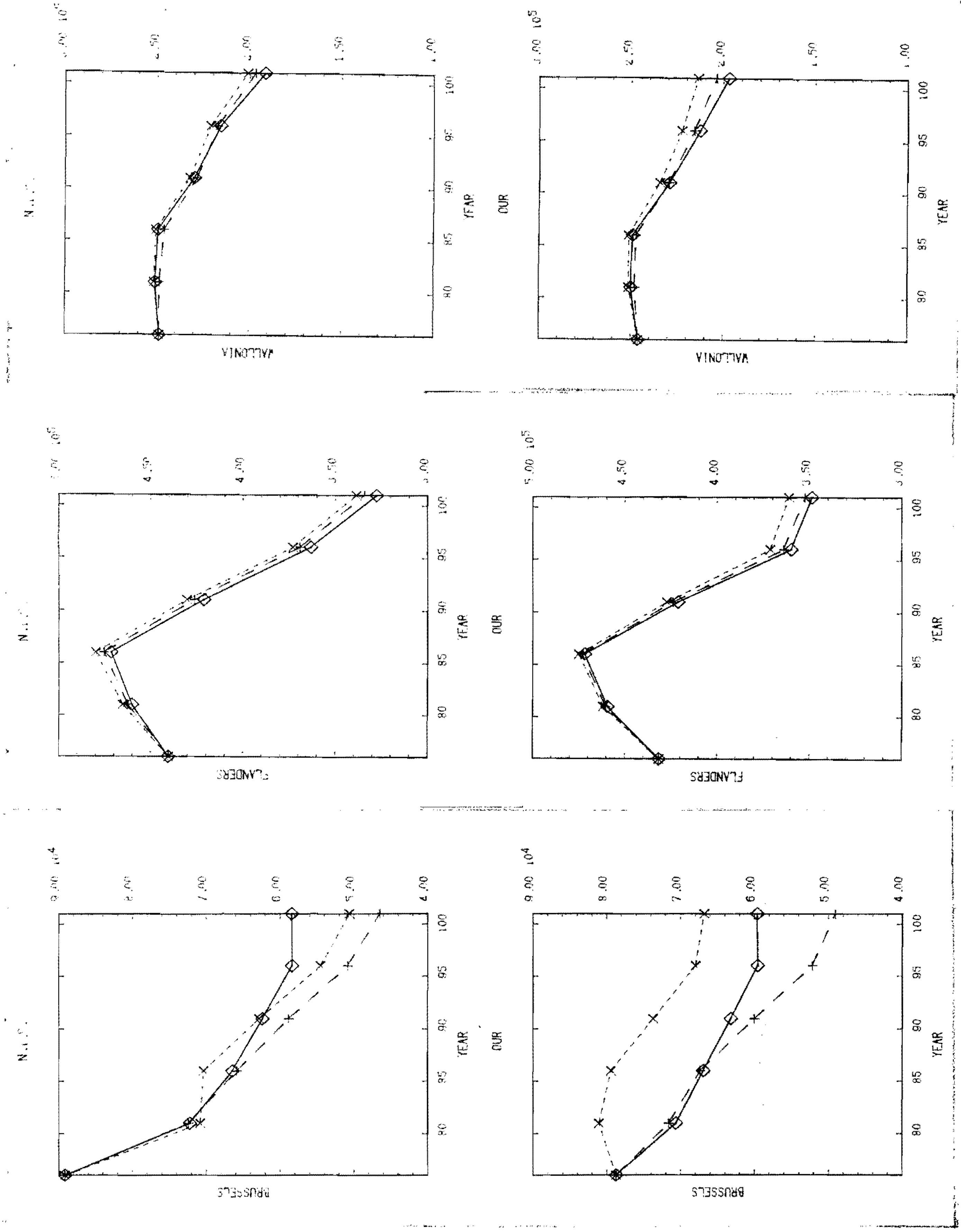
1) persons responsible for planning in Belgium
2) research workers in the social sciences who are interested both in the results presented and the methodology used to generate them. In this connection, comparisons effected in the course of the text between the latest N.I.S. projection results and our own show the extent to which different methodologies could concord with each other as concerns the results obtained. The close similarity observed in most of the comparisons made stems partly from the fact that of the results of only twenty-five projection years were used in these comparisons - projections over a longer time interval might have engendered more substantial dissimilarities than were actually noted. Figures 18 to 25 are presented in this context without further comment. They concern the regions Brussels, Flanders and Wallonia.

Fig. 18 : Evolution of total population in chosen regions[xxx] (1976-2001), according to different migration scenarios. Comparison of NIS and OUR results.
—— No migration --- Only internal migration ... Also international migration
xxx Brussels, Flanders and Wallonia.



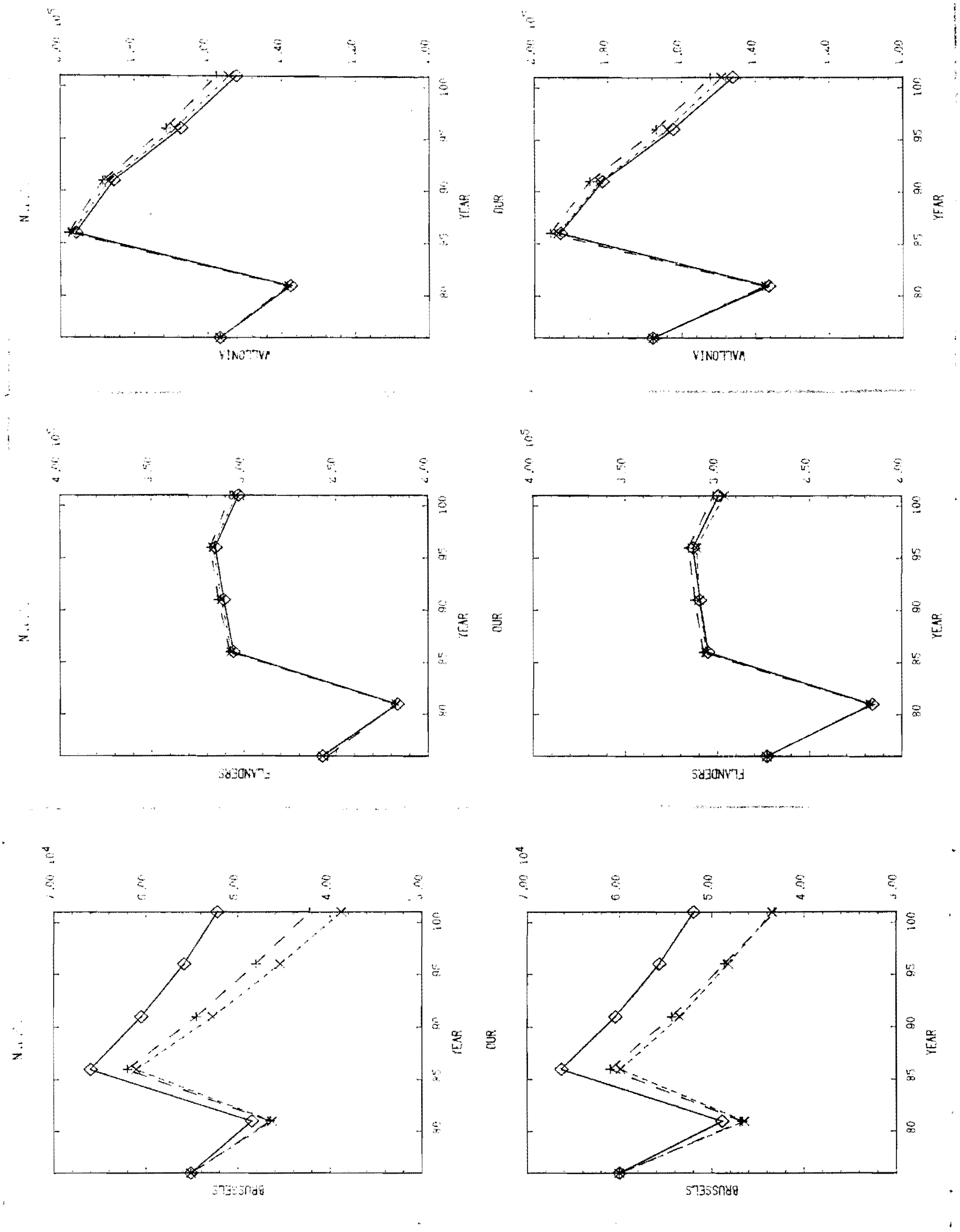
Note : All graphs refer to the two sexes taken together.

