

WORKING PAPER

WHAT THE AGE COMPOSITION OF MIGRANTS
CAN TELL US

Luis J. Castro
Andrei Rogers

October 1982
WP-82-94

NOT FOR QUOTATION
WITHOUT PERMISSION
OF THE AUTHORS

WHAT THE AGE COMPOSITION OF MIGRANTS
CAN TELL US

Luis J. Castro
Andrei Rogers

October 1982
WP-82-94

Working Papers are interim reports on work of the International Institute for Applied Systems Analysis and have received only limited review. Views or opinions expressed herein do not necessarily represent those of the Institute or of its National Member Organizations.

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

PREFACE

The evolution of human populations over time and space has been a central concern of many scholars in the Human Settlements and Services Area at IIASA during the past several years. From 1975 through 1978 some of this interest was manifested in the work of the Migration and Settlement Task, which was formally concluded in November 1978. Since then, attention has turned to disseminating the Task's results, to concluding its comparative study, and to exploring possible future activities that might apply the mathematical methodology to other research topics.

This paper is part of the Task's dissemination effort. It shows how family relationships among migrants are reflected in their aggregate age profiles. By disaggregating migrants into dependent and independent categories, the paper illuminates the ways in which the age profile of migrating populations are sensitive to relative changes in dependency levels and in rates of natural increase and mobility.

Andrei Rogers
Chairman
Human Settlements
and Services

CONTENTS

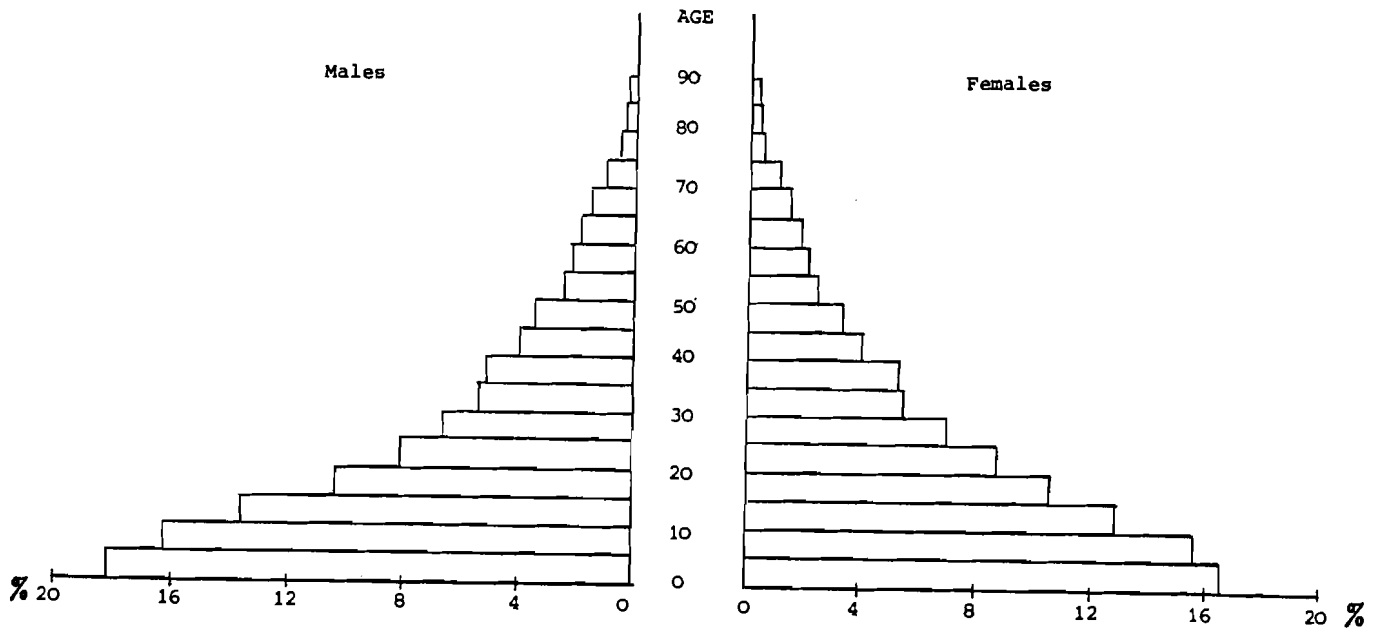
INTRODUCTION	1
ESTABLISHING THE REGULARITIES: MIGRATION MEASUREMENT	5
SUMMARIZING THE REGULARITIES: MODEL MIGRATION SCHEDULES	11
EXPLAINING THE REGULARITIES: FAMILY STATUS	20
CONCLUSIONS	29
REFERENCES	31

WHAT THE AGE COMPOSITION OF MIGRANTS CAN TELL US

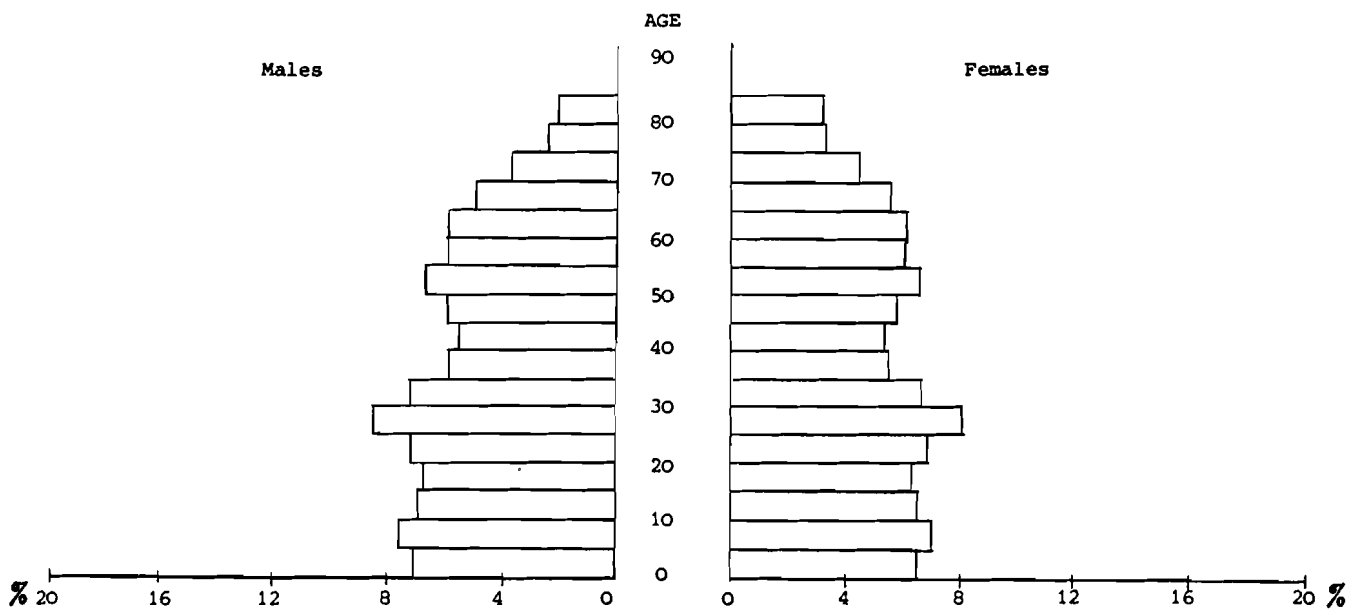
INTRODUCTION

A population pyramid graphically displays the age and sex distribution of a population; Figure 1 presents such pyramids for Mexico and Sweden. Mexico's population, with its large fraction of children and small fraction of elderly, may be called a "young" population in contrast to Sweden, which clearly exemplifies an "old" population.

The age composition of a population reflects the past history of fertility and mortality to which the population has been exposed. For example, high rates of natural increase give rise to age pyramids that taper more rapidly with age, and zero growth rates ultimately produce age pyramids that are nearly rectangular until ages 50 or 60 and that decline rapidly thereafter as death rates increase among the aged. Thus one may conclude that the age composition of a population tells us something about past patterns of fertility and mortality.



Mexico 1970



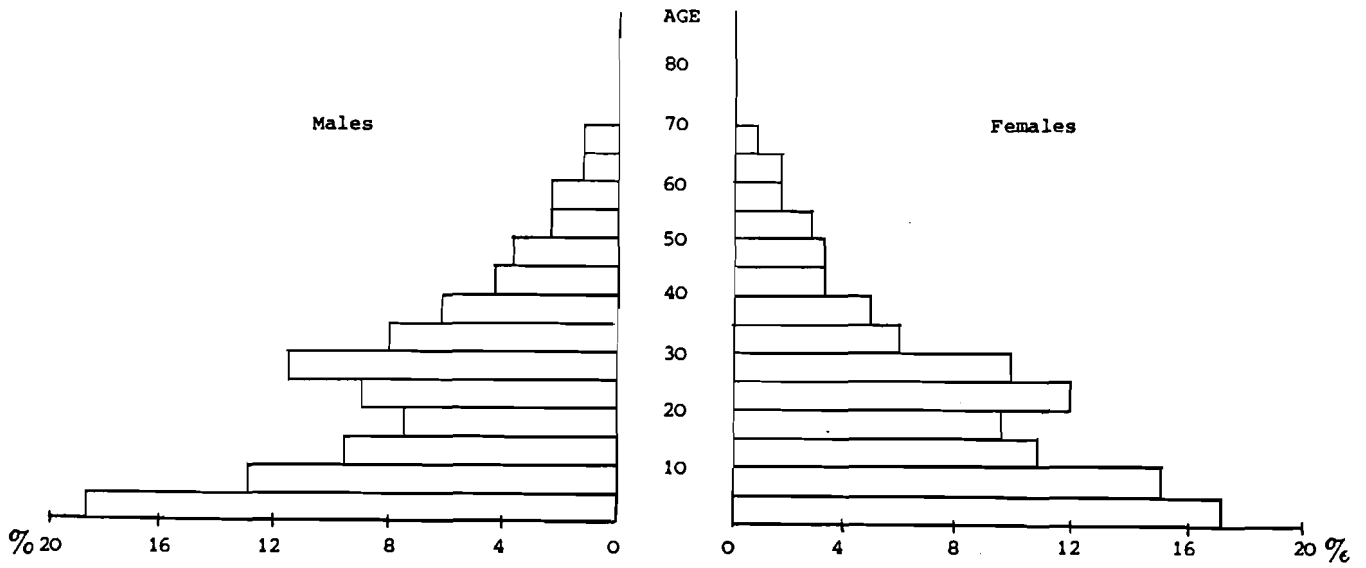
Sweden 1974

Figure 1. National population age compositions: Mexico 1970 and Sweden 1974. Sources: Federal Statistical Office 1970; Andersson and Holmberg 1980.

