Working Paper

The Concentration of Reproduction: A Global Perspective

Wolfgang Lutz

June 1987
WP-87-51

International Institute for Applied Systems Analysis
A-2361 Laxenburg, Austria

The Concentration of Reproduction: A Global Perspective

Wolfgang Lutz

June 1987
WP-87-51

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

Foreword

Standard techniques for demographic analysis deal mostly in averages, and so implicitly take populations as homogeneous. The standard life table tells us only that at a given age, for example, .99 (say) of the population will survive to the next age. Births are expressed as children per woman or some other average. The original raw data in the case of deaths are incapable of saying much about distributions, since they can tell us only that Mr. A died at age x. Women can have more than one birth, and so it is possible to know the distribution of childbearing among women, but in fact in the usual form of compilation the data are stripped of information on distributions.

While confining the analysis to averages is convenient for many purposes, it also leaves out much. Birth rates are the subject of policy, in some countries to raise below-replacement fertility, in other countries to hold increase down to what the economy and ecology can stand. But if most of the children are borne by a (relatively small) fraction of women, then those devising of policies will want to take account of this heterogeneity.

IIASA has produced a series of papers, authored by Anatoli Yashin and James Vaupel, dealing with the implications of heterogeneity in various fields. The present paper by Wolfgang Lutz takes an empirical turn; it assembles such data on childbearing as shows distributions, particularly those collected in the World Fertility Survey. The present assembly of data and its analysis is a further step forward in filling what has been a major gap in demographic analysis.

Nathan Keyfitz
Leader, Population Program

Abstract

This paper studies the heterogeneity of women with respect to achieved fertility under a global perspective. Besides the graphical analysis of Lorenz curves, the proportion of women that has half the number of all children is used as a quantitative indicator of concentration. The empirical basis for this paper are mainly the World Fertility Survey data for 41 less developed countries and 11 industrialized nations. This is supplemented by other sources including the Chinese one per thousand fertility survey.

The study shows that during the course of demographic transition concentration increases while the average level of fertility decreases. This strong negative association holds for time series of the historical fertility decline in Germany and Austria and also very clearly for the cross-section of 41 LDC's. The recent fertility decline in China presents a major exception from this general pattern since it was not associated with increasing concentration. In modern European societies concentration has been diminishing mainly because of an approximation of real parity distributions to the relatively homogeneous expected family sizes. The future trend of concentration in childbearing in low fertility countries will mainly depend on the extent of childlessness.

Acknowledgements

The author wants to thank James Vaupel and Dianne Goodwin for stimulating discussions on concentration in human reproduction, and Nathan Keyfitz and Douglas Wolf for helpful comments on the manuscript. Thanks are extended to Andreas Bakany for his able research assistance and to Susanne Stock for skillful textprocessing and editing. Parts of the work presented in this study were supported by Grant No. P6006 of the Austrian Science Foundation.

Contents

Page

The Concentration of Reproduction: A Global Perspective

Wolfgang Lutz

1. THE MEASUREMENT OF CONCENTRATION IN DEMOGRAPHY

1.1. Static and Dynamic Concentration

Every real population is heterogeneous with respect to various aspects: individual survival, reproduction, migration, marriage, divorce, etc. There are always some subgroups of the population that have a higher risk of death, marriage, or divorce at certain ages. There is also no population where all women bear the same number of children. If we do not take the individual but a total (e.g. national) population as the unit of observation, we also find considerable diversity among the populations in the world, which in some cases is greater, in others smaller, than the diversity within the populations.

Dispersion and concentration are two notions that are closely related. Without dispersion in the distribution there is no concentration and vice versa. The questions behind those two notions are, however, somewhat different: the indicators of dispersion tell us how strongly the units of observation differ from each other with respect to their *output*, whereas indicators of concentration tell us how the total *output* is attributed to individual units.

Our speaking of concentration usually covers two quite different aspects. We may refer to dynamic concentration, i.e. the process of a distribution becoming more concentrated, or to static concentration. Static concentration observes the status of the distribution at a given point in time. This second meaning seems to be much wider spread, at least in the economic literature (see Bruckmann 1981). The analysis of concentration as a process is then usually done by a comparative statics approach. This implies the calculation of static concentration measures at different points in time and their comparative analysis.

For demographic applications this static understanding of the word concentration also seems to be appropriate. Demographers may study the distribution at one point in time and then compare its changes over time. This seems easier to define unambiguously than the dynamic meaning which only would make sense under a spatial perspective, e.g. concentrating troops in one place. The question of clear definition is crucial to the demographic application of concentration analysis. Unlike for many economic questions, in population science it is less clear what is the *output* and what are the producing units. As mentioned above, the units may be all individuals, individuals with certain characteristics (e.g women of a certain age group) or populations. The *output* may be virtually everything that is measured in demography. Only nonrepeatable events that occur to everybody, such as death, are not appropriate for concentration analysis, because there cannot be any concentration. But other aspects of mortality, such as the concentration of child mortality among families, might well be studied. In this context, however, we will only focus on the concentration of fertility. The birth of a child is, on a global perspective, is the most often repeated demographic event (except perhaps for local migrations) and its distribution has important consequences for the mother, the child, and the population as a whole: population reproduction seems to be the most appropriate demographic field for concentration analysis.

Before discussing specific indicators of concentration we still must make another important distinction: concentration may be understood in absolute or relative terms. Absolute concentration focuses on the *output* of a small absolute number of the highest producing units, whereas relative concentration looks at the proportion of the units that produce that *output*. The essential empirical difference is that if a great number of additional units with little *output* were added to the total, the measure of absolute concentration should remain essentially unchanged, whereas relative concentration should increase significantly. This will be discussed in greater detail below.

1.2. The Absolute Concentration of Fertility

Because of the nature of demographic phenomena the study of absolute concentration is only reasonable and informative for a very restricted number of questions. Generally the concept of relative concentration will be the appropriate one because demographic information is mostly related to the total of the population or certain subgroups (age groups). One great advantage of measures of absolute concentration is that they may be applied to distributions that are truncated at the lower end (e.g. in tax records, or lists of companies that start at a certain size). In population statistics, however, this kind of data problem usually does not exist. Furthermore, in demography there is a natural limit to concentration. The number of children women can bear during their lifetime is biologically limited and it is very small in relation to the total number of children borne in a society. Hence a small absolute number of even extremely fertile women would never account for a sizable proportion of the total number of births in a society.

With all these reservations, there are a few questions in demography where the study of absolute concentration is informative if the units of observation are aggregate populations instead of individuals. It is a meaningful statement to say that in 1950-1955 more than one quarter of all children in the world where born in China, and that China, India, and the Soviet Union accounted for almost half of all births (see Table 1). Similar calculations can be made for other periods and the static statements on absolute concentration may then be compared over time.

How can absolute concentration be measured adequately? Bruckmann (1969) specified four conditions which every indicator of concentration should meet; the first two hold for absolute and relative concentration as well, the third and fourth are differentiating criteria between absolute and relative concentration:

1. Indicators of absolute and relative concentration must be insensitive to proportional changes in the *output* per unit; instead they should only depend on the proportion of the total *output* produced by each unit.
2. An increase of the proportion $p(A)$ at the expense of $p(B)$ by a certain amount e should—given $p(A) > p(B)$—lead to an increase in the indicators of absolute and relative concentration (and vice versa). For maximum concentration the indicator should be equal to unity, and otherwise be greater or equal to zero.
3. An increase in the number of producing units by drawing from the same distribution should affect the indicator of absolute concentration but not that of relative concentration. In other words, only the indicator of absolute concentration should depend on the sample size.
4. The inclusion of a greater number of producing units with very little *output* should affect the indicator of absolute concentration only marginally, whereas the indicator of relative concentration should respond markedly to such a change.

Table 1a. Absolute concentration of average annual numbers of births by countries in 1950-1955.

Rank order	Country	Number of births	Proportion of total births $p(i)$	Concentration ratio $\sum p(i)$
1	China	26675	0.2647	0.2647
2	India	17024	0.1689	0.4336
3	USSR	4947	0.0491	0.4827
4	USA	3946	0.0392	0.5128
5	Indonesia	3573	0.0355	0.5573
6	Brazil	2569	0.0255	0.5828
7	Pakistan	2091	0.0207	0.6035
8	Japan	2052	0.0204	0.6239
9	Nigeria	1784	0.0177	0.6416
10	Bangladesh	1769	0.0176	0.6591
11	Mexico	1378	0.0137	0.6728
12	Vietnam	1206	0.0120	0.6848
13	Korea	1121	0.0111	0.6959
14	Philippines	1094	0.0109	0.7067
15	Thailand	1016	0.0101	0.7168
16	Egypt	1014	0.0101	0.7269
17	Turkey	1003	0.0100	0.7368
18	Iran	920	0.0091	0.7460
19	Ethiopia	885	0.0088	0.7547
20	Italy	870	0.0086	0.7634
21	France	829	0.0082	0.7716
22	Great Britain	808	0.0080	0.7796
23	GFR	807	0.0080	0.7876
24	Poland	785	0.0078	0.7954
25	Rep. of Korea	773	0.0077	0.8031

Herfindahl-Index: 0.1079

These criteria will be used as guidelines in the following evaluation of absolute (this section) and relative (next section) measures of concentration.

The most often used indicator of absolute concentration, the concentration ratio, is defined as follows: let $a(i)$ be the absolute amount of *output* produced by unit i, and m a certain small integer. Then

$$C_m = \frac{\sum_{i=N-m+1}^{N} a(i)}{\sum_{i=1}^{N} a(i)} \quad . \tag{4.1}$$

For this ratio the producing units are ranked by *output* size and the m greatest producers are compared to the rest of the units. The selection of m is arbitrary. The ratio tells us what proportion of the total output is produced by the greatest 3, 5, 10, 25, or more production units.

Table 1b. Absolute concentration of average annual numbers of births by countries in 1975-1980.

Rank order	Country	Number of births	Proportion of total births $p(i)$	Concentration ratio $\sum p(i)$
1	India	23583	0.1893	0.1893
2	China	21313	0.1711	0.3603
3	Indonesia	5220	0.0419	0.4022
4	USSR	4745	0.0381	0.4403
5	Bangladesh	3889	0.0312	0.4715
6	Nigeria	3751	0.0301	0.5016
7	Brazil	3671	0.0295	0.5311
8	USA	3621	0.0291	0.5601
9	Pakistan	3569	0.0286	0.5888
10	Mexico	2433	0.0195	0.6083
11	Vietnam	1995	0.0160	0.6243
12	Japan	1757	0.0141	0.6384
13	Egypt	1593	0.0128	0.6512
14	Philippines	1540	0.0124	0.6636
15	Iran	1526	0.0122	0.6758
16	Ethiopia	1507	0.0121	0.6879
17	Korea	1478	0.0119	0.6998
18	Turkey	1475	0.0118	0.7116
19	Thailand	1380	0.0111	0.7227
20	Burma	1264	0.0101	0.7328
21	Zaire	1225	0.0098	0.7427
22	South Africa	1033	0.0083	0.7510
23	Rep. of Korea	930	0.0075	0.7584
24	Tanzania	885	0.0071	0.7655
25	Kenya	855	0.0069	0.7724

Herfindahl-Index: 0.0758

In case of the global distribution of births the concentration ratios can be seen in Table 1 for m ranging from 1 to 25. For the average annual number of births in the period 1950-1955, the top 25 countries accounted for more than 80% of all children born in the 156 countries considered by the UN population statistics. This value declines to 77% in 1975-1980 and is projected to decline to 74% by 1995-2000. These figures indicate a decrease in absolute concentration of births among all countries in the world. As we can see from the table this decline is mainly due to the success of the birth control program in China, while in other countries the number of births is still increasing. The proportion of all births that take place in China has been declining from 26.5% in 1950-1955 to 17.1% in 1975-1980; it is expected to decline further to 15.3% in 1995-2000. The five countries with the highest numbers of births, i.e. the concentration ratio for $m = 5$, accounted for 55.7% in 1950-1955, but only for 47.2% in 1975-1980, and their contribution is expected to decline to 43.0% in 1995-2000.

This decline in absolute concentration can also be described by giving the number of countries that account for about half of all children born in the world. These figures cannot be exact because countries may not be interpolated. In 1950-1955 three countries accounted for almost half of all births in the world, in 1975-1980 it needed six countries to produce half the children and in 1995-2000 it will be seven to eight countries. Two thirds of the births were born in 11 countries in 1950-1955, in 15 countries in 1975-1980, and will be born in 18 countries in 1995-2000.

Hence, in our case any selection of m observed over time results in the same finding: absolute concentration of births among countries diminishes considerably during the second half of the twentieth century. But not always the selection of different m yields equivalent results. For some distributions a certain m indicates an increase in concentration whereas another m may indicate a decrease. This property of the concentration ratio is clearly not desirable. In our case, even though all m indicated the same direction of change, the extent of change measured still depended on the arbitrary selection of m.

This deficiency in the consistency of the concentration ratio may be overcome by considering all information given by the distribution and not only that of those at the top of the list. Herfindahl (1950) first provided a consistent indicator for absolute concentration. The Herfindahl index is defined by

$$H = \frac{\sum_{i=1}^{N} a_i^2}{(\sum_{i=1}^{N})^2} = \sum_{i=1}^{N} p_i^2 \qquad (4.2)$$

where $p(i)$ again is the proportion of *output* produced by unit i. In the case of maximum concentration, i.e. all output being produced by one unit, this index reaches unity. In the case of no concentration, i.e. an even distribution, the Herfindahl index will be $1/N$, N being the number of units observed. The Herfindahl index meets all the conditions given above. Its minimum value of $1/N$ as compared to a possible value of zero is not a disadvantage but even a necessity in order to meet condition 3, i.e. the sensitivity of the index to changes in the sample size.