Fig. 19 : Evolution of age group 20-24 in chosen regions[xxx] (1976-2001), according to different migration scenarios. Comparison of NIS and OUR results.
—— No migration --- Only internal migration ... Also international migration
xxx Brussels, Flanders and Wallonia.



<u>Note</u> : All graphs refer to the two sexes taken together.

Fig. 20 : Evolution of age group 60-64 in chosen regions[xxx] (1976-2001), according to different migration scenarios. Comparison of NIS and OUR results.
—— No migration --- Only internal migration ... Also international migration
xxx Brussels, Flanders and Wallonia.

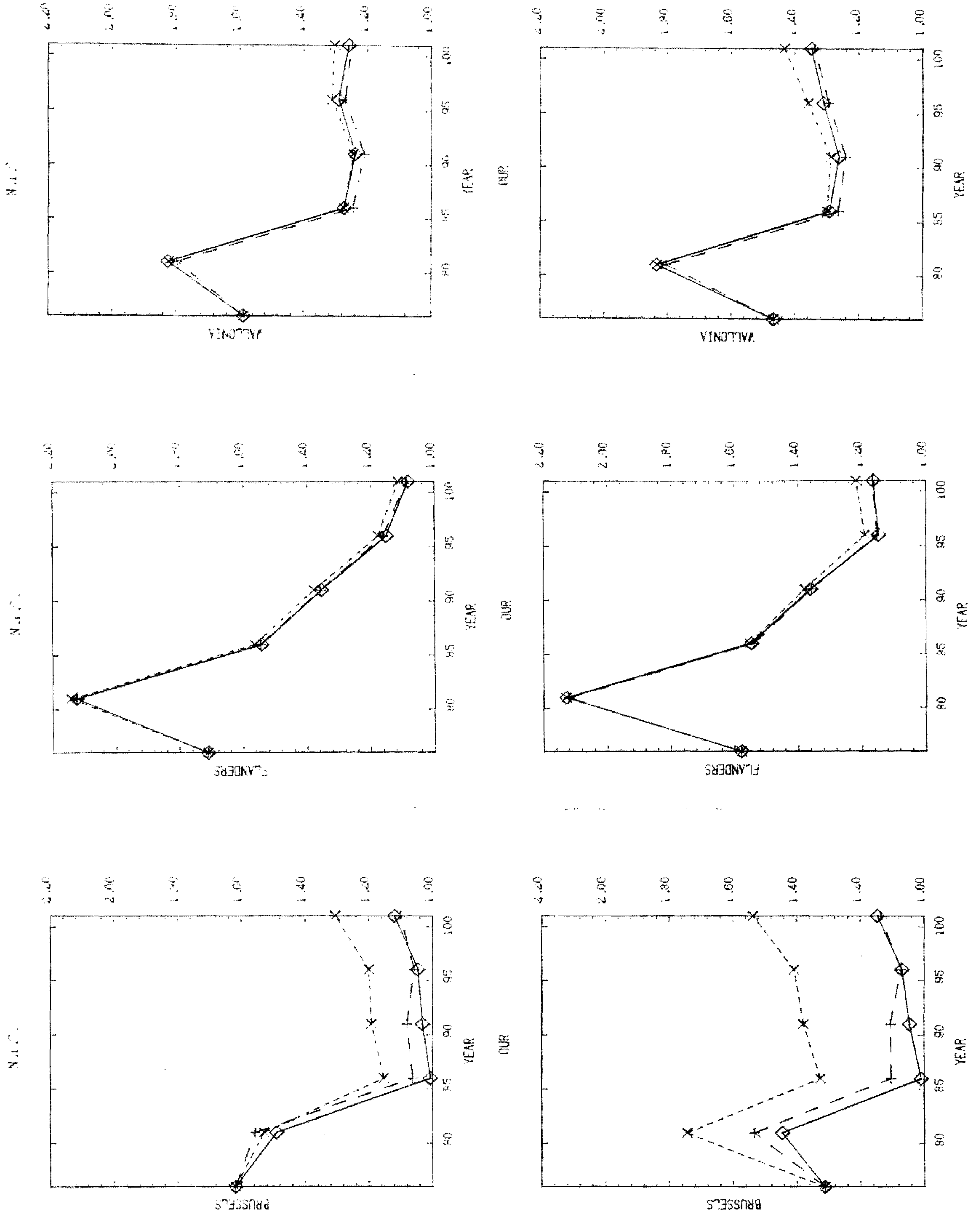


Note : All graphs refer to the two sexes taken together.

Fig. 21 : Evolution of ratio 20-24/60-64 in chosen regions[xxx](1976-2001), according to different migration scenarios. Comparison of NIS and OUR results.

—— No migration --- Only internal migration ... Also international migration

xxx Brussels, Flanders and Wallonia.

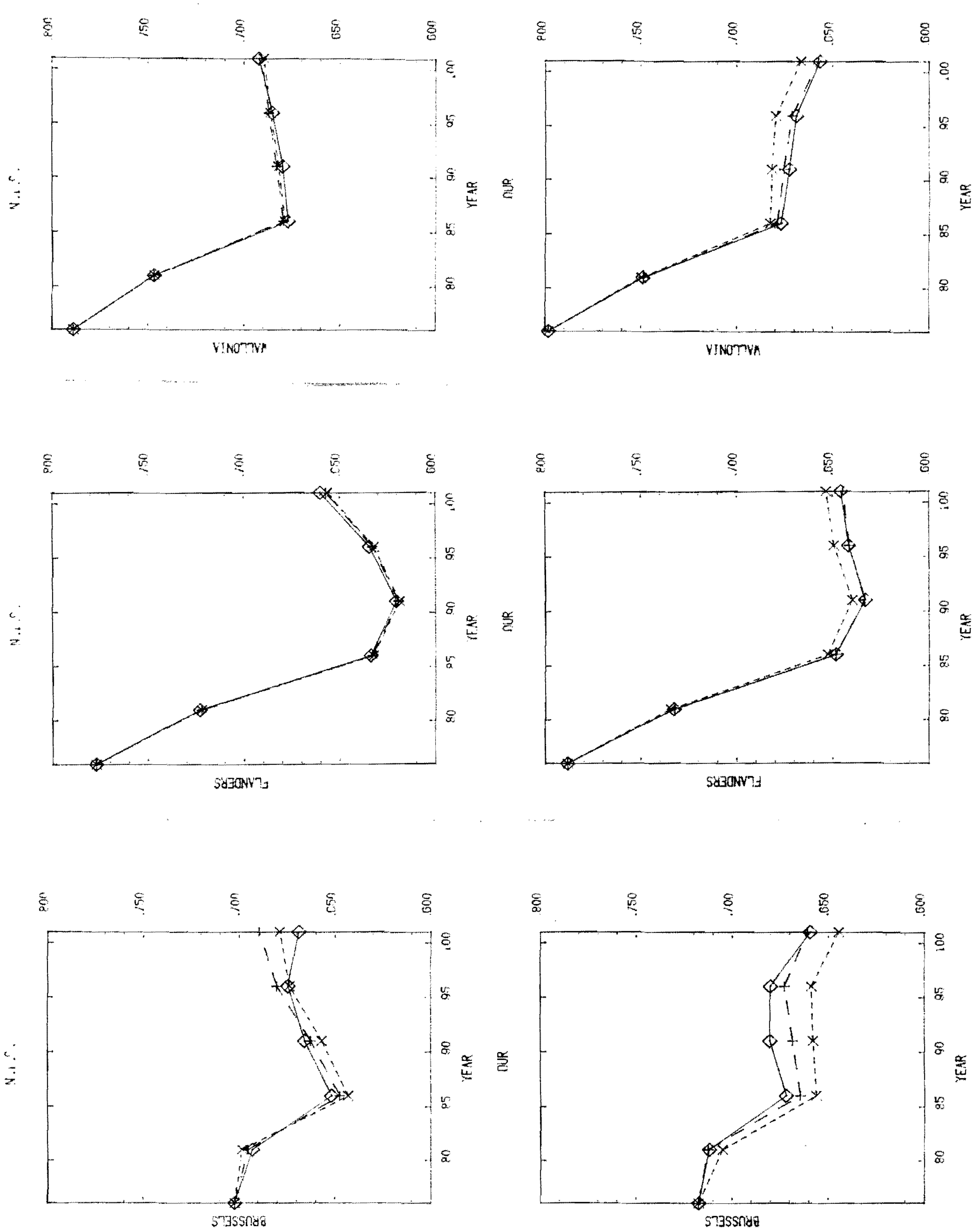


Note : All graphs refer to the two sexes taken together.