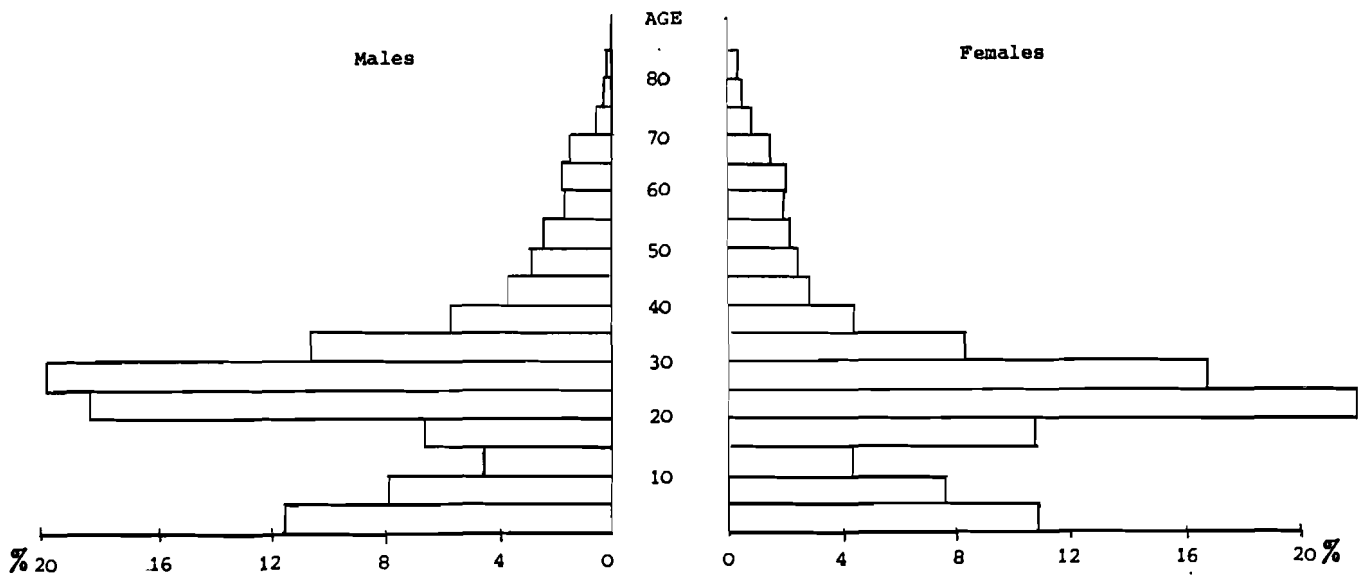
Since migrants are a subset of the population, does their age composition reflect analogous characteristics of recent patterns of fertility, mortality, and migration?

Figure 2 sets out the national migration pyramids for Mexico and Sweden. They exhibit a fundamental common finding of countless migration studies: the age composition of migrants reflects age selectivity, with young adults and infants generally being the most mobile group in any population. Migration propensities are high among children, varying from a peak at age 1 to a low point around age 16. Beyond that age, migration increases sharply to another peak around age 22, after which it declines regularly until possibly interrupted by a retirement peak at the older ages.

This paper seeks to identify some of the factors that are responsible for the widespread regularities in age profiles exhibited by empirical schedules of migration rates. We begin by briefly considering the problem of migration measurement and then go on to adopt a mathematical functional description of migration age compositions. Armed with this succinct representation of the age structure of migrants, we go on to examine how differences in family status patterns structure the age profile of migrants.



a. Interstate migration, Mexico 1970.



b. Interregional migration, Sweden 1974.

Figure 2. National migration age compositions: Mexico 1970 and Sweden 1974. Sources: One-percent sample of the 1970 Mexican Population Census; Andersson and Holmberg 1980.

ESTABLISHING THE REGULARITIES: MIGRATION MEASUREMENT

Migration studies have in the past exhibited a curiously ambivalent position with regard to the measurement of geographical mobility. This ambivalence is particularly striking because of the contrast it poses with respect to the corresponding studies of mortality and fertility—studies that are richly endowed with detailed discussions of measurement problems. Haenszel (1967) attributes this paradox to the strong influence of Ravenstein's early contributions to migration analysis:

Work on migration and population redistribution appears to have been strongly influenced by the early successes of Ravenstein in formulating "laws of migration". Subsequent papers have placed a premium on the development and testing of new hypotheses rather than on descriptions of facts and their collation... This is in contrast to the history of vital statistics. While Graunt more than two centuries before Ravenstein, had made several important generalizations from the study of "bills of mortality" in London, his successors continued to concentrate on descriptions of the forces of mortality and natality by means of rates based on populations at risk. (Haenszel 1967:260)

It is natural to look to the state of mortality and fertility measurement for guidance in developing measures of migration. Like mortality, migration may be described as a process of interstate transfer; however, death can occur but once, whereas migration is a potentially repetitive event. This suggests the adoption of a fertility analog, i.e., instead of births per mother, moves per migrant; but migration's definitional dependence on spatial boundaries and on different forms of data collection introduces measurement difficulties that do not occur in the analysis of fertility.

One of the central problems in migration measurement arises as a consequence of the different sources of migration data. Most information regarding migration is obtained from population censuses or population registers that report migration data, for a given time interval, in terms of counts of migrants or of moves, respectively. Yet another source of migration data is the sample survey, which may be designed to provide information about both migrants and moves. Migration data produced by censuses are usually in the form of transitions. Population registers treat migration as an event and generate data on moves.

A mover is an individual who has made a move at least once during a given interval. A migrant on the other hand, is an individual who at the end of a given interval no longer inhabits the same community of residence as at the start of the interval. Thus paradoxically a multiple mover can be a nonmigrant, if after moving several times he returns to his initial place of residence before the end of the unit time interval.

Because migration occurs over time as well as across space, studies of its patterns must trace its occurrence with respect to a time interval, as well as over a system of geographical areas. In general, the longer the time interval, the larger will be the number of return movers and nonsurviving migrants and, hence, the more the count of migrants will understate the number of interregional movers (and, of course, also of moves).

Most migration data collected by population censuses come from responses to four typical questions: place of birth, duration of residence, place of last residence, and place of residence at a fixed prior date (United Nations 1970). From these questions it is possible to establish the count of surviving migrants living in a region at the time of the census, disaggregated by different retrospective time intervals. The longer the time interval, the less accurate becomes the migration measure.

Because population registers focus on moves and not transitions, differences will arise between data obtained from registers and from population censuses. In the annex to the U.N. *Manual on Methods of Measuring Internal Migration* (United Nations 1970) it is stated:

Since at least some migrants, by census definition, will have been involved, by registration definition, in more than one migratory event, counts from registers should normally exceed those from censuses... Only with Japanese data has it so far been possible to test the correspondence between migrations, as registered during a one-year period and migrants enumerated in the census in terms of fixed-period change of residence. (United Nations 1970:50)

Table 1, taken from the UN analysis, illustrates how the ratio of register-to-census migration data is in general bigger than unity, increasing with decreasing distance, as for example, in the case of intra- versus interprefectural migration in Japan. In general, the ratio of register-to-census migration data should tend to unity as longer distances are involved, and also as time intervals become shorter (Figure 3). Clearly, the ratio should be greater than unity when short distances are considered and close to unity when the time interval is short, because the probability of moving across long distances several times should be expected to be less than the probability of moving the same number of times between short distances. And, the probability of moving several times during a long interval of time should be greater than the probability of experiencing the same number of moves during a shorter period of time.

A fundamental aspect of migration is its change over time. As Ryder (1964) has pointed out for the case of fertility, period and cohort reproduction rates will differ whenever the age distribution of childbearing varies from one cohort to another. The usefulness of a cohort approach in migration, as in fertility analysis, lies in the importance of historical experience as an explanation of current behavior. Morrison (1970) indicates that migration is induced by transitions from one stage of the life cycle to another, and "chronic" migrants may artificially inflate the migration rates of origin areas that are heavily populated with migration-prone individuals. Both influences on period migration are readily assessed by a cohort analysis.

It is the migration of a period, however, and not that of a cohort, that determines the sudden redistribution of a national population in response to economic fluctuations, and it is information on period migration that is needed to calculate spatial population projections.

Current period migration indices do not distinguish trend from fluctuation and therefore may be distorted; current cohort migration indices are incomplete. Thus it may be useful to draw on Ryder's (1964) translation technique to change from one to the other. As Keyfitz (1977:250) observes, the cohort and period

Table 1. Comparison of migration by sex and type based on the population register and the census for the one-year period between October 1959 and October 1960, Japan.