Table 1c. Absolute concentration of average annual numbers of births by countries in 1995-2000.

Rank order	Country	Number of births	Proportion of total births $p(i)$	Concentration ratio $\sum p(i)$
1	China	22786	0.1584	0.1584
2	India	22007	0.1530	0.3113
3	Nigeria	7208	0.0501	0.3614
4	USSR	5038	0.0350	0.3965
5	Bangladesh	4798	0.0333	0.4298
6	Indonesia	4436	0.0308	0.4606
7	Pakistan	4355	0.0303	0.4909
8	Brazil	4121	0.0286	0.5195
9	USA	3810	0.0265	0.5460
10	Mexico	2668	0.0185	0.5646
11	Ethiopia	2563	0.0178	0.5824
12	Zaire	2096	0.0146	0.5970
13	Vietnam	1868	0.0130	0.6099
14	Iran	1801	0.0125	0.6225
15	Kenya	1765	0.0123	0.6347
16	Egypt	1758	0.0122	0.6469
17	Tanzania	1731	0.0120	0.6590
18	Philippines	1682	0.0117	0.6707
19	Turkey	1637	0.0114	0.6820
20	Japan	1627	0.0113	0.6934
21	Burma	1528	0.0106	0.7040
22	South Africa	1515	0.0105	0.7145
23	Korea	1476	0.0103	0.7248
24	Thailand	1431	0.0099	0.7347
25	Sudan	1211	0.0084	0.7431

Herfindahl-Index: 0.0603

The Herfindahl index for the three periods is also given in Table 1. It confirms the above finding that absolute concentration declines significantly from 1950-1955 to 1995-2000. It also becomes clear that the decline was markedly stronger during the first 25 years than the expected decline over the next quarter century. The main reasons for this lie in the dramatic Chinese fertility declines between 1965 and 1980 that has already reached such low levels, that it cannot decline much further. Simultaneously to the Chinese decline the number of births in a large fraction of less developed countries, most prominently in India, has increased substantially, a fact that brought about more evenness among the countries with the highest numbers of births, i.e. less concentration. For the period up to the end of the century, absolute numbers of births are expected to decline in several large Asian countries, whereas they are projected to increase in parts of Latin America and especially strong in Africa. This will further diminish the differentials between the largest countries in terms of the future sizes of their youth cohorts.

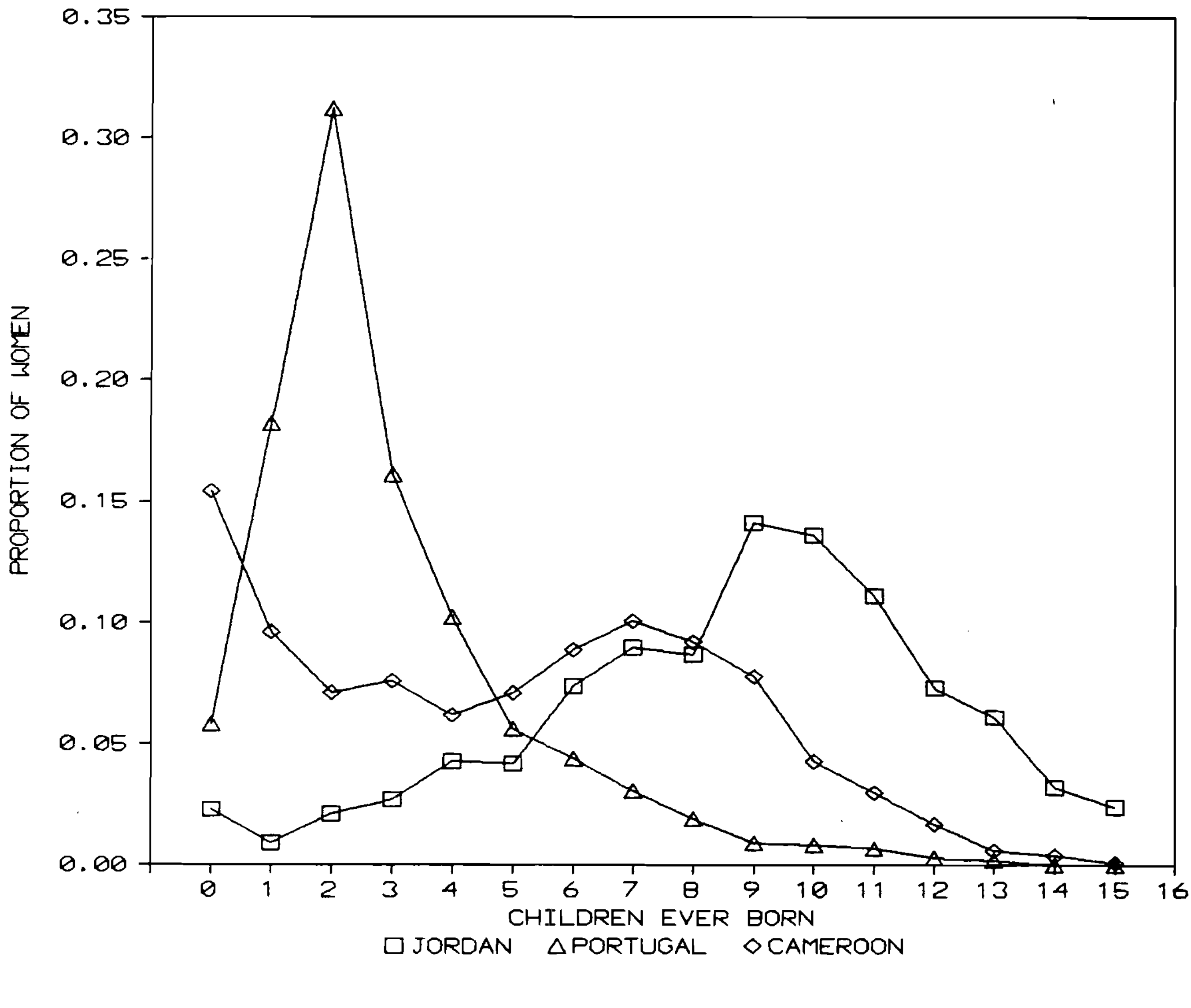
1.3. The Relative Concentration of Fertility

The major criterion that distinguishes relative concentration from absolute concentration is that measures of relative concentration should be also sensitive to the addition of units at the very end of the list, ranking units by output. Suppose two populations, A and B, had exactly the same numbers of fertile women and identical parity distributions but only population B had, in addition to the fertile women, a sizable number of childless women; then the relative concentration of fertility in B should be higher than that in A although the absolute numbers of children born and their distribution are identical.

The Lorenz curve provides a natural tool to describe relative concentration. Introduced by Lorenz (1905), it depicts the relationship between cumulated producing units and cumulated output units as fractions of the total of producing units and the total output. Because of this basic setup the Lorenz curve becomes the central approach (see Piesch 1975) to the analysis of relative concentration. Almost all further generalizations in the measurement of relative concentration take this approach and focus on specific features, e.g. the slope of the Lorenz curve at different points.

The Lorenz curve clearly refers to relative concentration because on both axes there are cumulated proportions: the x-axis shows the cumulated proportion of producing units, on the y-axis that of output units. If the ranking of producing units by output is done in a way that puts the most productive units to the left, then the curve comes to lie above the diagonal, otherwise below. Lorenz (1905) originally gave curves that lie above the diagonal but especially in economic concentration analysis the curves often lie below the diagonal. Whether the ranking goes from lowest to highest or highest to lowest does not affect the mathematics or the general setup of the curve. It only reflects the focus of the specific research, whether one is more interested in the lower end (such as poverty analysis in economics) or in the upper end of the distribution. In the life sciences and animal ecology where questions of dominance play an important role (see Goodwin and Vaupel 1985), researchers mostly put the most productive at the beginning.

Figure 1. Densities of children ever born in Jordan, Portugal, and Cameroon to ever-married women aged 40-49 (WFS).



Figures 1 to 5 show how the Lorenz curve may be built up by a graduation scheme (see Piesch 1975). Figure 1 gives three densities, indicating how women are distributed over 16 possible completed parities (0 to 15 children) in three WFS countries with very different reproductive patterns: Jordan, Cameroon, and Portugal. Women aged 40-49 in Jordan at the time of the survey had the highest fertility of all countries considered with the mode at parity nine. In Cameroon the pattern is quite different mainly because of a high proportion being childless (15%). The distribution of women with more than one child peaks at parity seven in Cameroon. Portugal is an example of a country that has essentially completed the fertility transition. In Portugal completed marital fertility clearly peaks at parity two with more than 15% of the women each at parities one and three and around 10% at parity four.

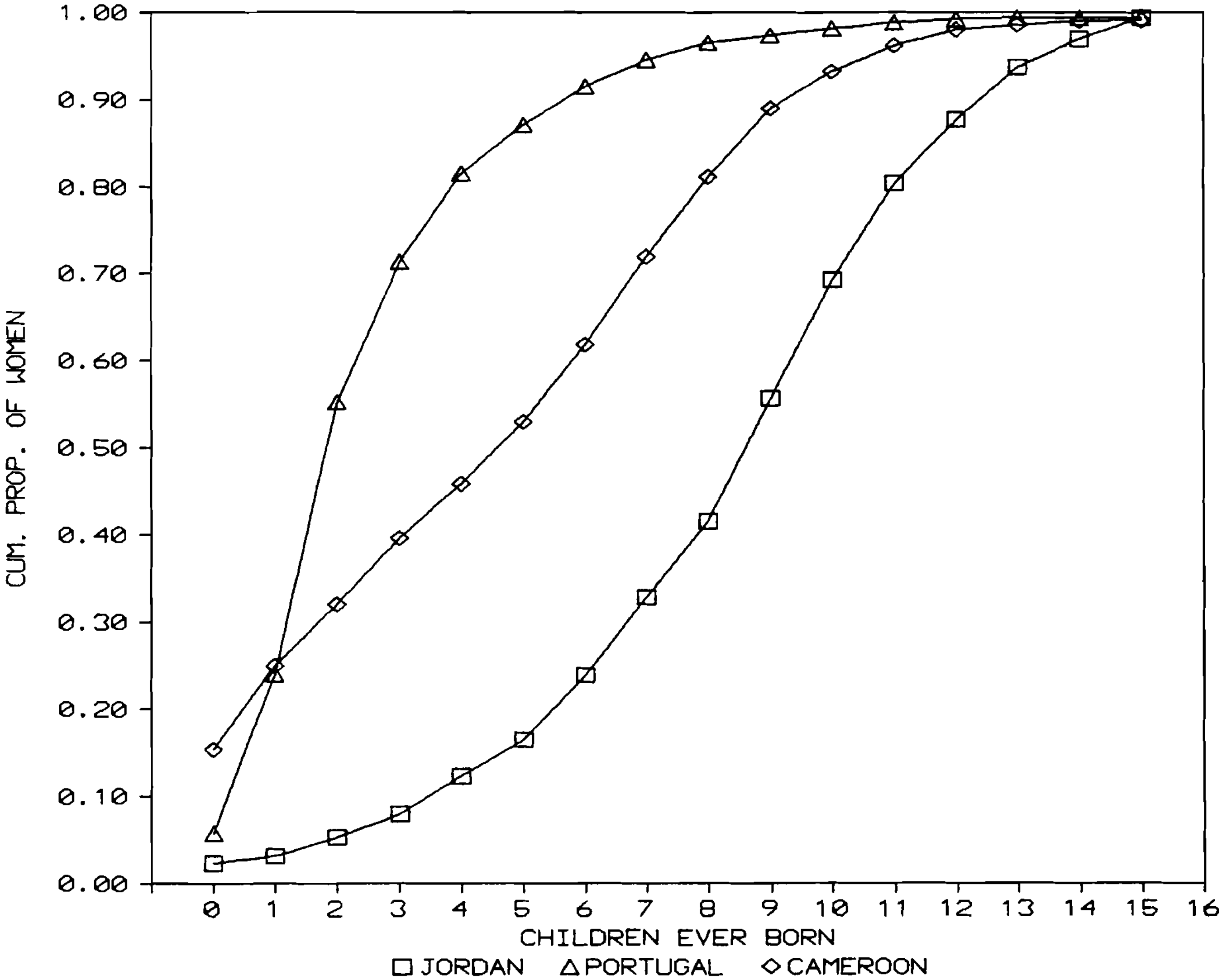
Figure 2 gives the distribution functions of the three densities for Jordan, Cameroon, and Portugal. This is simply done by cumulating the densities over all parities from lowest to highest. Because of the concentration of women at lower parities in Portugal the distribution function there increases sharply. In Portugal women with 0 to 3 children already make up more than 70% of all women. In Jordan the corresponding figure is under 10%. Figure 3 next gives the inverted distribution function with the cumulated proportion of women now on the x-axis and the distribution of children ever born on the y-axis.

Figure 4 shows a modification of the inverted distribution function where the x-axis is normed and adjusted to the fact that the categories of children ever born contribute differently to the total number of children born. Hence y from Figure 3 became $y \rightarrow \frac{y \cdot c}{\text{mean of } y}$ in Figure 4, where c is the density shown in Figure 1.

Since Figure 4 may also be seen as a density with respect to the cumulated proportion of women, the distribution function of this density may be calculated by cumulating again along the x-axis. This transition to cumulated proportions of children on the y-axis yields the Lorenz curve given in Figure 5. The further the Lorenz curve lies from the diagonal, the higher the concentration. In our example the distributions in Cameroon and Portugal are clearly more concentrated than that in Jordan.