Fig. 22 : Evolution of ratio ((65+) + (0-19))/(20-64) in chosen regions[xxx] (1976-2001), according to different migration scenarios. Comparison of NIS and OUR results.

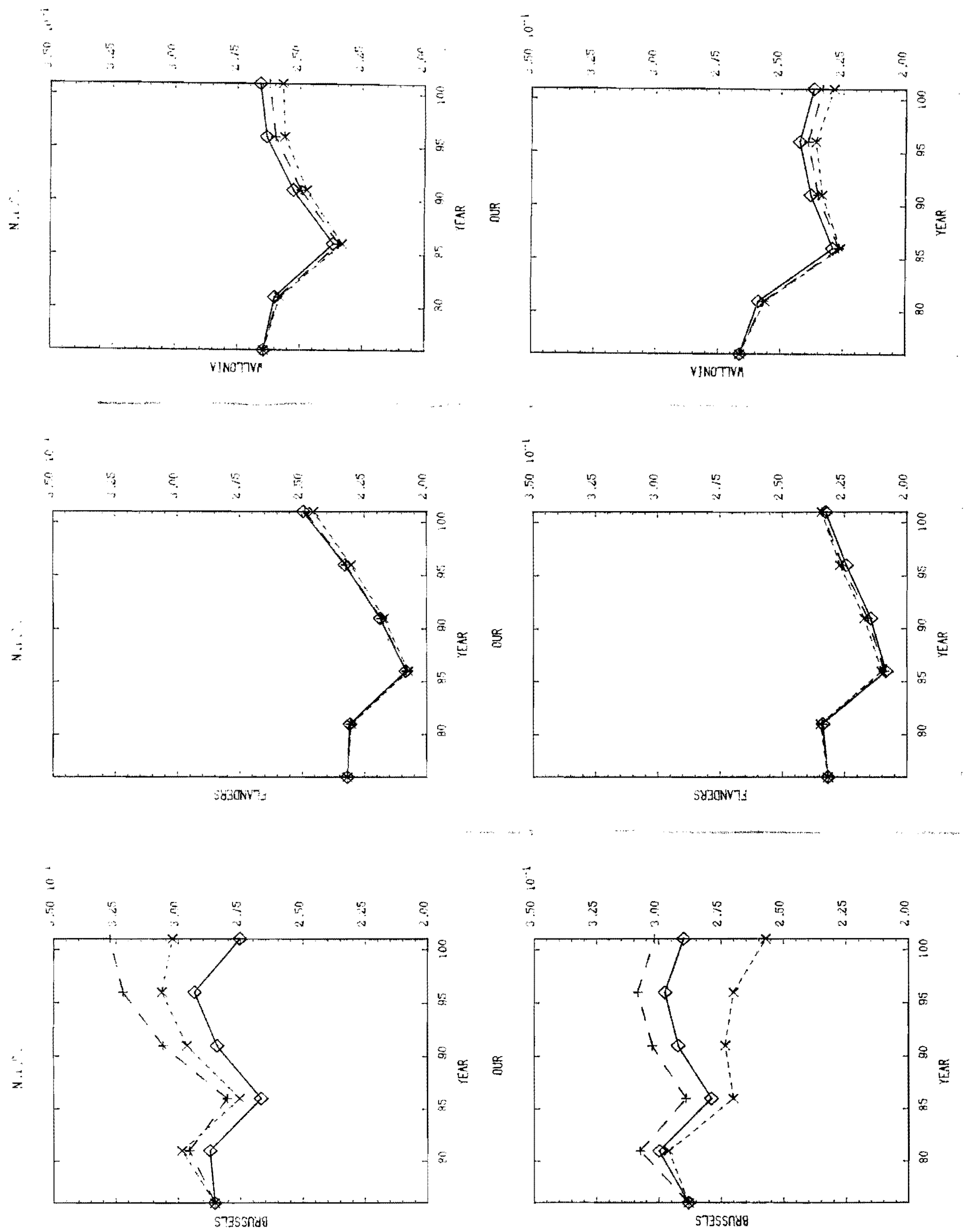
—— No migration --- Only internal migration ... Also international migration

xxx Brussels, Flanders and Wallonia.



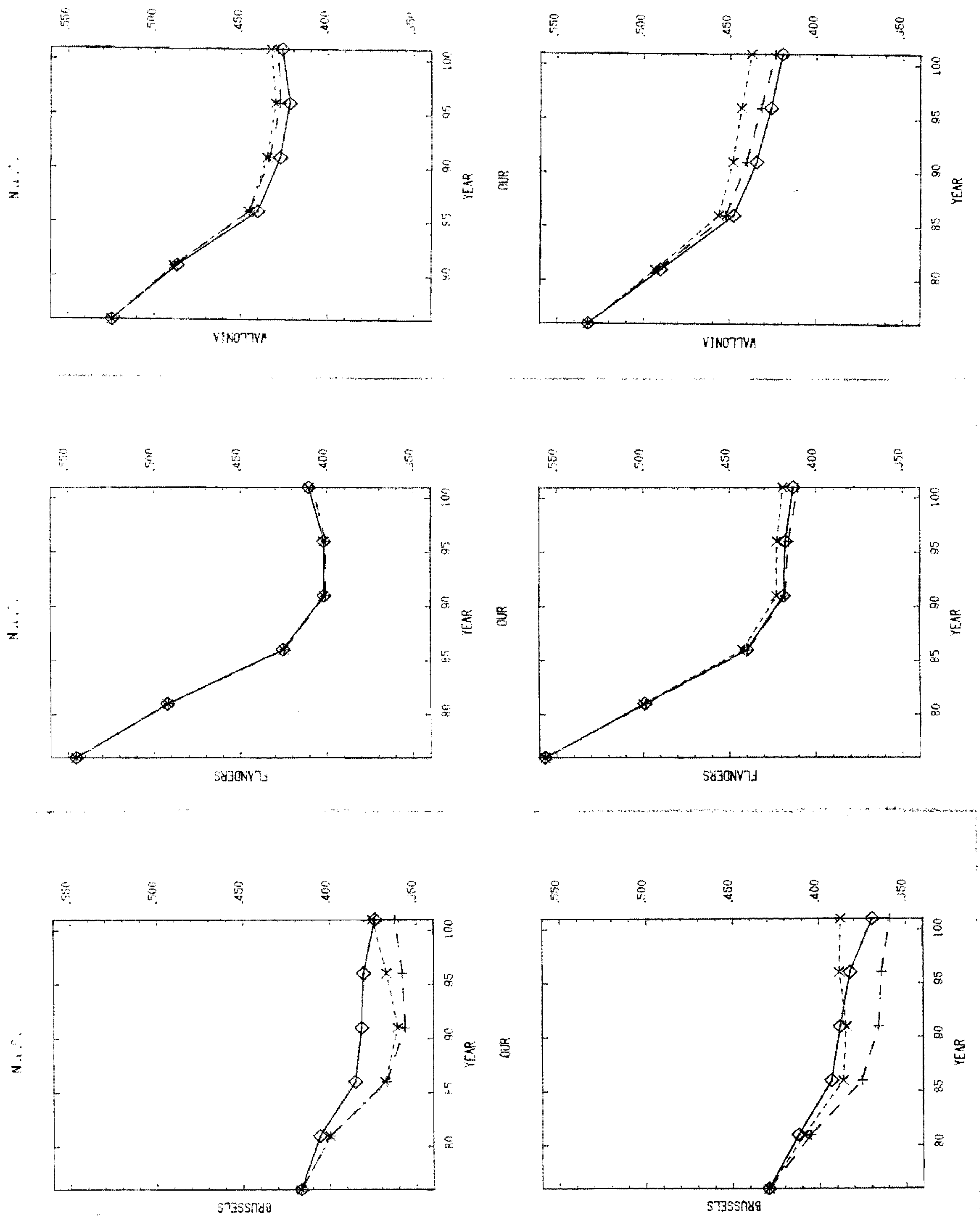
Note : All graphs refer to the two sexes taken together.

Fig. 23 : Evolution of ratio 65+/20-64 in chosen regions[xxx] (1976-2001), according to different migration scenarios. Comparison of NIS and OUR results.
— No migration --- Only internal migration ... Also international migration
xxx Brussels, Flanders and Wallonia.