Sex and type of migration	Register Data	Census Data	Ratio × 100
<i>Both Sexes</i>			
Intra-prefectural	2,966,621	1,998,171	148.47
Interprefectural	2,625,135	2,590,751	101.33
<i>Males</i>			
Intra-prefectural	1,488,935	1,001,745	148.63
Interprefectural	1,450,817	1,466,898	98.90
<i>Females</i>			
Intra-prefectural	1,477,686	996,426	148.30
Interprefectural	1,174,318	1,123,853	104.49

Source: United Nations (1970 Table 42:50).

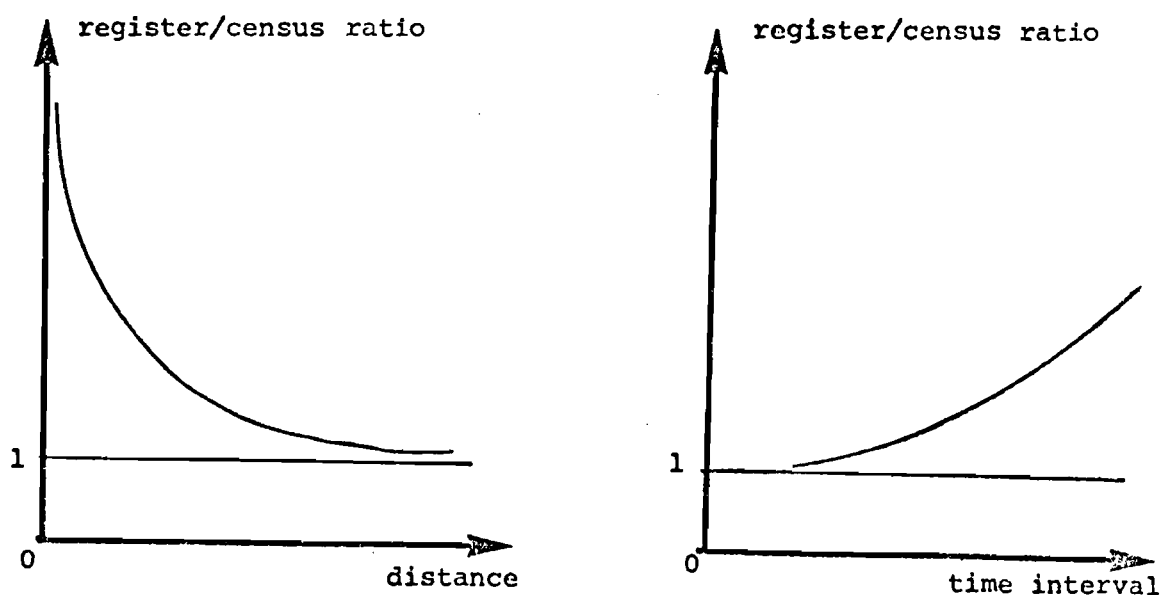


Figure 3. Ratio of register to census migration data with respect to distance and time interval.

moments in Ryder's formulas can "be interpreted, not as child-bearing, but as mortality, marriage, school attendance, income, or some other attribute of individuals". Migration is clearly such an attribute.

The importance of historical experience in interpreting and understanding current migration behavior led Peter Morrison (1970:9) to define the notion of *staging* as being "any linkage between a prior sequence and subsequent migration behavior". Morrison recognizes four kinds of staging: geographic, life cycle, socioeconomic, and experiential. Geographical staging refers to return migration and to what is conventionally understood to mean "stage migration", i.e., the idea that migrants tend to move to places not very dissimilar from those they left behind. Life-cycle staging views migration as arising out of breaks in an individual's or a household's life cycle, such as entry into the labor force, marriage, and retirement. Socioeconomic staging sees migration sequences as being conditioned by sociostructural factors such as occupation, educational attainment, and income level. Finally, experiential staging refers to movement experience in terms of number of previous moves and duration since the last move; it is the "parity" dimension of migration analysis.

Calculations of migration rates of increasing specificity seek to unconfound the "true" migration rates from weights that reflect the arithmetical influence of the past. This process of measuring migration

...at different levels of specificity of occurrence and exposure yields products which draw ever finer distinctions between current behavior and the residue of past behavior reflected in the exposure distribution at any time (Ryder 1975:10).

Such products may be weighted and aggregated to produce the "crude" rates of higher levels of aggregation. For example, the age-sex specific migration rate is a weighted aggregation with respect to the migration "parity-duration" distribution just as the crude migration rate is a weighted aggregation with respect to the age-sex distribution.

The age profile of a schedule of migration rates reflects the influences of two age distributions: the age composition of migrants and that of the population of which they were a part (Rogers 1976). This can be easily demonstrated by decomposing the numerator and denominator of the fraction that defines an age-specific migration rate, $M(x)$, say.

If $O(x)$ denotes the number of outmigrants of age x , leaving a region with a population of $K(x)$ at that age, then

$$M(x) = \frac{O(x)}{K(x)} = \frac{O \cdot N(x)}{K \cdot C(x)} = o \cdot \frac{N(x)}{C(x)} \quad (1)$$

where

O = total number of outmigrants

$N(x)$ = proportion of migrants aged x years at the time of migration

K = total population

$C(x)$ = proportion of total population aged x years at mid-year

o = crude outmigration rate

We define the collection of $N(x)$ values to be the *migration proportion schedule* and the set of $M(x)$ values to be the *migration rate schedule*.

SUMMARIZING THE REGULARITIES: MODEL MIGRATION SCHEDULES

Observed age-specific migration rate schedules universally exhibit a common shape (Rogers and Castro 1981). The same shape also characterizes the age composition of migrants, i.e., migration proportion schedules. Starting with relatively high levels during the early childhood ages, migration rates or proportions decrease monotonically to a low point at age x_1 , say, increase until they reach a high peak at age x_h , and then decrease once again to the ages of retirement before leveling off around some constant level, c say. Occasionally a "post-labor force" component appears, showing either a bell-shaped curve with a retirement peak at age x_r or an upward slope that increases monotonically to the last age included in the schedule, age w say. Thus the migration age profile may be divided into child (dependent), adult, and elderly components; however, we shall confine our attention in this paper to only the first two. But our argument is equally valid for profiles showing a retirement peak or an upward retirement slope.

The observed age distribution of migrants, $N(x)$, may be described by a function of the form:

$$N(x) = N_1(x) + N_2(x) + c \tag{2}$$

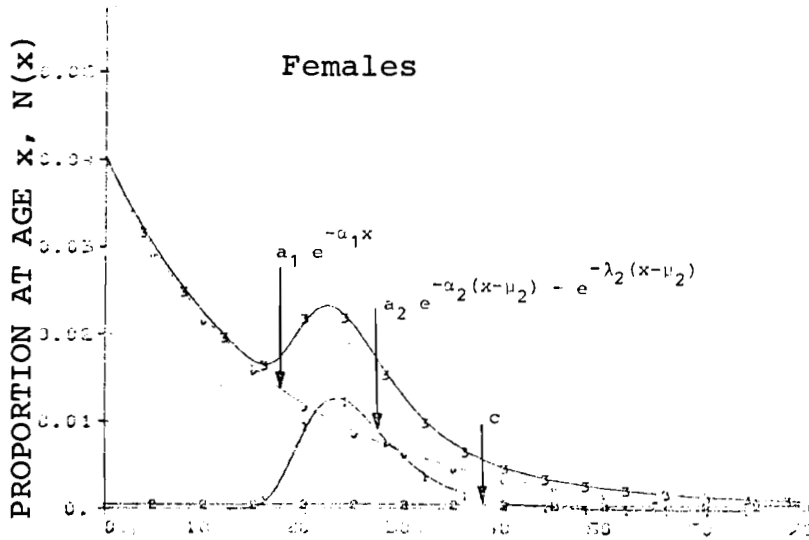
where

$$N_1(x) = a_1 e^{-\alpha_1 x}$$

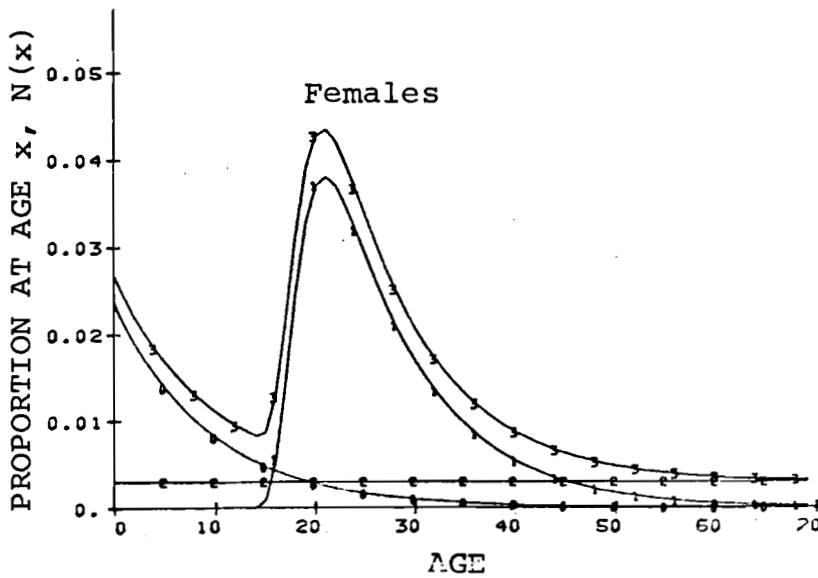
for the child (dependent) component,

$$N_2(x) = a_2 e^{-\alpha_2(x-\mu_2)} - e^{-\lambda_2(x-\mu_2)}$$

for the adult (independent) component, and c is the constant term that improves the fit when migration distributions at older ages are relatively high. Figure 4 illustrates the female model migration proportion schedules of the observed data presented in Figure 2, which by definition show an area of unity under each curve.



a. Interstate migration, Mexico 1970.



b. Interregional migration, Sweden 1974.