The Lorenz curve is a very intuitive way to describe concentration and it gives a complete picture of the relationship between cumulated proportions of producing units and output units. In some instances however, it seems desirable to have the concentration of a curve not only given by a graph but also calculate a

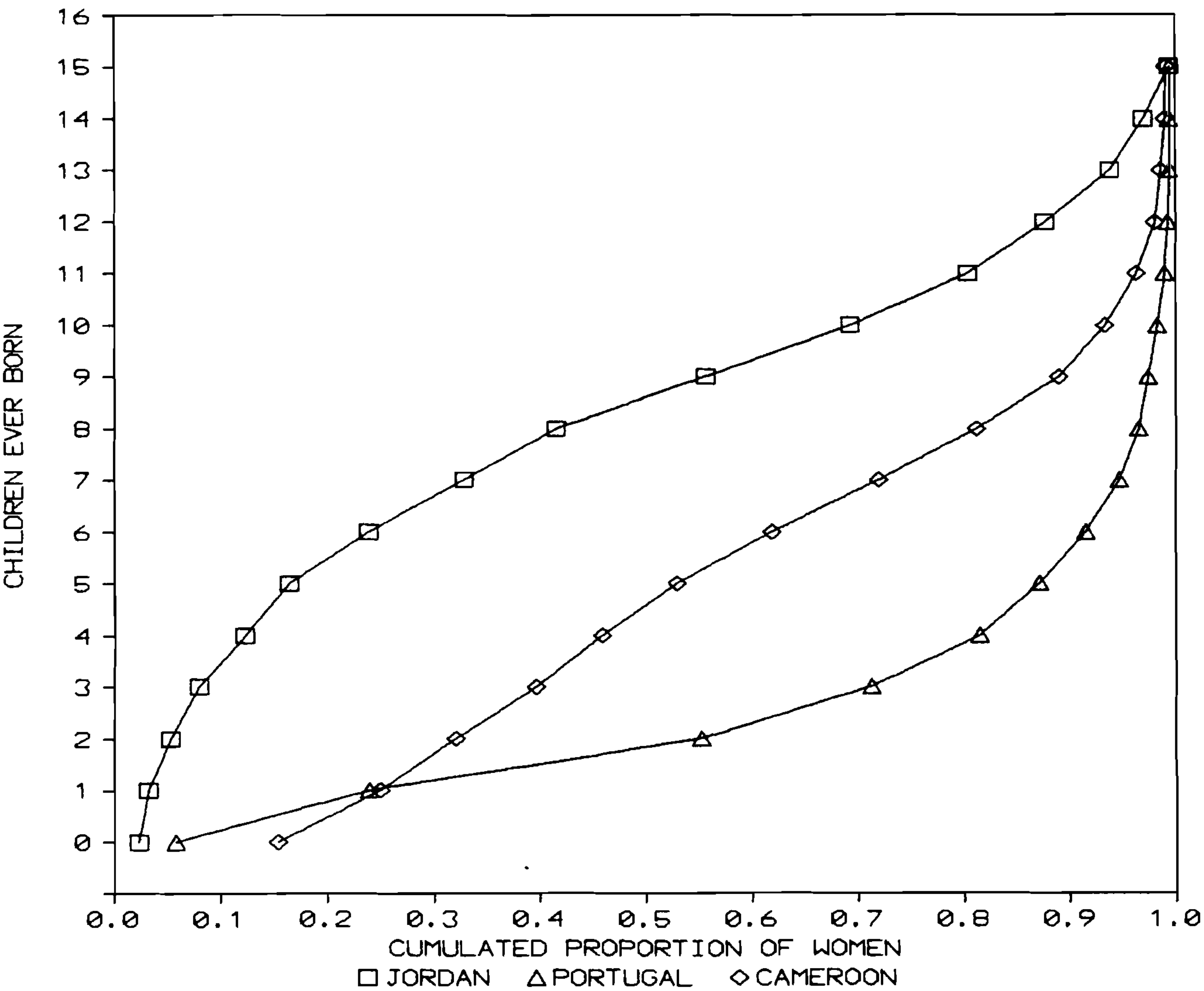
Figure 2. Distribution functions for the three densities from Figure 1.



single quantitative indicator of concentration. There are also cases where the Lorenz curves cross over each other and we need some additional criteria to decide which distribution is higher concentrated.

Numerous indicators of relative concentration have been suggested in the literature. At this point we will not give a survey of them. Since relative concentration is directly a function of relative variance, many indicators of disparity, dissimilarity, and unevenness may also be taken as indicators of the degree of concentration. Other concentration coefficients are directly based on the Lorenz curve. Perhaps the best known indicator of this kind is the *Gini coefficient*. In terms of the Lorenz curve approach, the *Gini coefficient* is twice the area

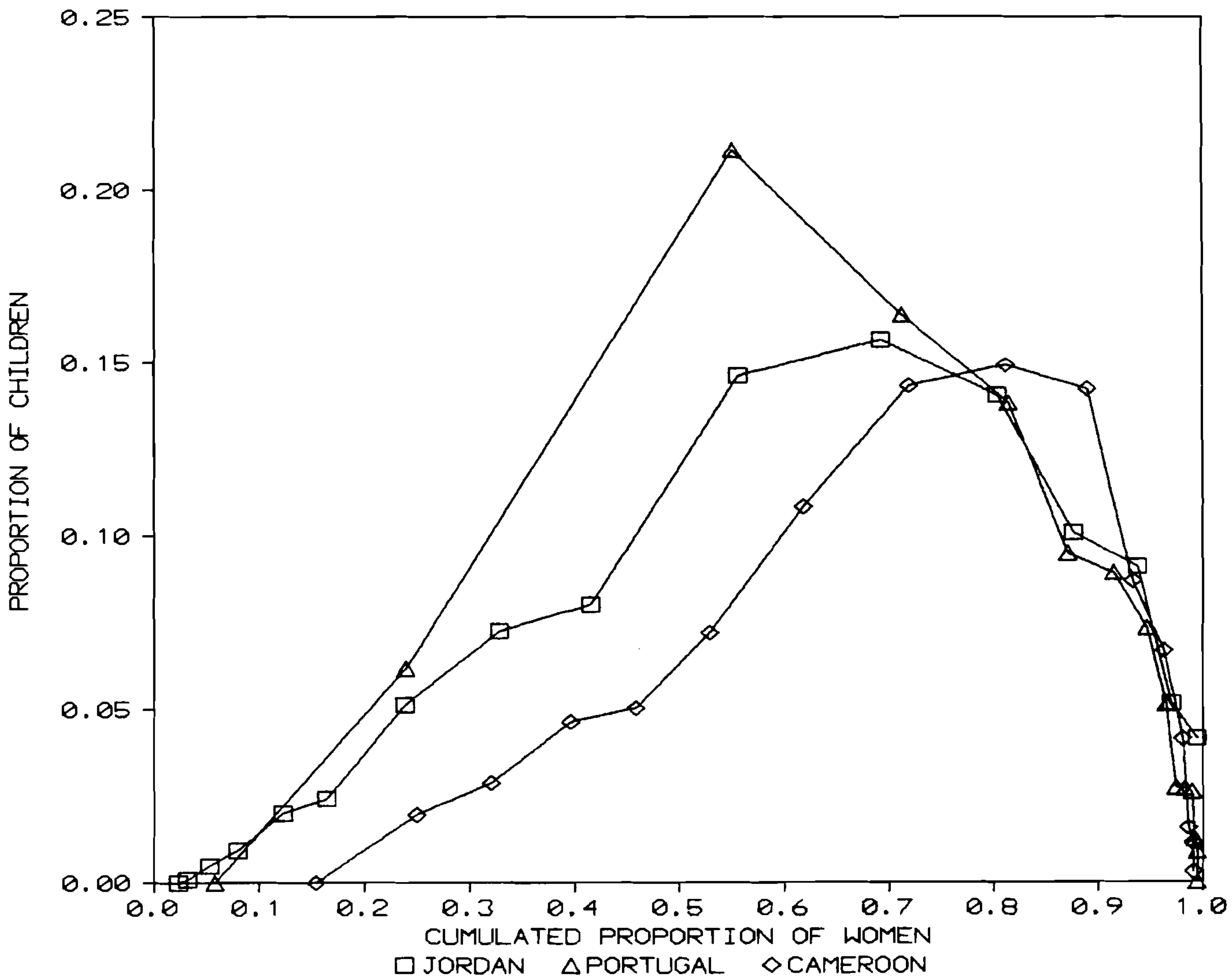
Figure 3. Invested distribution function (based on Figure 2).



between the concentration curve and the diagonal (Foster 1985).

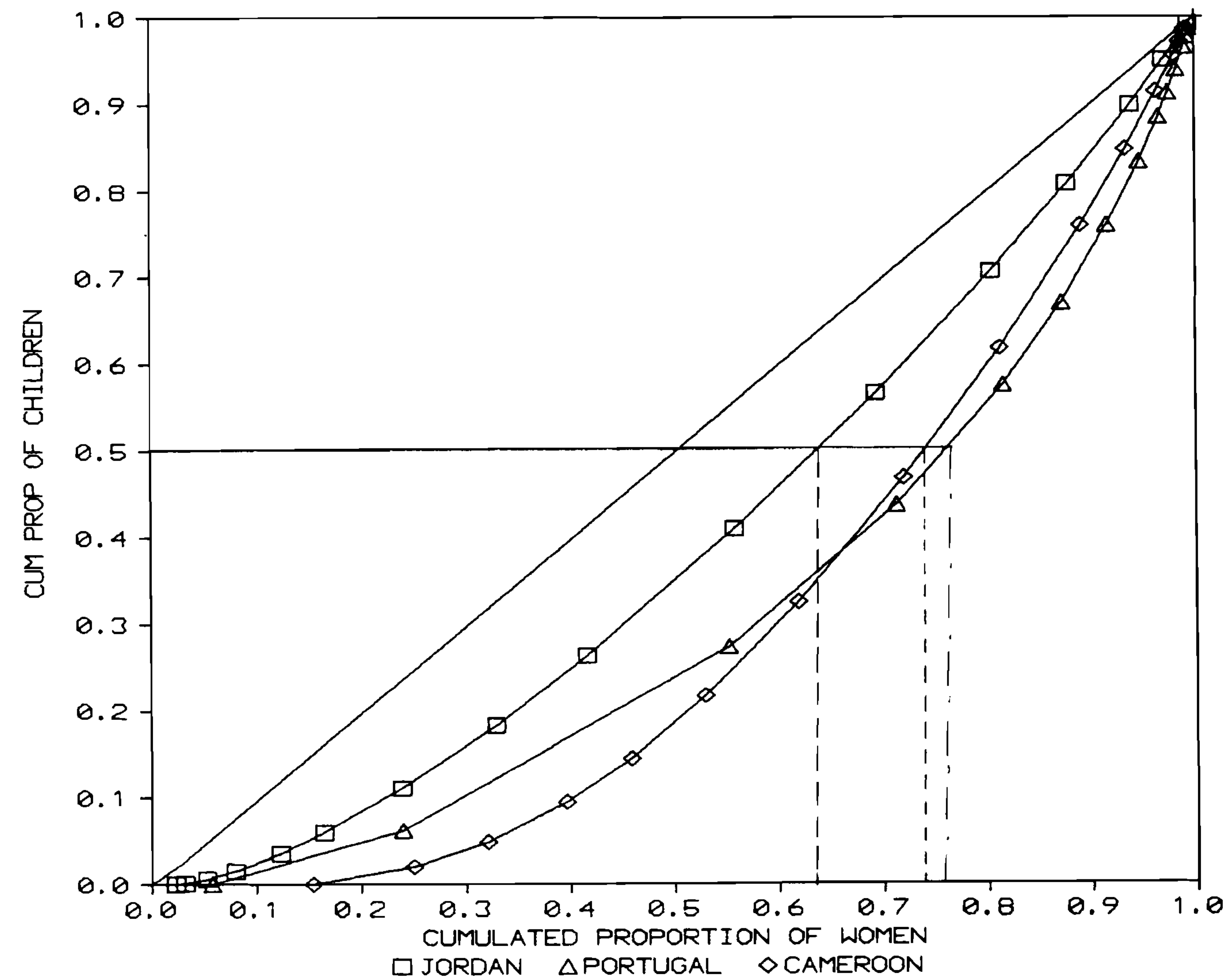
The Gini coefficient has the advantage of summarizing the complete information given by the Lorenz curve. It may be used to compare the degree of concentration of two different distributions; but it is not easy to interpret it in terms of the original data. What does a Gini coefficient of .7 in the distribution of births mean in terms of certain fractions of women having certain proportions of all children born?

Figure 4. Adjusted inverted distribution function (see text).



In this context it seems desirable to use an analogon to the concentration ratio, c_m, which we introduced for the study of absolute concentration. The concentration ratio tells us what proportion of the total output was produced by a certain absolute number of producers. For relative concentration we would ask for the proportion of children produced by a certain *proportion* of women. These proportions may be called fractiles. If women are ordered by their family size we may ask what proportion of women gave birth to 10% (.1 fractile), 50% (.5 fractile), or 90% (.9 fractile) of all children. These values may be readily seen from the Lorenz curve.

Figure 5. Lorenz curves resulting from cumulation of adjusted inverted distribution functions.