Note : All graphs refer to the two sexes taken together.

Fig. 24 : Evolution of ratio 0-19/20-64 in chosen regions[xxx] (1976-2001), according to different migration scenarios. Comparison of NIS and OUR results.
—— No migration --- Only internal migration ... Also international migration
xxx Brussels, Flanders and Wallonia.

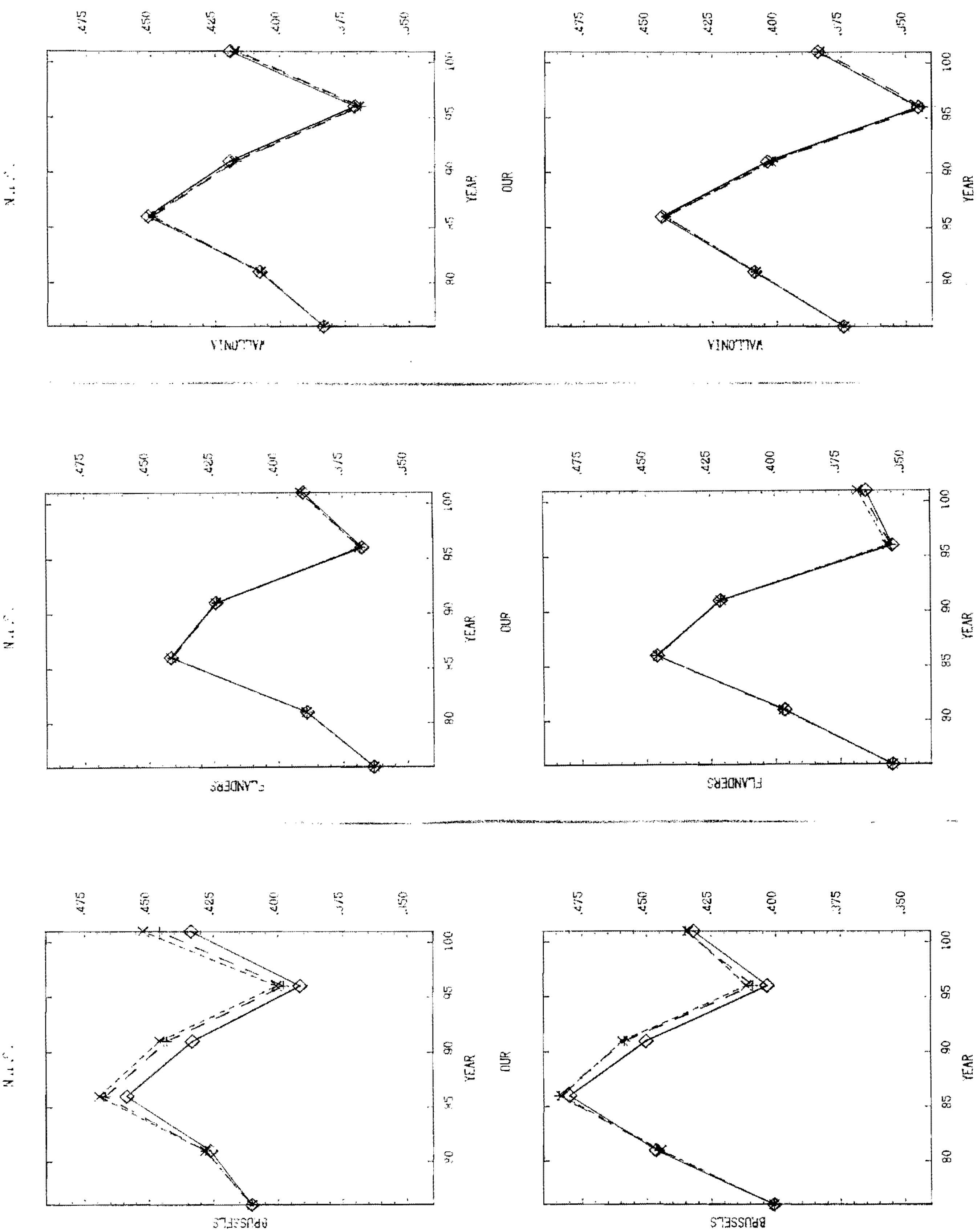


<u>Note</u> : All graphs refer to the two sexes taken together.

Fig. 25 : Evolution of ratio 75+/65+ in chosen regions[xxx] (1976-2001), according to different migration scenarios. Comparison of NIS and OUR results.

—— No migration --- Only internal migration ... Also international migration

xxx Brussels, Flanders and Wallonia.



Note : All graphs refer to the two sexes taken together.

Appendix I : Detailed notes concerning certain features of the methodology used.

The following facets of the methodology used call for detailed explanation :

A) the multiregional projection machinery used;

B) the computations instrumental in generating the type of internal migration data needed for the operation of the projection engine used;

C) how international migration was dealt with; and

D) certain specific features of the male population projections.

A. Multiregional projection machinery

For purposes of facilitating explanation, we will first deal with the case (β)(-cf text -) where the sub-national regions of Belgium are open to internal migration only, Belgium as a whole being closed to international migration; and when necessary, for purposes of exemplification, treat Belgium as an unit composed only of two sub-national regions (i.e. to simplify explanations still further). What follows is a detailing of the projection machinery used in the case of females.

The mathematics of the projection process is expressed in the following equation [1]

$$\left\{ \underset{\sim}{K}^{(t+1)} \right\} = \underset{\sim}{G} . \left\{ \underset{\sim}{K}^{(t)} \right\} \qquad 1$$

where $\left\{ \underset{\sim}{K}^{(t)} \right\}$ is a vertical vector whose elements give the age and and regional distribution of females in Belgium at a specified time t. The structure of $\left\{ \underset{\sim}{K}^{(t)} \right\}$ is expressed through the partioning equation

$$\left\{ \underset{\sim}{K}^{(t)} \right\} = \begin{bmatrix} \left\{ \underset{\sim}{K}^{(t)}(0) \right\} \\ \left\{ \underset{\sim}{K}^{(t)}(5) \right\} \\ \vdots \\ \left\{ \underset{\sim}{K}^{(t)}(x) \right\} \\ \vdots \\ \left\{ \underset{\sim}{K}^{t}(z) \right\} \end{bmatrix} \qquad 2a$$

where, again, $\left\{ \underset{\sim}{K}^{(t)}(x) \right\}$ is a vertical vector whose elements are scalars giving the numbers of females between exact ages x and x+5 in the different sub-national regions of Belgium at time t : so that we have, for n regions ,

$$\left\{ \underset{\sim}{K}^{(t)} (x) \right\} = \begin{bmatrix} k_1^{(t)} (x) \\ k_2(t) (x) \\ \vdots \\ k_n(t) (x) \end{bmatrix} \qquad 2b$$

z is the lower bound of the last half open age interval used.

---

(1) The system of symbols used is borrowed from F. Willekens and A. Rogers (1978), op. cit. A wriggle, ~ , under a letter indicates a matrix. The use of double brackets in conjunction with a wriggle points to a vector.

$\{\underset{\sim}{K}^{(t+1)}\}$ bears the same meaning as $\{\underset{\sim}{K}^{(t)}\}$, the time specification indicating a time point 5 years after (t). $\underset{\sim}{G}$, the growth matrix, is a generalisation of the Leslie matrix[1] and has the partionned structure found in equation (3)

$$\underset{\sim}{G} = \begin{bmatrix} \underset{\sim}{0} & \underset{\sim}{0} & \underset{\sim}{B}(\alpha-5)\cdots\cdots\underset{\sim}{B}(\beta-5)\cdots\cdots\underset{\sim}{0} & & \underset{\sim}{0} \\ \underset{\sim}{S}(0) & \underset{\sim}{0} & \underset{\sim}{0}\cdots\cdots & & \underset{\sim}{0} \\ \underset{\sim}{0} & \underset{\sim}{S}(5) & \underset{\sim}{0}\cdots\cdots & & \vdots \\ \underset{\sim}{0} & \underset{\sim}{0} & \underset{\sim}{S}(10) & & \vdots \\ \vdots & \vdots & \quad \underset{\sim}{S}(x) & & \vdots \\ \underset{\sim}{0} & \underset{\sim}{0} & \quad \underset{\sim}{0} & \underset{\sim}{S}(Z-5) & \underset{\sim}{0} \end{bmatrix} \tag{3}$$

The elements of $\underset{\sim}{G}$ are null matrices, $\underset{\sim}{0}$, except for

(a) those found in the principle sub diagonal (i.e. the $\underset{\sim}{S}$ matrices) which account for modifications arising in the projection process due to mortality and outmigration; and

(b) the $\underset{\sim}{B}$ matrices in the first row which take care also of the fertility processes involved in the operation.