Figure 4. Components of the model migration proportion schedule.

An alternative way of expressing equation (2) is as a weighted linear combination of the density functions representing the above three components (Castro and Rogers 1981):

$$N(x) = \phi_1 f_1(x) + \phi_2 f_2(x) + \phi_c (1/w) \quad (3)$$

where w is the last age included in the schedule, ϕ_1 and ϕ_2 are the relative shares of the child and adult components, ϕ_c is the share of the constant term, $f_1(x)$ and $f_2(x)$ are respectively, the single and double exponential density functions

$$f_1(x) = \alpha_1 e^{-\alpha_1 x} \quad (4)$$

$$f_2(x) = \frac{\lambda_2}{\Gamma(\alpha_2/\lambda_2)} e^{-\alpha_2(x-\mu_2)} - e^{-\lambda_2(x-\mu_2)} \quad (5)$$

and $\Gamma(\alpha_2/\lambda_2)$ represents the gamma function value of α_2/λ_2 . Note that $\phi_1 + \phi_2 + \phi_c = 1$ by definition.

Equations (2) through (5) imply that

$$a_1 = \phi_1 \alpha_1 \quad (6)$$

$$a_2 = \phi_2 \frac{\lambda_2}{\Gamma(\alpha_2/\lambda_2)} \quad (7)$$

and

$$c = \frac{\phi_c}{w} \quad (8)$$

The six parameters a_1 , α_1 , a_2 , α_2 , λ_2 , and μ_2 do not seem to have demographic interpretations. Both a_1 and a_2 reflect the heights of their respective parts of the profile; α_1 and α_2 refer to the descending slopes; λ_2 reflects the ascending slope; and μ_2 positions the adult component on the age axis. Taken as a group, these parameters suggest a number of useful and robust

measures for describing an observed migration schedule (Table 2). For example, the ratio $D_o = \phi_1/\phi_2$, the child-adult dependency migration ratio, is one of several important ratios that may be used to interpret particular patterns of dependency among migrants. It assumes a central role as an indicator of family dependency structure by defining the number of dependents per adult migrant.

The child-adult dependency migration ratio varies as a function of the parameters that define the age profile of migrants. If the constant term c is close enough to zero to be ignored, as normally is the case, then $\phi_c = 0$ and

$$D_o = \frac{\phi_1}{\phi_2} = \frac{a_1 \lambda_2}{a_2 \alpha_1 \Gamma(\alpha_2/\lambda_2)}$$

Since

$$\Gamma(\alpha_2/\lambda_2) = \frac{\Gamma(1 + \alpha_2/\lambda_2)}{(\alpha_2/\lambda_2)}$$

we obtain the result

$$D_o = \frac{1}{\beta_{12} \delta_{21} \Gamma(1 + 1/\sigma_2)} \quad (9)$$

where $\delta_{21} = a_2/a_1$, $\beta_{12} = \alpha_1/\alpha_2$, $\sigma_2 = \lambda_2/\alpha_2$ are the labor dominance, parental-shift, and labor asymmetry indexes defined in Rogers and Castro (1981). These three ratios and μ_2 may be used to fully characterize observed migration age profiles.

Another useful indicator of the average size of family among migrants is the value $s_o = 1/\phi_2$, which reflects the total number of migrants per adult. In a single-sex formulation, for instance, if adults are considered as heads of each migrant family (interpreting single individuals as one-person families) then the sum of the two sex-specific values of s_o closely approximates the average size of family among migrants.

Figure 5 sets out several age profiles of internal migration flows to different cities around the world, together with

Table 2. Principal indices defining observed age-specific migration characteristics.

Characteristic	Index
— Proportion of children (dependents), ϕ_1	a_1/α_1
— Proportion of adults, ^a ϕ_2 (labor force)	$\frac{a_2}{\alpha_2} \Gamma(\alpha_2/\lambda_2)$
— Labor asymmetry, σ_2	λ_2/α_2
— Labor dominance, δ_{21}	a_2/a_1
— Parental-shift, β_{12}	α_1/α_2
— Child-adult dependency migration ratio, D_o	$\frac{1}{\beta_{12} \delta_{21} \Gamma(1 + 1/\sigma_2)}$

^a The reciprocal index is also of interest inasmuch as it reflects the total number of migrants per adult, $s_o = \frac{\alpha_2}{a_2 \Gamma(\alpha_2/\lambda_2)}$.

a typical international migration (immigration) age distribution for males and females. These profiles were generated by model migration proportion schedules fitted to observed data, the parameters of which are included in Table 3. The quantitative indices presented in Table 4 confirm the regularities illustrated in Figure 5. For example, the migration flows to Mexico City and to Lagos differ sharply from the corresponding flows to Stockholm. The former show about double the proportion of dependents exhibited by the latter. The same table also indicates that the average size of family in the flow to Mexico City, with about $2.65 + 2.20 = 4.85$ members per migrating family, is the largest among the examples presented.

All of the migration characteristics in Figure 5 and Table 4 indicate low or high family dependency patterns. In the next section, we seek an explanation for such characteristics by linking them with the family characteristics of the population as a whole.

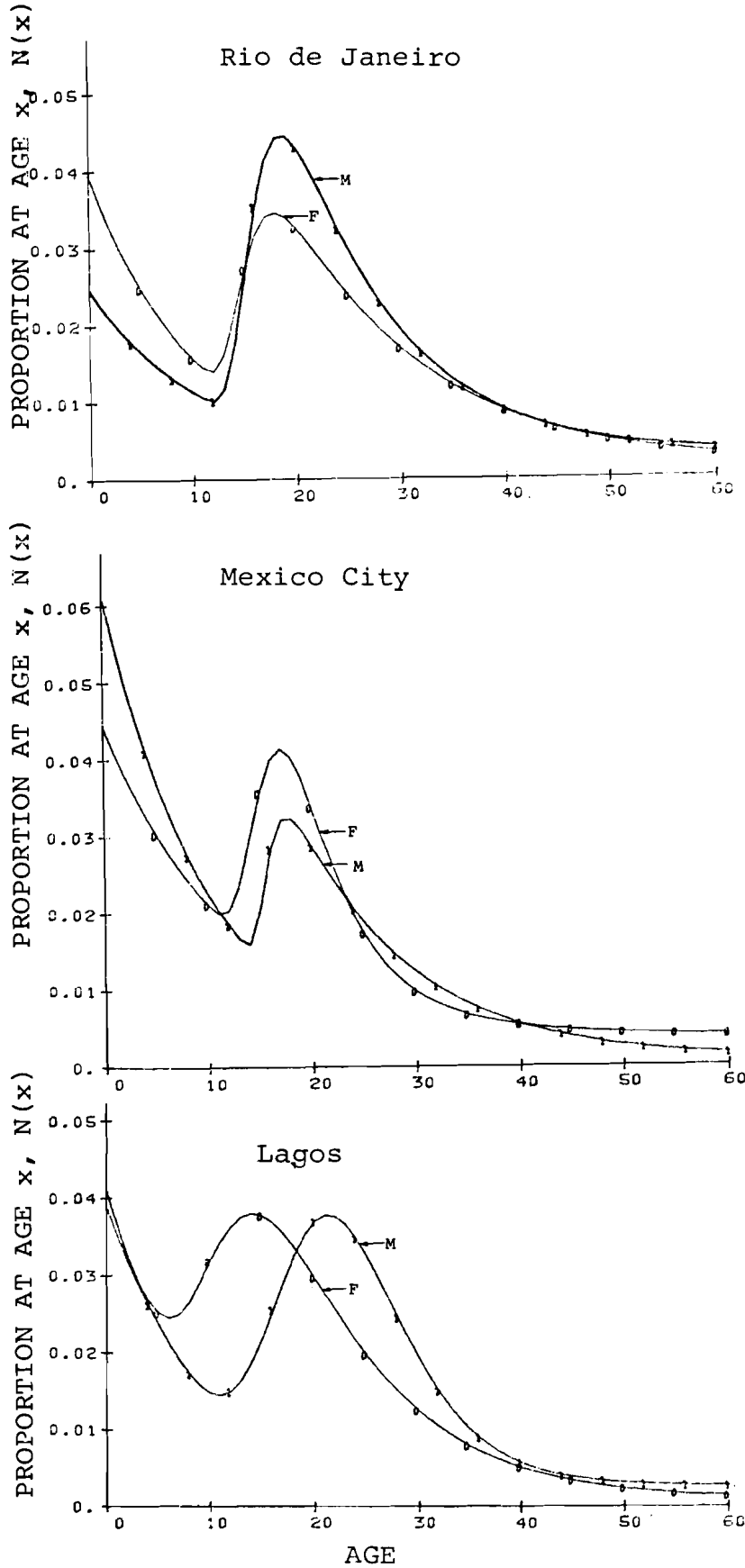


Figure 5. Model migration proportion schedules for selected cities around the world and a typical national immigration flow. Sources: Alberts 1977; one-percent sample of the 1970 Population Census of Mexico; George and Eigbefoh 1973; Kawabe and Farah 1973; Andersson and Holmberg 1980; UN 1979.