Being very intuitive and easy to interpret as quantitative indicators of concentration, the fractiles have the shortcoming of not reflecting all the information given in the curve. The .1 fractile tells us what percentage of highest-fertility women gave birth to 10% of all children. It mainly reflects the distribution among very high-fertility women and does not tell much about the degree of concentration at the lower end of the distribution. The .9 fractile would suffer from the opposite shortcoming. The least amount of information would be lost when using the .5 fractile because it is at the center of the distribution and reflects both the shape of the curve before and after the .5 fractile.

This may be illustrated with the help of Figure 5. Since in this figure women were ranked from low fertility (at the left) to high fertility, the curve lies below the diagonal. But because in this study the fractiles will consistently be defined as percentages of a distribution ordered from highest to lowest. In Figure 5, the x-fractiles should be read as 1-x. Although the Gini coefficients are at similar magnitude for Portugal and Cameroon, the curves look quite different. In Cameroon the curve is steeper for high-parity women and less steep for low-parity women, mainly because of high proportions of childless women. Because of this cross-over in the concentration curves, the fractiles from highest fertility down to about the center of the curve indicate higher concentration for Portugal and thereafter higher concentration for Cameroon. In this specific case the .5 fractile indicates still somewhat higher concentration for Portugal since it is above the cross-over of the two curves. But generally the correlation between the Gini coefficient and the .5 fractile should be higher than for other fractiles. Empirical studies (Goodwin, Lutz, and Vaupel 1986) on 41 less developed countries result in correlation coefficients between the Gini index and the .5 fractile of above .9.

Portugal and Cameroon are extreme cases in a way that their normalized parity distributions (Figure 4) have very different shapes. It is interesting to further note the differences in the curves for Portugal and Cameroon. The curve for Portugal is initially steeper but then it crosses that of Cameroon and flattens out. Thus the curve for Portugal initially shows more concentration than that for Cameroon but beyond the crossover point this situation is reversed. The flat end on the curve for Cameroon indicates an extraordinarily high proportion of married women with completed parity zero (15.4%) and parity one (9.6%). For most other countries in the world the Lorenz curves are of similar shape (varying only in their distance from the diagonal) and hardly cross.

Vaupel and Goodwin (1985) call the fractiles we defined here *Have-statistics* because they indicate what proportion of women *has* a certain proportion of children. The .5 fractile in this terminology becomes the *Havehalf*, a name that clearly indicates the meaning of the coefficient. Because of its easy interpretation and the fact that it is a consistent statistical measure (Goodwin and Vaupel 1985) that is sensitive to not-proportional changes in any of the values of the underlying frequency distribution, we will use the .5 fractile (interchangeably called *Havehalf*) as our basic measure of relative concentration in the following analysis.

2. RELATIVE CONCENTRATION OF FERTILITY ALONG VARIOUS DEMOGRAPHIC DIMENSIONS

2.1. Time

Concentration analysis always refers to the distribution of *output* units among *producing* units. The *output* units are always births in this study; the *producing* units may be individual women but also aggregates of women defined with respect to different demographic dimensions. With respect to historical time we may define a given time unit (year, month, day) as the *producing* unit and study the distribution of births over those time units. With respect to age, i.e. subjective time, we may define certain years of age as *producing* units and observe the distribution of births over ages. An equivalent approach can be taken when we study the distribution of births over marital durations. Finally, not only temporal aggregates but also spatial aggregates may be regarded as *producing* units. We may for instance look at the distribution of births over all countries in the world or over all km^2 of land on our planet.

In this section we will focus on the distribution of births over historical time. Table 2 and Figure 6 show the concentration of births on the world over ten thousands of years from 8,000 B.C. to 2,000 A.D. The estimates for the period before modern demographic records became available are based on population sizes and average annual increases suggested in United Nations (1973), assuming a crude birth rate of 50 per thousand up to 1900 and later empirical figures. For the period 1950-2000 A.D., United Nations (1985) estimates and projections have been used.

Table 2. Crude estimates of the distribution of total births between 8,000 B.C. and 2,000 A.D.

Total of Births 8,000 B.C. to 2,000 A.D.: about 80 billion

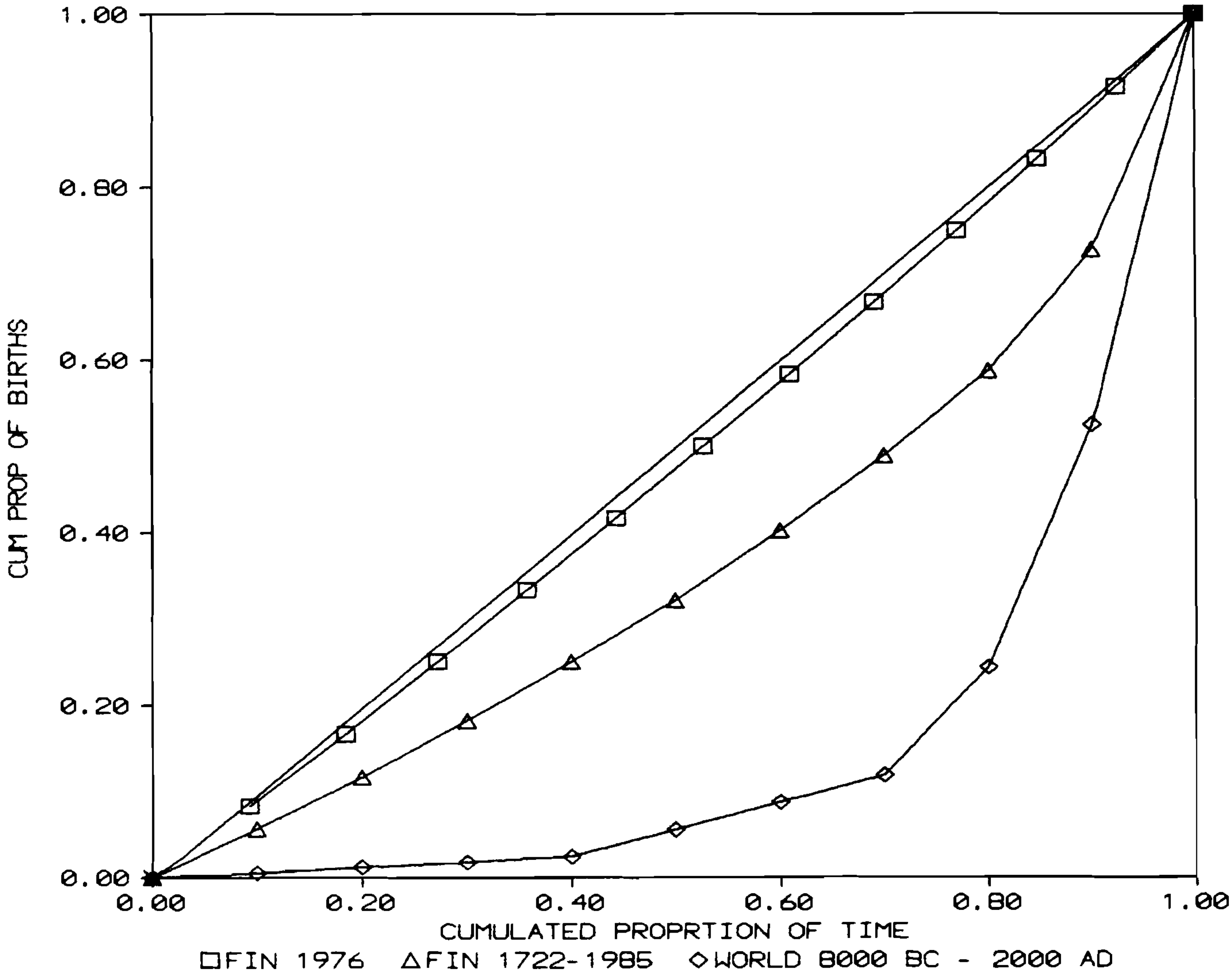
Fractile	Birth	Time Period
.5	40 billion	900–1,000 A.D. to 2,000 A.D.
.25	20 billion	around 1760 A.D. to 2,000 A.D.
.10	8 billion	1931 A.D. to 2,000 A.D.

The estimates suggest that half of all children ever born within these 10,000 years have been born within the last 1,000 years, i.e. one tenth of the time considered. Since world population growth has speeded up especially during the last century the most recent percentiles show an even greater discrepancy between cumulated birth and cumulated years: 10% of all births were and will be born during only 70 years from 1931 to 2,000 A.D. These are only .07% of the total time considered. If we had not only tried to estimate the distribution of births over time but also that of people alive at any point in time, the concentration would be even greater because of significant improvements in live expectancy.

If we want to base our study on reliable records rather than the crude estimates given above, we are restricted to the analysis of much shorter time periods. Like Sweden, Finland has reliable annual figures on fertility since 1722. The concentration of births over the 264 years of Finnish population history up to 1985 are also plotted in Figure 1. It turns out that 32% of all years considered (i.e. 85 years) *produced* half of the Finns born over the last 264 years. The 85 most fertile years do not include the most recent years since 1968; they include years from the middle of the nineteenth century to the post-war baby boom. Even though the total fertility rate was highest in the eighteenth century, these early periods contributed only relatively little to the total number of births because the size of the population in 1750 was less than one tenth of today's population size. But still the 264 years of Finnish fertility history are much less concentrated than the 10,000 years of world history.

Temporal variations of births do not only occur between years, they may also be observed within a year. In most countries births show some distinctive seasonal pattern and also some variation between different days of the week. The seasonality of births seems to be especially strong in a Northern climate (see Rantakallio 1971) and in countries where the marriage pattern is strongly seasonal. For this reason we again selected Finland to demonstrate the concentration with respect to the month of birth. In 1976—a year with higher seasonal variation than more recent years—53% of all births occurred within 50% of all months. In this calculation we adjusted for the fact that months are of different length. By far the greatest numbers of children were born in the months of March and April, nine months after midsummer. A second smaller peak occurred in September, nine months after Christmas.

Figure 6. Lorenz curves for the temporal concentration of fertility: over the period 8,000 B.C. to 2,000 A.D. for the world as a whole, for 1722-1985 in Finland, and for monthly variations within the year 1976 in Finland.



Very short-term variations in births, namely variations by weekdays, are not likely to depend on the time of conception but rather on the working hours in hospitals around the time of birth. Table 3 gives the adjusted distribution of births over weekdays in Austria. The pattern reveals that on Sundays only 85% of the births occurred that usually occur on an average working day. On Saturdays this ratio is 91%. It is hard to calculate a .5 fractile in the case of seven weekdays; but assuming an even distribution that 52.1% of all births are born on the 3.5 days that have the highest birth frequencies. The Lorenz curve of the concentration of fertility among weekdays has almost exactly the same shape as that for the seasonal

Table 3. Distribution of births over weekdays: Austria, 1984.

	Absolute number*	In percent
Monday	12.684	14.5
Tuesday	13.318	15.3
Wednesday	12.941	14.8
Thursday	12.625	14.5
Friday	12.868	14.8
Saturday	11.702	13.4
Sunday	11.065	12.7

*adjusted for the case that all weekdays occur 52 times a year

concentration.

In summary we may say that we found higher degrees of relative variation with respect to temporal changes when we observe longer periods of time than within shorter time units. The distribution of births over 10,000 years of global history is clearly one of the highest concentrated curves that can be found in the field of fertility analysis. Monthly and daily variations are minimal by these standards.

2.2. Age

The concentration of fertility with respect to subjective time, i.e. age, is very different from that over historical time. We do not evaluate the concentration within a period of time that includes many demographic changes, but we observe the distribution of births over the average life course of a real or synthetic cohort. This distribution can be made subject to the analysis of static concentration. Comparing the static measures over different cohorts in different historical periods or different countries makes the analysis one of comparative statics.

When studying the age concentration of fertility we look at the distribution of births over the potentially fractile ages (15-49), rank single-year age groups according to their fertility and calculate what proportion of ages *produces* (single-year age groups being the *producing* unit) a certain fraction of all births. Table 4 shows for selected less developed countries participating in WFS how many single-year age groups produce half the number of children born to all women interviewed in the survey. The first three columns give the figures that reflect the actual age distribution of women, column 4 gives age-standardized results, i.e. the results for a synthetic cohort disregarding mortality. Since we consider 35 age groups, 6 age groups mean a .5 fractile of .17 while eleven age groups indicate a value of .34 for the ***havehalf***.

Table 4. Number of single-year age groups that produced 50% of all children in the year before the survey for selected WFS countries.