Thus the $\underset{\sim}{S}$ matrices move regional age specific population elements present at t forward (over a 5 year projection interval) in age and space as shown by equation (4a)

$$\left\{\underset{\sim}{K}^{(t+1)}(x+5)\right\} = \underset{\sim}{S}(x).\left\{\underset{\sim}{K}^{(t)}(x)\right\} \tag{4a}$$

and the $\underset{\sim}{B}$ matrices have the double function of computing region specific births in the projection interval and assigning them to age group 0-4 (completed years) in the different regions at (t+1). The operation of the $\underset{\sim}{B}$ matrices is thus summarised by

---

(1) For a detailed explanation of the Leslie matrix see

- A. Rogers (1975) op. cit.
- N. Keyfitz "<u>Introduction to the mathematics of population</u>" (Addison-Wesley, 1968)

$$\left\{ \underset{\sim}{K}^{(t+1)}(0) \right\} = \sum_{\alpha-5}^{\beta-5} \underset{\sim}{B}(x) . \left\{ \underset{\sim}{K}^{(t)}(x) \right\} \qquad (4b)$$

where α and β are the lower and upper bounds of the reproductive age span of a woman. The constituant elements of the $\underset{\sim}{S}$ matrices and the $\underset{\sim}{B}$ matrices are most easily explained by taking Belgium as a unit divided into two sub national regions. In this case $\underset{\sim}{S}(x)$ would have the format given by

$$\underset{\sim}{S}(x) = \begin{bmatrix} s_{11}(x) & s_{21}(x) \\ s_{12}(x) & s_{22}(x) \end{bmatrix} \qquad (5a)$$

where $s_{ij}(x)$, a scalar, stands for the projective probability of persons aged x, x+4 (completed years) in region i at time t being alive in region j five years later; and is obtained from the multiregional life table corresponding to the conditions of the experiment. In the same two-region model the $\underset{\sim}{B}(x)$ matrix would be given by

$$\underset{\sim}{B}(x) = \begin{bmatrix} b_{11}(x) & b_{21}(x) \\ b_{12}(x) & b_{22}(x) \end{bmatrix} \qquad (5b)$$

where $b_{ij}(x)$, a scalar, gives the number of babies (female in our case) born between t and t+1, and surviving in j at t+1, per woman aged x, x+5 (exact years) in i at t. Apart from a knowledge of fertility rates specified by age and region, the construction of a $\underset{\sim}{B}$ matrix too uses information found in the multiregional life table. Relegating further details concerning the $\underset{\sim}{S}$ and $\underset{\sim}{B}$ matrices and their relation to a multiregional life table to Appendix II, it is useful to note at this stage that :

1) multiregional projections work on the Markovian hypothesis that persons found in a region i at time t experience the same age specific rates of mortality, outmigration and fertility specific to i whatever be their history previous to t;

2) these region and age specific rates used in our projection apparatus need the following forms of data for their computation :

   a) sex - age group - region specific distribution of population at a specified time point.

   b) sex - age group - region specific distribution of deaths experienced by the population in (a) over a specified period of time.

c) Age group of mother - region specific distribution of births occurring within the population in (a) over a specified interval of time.

d) Sex - age group - region of origin - region of destination specific distribution of migration witnessed in the population in (a) over a specified time interval.

Unpublished data obtained at the N.I.S. satisfied data requirements (a), (b) and (c).[1] No data of the form required in (d) could be found even in unpublished form. How this data was generated is explained in the section that follows.

B. Generation of internal migration data

The following sets of data concerning internal migration were available.[2]

1) In published form : Data set D1, contains sex, but not age group specific migration data, for 1976, cross-classified by arrondissement of origin and arrondissement of destination. The corresponding 43 x 43 interarrondissemental migration flow matrix can thus be formed; an element of which can, in general, be symbolised $m_{ij}(\cdot)$ and signifies the migration from region i to region j in the absence of age specification (i.e. a summation over all age groups).

---

(1) In a small country like Belgium a choice has to be made between the use of :

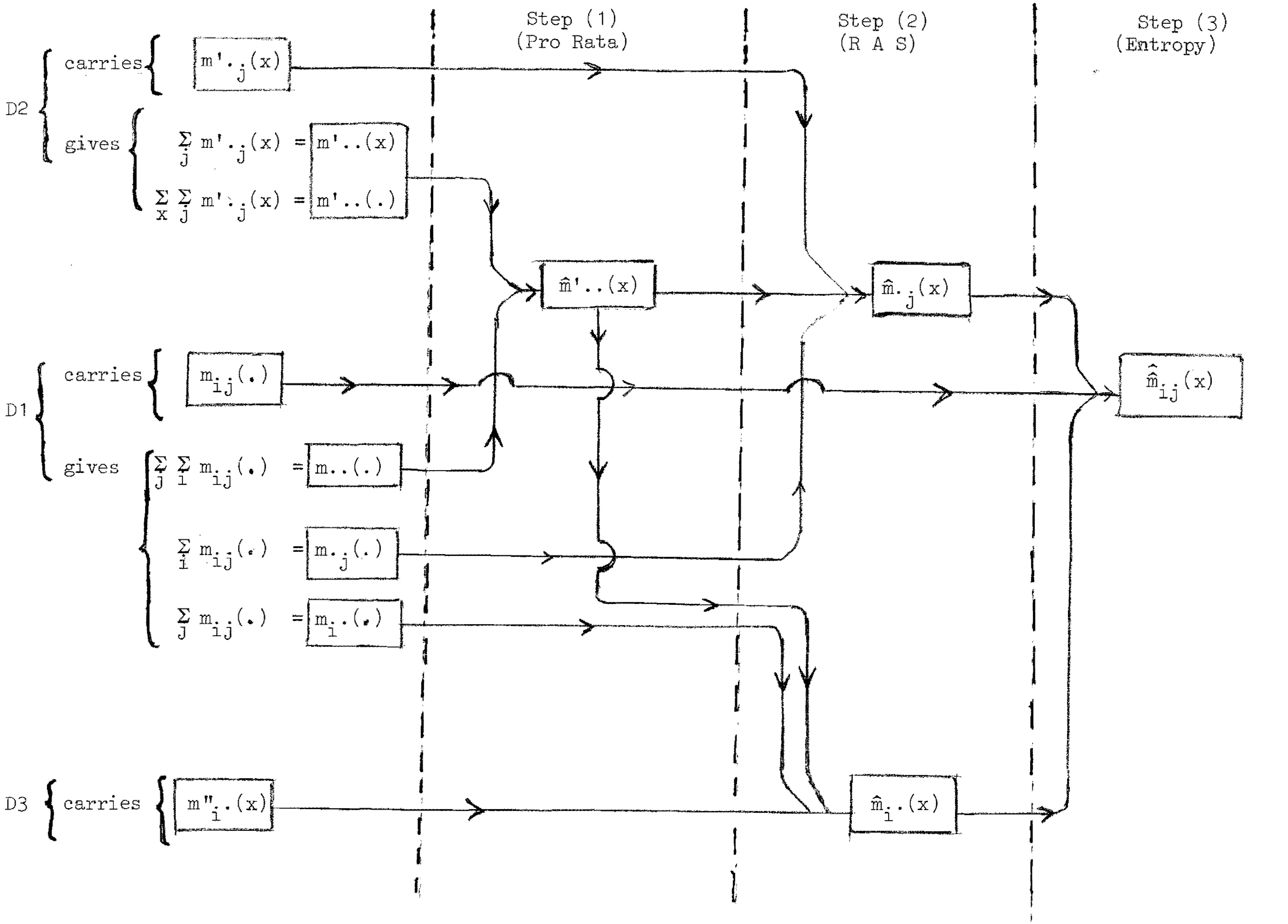
a) nationally computed mortality and fertility rates as being valid for regional purposes (- these rates would naturally be inadequate in the presence of marked regional diversity); and

b) rates computed off region specific material (- these rates run the risk of being more random-erratic than those in (a) because of the smaller data sets used in their computation).