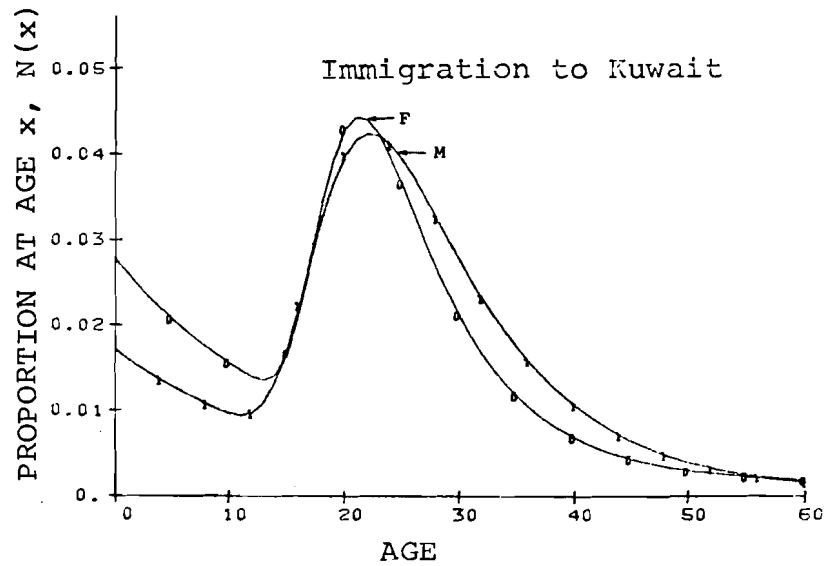
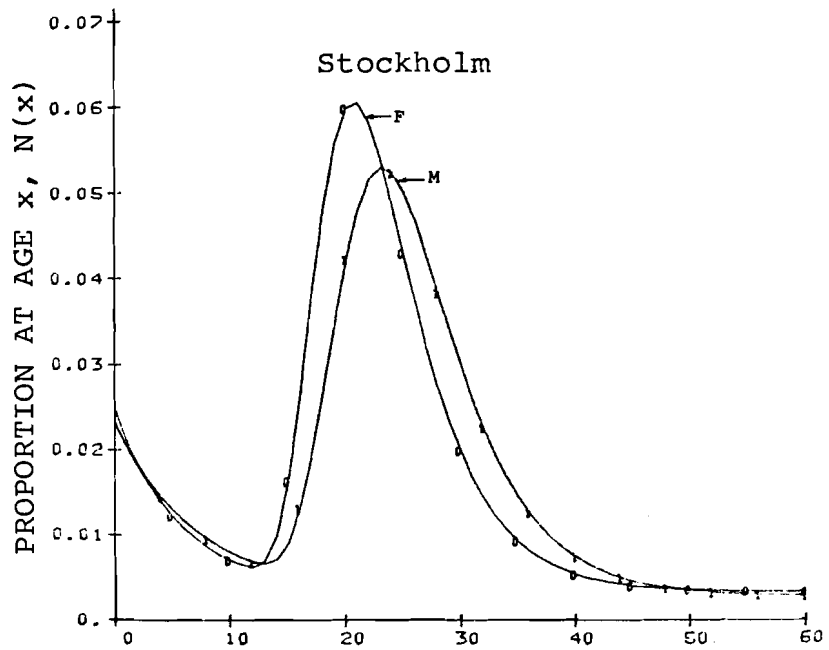
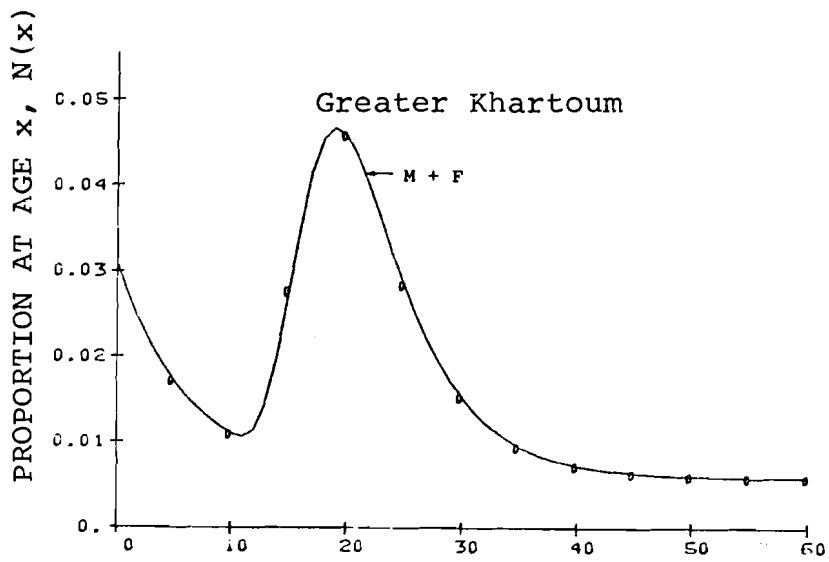


Figure 5 continued.

Table 3. Parameters and variables defining observed model migration proportion schedules for selected cities around the world and a typical national immigration flow.^a

Parameter or variable	Rio de Janeiro Brazil		Mexico City Mexico		Lagos Nigeria		G. Khartoum Sudan	Stockholm Sweden		Immigration to Kuwait	
	Males	Females	Males	Females	Males	Females	Total	Males	Females	Males	Females
	a_1	0.025	0.041	0.065	0.048	0.042	0.038	0.031	0.025	0.023	0.018
α_1	0.075	0.092	0.101	0.081	0.099	0.065	0.099	0.116	0.095	0.056	0.047
a_2	0.051	0.037	0.027	0.028	0.062	0.048	0.054	0.088	0.096	0.086	0.084
μ_2	15.394	14.905	15.765	13.878	17.223	11.646	15.053	16.975	19.648	19.658	19.946
α_2	0.069	0.059	0.070	0.060	0.092	0.098	0.069	0.098	0.110	0.108	0.161
λ_2	0.694	0.583	1.107	1.263	0.294	0.318	0.531	0.508	0.334	0.229	0.301

^aThe c parameter value was set equal to zero in the nonlinear parameter estimation procedure.

Table 4. Estimated characteristics of observed model migration population schedules for selected cities around the world and a typical national immigration flow.

Characteristic	Rio de Janeiro ^a		Mexico City ^b		Lagos ^c		G. Khartoum ^d	Stockholm ^e		Immigration to ^f	
	Brazil 1968-72		Mexico 1969-70		Nigeria 1967-68		Sudan 1960-64	Sweden 1974		Kuwait 1965-70	
	Male	Female	Male	Female	Male	Female	Total	Male	Female	Male	Female
Proportion of dependents (%)	33.70	44.81	64.29	59.50	42.28	57.80	31.60	24.07	21.31	31.46	57.09
Proportion of adults (%)	70.14	59.54	37.67	45.55	59.90	43.88	73.77	78.06	82.17	70.54	46.27
Total number of migrants per adult	1.43	1.68	2.65	2.20	1.67	2.28	1.36	1.28	1.22	1.42	2.16
Labor asymmetry	10.03	9.83	15.74	21.01	3.20	3.24	7.73	3.04	5.18	2.12	1.87
Labor dominance	2.02	0.90	0.42	0.58	1.47	1.27	1.72	4.18	3.55	4.88	3.12
Parental shift	1.08	1.56	1.43	1.34	1.08	0.67	1.44	0.87	1.18	0.52	0.29
Child-adult migration ratio	0.48	0.75	1.71	1.31	0.71	1.32	0.43	0.31	0.26	0.45	1.23

Sources: ^a Alberts 1977
^b One-percent sample of the 1970 Mexican Census of Population
^c George and Eigbefoh 1973
^d Kawabe and Farah 1973
^e Andersson and Holmberg 1980
^f United Nations 1979

EXPLAINING THE REGULARITIES: FAMILY STATUS

It is widely recognized that a large fraction of total migration is accounted for by individuals whose moves are dependent on those of others. Indeed family migration is such a well-established phenomenon that Ryder (1978) has even suggested its use as a criterion for identifying family membership: a family comprises of those individuals who would migrate together.

To understand the influences that family and dependency relationships have on migration age compositions, it is useful to examine how such profiles respond to fundamental changes in dependency patterns. To illustrate this, consider a single-sex population that is divided into two groups: dependents and heads, where dependents are simply individuals who have not left home to become heads. (Included as heads are independent single individuals who may be viewed as one-person families.) Thus the age distribution of the female population $C(x)$ may be composed by weighting the density functions of dependents and heads:

$$C(x) = \phi_{1c} f_{1c}(x) + \phi_{2c} f_{2c}(x)$$

where ϕ_{1c} and ϕ_{2c} are the proportions of dependents and heads in the total female population and, $f_{1c}(x)$ and $f_{2c}(x)$ are their corresponding age distributions, respectively.

The ratio of the weights associated with the age profiles of dependents and heads defines the child-adult dependency population ratio, D_c , which is similar to the D_o defined earlier for the migrant population:

$$D_c = \frac{\phi_{1c}}{\phi_{2c}}$$

As in the case of migration, we can also define the total number of persons per adult (head) as $s_c = 1/\phi_{2c}$. To investigate analytically some of the underlying patterns of "head formation" requires some mathematical theorizing.

Let y_0 denote the age at which an appreciable number of females first leave home to establish their own household. Since marriage is an important reason for leaving the family home, it is likely that the probability density function describing the pattern of head formation by age is similar to the one found in studies of nuptiality, i.e., the double exponential function defined in equation (5). If $g(y)$ is such a function then

$$G(x) = \int_{y_0}^x g(y) dy$$

defines the proportion of females who have ever left home by age x , i.e., who are heads according to our definition.