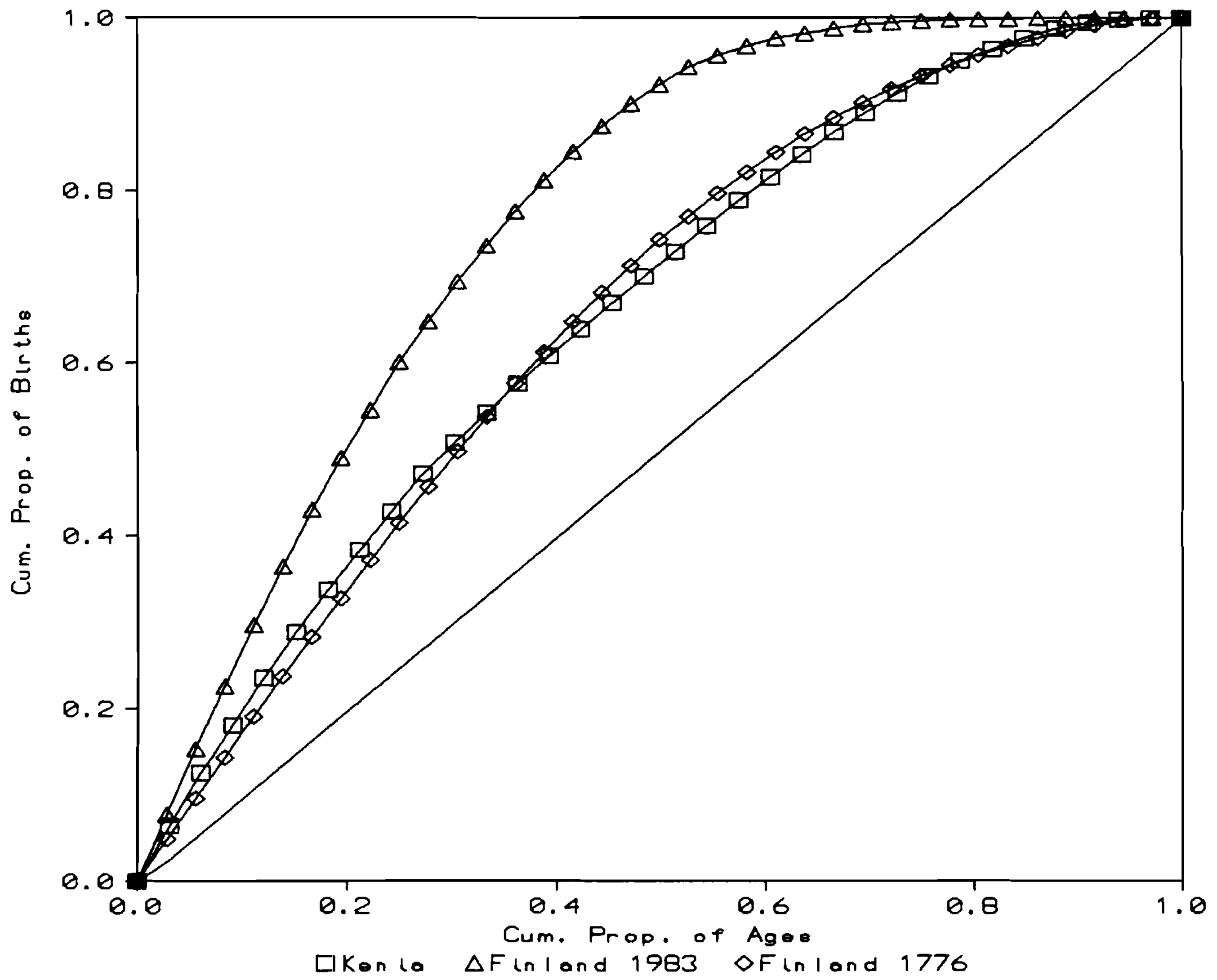
	Rural women	Urban women	Total	Total age-standardized
Costa Rica	9	5	7	8
Kenya	9	7	9	11
Pakistan	9	6	9	9
Peru	9	7	9	10
Sri Lanka	8	6	7	8

The table indicates that the age concentration of fertility is higher among urban women than among rural women. The total is usually close to the rural value because of high rural percentages in the populations considered. Age-standardization seems to make the distribution over all ages in most cases more even.

The difference between the age concentration of Finnish fertility in 1776 and 1983 plotted in Figure 2 lies almost parallel to the urban/rural differential observed in Table 4. In both cases a lower level of fertility is associated with higher age concentration. An explanation for this may be found in the concepts of natural fertility and controlled fertility. As defined by Henry (1961) we may speak of natural fertility if the birth of a child does not depend on the number of children already borne by the mother. Since parity and age strongly correlate the existence of natural fertility it may also be inferred from the age pattern of fertility if it is concave, i.e. shows a relatively slow decline after the age of peak fertility. In contrast to this, the pattern of controlled fertility produces a rather pronounced peak with fertility sharply declining after the peak ages. Because of this a natural fertility pattern like that in Finland in 1776 or in many rural less developed populations today is expected to show only a weak age concentration as compared to populations with widespread use of birth control methods.

In Figure 7 the age concentration curves for the two high fertility populations—Kenya in the 1970s and Finland in 1776—contrast against the pattern of much higher concentration for the low fertility of Finland in 1983. For Finland where we have annual time-series of age-specific fertility rates for more than 200

Figure 7. Lorenz curves for the age concentration of births (considering ages 15-49) in Kenya (WFS), Finland 1776, and Finland 1983.



years, we may follow this development and identify the period during which the transition from low to high age concentration took place. Figure 8 plots the total fertility rate against the .5 fractile of ages for 67 three-year periods in Finland[1] for 1776-1976. We can see that until around 1930 the age concentration did not show any lasting increase despite a strong decline in the total fertility rate from well above 5 to under 2.5. For the pre-industrial period we see some short-term fluctuations that had no lasting effect. The secular increase in age concentration

[1]Since only five-year age groups are given, we had to interpolate to single-year age groups.

started about 20 years after the onset of the great fertility decline. It is also interesting to notice that the post-war baby boom that peaked around 1947 in Finland was associated with higher total fertility rates but not with a return to a premodern shape of the curve of age-specific fertility rates (see Lutz 1984). Since 1960 the pattern of age-specific rates has become even more focused around 25, the current age of peak fertility in Finland. The increasing concentration of childbearing within a relatively short age span is typical for most industrialized countries (see Lutz and Yashin 1987).

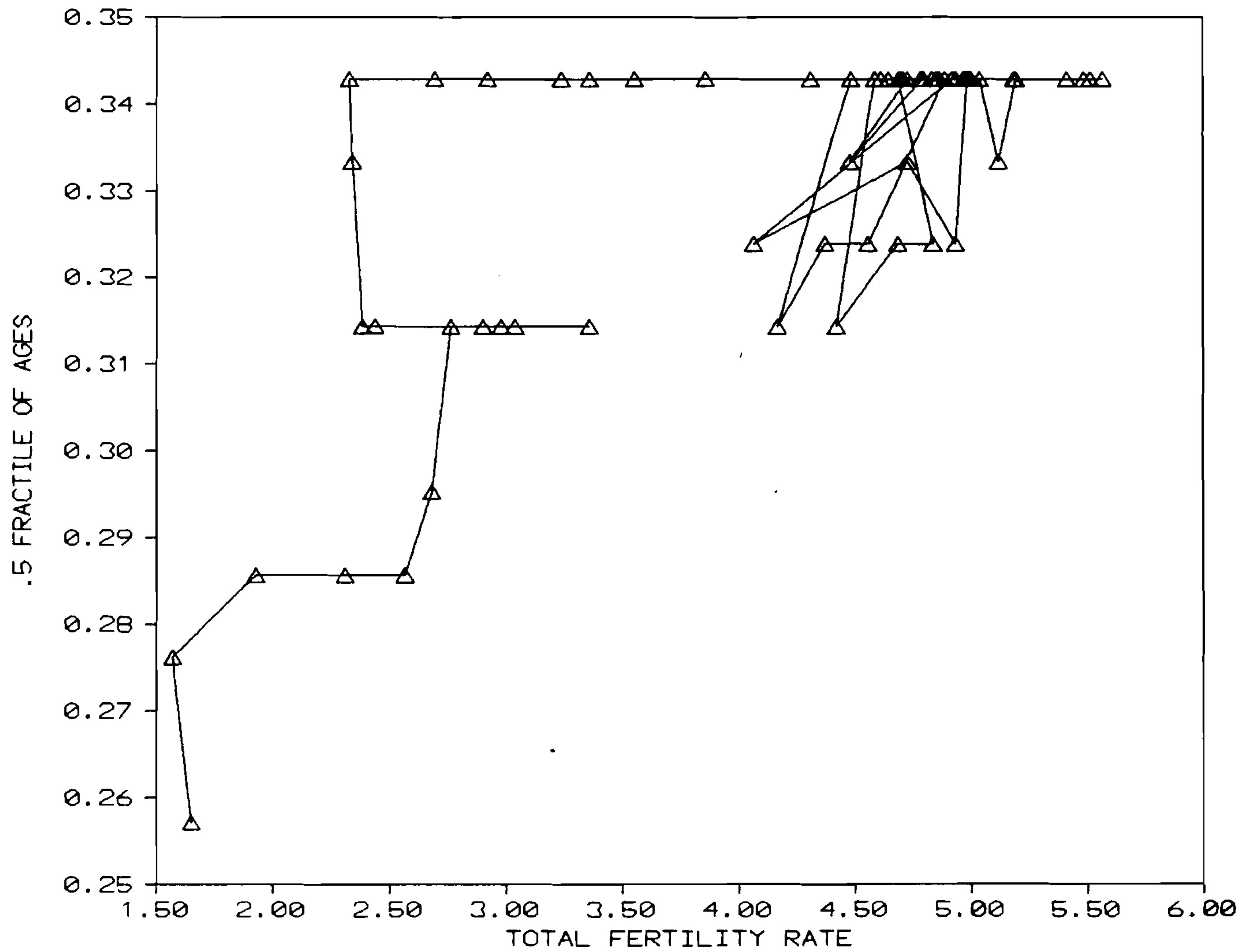
2.3. Marital Duration

Another aspect of the subjective time dimension that is of high relevance for fertility variations over the life cycle is marital duration. We know that age and marital duration exert independent influences on fertility (see e.g. Page 1977 and Hobcraft and Casterline 1983) and that there is some interaction between those two variables. When women marry late--as in the case of the GFR in Table 5—and the overall level of fertility is low, then the bulk of children tends to be born within the first few years of marriage. The case of Nepal shows the other extreme where women marry at a very young age (often before sexual maturity) and almost no voluntary family limitation takes place over the life course. In such a case childbearing is concentrated around some central marital duration of 10-14 years.

For Peru the distribution over marital durations is somewhat less concentrated than in Nepal, mainly because of a higher age at marriage which results in higher birth frequencies during the first 0-4 years of marriage. Marital fertility in Portugal shows the most even distribution of the four countries considered here: with a substantially lower age at marriage than in Germany and some degree of voluntary childspacing combined with a rather strong heterogeneity of the population with respect to the quantum and timing of births. Portugal has the Lorenz curve that lies closest to the diagonal.

In Figure 9 the German distribution of births over marital duration in 1983 is by far the most concentrated one: in the German Federal Republic more than 57% of all marital births occur during the first four years of marriage. As has been hinted at above, this is not only because of the high age at marriage (27.2 for women in 1983) but also because of the fact that many couples have only one child, and if they have two they often try to space them close to each other. All in all, we can say that marital duration concentrations of fertility vary within the same range as

Figure 8. Changes in the relationship between the age concentration of fertility and the total fertility rate in Finland 1776-1976 (in three-year steps).



age concentration: both depend crucially on the fertility and nuptiality pattern of the population concerned.

2.4. Space

We may not only consider temporal aggregates as units that *produce* children but we might as well think of spatial entities as bringing about children. In the section on absolute concentration we already considered nations as *producing* units. The same approach may also be taken for the analysis of relative concentration.

Table 5. Fraction of children born to certain marital durations of all children born up to duration 25-29.

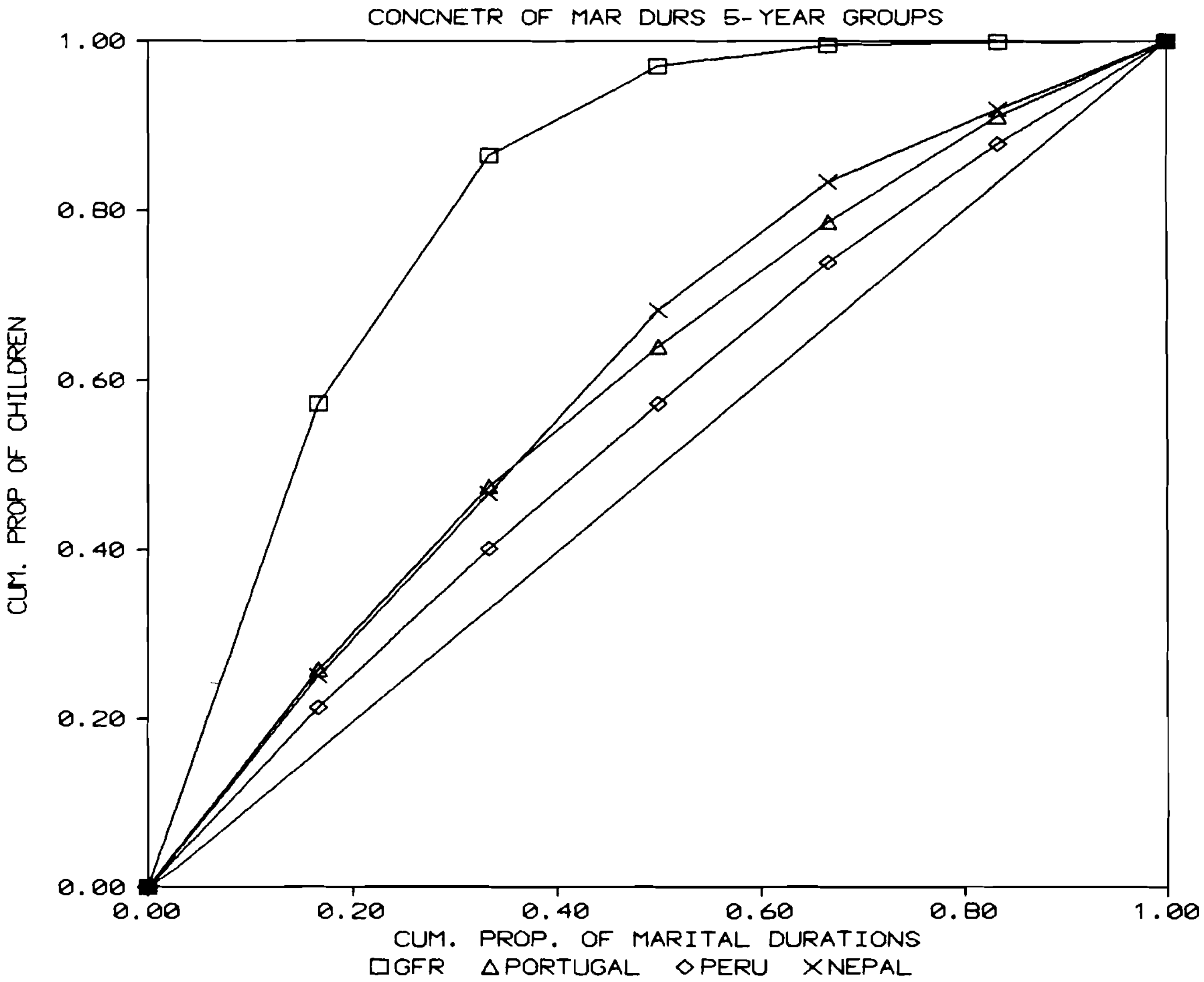
	0-4	5-9	10-14	15-19	20-24	25-29
GFR	.573	.291	.106	.025	.004	.001
Nepal	.081	.216	.250	.216	.150	.086
Peru	.166	.213	.188	.171	.121	.140
Portugal	.257	.217	.146	.125	.089	.165

Figure 10 plots the Lorenz curves for the 100 countries that *produce* most births. The figure shows curves for 1950-1955 and 1995-2000. The Lorenz curve for 1975-1980 comes to between those two curves. In all cases the People's Republic of China is to the very left because it contributes by far the largest proportion of births. We see that in 1995-2000 China is supposed to contribute a smaller fraction to the total number of children born on earth than in 1950-1955. This is a major reason for the fact that the 1995-2000 curve lies closer to the diagonal and hence is less concentrated.