We opted for the second possibility. Mr. Larmuseau of the N.I.S. was very helpful in our search for the data necessary.

(2)The discussion that follows is made easy through the schema in Fig.A .

Fig. A : Summary of operations generating internal migration information in desired form



2) In unpublished form (obtained from the N.I.S.) :

- Data set D2 carries sex and age group specific inmigrations, in 1976, to each of the 43 arrondissements from the rest of Belgium. The corresponding matrix formed carries the element (in general) $m'_{.j}(x)$ giving the inmigration aged x, x+5 (exact years) to region j. Here, a summation over all regions of origin is in evidence.

- Data set D3, parallel to D2, gives information about age specific outmigrants in 1976 from each of the 43 arrondissements. Here we have $m''_{i.}(x)$.

The computation of $\hat{m}_{ij}(x)$, corresponding to the required form (d)[1] indicated above, is set out in the series of steps that follow. The explanation is for the female sex, though the same procedure holds good for, and was used in, the case of males (Fig.A summarises the text).

Step 1

Arising from errors in the collection and totalising of data, the three data sets D1, D2 and D3 were not in complete accord with each other [e.g. $\sum_i m_{ij}(.)$ was not equal to $\sum_x m'_{.j}(x)$, as it should!], and some effort at arriving at consistency was necessary at this stage. With this end in view, the set D1 [containing information re $m_{ij}(.)$] was taken as a correct source of information concerning the origin-destination volume of migration flow; and $\sum_j m'_{.j}(x) = m'..(x)$ together with $\sum_x \sum_j m'_{.j}(x) = m'..(.)$ (as found in D2) were presumed to give the correct relative distribution by age of arrivals. On the basis of this distribution, the total volume of arrivals $m..(.)$ $\left[= \sum_j \sum_i m_{ij}(.)\right]$ from D1 was pro rata distributed, giving rise to a new version ($\hat{m}'..(x)$, say) of age distributed arrivals consistent with $m..(.)$ from D1.

In other words

$$\hat{m}'..(x) = \frac{m'..(x)}{m'..(.)} \cdot m..(.)$$

(1) i.e. migration data carrying specification by sex, age, arrondissement of origin and arrondissement of destination.

Step 2

$\hat{m}'..(x)$ (just computed) and $m._j(.)$ (= $\sum_i m_{ij}(.)$, from D1) are taken respectively as the correct marginal row and column totals of the matrix carrying migrations cross-classified by age and region of arrival. Prior information concerning the elements of this matrix available in the form of $m'._j(x)$ (from D2), is however not consistent with the marginals $\hat{m}'..(x)$ and $m._j(.)$. Consistency is achieved through a "biproportional" adjustment (also referred to as the "RAS" method). This iterative procedure transforms the original elements $(m'._j(x))$ into new elements $\hat{m}._j(x)$ (say) which satisfy the specified marginal constraints and also retain the original cross-product ratios proper to $m'._j(x)$. The two-factor (or first order interaction) effect of the initial matrix D2 is thus not lost.

Using $\hat{m}'..(x)$ (computed above) and $m_i.(.)$ (= $\sum_j m_{ij}(.)$, from D1) as marginal constraints, with the prior information concerning $m''_i.(x)$ (i.e. age specific departures from region i, $\forall$ i) as found in D3, a new application of the RAS method generates the elements $(\hat{m}_i.(x))$ of the age-departure matrix, which respects the two-factor effects of D3 and is also consistent with the marginals earlier specified as correct.(1)

Step 3

This last step consists of using $m_{ij}(.)$ (from D1) and $\hat{m}._j(x)$ and $\hat{m}_i.(x)$ (both computed as shown above) to generate $\hat{\hat{m}}_{ij}(x)$, the data needed for the construction of a multiregional life table. $\hat{\hat{m}}_{ij}(x)$ can be regarded as the constitutive elementary blocks of a solid three dimensional rectangular figure with edges mutually at right

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(1) The use of $\hat{m}'..(x)$ as a marginal constraint in the construction of the age-departure matrix is justified on the score

(1) that the age distribution of departures for the country as a whole must, if correct, be identically the same as the correct age distribution of arrivals for the whole country - i.e. summing across the regions;

(2) that entries regarding inmigration are generally held to be more fiable than those concerning departures (in this regard however note the caveats found in M. Poulain's "Du registre de Population aux statistiques de migration interne en Belgique : critique des sources et correction des données"(Population et Famille, 45, 1978-3, pp. 1-43)

angles whose faces represent $m_{ij}(.)$, $\hat{m}_{.j}(x)$ and $\hat{m}_{i.}(x)$. Since no prior information is available regarding these elementary blocks, no recourse to the usual RAS method is possible; and one has to be satisfied with an application of the "entropy" method. This operation provides the most likely estimate of the elements of our solid figure when the only prior information available concerns its faces. That such a guess is equivalent to that obtainable by the RAS method when used in conjunction with the given marginal constraints (i.e. the faces of our cube) together with the presumed prior information that the elementary blocks in question are all equal to unity has already been established[1] : and this fact is used in the algorithm governing the corresponding iterative process necessary. Appendix III gives details concerning the algorithms used for the simple RAS method as well as the entropy method.

Once $\hat{\hat{m}}_{ij}(x)$ is available for a system of 43 regions (- data was collected at the arrondissemental level -), the data necessary for the three systems (A, B and C - cf. <u>supra</u>) of regionalisation used is obtained through a process of aggregation.

The explanation given above concerns projections for females with only internal migrations accounted for : i.e. case (β). A simplification of (β) gives case (α), where even internal migration is presumed absent. Here the off-diagonal elements of both the $\underset{\sim}{S}$ matrix and the $\underset{\sim}{B}$ matrix of equations (5a) and (5b) respectively - using the two-region model for purposes of explanation - will have the value zero.

C. How international migration was handled

In the methodology proper to case (γ) (where both internal and international migration enter the picture), exits from end entries to Belgium are dealt with differently. Emigration is taken care of by considering it as equivalent to mortality - hence a mere loss to the system (for which, no data specifying place of arrival is necessitated). The effect of this loss shows up in a diminution in the values of the elements of the $\underset{\sim}{S}$ and $\underset{\sim}{B}$

(1) cf. F. Willekens, A. Por and R. Raquillet "Entropy, Multiproportional and Quadratic techniques for inferring detailed migration patterns from aggregate data. Mathematical theories, algorithms applications and computer programs" (Working Paper 79-88, I.I.A.S.A., 1979).

matrices of equations (5a) and (5b). Adequate data for 1976, at the arrondissemental level, was found at the N.I.S.; and aggregated to suit the systems A, B and C used. Rates and probabilities of loss due to mortality and emigration were kept constant at their 1976 level throughout the projection period. While emigration, like mortality, is handled through the use of rates and probabilities; immigration does not lend itself to the same treatment, as the projection machinery used is incapable of keeping tag of what exists and happens outside Belgium. One has therefore to be satisfied with considerations regarding only the flow of migrations into Belgium. Data from the N.I.S. give the sex, age and region of arrival specific immigrations for 1976. On the hypothesis (1) that this remains constant thereafter and (2) that over each projection interval (t, t+1) of 5 years, half the inflow arrives at the beginning of the interval (and therefore has to be survived like the rest of the population) and the remaining half comes in only at the end of the interval (and needs merely to be added to the population already projected to t+1), the immigrant flow was incorporated into the projection machinery.

D. Some features specific to male population projections

Projections for males follow the same pattern outlined for females with one important modification : the $\underset{\sim}{B}$ matrices found in equation (3), (4b) and (5b) are made ineffective, and the result of their normal operation - i.e. the spatial assignation at time t+1, in age group (0-4), of births occurring in the different regions during the projection interval t, t+1, - is obtained by using the already computed spatial distribution of female births, and operating on them with the requisite multiregional projective probabilities of survival (these probabilities are designated X in equation (2A) of Appendix II) for males.

This Appendix is terminated with the following remarks :

- While the advantages of using Multiregional techniques in population projections are manifold,[1] the present state of its methodology is not without blemish. In this regard, some of the drawbacks that need remedying are the universal use of (1) the Markovian hypothesis and (2) the linear hypothesis of the survival function through which region specific projective survival probabilities are computed.[2]
- In the construction of a age group-region-specific rate, the denominator usually employed in work of the present nature is the appropriate mid-interval population. However, in the computations reported here, use has been made (for reasons of facility) of the relevant population at the beginning of the year concerned - i.e. the year during which the deaths, births and migrations used in the numerator occur. These numerators being in general very small in relation to their denominators, small errors in the denominators (- they are presumably small, since the time interval involved is only one year) should not trouble the results too seriously.