Since $f_{2c}(x)$ defines the proportion of the population of heads that are of age x , and $G(x)$ defines the proportion of the population who are heads by age x , it is evident that in a stable population growing at an intrinsic rate of growth r ,

$$f_{2c}(x) = \frac{e^{-rx} l(x) G(x)}{\int_0^{\infty} e^{-ry} l(y) G(y) dy}$$

where $l(x)$ denotes the probability of surviving from birth to age x . For similar reasons

$$f_{1c}(x) = \frac{e^{-rx} l(x) [1 - G(x)]}{\int_0^{\infty} e^{-ry} l(y) [1 - G(y)] dy}$$

Given these equations, the child-adult dependency population ratio D_c may be defined as

$$D_c = \frac{\int_0^{\infty} e^{-ry} l(y) [1 - G(y)] dy}{\int_0^{\infty} e^{-ry} l(y) G(y) dy}$$

Figure 6 illustrates the above argument with hypothetical data. It presents the survivorship curve, $l(x)$, which is that of the Brass standard with $\alpha = -0.80$ and $\beta = 1.75$ with an expectation of life at birth of approximately 69 years (Brass 1971); and the head formation curve $G(x)$ is the Coale-McNeil double exponential (Coale and McNeil 1972) expressed by the Rodriguez and Trussell (1980) standard with mean (22 years) and variance (5 years) of age of becoming a head. Figure 7 shows the resulting dependent, head, and population (dependents plus heads) distributions of stable populations growing at intrinsic rates $r = 0$ and $r = 0.03$, respectively.

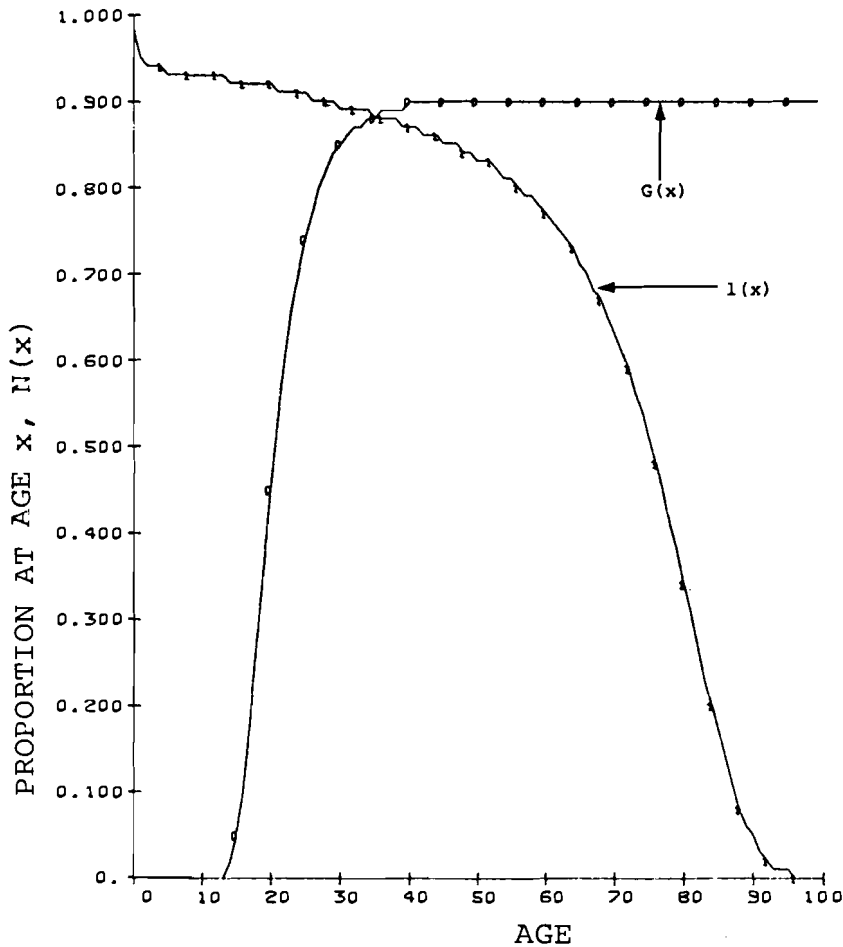


Figure 6. Proportion surviving to age x , $l(x)$, and proportion of individuals who have ever left home by age x , $G(x)$.

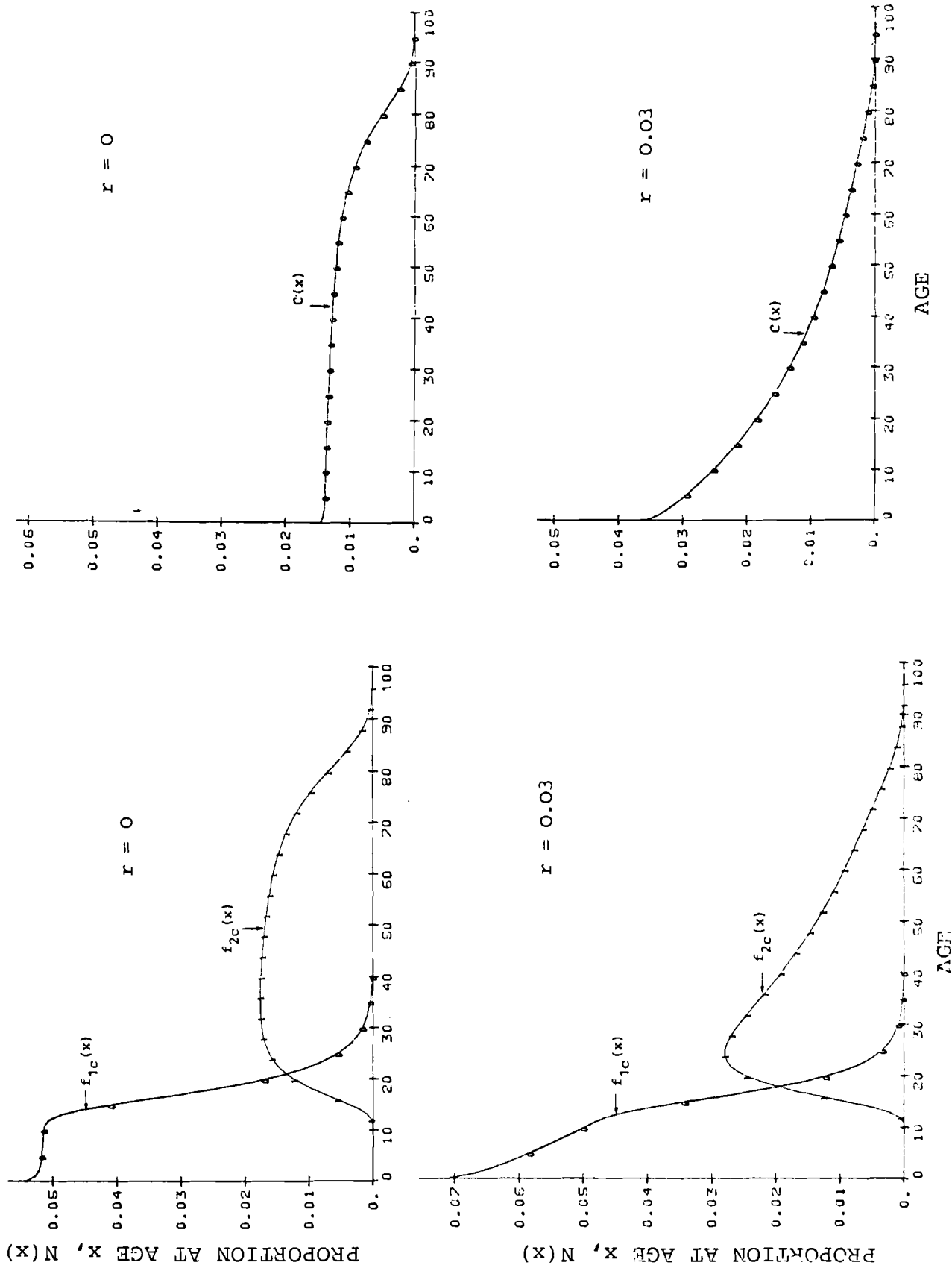


Figure 7. Proportion of dependents at age x , $f_{1c}(x)$, $f_{2c}(x)$, proportion of heads at age x , $f_{1c}(x)$, $f_{2c}(x)$, and the resulting population age composition, $c(x)$, for intrinsic rates of growth r of zero and 0.03, respectively.

To derive the corresponding age compositions of migrants we introduce the probabilities $p_1(x)$ and $p_2(x)$ that a dependent and a head, respectively, migrate at age x in an interval of time. The age distribution of migrants is defined as before:

$$N(x) = \phi_1 f_1(x) + \phi_2 f_2(x)$$

where

$$f_1(x) = \frac{e^{-rx} l(x) [1 - G(x)] p_1(x)}{\int_0^{\infty} e^{-ry} l(y) [1 - G(y)] p_1(y) dy}$$

and

$$f_2(x) = \frac{e^{-rx} l(x) G(x) p_2(x)}{\int_0^{\infty} e^{-ry} l(y) G(y) p_2(y) dy}$$

The child-dependency migration ratio D_o , equivalent to equation (9), may now be defined as:

$$D_o = \frac{\int_0^{\infty} e^{-ry} l(y) [1 - G(y)] p_1(y) dy}{\int_0^{\infty} e^{-ry} l(y) G(y) p_2(y) dy}$$

Both child-adult dependency ratios, D_c and D_o , may be analyzed by using hypothetical populations once again. To specify correctly the probabilities $p_1(x)$ and $p_2(x)$ from different sources of migration data, it is necessary to identify first the number of moves a person undertakes during a unit interval. However, for our purposes we may assume that both dependents and heads follow a negative exponential propensity to migrate with respect to age, with the function's parameter reflecting the average rate of moving per unit of time. Formally, we have then

$$p_1(x) = o_1 e^{-o_1 x}$$

and

$$p_2(x - y_0) = o_2 e^{-o_2(x - y_0)}$$

where y_0 denotes, as before, the age at which an appreciable number of females first leave home to establish their own household, and o_1 and o_2 denote the average rates of moving per unit of time of dependents and heads, respectively. One might expect that the average rate of moving per unit of time for dependents, o_1 , should not exceed o_2 , the corresponding rate for heads. In general, dependents (children) move with their parents and independent, single individuals are most likely to be found among adults.