Countries are of very different size and it is not at all surprising that large countries contribute a higher fraction of all births. For this reason it seems desirable from a spatial point of view to take a country's area into account. We then may ask what proportion of all km^2 of land on earth *produces* what proportion of children. This is done by calculating a ***birth density*** for each country (i.e. birth per km^2) and ranking the countries according to that density. After ranking, the countries must be weighted again by the land area they cover in order to calculate fractiles.

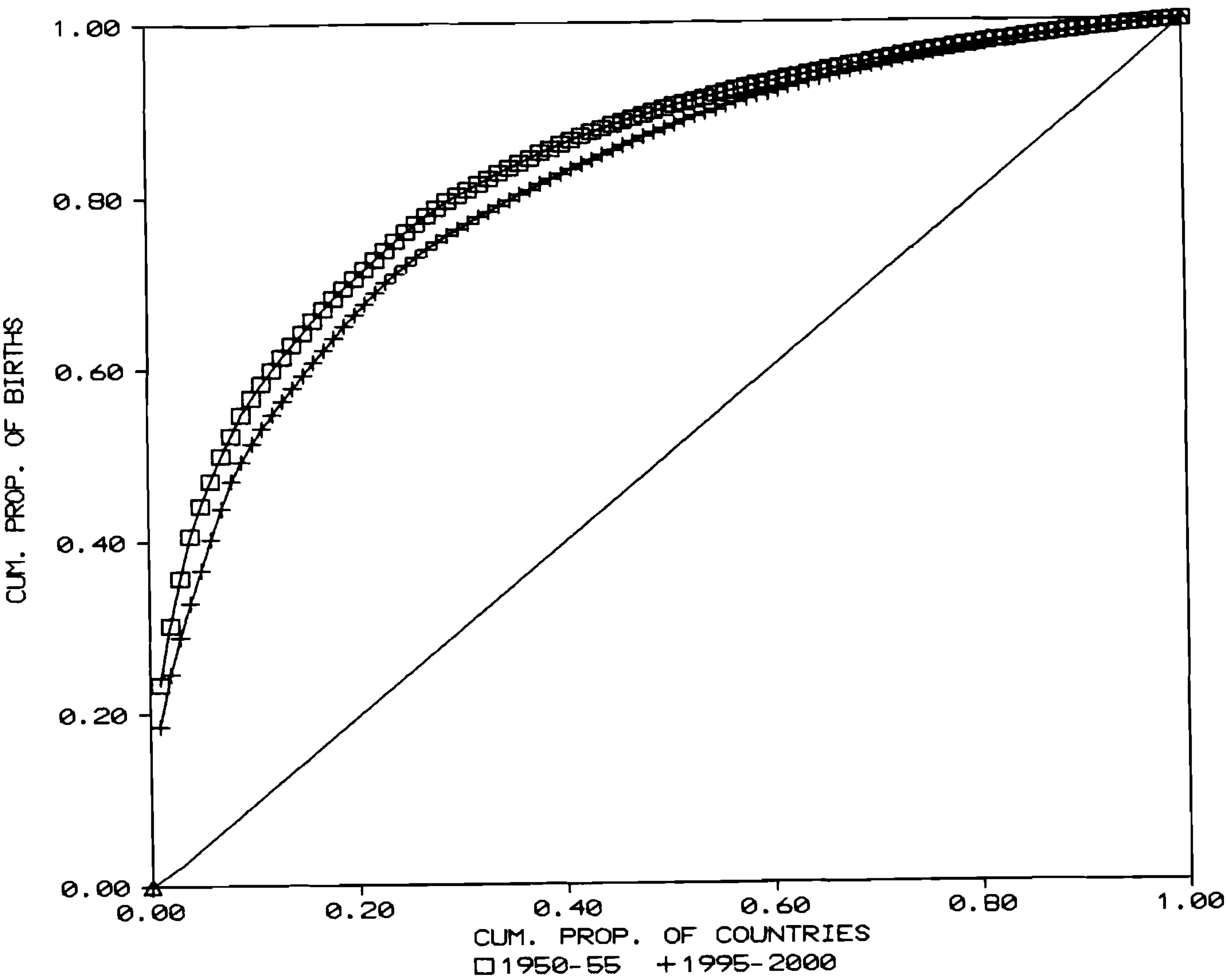
From Table 6 we see that only less than 1% of land area *produces* 10% of all children; exactly 10% of all land *produces* half the children, and less than half of the land *produces* 90% of all children. This indicates already a very high concentration of births with respect to spatial distribution. In order to calculate this we had to make one very restrictive and unrealistic assumption, namely that within each nation births are evenly distributed over all km^2. Especially for countries like the Soviet Union or nations with high fractions of their territory being desert or rain forest, this is very misleading. In reality the spatial concentration of births is much higher, especially if we consider the great urban agglomerations separately.

Figure 9. Lorenz curves for the concentration of births along six marital duration categories (see Table 4) for the German Federal Republic in 1983, and the WFS data for Portugal, Peru, and Nepal.



Without going into the vast geographical literature on spatial distribution, it shall be pointed out that the distribution of births in some respect is more important than the distribution of living people. The spatial distribution of births is crucial for future food supply, industry, and education—all factors that affect the standard of living and the level of development.

Figure 10. Lorenz curve for the 100 countries that *produce* the most births, 1950-1955 and 1995-2000.



2.5. Individual Women

So far we had looked at temporal and spatial aggregates that *produced* children. These were all aggregates of women that gave birth to children at different times, different ages, different marital durations, and in different places. These aggregates all showed specific macro-aspects of the distribution of births. To study the concentration of reproduction in a specific group of women at a specific time and place, however, we have to go back to the micro level and consider the original *producing* unit: the individual woman.

Table 6. Cumulated proportions of land area on earth (ranked from highest *birth density* to lowest) producing certain fractiles of all births in the world.

Fractiles of births	Percentage of total area producing certain fractiles of births
.10	0.9
.20	2.2
.30	3.7
.40	6.2
.50	10.0
.60	14.2
.70	19.3
.80	27.4
.90	46.2

All the remaining sections of this study will focus on the concentration of fertility among individual women in certain countries or socio-economically defined subpopulations in certain historical periods. Since it takes not only a woman but also a man to *produce* children, one might ask why we should not also look at the distribution of births among men. There are two reasons for treating this question only marginally: first, there are almost no data available on male fertility and male parity distributions, and secondly in the vast majority of cases male and female completed parity can be expected to be identical, especially when we look at marital fertility.

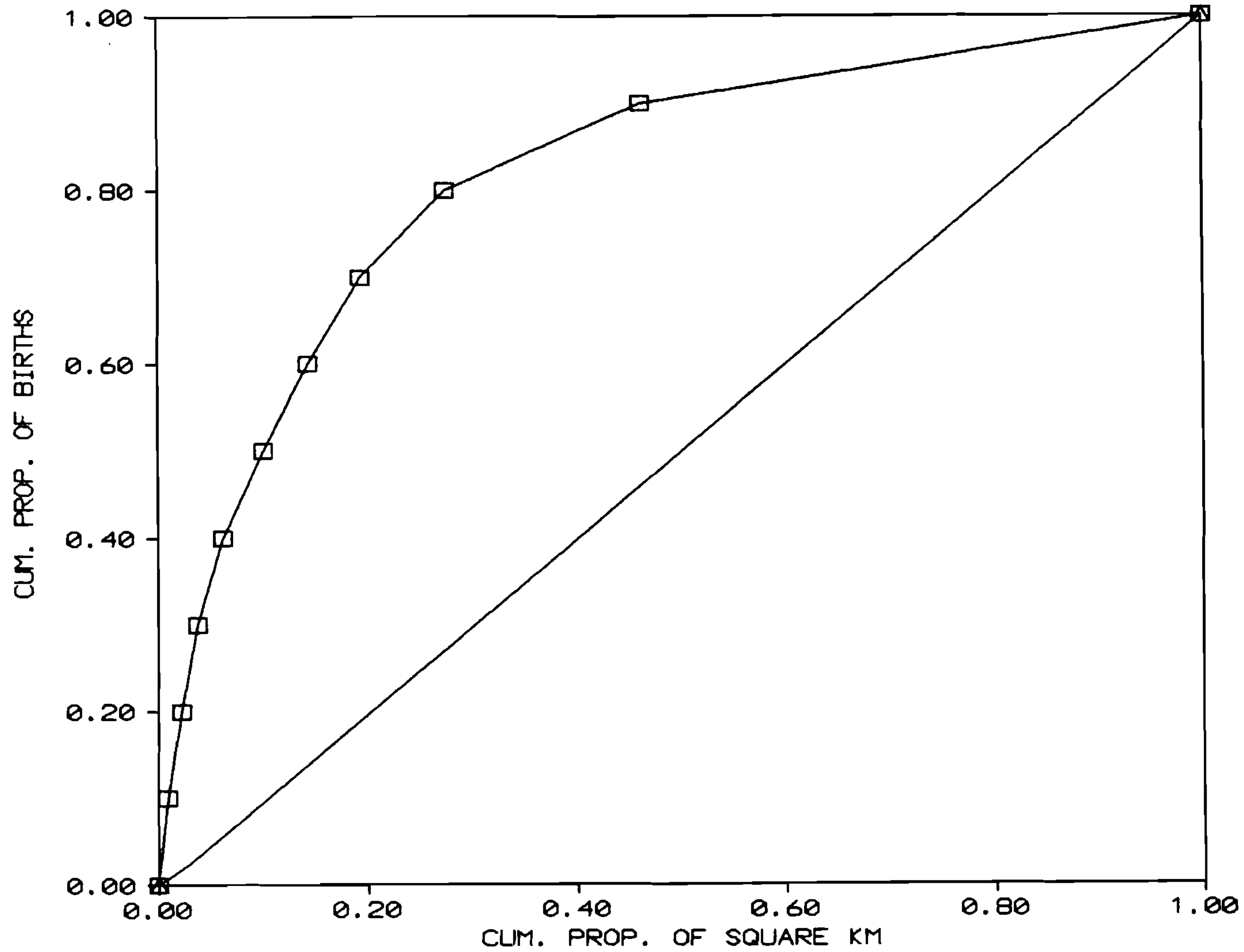
Before going into a more detailed study of the concentration among women at different stages of the demographic transition process and in different socio-economic groups, we shall stress one important demographic aspect following the variation in the distribution of family sizes. Among several authors Goodman, Keyfitz, and Pullum (1975) and Preston (1976) pointed at the difference between the mean family size from the women's perspective and from the children's perspective in the case that not all women have the same number of children.

Preston (1976) formalized this relationship in the following way: Let $f(x)$ be the proportion of women with completed parity x. Then the mean family size for women is

$$\bar{x} = \sum_{x=1}^{n} f(x)x \tag{3}$$

where n is the maximum parity considered. The average family size for children then is:

Figure 11. Lorenz curves for proportions of land area on earth *producing* certain fractiles of all births.



$$\bar{c} = \sum_{1}^{n} \frac{f(x)x}{\sum_{1}^{n} f(x)x} x = \frac{\sum f(x)x^2}{\bar{x}} \tag{4}$$

where the weight in the summation represents the proportion of children from families of size x.

It can be shown (Preston 1976) that the difference between women's mean family size ($\bar{x}$) and children's mean family size ($\bar{c}$) is a function of the variance of the distribution:

$$\bar{c} = \frac{\sigma_x^2}{x} + \bar{x} \tag{5}$$

where σ_x^2 is the variance of the distribution of family sizes among women.