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(1) The essential advantage of the Multiregional approach over other approaches is that the projection process is made to take note of regional differences (in mortality, fertility and migration) while a simultaneous concern for the internal consistency of the system - the projection results at the national scale should be in conformity with results at the regional level - is maintained. Other forms of methodology, categorised as "top-down", "bottom-up", and "hybrid" by F. Willekens in "Multiregional population analysis for urban and regional planning", N.I.D.I., Working Paper No. 18, 1981, do not succeed in this regard. Multiregional methodology is also suitable for projections which take note of marital status, working life status etc.

(2) Cf. J. Hoem and H. Jensen : "Multistate life table methodology : a probalistic critique", Working Paper No. 38, Laboratory of Actuarial Mathematics, University of Copenhagen, 1981, who speak of the possible advent of negative probabilities arising from the use of the linear hypothesis.

- The work reported here has benefited enormously from the contents of two theses presented by E.T.K. Joo and P. Ramachandran[1] as partial requirement for obtaining the Master of Arts degree in the Interuniversity Programme in Demography.

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(1) E.T.K. Joo : "On the estimation of migration flows by migrant categories" (1980).

P. Ramachandran : "Simulation of multiregional population change : an application to Belgium (1980).

Appendix II : Notes concerning the matrices $\underset{\sim}{S}$ and $\underset{\sim}{B}$

To avoid needlessly repeating what is now found in printed form, we will restrict ourselves to pointing out salient features of the matter under discussion and referring the reader for further explanations to F. Willekens and A. Rogers, 1978 (Op. cit.). Precise indications of page etc. are given in the latter instance. The construction of matrix $\underset{\sim}{S}(x)$ is based on the equation (Equation (3.6), p. 58) applicable when multiple transitions in any given projection interval are allowed. The equation in question is

$$\underset{\sim}{S}(x) = \left[\underset{\sim}{I} + \frac{5}{2}\,\underset{\sim}{M}(x+5)\right]^{-1} \left[\underset{\sim}{I} - \frac{5}{2}\,\underset{\sim}{M}(x)\right] \qquad (1A)$$

when $\underset{\sim}{I}$ stands for the identity matrix and the meaning of $\underset{\sim}{M}(x)$ (and hence of $\underset{\sim}{M}(x+5)$) is given on p. 49 Equation 2-24. One notes that the elements of $\underset{\sim}{M}(x)$ are formed of:

1) age and region specific mortality rates, for the computation of which data specification (b) given in our text is necessary; and

2) age-region of origin-region of destination specific outmigration rates for which data specification (d) is indispensable.

When the last open ended age interval is concerned, the $\underset{\sim}{S}$ matrix in question is computed according to Equation (3.8), p. 58.

The construction of the $\underset{\sim}{B}$ matrices follows the equation, found at the bottom of page 58, which is the matrix counterpart of the equation giving the elements found in the first row of the single region Leslie matrix. The equation in question is

$$\underset{\sim}{B}(x) = \underbrace{\underset{\sim}{L}(0).\left[5\,\underset{\sim}{\hat{l}}(0)\right]^{-1}}_{X} \underbrace{\frac{5}{2}\left[\underset{\sim}{F}(x) + \underset{\sim}{F}(x+5).\underset{\sim}{S}(x)\right]}_{Y} \qquad (2A)$$

The part designated X has the function of assigning births computed through the use of part Y (containing the necessary fertility apparatus) to age group (0-4) at time t+1 in a projection interval t, t+1. Page 59 gives the composition of the $\underset{\sim}{F}$ matrices in Y. Data specification (c) of our text is necessary for their construction.

Appendix III : Notes re algorithms used.

a) Algorithm used for the simple RAS method.

- Given : (a) Prior information : a matrix $\underset{\sim}{M}^{o}$ with elements m^{o}_{ij} .

(b) Marginal constraints to be respected :

1) $x_{.j}$, the value of the column total for column j (fixed for each different column j).

2) $x_{i.}$, the value of the row total for row i (fixed for each different row i).

- Required : Coefficients r_i (for all i) and s_j (for all j) such that a new matrix $\underset{\sim}{M}$ is found with elements m_{ij} having the following properties

$$m_{ij} : r_i . s_j . m^{o}_{ij} \qquad (\forall i,j)$$

$$\sum_i m_{ij} = x_{.j} \qquad (\forall i)$$

$$\sum_j m_{ij} = x_{i.} \qquad (\forall j)$$

- Procedure : Follow the iterative process governed by the following algorithm

Step 0 : $k = 0$

$$r_i^{(0)} = 1 \qquad (\forall i)$$

Step 1 : $k = k + 1$

$$s_j^{(k)} = \frac{x_{.j}}{\sum_i r_i^{(k-1)} . m^{o}_{ij}} \qquad (\forall j)$$

Step 2 : $$r_i^{(k)} = \frac{x_{i.}}{\sum_i s_j^{(k)} . m^{o}_{ij}} \qquad (\forall i)$$

Go to step 1 unless stopping criterion is reached.

b) Algorithm used for the entropy method.

- Given : (a) No prior information concerning the elementary blocks required,
  (b) marginal constraints to be respected

  (1) $x_{ij.}$

  (2) $x_{i.k}$

  (3) $x_{.jk}$

- Required : the elementary blocks m_{ijk} of solid box M which respect the marginal constraints given above i.e.

  $\sum_k m_{ijk} = x_{ij.}$ etc.

- Procedure : the iterative process used sets each elementary block to be estimated (m_{ijk}) at an initial value ($\overset{o}{m}_{ijk}$) equal to unity and adheres to the following algorithm

Step 0 : $S = 0$

$\overset{o}{m}_{ijk} = 1 \qquad \forall\ i,j,k$

Step 1 : $m_{ijk}^{(3S+1)} = m_{ijk}^{(3S)} \cdot \dfrac{x_{ij.}}{\sum_k m_{ijk}^{(3S)}} \qquad \forall\ i,j$

Step 2 : $m_{ijk}^{(3S+2)} = m_{ijk}^{(3S+1)} \cdot \dfrac{x_{.jk}}{\sum_i m_{ijk}^{(3S+1)}}$

Step 3 : $m_{ijk}^{(3S+3)} = m_{ijk}^{(3S+2)} \cdot \dfrac{x_{i.k}}{\sum_j m_{ijk}^{(3S+2)}}$.

If $\left| \dfrac{m_{ijk}^{(3S+3)}}{m_{ijk}^{(3S+2)}} - 1 \right| \leq \epsilon \ ; \ \forall\ i,j,k$ [ϵ is a very small positive value], stop.

Else S = S+1, and go to step 1

GLOSSARY - in alphabetical order

The list of terms or expressions annotated here are all found used in the detailed results presented.

ABROAD : Refers to that part of the world which is not Belgium. The word (1) occurs in connection with data used as input, where it refers to region (of origin) and age specific annual emigrations; and (2) refers to region (of origin) and age specific rates of emigration when found under the caption AGE-SPECIFIC RATES.

AGE-SPECIFIC RATES : The rates given under this heading are annual rates for five year age groups. ("Age 80" stands for 80+, here as well as in all other places where it occurs). They are kept constant throughout the projection exercise.

ANTW : The province of Antwerp. It figures only in projections with eleven regions.

BIRTHS : This word has two meanings :

1) It signifies annual births observed, by age of mother and region of occurrance, when it is given as part of the data input.
2) When given under the projected population figures, it stands for an estimation of the annual births that would be experienced by the population (with projected size and distribution) under the prevailing rates of fertility.

Since the projection process is female-dominant and a constant sex ratio at birth of 105/100 has been used throughout, "BIRTHS" refers only to female births.

BRUS : Stands for the set of 19 communes which go to form Brussels-Capital. It is one of the three regions into which the province of Brabant was divided - the other two regions being Walloon Brabant, consisting of Nivelles, and Flemish Brabant formed of Halle-Vilvoorde and Leuven. The word BRUS figures only in the projection with eleven sub-national regions.

BRUSSEL : Has the same meaning as BRUS. It is found only in the projection with five sub-national regions.

DEATHS : Has the following two significations :

1) When given as part of the data input, it refers to annual deaths by age (of male/female) and region of occurrance.
2) When given under the projected population figures, it refers to annual deaths (of males/females) estimated, mutatis mutandis, as in the case of BIRTHS (see 2nd signification).