Figure 8 presents the variation of D_0 with respect to D_c for the hypothetical populations of Figure 7, under various mobility conditions as expressed by the ratio o_1/o_2 . It may be seen that the ratio D_0/D_c more closely approaches unity as the migration of heads increases.

The parameters defining the mobility conditions may be used to set out a typology of migration profiles that helps to identify how a particular family migration pattern may be reflected in a migration age composition, and how important the migration propensities among heads and dependents are in structuring that age composition. Figures 9 and 10 present a set of profiles classified according to two distinctly different rates of natural increase. For each of the hypothetical populations we show three alternative combinations of propensities to migrate among heads and dependents. First, Figure 9 sets out, for low head migration propensities ($o_2 = 0.08$), profiles showing a significant degree of family migration ($o_1 = o_2$) and also of low family dependency ($o_1 = 0.10o_2$ and $o_1 = 0.20o_2$). In a similar format, Figure 10 presents the corresponding profiles for high head migration propensities ($o_2 = 0.16$). With the aid of these two figures we can see that patterns such as those of Stockholm indicate a relatively low family migration dependency with high head migration propensities and low population growth rates, whereas profiles such as those of Mexico City present characteristics that correspond to high family migration dependency and relatively high dependent and head migration propensities.

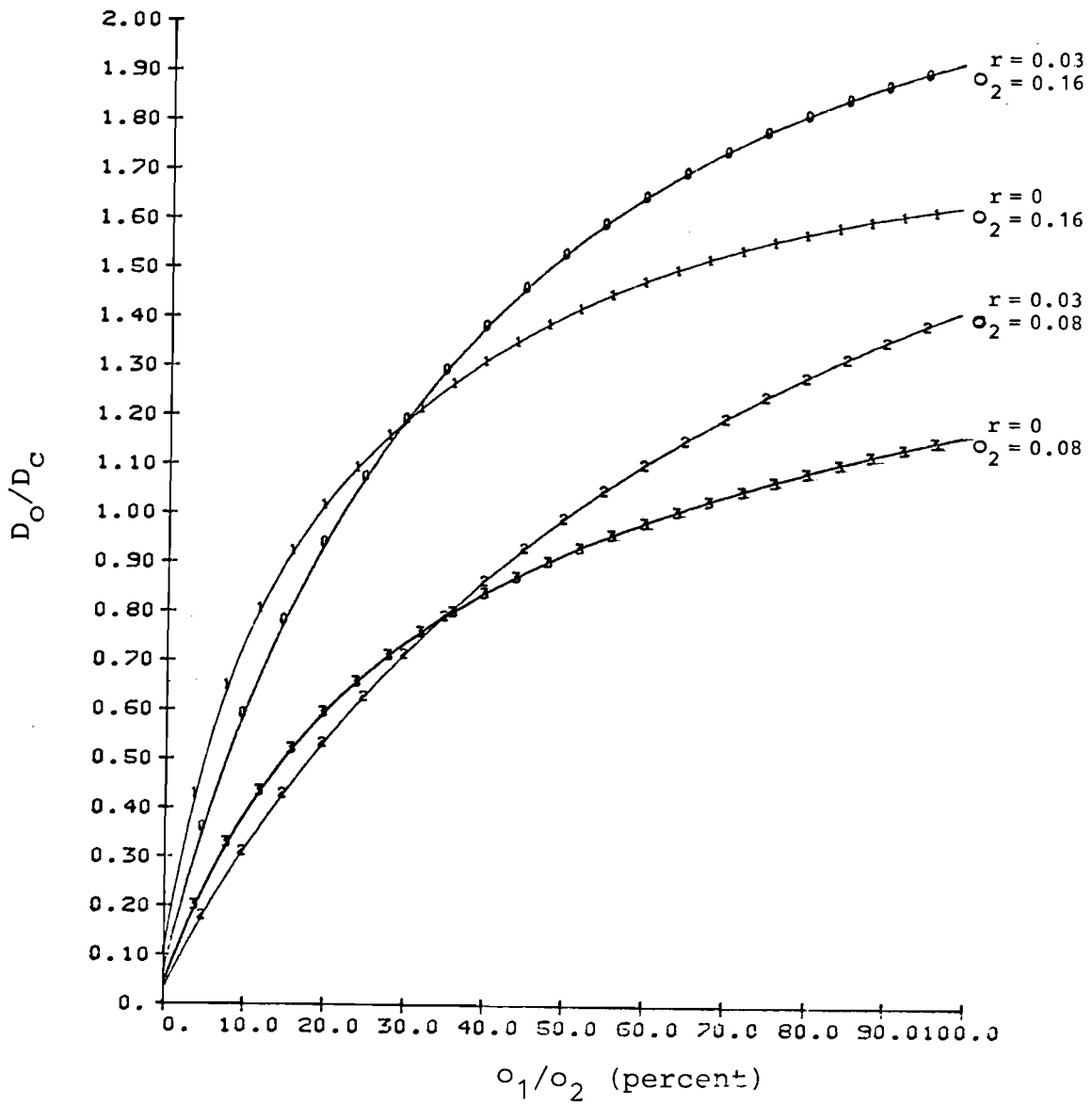
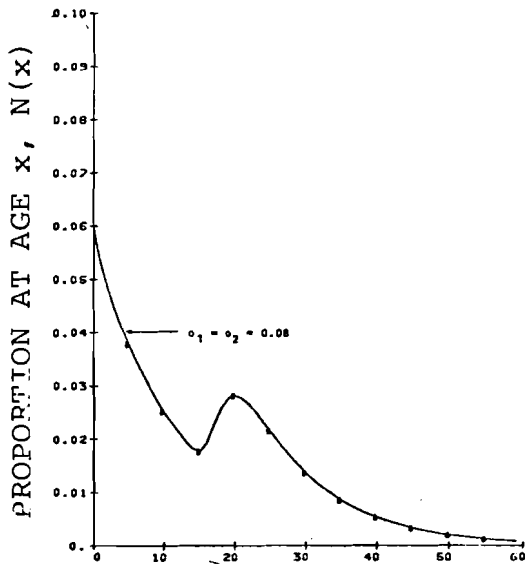
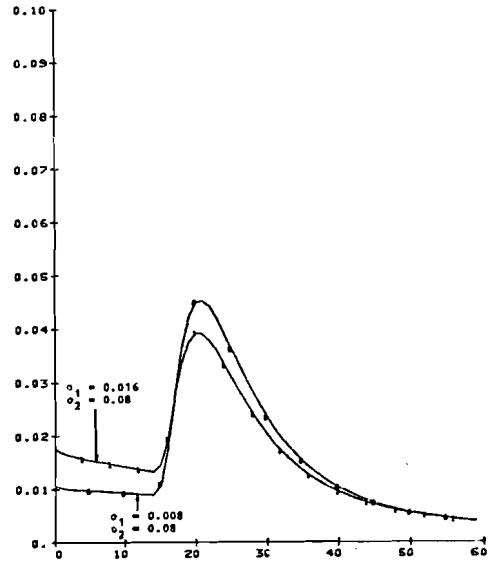


Figure 8. Variation of child-adult dependency ratios among migrants (D_O) and the population (D_C) with respect to different levels of natural increase (r), family migration (o_1/o_2), and migration propensities of heads (o_2).

Low Population Growth, $r = 0$
 Low Head Migration Propensity,
 $\sigma_2 = 0.08$; $\sigma_1 = 0.08, 0.016, \text{ and } 0.008$

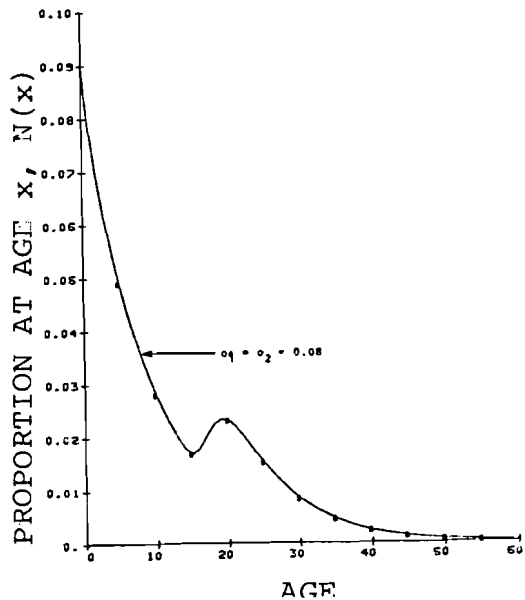


a. Family migration

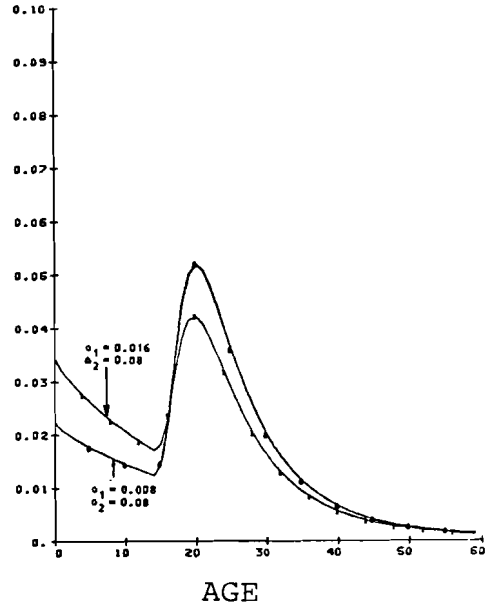


b. Low family dependency

High Population Growth, $r = 0.03$
 Low Head Migration Propensity,
 $\sigma_2 = 0.08$; $\sigma_1 = 0.08, 0.016, \text{ and } 0.008$