Vaupel and Goodwin (1986) extend Preston's algebra a bit by giving the mean ratio:

$$\rho = \frac{\bar{x}}{\bar{c}} = \frac{1}{I + 1} \tag{6}$$

where I is the square of the coefficient of variation of the distribution of women by number of children. That is

$$I = \frac{\sigma_x^2}{\bar{x}^2} \quad . \tag{7}$$

I was introduced by Crow (1958) for a summary measure of unevenness of a distribution.

This difference between the mean family sizes for women and children has several demographic and non-demographic consequences that will be considered at a later point.

The following sections will give empirical studies of the concentration of fertility among individual women. The study of distributional aspects of fertility seems to be a necessary complement to the usual study of average levels of fertility, especially during periods of demographic transformations that will give some surprising results.

3. DEMOGRAPHIC TRANSITION AND CONCENTRATION

3.1. Marital Fertility in Germany and Austria from the Late 1800's to 1939

This section will focus on changes in the relative concentration of fertility during the course of demographic transition. We want to look at the relationship between the average level of fertility in a certain population at a point in time and the concentration of the distribution of children among women. Wherever possible we would like to observe this relationship separately for different social-economic strata.

It is not easy to find data on completed parity distributions for the premodern period in Europe for women differentiated by certain socio-economic characteristics. In most cases censuses, registers, or other sources of information give only distributions of children currently living in the same household. There are, however, several sources of data that provide the necessary information, mostly censuses at the beginning of our century that asked the question of children ever born to all women covered by the census. If this information is broken down by birth or marriage cohort of the woman and possibly by some socioeconomic variables, it offers a great possibility for studying differentials in the relationship between the level of fertility and distributional disparity as measured by concentration.

One such data set that is still virtually unknown by demographers is the German census (Reichsfamilienstatistik) of 1939. In the whole area that belonged to the German Reich in 1939 (including Austria) married women were asked for the number of children they had borne during their life and for the year when they had first married. Spree (1982, 1984) grouped those women into several marriage cohorts and distinguished between 64 occupational categories of husbands. Spree (1984) gives parity distributions up to parity five and more and mean numbers of children per woman (calculated from a longer parity distribution) for all occupational categories and three marriage cohorts that may be considered as having completed fertility: the cohort of women that married before 1905, between 1905 and 1910, and between 1920 and 1924. Since the mean age at marriage was above 25 for women around that time, even that last cohort should have almost completed their reproductive carrier by 1939.

Table 7 gives measures of fertility and reproductive concentration for the three marriage cohorts and 13 selected occupational groups. The mean number of children ever born declined significantly in all social groups. For those who mar-

Table 7. Concentration of fertility among marriage cohorts by occupational groups for Germany and Austria (German census of 1939).

Occupation of husband	Year of marriage	Mean number of children Mothers' point of view	Mean number of children Children's point of view	Havehalf
Laborers in agriculture	before 1905	6.0	7.6	0.31
	1905-1910	5.2	6.7	0.30
	1920-1924	3.5	4.9	0.26
Independent farmers	before 1905	5.6	7.5	0.29
	1905-1910	4.7	6.7	0.27
	1920-1924	3.1	4.6	0.25
Miners	before 1905	5.7	7.7	0.29
	1905-1910	4.9	6.8	0.28
	1920-1924	2.9	4.4	0.25
Construction workers	before 1905	5.2	6.7	0.30
	1905-1910	4.4	5.8	0.28
	1920-1924	2.9	4.5	0.24
Self-employed craftsmen	before 1905	4.4	5.7	0.28
	1905-1910	3.5	5.3	0.24
	1920-1924	2.2	4.0	0.22
Self-employed in transportation	before 1905	4.4	6.4	0.26
	1905-1910	3.3	5.1	0.23
	1920-1924	2.0	3.5	0.22
Workers in iron and metal industry	before 1905	4.3	5.8	0.28
	1905-1910	3.4	5.3	0.24
	1920-1924	2.1	3.4	0.23
Self-employed innkeepers	before 1905	4.0	6.3	0.24
	1905-1910	3.0	4.5	0.25
	1920-1924	1.8	3.1	0.23
Church officials, ministers	before 1905	3.9	5.8	0.26
	1905-1910	3.4	4.5	0.29
	1920-1924	2.7	3.8	0.27
Civil servants with railroad and postal service	before 1905	3.5	5.2	0.25
	1905-1910	2.9	4.4	0.25
	1920-1924	1.9	3.5	0.22
Independent artists, actors, etc.	before 1905	3.1	5.1	0.22
	1905-1910	2.3	4.3	0.20
	1920-1924	1.4	3.7	0.15
University professors and deans	before 1905	2.7	3.8	0.28
	1905-1910	2.6	3.7	0.28
	1920-1924	1.9	3.1	0.24
Self-employed physicians	before 1905	2.6	3.6	0.28
	1905-1910	2.5	3.9	0.26
	1920-1924	2.0	2.3	0.30
All	before 1905	4.7	6.5	0.27
	1905-1910	3.6	5.3	0.24
	1920-1924	2.3	4.0	0.21

Source of data: Spree (1984).

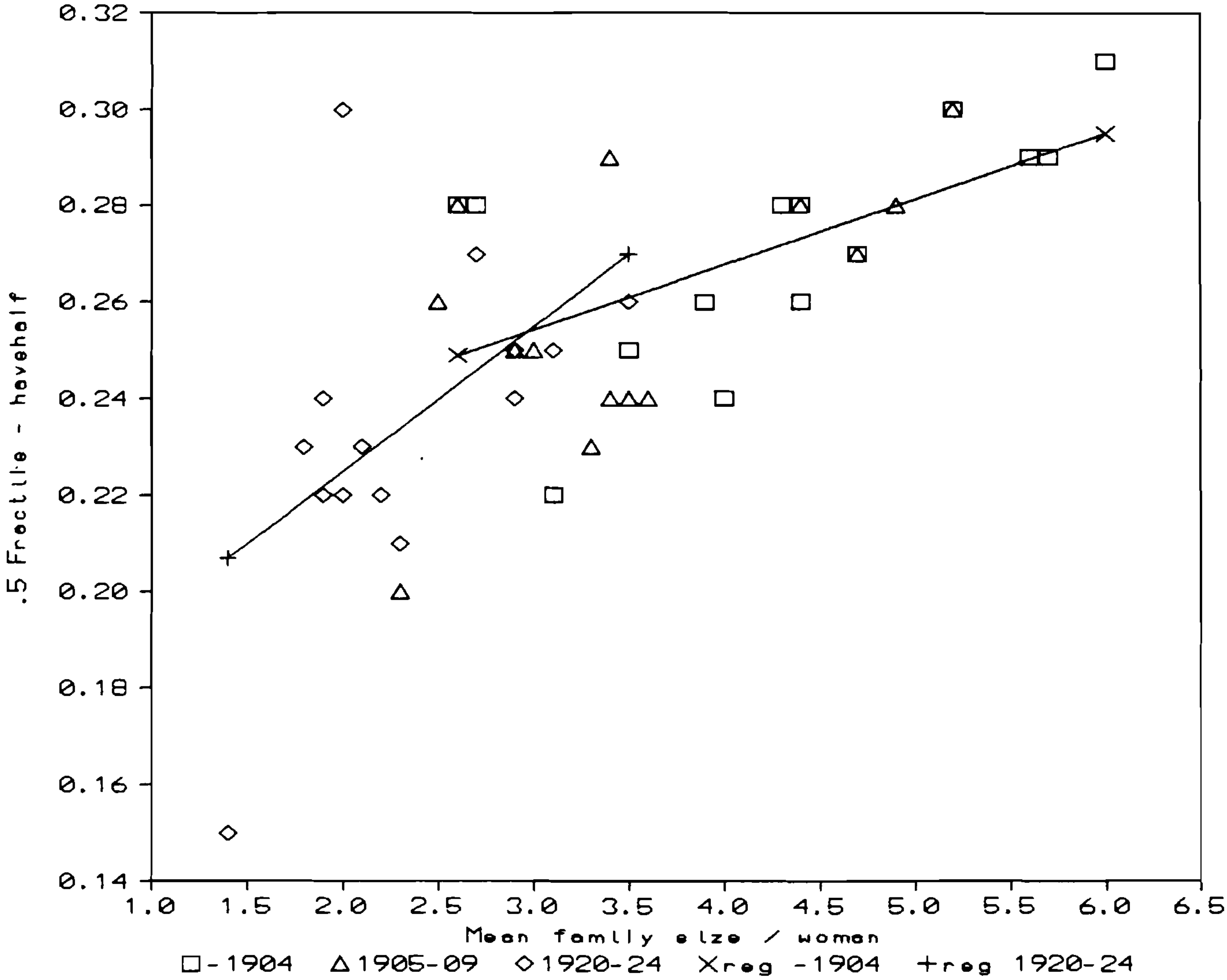
ried before 1905, agricultural workers and miners and independent farmers had, on the average, more than 5.5 children. The lowest fertility was found among the families of self-employed physicians and university professors, social elites that had anticipated the fertility decline. Concentration for the cohort that had married before 1905 was lowest in the highest fertility groups: 31% of families of agricultural laborers had half the number of children born to families in that group. Only 4% of such families had remained childless, while 64% had five or more children. The distribution was similar among independent farmers, miners, and construction workers. For most other occupational groups the concentration coefficient (*Havehalf*) ranges from 22% to 28%.

Couples who had married between 1905 and 1909 had, on the average, more than one child less than those who married before 1905. The concentration of reproduction also increased in most occupational groups. This implies that some members of the groups moved faster towards the new fertility regime than others, thus increasing the relative variance. Among our selected 13 occupational groups, only for church officials and ministers did the completed parity distributions become more even.

Figure 12 plots the relationship between the average level of fertility per couple and the concentration of the distribution for the 13 selected groups and the total of all occupational groups together for the three different marriage cohorts considered. The figure also gives regression lines for the association within each cohort that were calculated by giving equal weight to all occupational groups. We clearly see a positive association between the *havehalf* and the level of fertility within cohorts and over time. In other words, lower average fertility was associated with higher concentration.

Figure 13 shows the change in the association over time within four selected occupational groups and the total. For all occupational groups together the declines in average fertility and the *havehalf* were almost exactly proportional from the cohort married before 1905 to that of 1905-1909 and that of 1920-1924, i.e. the association was linear. For other occupational groups, especially the big ones of agricultural laborers and miners, the lines of development are almost parallel to the total, but starting at different levels of fertility and concentration. The groups of independent artists and actors and that of professors and university officials show an even steeper increase of concentration with declining average fer-

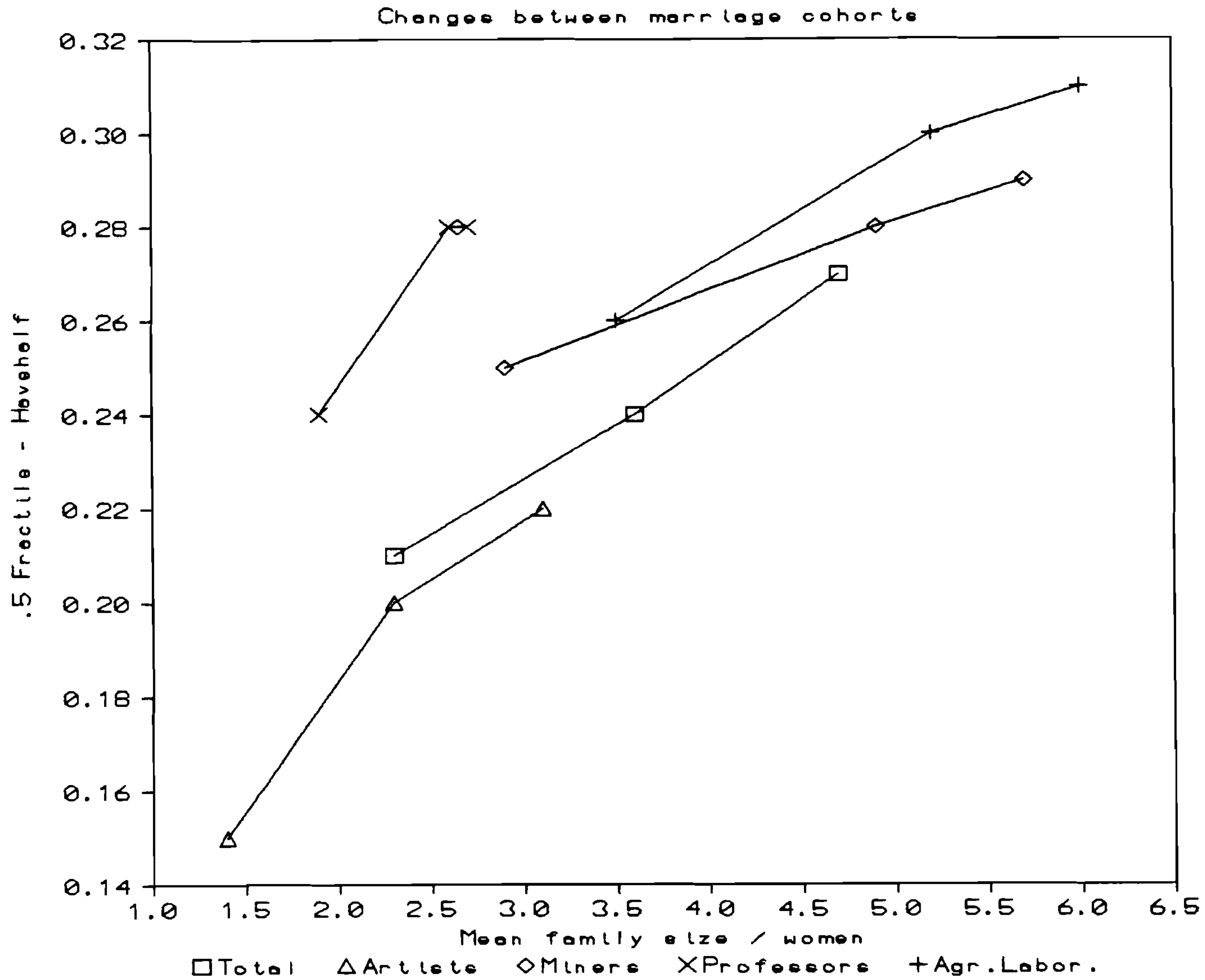
Figure 12. Relationship between mean family size per woman and the .5 fractile for different occupational groups in Germany and Austria and marriage cohorts (before 1904 to 1920-1924).



tility. For those groups as many as 22% (professors) and 35% (artists) of the marriage cohort 1920-1924 were childless in 1939.