DEMOGRAPHIC PARAMETERS : This caption introduces (1) a series of region specific rates (GRR, GDR, GMR and GER) which aggregate the relevant performances (as regards fertility, death, internal migration and emigration respectively) over age. In each case it is equal to five times the sum of the corresponding age specific rates; and (2) the region (of destination) specific annual flow of immigration into Belgium; which is designated GOIMR.

DEP R : The dependency ratio, computed as the ratio of persons (male/female) outside the age range 15-64 (completed years) to persons (male/female) within this age range.

EMIG : This word is found under the projected population figures and refers to the number of annual emigrations (of males/females) estimated, mutatis mutandis, as in the case of BIRTHS (see 2nd signification).

EXPECTANCIES : This caption introduces three types of expected values.

1) LIFE EXPECTANCIES The entries in the matrix presented give the number of person-years that a person (male/female) born in the region designated at the head of

a column would be expected to live in the region given at the beginning of a row, when exposure to both risks of mortality and emigration is experienced.

2) FERTILITY EXPECTANCES Give the number of female children that a woman born in the region indicated at the head of column is expected to have (throughout her life) in the region given at the beginning of a row. The entries, given in matrix form, can be multiplied by 1000 to give the corresponding value for 1000 women at birth. Note that here too the expected values given are net values computed in the presence of exposure to mortality and migration.

3) MOBILITY EXPECTANCIES Here, the entries of the matrix presented give the number of interregional moves expected of a person (male/female) born in the region indicated at the head of a column. The region given at the beginning of a row gives the region of origin of the migratory move concerned. Multiplication by 1000 makes each figure more intelligible - the interregional migrations being then available in whole numbers. Note that here too the expected values calculated take account of the disturbing influence of mortality.

NET ALLOCATIONS merely distribute each of the above three expectancies as a fraction of unity.

EXT. MIG NET : Gives (for each of the regions and for Belgium as a whole) the crude annual rate accounting for international migrations. The rate is computed as the ratio of the estimated net annual international migratory flow to the projected population size. EXT. MIG NET is found under the caption SUMMARY TABLE.

FERTILITY EXPECTANCIES : See under EXPECTANCIES

FL. BRAB : Stands for the Flemish part of Brabant and consists of Halle-Vilvoorde and Leuven. FL. BRAB figures in the projections with 5 regions.

GDR : A mortality indicator equal to five times the sum of the age group (in five year age groups) specific death rates. This region specific mortality rate is equivalent to a standardised death rate where the standard used (a rectangular population) corrects for age structure differences. Since its mode of computation is very similar to that of the Gross Reproduction Rate (GRR) it has been named "Gross Death Rate", (See also under DEMOGRAPHIC PARAMETERS).

GER : Is an indicator of emigration. All the explanations given for GDR (see under GDR) hold good, mutatis mutandis, here too. It has been named "Gross emigration rate". The region specified is the region of origin.

GMR : Is an indicator of internal migration : hence the double specification of region of origin and region of destination. Zero values have been attributed to moves in which the regions of origin and destination coincide. Entries in the matrix presented have to be read from head of column (region of origin) to head of row (region of destination). For computational procedure and meaning see under GDR where the explanations given hold good here too mutatis mutandis. GMR has been named "Gross migration rate".

GMR TOT : Gives the total of each column of the GMR matrix.

GOIMR : Gives the region of destination specific annual immigration (i.e. from ABROAD) flow. Unlike GDR, GER, GRR and GMR we have here an annual flow and not a rate. The annual flows concerned are kept constant during the projection exercise. (See also DEMOGRAPHIC PARAMETERS).

GROWTH RATE : Is a crude rate computed as the ratio of the estimated annual net inflow (due to births and incoming migration less deaths and outgoing migration) to the projected population size.

GRR : The familiar gross reproduction rate of single region demography is here made region specific. For a given region it is equal to five times the sum of the corresponding age specific (i.e. in five year age groups) rates.

HENE : Refers to the province of Hainaut. It figures only in the projections with eleven regions.

HV-L : Stands for a region composed of the arrondissement Halle-Vilvoorde and Leuven. It figures only in the projections with eleven regions. HV-L is referred to as FL. BRAB in the projections with five regions.

IMMIG : Gives the annual flow of immigration (i.e. migration originating outside Belgium) to Belgium as a whole or to any one of the specified regions. The values given form part of the input data and are kept constant throughout the projection exercise. IMMIG is found under the projected population figures.

IMMIGRAN : Introduces age specificity to IMMIG (see IMMIG). IMMIGRAN is found as part of the input data printout.

INBIR : Gives the region specific female births computed as occurring in the five year interval immediately preceding the time point for which the corresponding projected population figures hold good. INBIR is given only for female projections. The corresponding male values are obtained through the use of the constant sex ratio at birth equal to 105/100.

INTERNAL MIGRATION RATES : This caption, found under SUMMARY TABLE, presents a series of region specific annual crude rates characteristic of internal migration OUT of and IN to a specific region. Both total annual outmigration as well as inmigration flows are estimated as experienced by the projected population under the action of the constant age specific in and outmigration rates used as input.

LAM : Gives the ratio of the projected population size (of region or of Belgium as a whole) to the projected population size (of corresponding region or of Belgium) five years earlier.

LIFE EXPECTANCIES : See under EXPECTANCIES

LIMB : The province of Limburg. It figures only in the projections with eleven regions.

LUIK : The province of Liège. It figures only in the projections with eleven regions.

LUX : The province of Luxemburg. It figures only in the projections with eleven regions.

MIGRATION FLOWS : The matrix presented carries entries giving estimated annual internal migration flow (for projected population values operating with the constant age specific rates used) specified by region of origin (heading of column) and region of destination (heading of row). Zero values are attributed to moves in which the two regions (i.e. of origin and destination) coincide. OUTMIGRATION RATES figuring under MIGRATION FLOWS give the corresponding annual crude rates.

NAM : The province of Namur. It figures only in the eleven region projections.

NET ALLOCATIONS : See under EXPECTANCIES.

NIJV : The arrondissement of Nivelles. It figures only in the eleven region projections. It refers however to the same territory as WA. BRAB, which is used in the five region projections. (See also under WA. BRAB and BRUS).

OUTMIGRATION RATES : See under MIGRATION FLOWS.

O. VL : Stands for the province of East-Flanders and is found only in the eleven region projections.

POPULATION : As found under SUMMARY TABLE has the following three sub titles
1) ,000 which gives population size by the thousand
2) % ....as a percentage of the total (Belgium)
3) M. AGE which gives the mean age of persons forming the population.

R : Stands for the population growth rate computed on the assumption of exponential population growth. As such it is equal to $\frac{1}{5}.\log_e(\text{LAM})$.

RATES OF NATURAL INCREASE : Give crude annual rates of BIRTH, DEATH and consequent GROWTH. The computations involved use the projected population figures and the estimated annual births (see under BIRTHS, 2nd signification) and deaths (see under DEATHS). SUMMARY TABLE carries the RATES OF NATURAL INCREASE in question.

REP R : Stands for the ratio of population size aged 15-39 (completed years) to the population size 40-64 (completed years). It gives an idea of the reproductive capacity of the entire adult population.

R. FLAND : This is found in the three region projections and stands for a region composed of the provinces of Antwerp, East Flanders, West Flanders and Limburg.

R OF FL : This is found in the five region projections, and refers to the same territory as R. FLAND used in the three region case.

R OF WA : This is found in the five region case, and refers to the same territory as R. WALLO used in the three region case.

R. WALLO : This is found in the three region projections and stands for a region composed of the provinces of Liège, Luxemburg, Namur and Hainaut.

SEN R : Stands for the ratio of the population age 65 and above to the population aged 0-14 (completed years)

SUMMARY TABLE : Under this caption is a summary of population characteristics (see under POPULATION) together with a series of annual crude rates (see under RATES OF NATURAL INCREASE, INTERNAL MIGRATION RATES, EXT. MIG. NET, and GROWTH RATE).

TOT : This word introduces the last row of region specific entries found under the caption AGE-SPECIFIC RATES. Each entry corresponding to TOT is equal to five times the sum of rates found in the corresponding column.

WA. BRAB : Stands for Walloon Brabant and consists of the arrondissemt of Nivelles. WA. BRAB figures in the five year region case.

W. VL : Stands for the province of West Flanders.

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