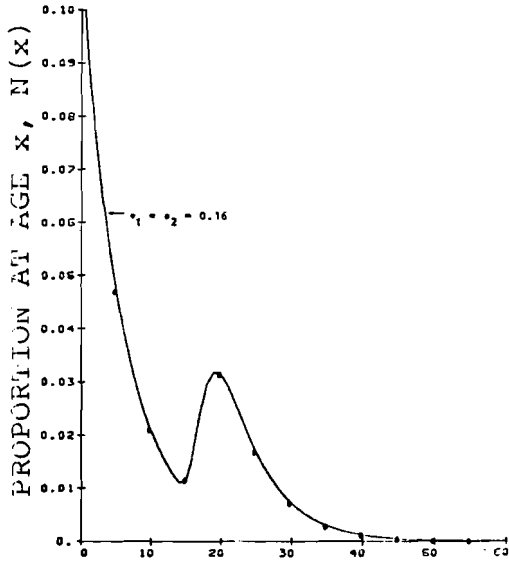
c. Family migration



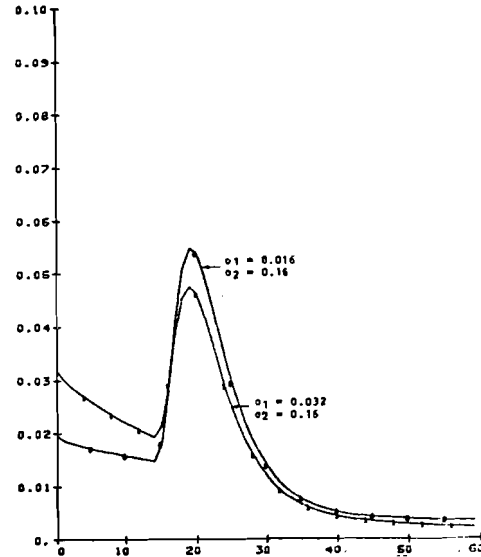
c. Low family dependency

Figure 9. A typology of age migration distributions for low and high population growth, family migration dependencies, and low head migration propensities.

Low Population Growth, $r = 0$
High Head Migration Propensity,
 $\sigma_2=0.16; \sigma_1=0.16, 0.032, \text{ and } 0.016$

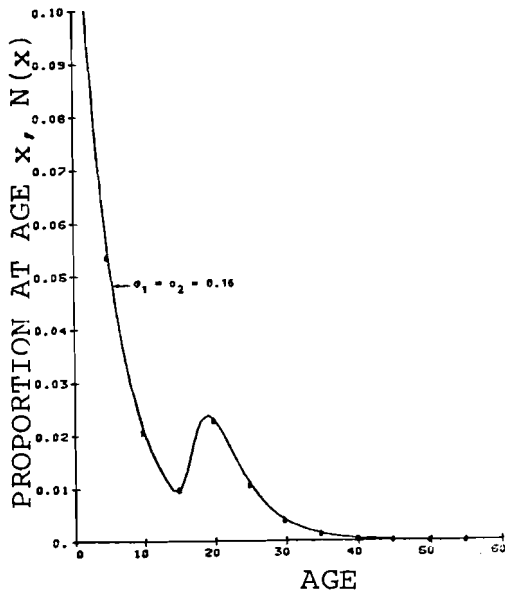


a. Family migration

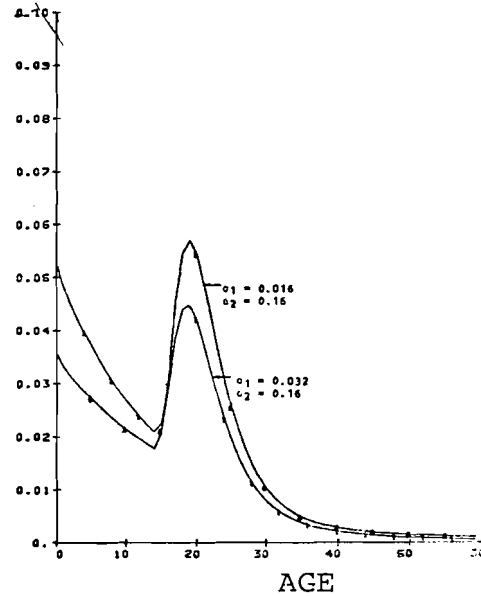


b. Low family dependency

High Population Growth, $r = 0.03$
High Head Migration Propensity,
 $\sigma_2=0.16; \sigma_1=0.16, 0.032, \text{ and } 0.016$



c. Family migration



d. Low family dependency

Figure 10. A typology of age migration distributions for different population growth, family migration dependencies and high head migration propensities.

CONCLUSIONS

The aim of this paper has been to show how the regularities that appear in migration age compositions can be summarized in a useful manner and to suggest what such regularities may be telling us about patterns of natural increase, family relationships, and mobility levels among migrants.

A disaggregation of migrants into dependent and independent categories, and the adoption of model migration proportion schedules, illuminates the ways in which the age profile of migration is sensitive to relative changes in dependency levels and in rates of natural increase and mobility. Viewing the migration process within a framework of dependent and independent movements allows one to observe that if the independent component is mainly comprised of single persons, then the associated dependent migration may be insignificant in terms of its relative share of the total migration. On the other hand, if migration tends to consist principally of family migration, then the share of dependent children may become a very important part of total migration.

Observed migration distributions, when analyzed in the context of the family status approach, confirm the indications given by the parameters of the associated model proportion schedules. For example, high migration dependencies were correctly indicated for Mexico City; for Stockholm they were low; and falling somewhere in between these two extremes was the case of Rio de Janeiro.

The degree of propensity to migrate among independent migrants is also evident from observed age profiles. Strongly skewed distributions in the adult ages, corresponding to high λ_2 and α_2 parameter values, indicate relatively higher migration propensities for the independent component. Profiles with high dependency levels show much more weakly skewed adult migration compositions due to lower propensities for individual moves among heads.

Just as population age compositions reflect particular characteristics of fertility and mortality regimes, so do observed migration age compositions reflect key aspects of family structure and migration patterns. Although, many of the relationships set out in this paper are still conjectural, a modest start has been made. A framework for assessing the impacts of natural increase, family dependencies, and differing migration propensities has been set out.

REFERENCES

- Andersson, Å. E., and I. Holmberg (1980) *Migration and Settlement: 3. Sweden*. RR-80-5. Laxenburg, Austria: International Institute for Applied Systems Analysis.
- Alberts, J. (1977) *Migración hacia áreas metropolitanas de América Latina* (Migration in Latin American Metropolitan Areas). Rio de Janeiro: Centro Latinoamericano de Demografía.
- Brass, W. (1971) On the Scale of Mortality. Pages 69-110 in *Biological Aspects of Demography* edited by W. Brass. London: Taylor and Francis Ltd.
- Castro, L.J., and A. Rogers (1981) *Model Migration Schedules: A Simplified Formulation and an Alternative Parameter Estimation Method*. WP-81-63. Laxenburg, Austria: International Institute for Applied Systems Analysis.
- Coale, A.J., and D.R. McNeil (1972) The Distribution by Age of the Frequency of First Marriage in a Female Cohort. *Journal of the American Statistical Association* 67:743-749.
- Federal Statistical Office (1970) *IX Censo General de Población (Ninth General Population Census)*. Mexico City.
- George, M. V., and A. A. Eiqbefoh (1973) Population Growth and Migration in Lagos, 1911-1963. In *Urbanization and Migration in Some Arab and African Countries*. Cairo: Cairo Demographic Center.
- Haenszel, W. (1967) Concept, Measurement, and Data in Migration Analysis. *Demography* 4:253-261.

- Kawabe, H., and A. A. M. Farah (1973) *An Ecological Study of Greater Khartoum. In Urbanization and Migration in Some Arab and African Countries.* Cairo: Cairo Demographic Center.
- Keyfitz, N. (1977) *Applied Mathematical Demography.* New York: Wiley.
- Morrison, P.M. (1970) *Implications of Migration Histories for Model Design.* P-4342. Santa Monica, California: The Rand Corporation.
- Rodriguez, G., and J. Trussell (1980) *Maximum Likelihood Estimation of the Parameters of Coale's Model Nuptiality Schedule from Survey Data.* World Fertility Survey, Technical Bulletin 7, Tech. 1261. Voorburg, Netherlands: International Statistical Institute.
- Rogers, A. (1976) *Two Methodological Notes on Spatial Population Dynamics in the Soviet Union.* RM-76-48. Laxenburg, Austria: International Institute for Applied Systems Analysis.
- Rogers, A., and L.J. Castro (1981) *Model Migration Schedules.* RR-81-30. Laxenburg, Austria: International Institute for Applied Systems Analysis.
- Ryder, N.B. (1964) *The Process of Demographic Translation.* *Demography* 1:74-82.
- Ryder, N.B. (1975) *Fertility Measurement Through Cross-sectional Surveys.* *Social Forces* 54:7-35.
- Ryder, N.B. (1978) *Methods in Measuring the Family Life Cycle.* Proceedings of the International Population Conference, International Union for the Scientific Study of Population.
- United Nations (1979) *Trends and Characteristics of International Migration Since 1950.* New York: United Nations.