This pattern of lower concentration in high fertility groups results in a more even picture of mean family sizes from the children's perspective than from the women's perspective for the cohort married before 1905. Children of independent farmers had, on the average, 6.5 brothers and sisters, children of church officials 4.8, children of innkeepers 5.3, and children of construction workers 5.7. Only families of physicians and professors lie outside this pattern with both fertility

Figure 13. Changes in the association between concentration and the level of fertility over time for selected occupational groups for cohorts married before 1904, 1905-1909, and 1920-1924 in Germany and Austria.



and concentration rather low. Consequently, the child of a physician who had married before 1905 had only 2.6 brothers and sisters on the average.

The same trend continued between 1905-1909 and 1920-1924. For several occupational categories the mean number of children per couple had fallen to 2.0 or below. With 1.4 children per couple, independent artists and actors were even well below the fertility of physicians and professors, and showed extremely high concentration; this was mainly due to childlessness among 35% of the couples. At the upper end of the spectrum agricultural laborers still had 3.5 children on the average. Concentration also continued to increase in most occupational groups. It is interesting to notice that the concentration within the aggregate of all 64 occupational groups in the pre-1905 marriage cohort was about the mean of the values of the .5 fractile of the individual groups. For the marriage cohort of 1920-1924, however, the aggregate is clearly higher concentrated than the majority of the occupational groups taken separately. This indicates that variation between the various occupational groups had increased even stronger than the variation within those groups.

Another interesting finding is that the marital fertility transition in Germany and Austria was much less significant from the children's perspective than from the couple's point of view: while the mean number of children per couple declined by more than half between the pre-1905 and the 1920-1924 marriage cohorts, the mean family size for children declined by only 38% on the average.

In the following section we will study if this pattern of increase in concentration is only true for the historical fertility transition in today's industrialized countries or if equivalent patterns may be observed in the countries that currently experience their secular fertility transition.

3.2. Time Series for Selected Less Developed Countries

For countries that are still in the process of the secular fertility transition it is very difficult to find data that indicate trends in the distribution of children among mothers over the course of the fertility decline. One possible source of information are census questions that ask for the number of children ever born to women of different ages. Comparing subsequent birth cohorts as we did for subsequent marriage cohorts in the previous section can give us information on trends in the level of fertility as well as its concentration.

Only for a few less developed countries completed parity distributions by age are provided by official censuses. Table 8 lists some of these countries. The data come from the special topic tables on nuptiality of the United Nations Demographic Yearbook (1981). For Costa Rica, Republic of Korea, and Libya the female population is broken down by place of residence; for Bolivia, Egypt, and Fiji the data refer to the total female population. The information provided may be subject to age misreporting and parity misreporting which, especially at higher ages, might be significant. Women above age 65 or even 75 might forget to mention some births especially if the child died at a young age. Another possible bias is selectivity (by mortality) with respect to achieved fertility.

In terms of period fertility the pattern shown in these data mainly refers to the time from 1920 to the late 1960s when the women considered were in their prime childbearing ages. In all populations considered here, with the exception of urban Korea, the average level of fertility seems to have increased over time at least from the age groups 60-64 to 45-49. This increase is most pronounced in Egypt and Libya where the mean completed family size increases by almost one child. From the given data it is difficult to assess whether this increase was real or a consequence of differential parity misreporting by age. In some populations such as urban Costa Rica and Fiji, we observe a slight decline in mean family sizes from the age groups 70-74 to 60-64. Since we could expect parity underreporting to be most serious in the oldest age groups, this may be seen as evidence against a very strong effect of misreporting. But probably the pattern is different in every culture.

It does not seem too unreasonable to assume a slight increase in fertility between about 1930 and 1950. It is often observed that before the fertility transition the average level of fertility increases somewhat because of higher fecundability due to improved health conditions and still very high desired family sizes and the lack of birth control (see e.g. Easterlin 1978). Only in the case of urban populations in Korea do we see the onset of the fertility transition resulting in markedly lower average family sizes for women aged 45-49 than women aged 55-59 in 1975.

Generally the concentration of fertility does not change dramatically over the more than 30 years from the cohorts aged 75 and more to those aged 45-49, but some decrease of concentration is visible in every country considered. It is most pronounced in Egypt where the .5 fractile increases from .23 to .28 while the mean number of children per woman increases from 4.25 to 5.23. Hence this is consistent with the finding from the previous section that higher fertility is associated with lower concentration, but this time the trend goes in the other direction than that for the marital fertility transition in Germany and Austria. An explanation for this decrease in relative variation is that differences in fecundability—the major source of variation in natural fertility populations—diminished due to improved health conditions. This resulted in a decline in the proportion of women childless or with low completed parities. In Egypt the proportion childless declined from 18% (age 60+) to 9% (age 45-49). On the upper end of the distribution women already close to the maximum fertility possible in the specific culture with given birth spacing practices, etc., could hardly increase their fertility further. This

Table 8. Mean family sizes and concentration of parity distributions for women beyond reproductive age in selected LDC's.

Country, year of census	Age group	Mean/woman	Mean/child	.5 fractile
Bolivia, 1976	45-49	6.08	8.09	0.29
	50-54	5.97	8.09	0.29
	55-59	5.90	8.05	0.29
	60-64	5.58	7.82	0.28
	65+	5.42	7.73	0.27
Costa Rica, 1973	45-49	4.94	7.60	0.24
Urban	50-54	4.84	7.69	0.23
	55-59	4.80	7.69	0.23
	60-64	4.53	7.67	0.22
	65-69	4.72	8.01	0.22
	70-74	4.69	8.02	0.22
	75+	4.89	8.16	0.23
Costa Rica, 1973	45-49	7.37	9.37	0.30
Rural	50-54	7.17	9.34	0.29
	55-59	7.11	9.31	0.29
	60-64	6.82	9.20	0.28
	65-69	6.95	9.26	0.28
	70-74	6.73	9.18	0.28
	75+	6.73	9.19	0.28
Egypt, 1976	45-49	5.23	7.07	0.28
	50-54	4.81	6.98	0.26
	55-59	4.89	7.08	0.26
	60+	4.25	6.83	0.23
Fiji, 1976	45-49	7.99	9.56	0.31
	50-54	7.99	9.52	0.31
	55-59	7.77	9.37	0.31
	60-64	7.46	9.25	0.31
	65-69	7.48	9.23	0.31
	70-74	8.41	9.83	0.31
	75+	4.99	6.39	0.30
Korea, Rep. of, 1975	45-49	4.66	5.66	0.30
Urban	50-54	5.03	6.24	0.30
	55-59	5.10	6.50	0.29
	60-64	5.00	6.51	0.28
	65-69	4.79	6.40	0.28
	70-74	4.66	6.20	0.27
	75+	4.53	6.10	0.27
Korea, Rep. of, 1975	45-49	5.72	6.67	0.33
Rural	50-54	5.85	6.99	0.33
	55-59	5.72	6.95	0.32
	60-64	5.38	6.70	0.31
	65-69	5.17	6.47	0.30
	70-74	5.00	6.27	0.30
	75+	4.83	6.06	0.29

Libya, 1973	45-49	7.46	8.87	0.33
Urban	50-54	7.05	8.61	0.33
	55-59	6.99	8.55	0.33
	60-64	6.58	8.29	0.32
	65-69	6.63	8.22	0.32
	70-74	6.39	8.08	0.32
	75+	5.99	7.81	0.30
Libya, 1973	45-49	7.72	8.91	0.35
Rural	50-54	7.36	8.73	0.34
	55-59	7.26	8.62	0.34
	60-64	6.93	8.37	0.34
	65-69	6.93	8.31	0.34
	70-74	6.48	8.02	0.33
	75+	6.31	7.91	0.32

made the distribution of children ever born more even and consequently reduced the concentration of reproduction.

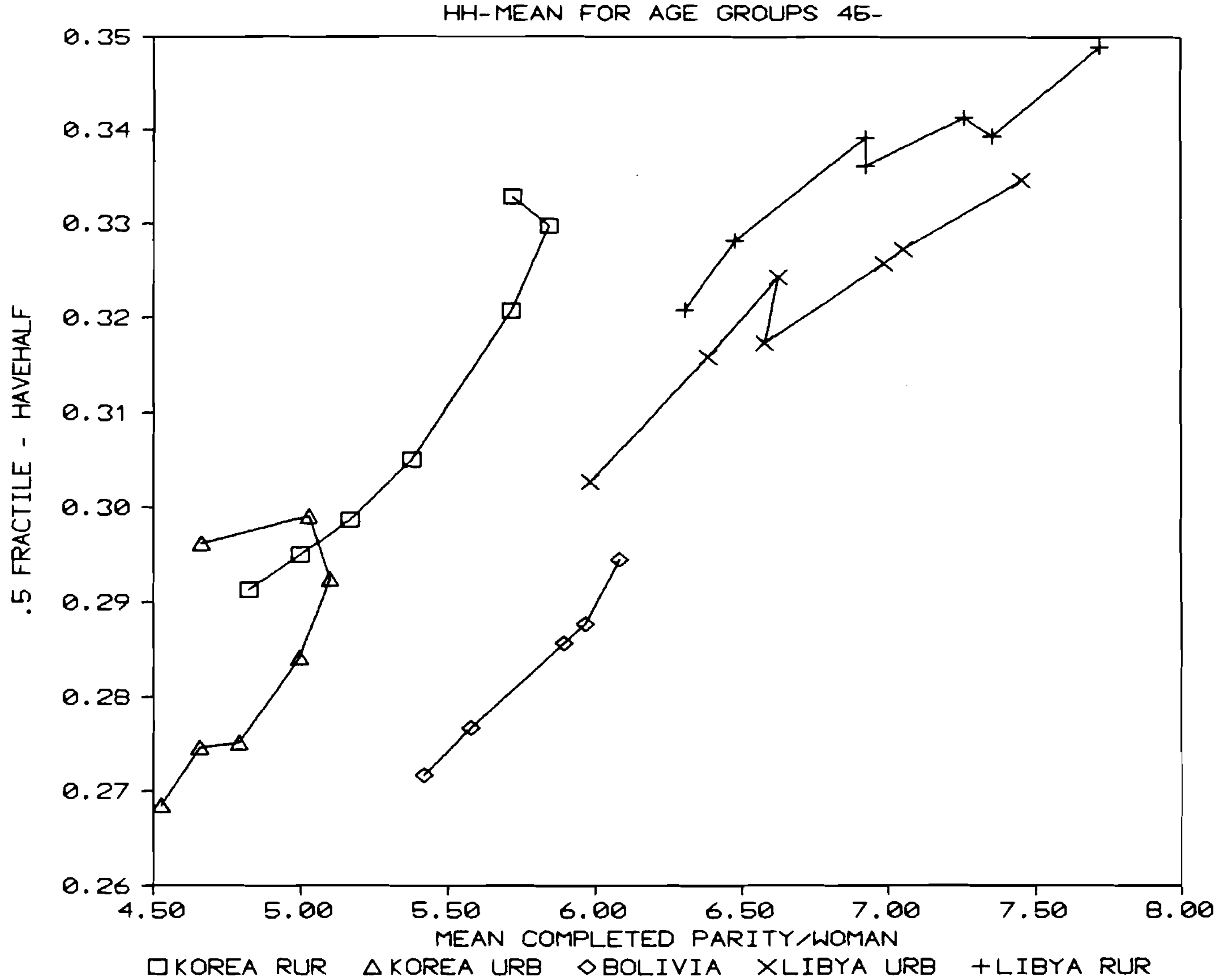
In the case of urban Korea (see also Figure 14) the beginning of the fertility transition also meant a reversal of the decreasing trend of concentration. The introduction of birth control tended to increase relative variation again.

3.3. A Cross-Sectional View on 41 Less Developed WFS Countries

A more reliable and complete source of data than the few censuses with age-specific information on the number of children ever born is given by the World Fertility Survey. For these data a tremendous amount of work was invested (Cleland and Hobcraft 1985) to check the consistency and accuracy of information given. For this reason the World Fertility Survey is the best body of standardized information on fertility for a large number of less developed countries.

In this section we want to utilize the information on children ever born by ever-married women aged 40-49 at the time of the survey for the analysis of relative concentration. The Lorenz curves given in Figure 15 already indicates the large differentials between countries in terms of the concentration of reproduction within their populations. Since we have only one age group and one point in time per country we cannot study the demographic transition in a longitudinal manner. Instead we take a cross-sectional approach and relate the findings to real trends under the assumption that essentially all countries follow a similar pattern but stand at the time of the survey at different stages of their fertility transition.

Figure 14. Relationship between average parity and the concentration of reproduction in five selected less developed populations for age groups 40-49 to 75+ (for data, see Table 8).



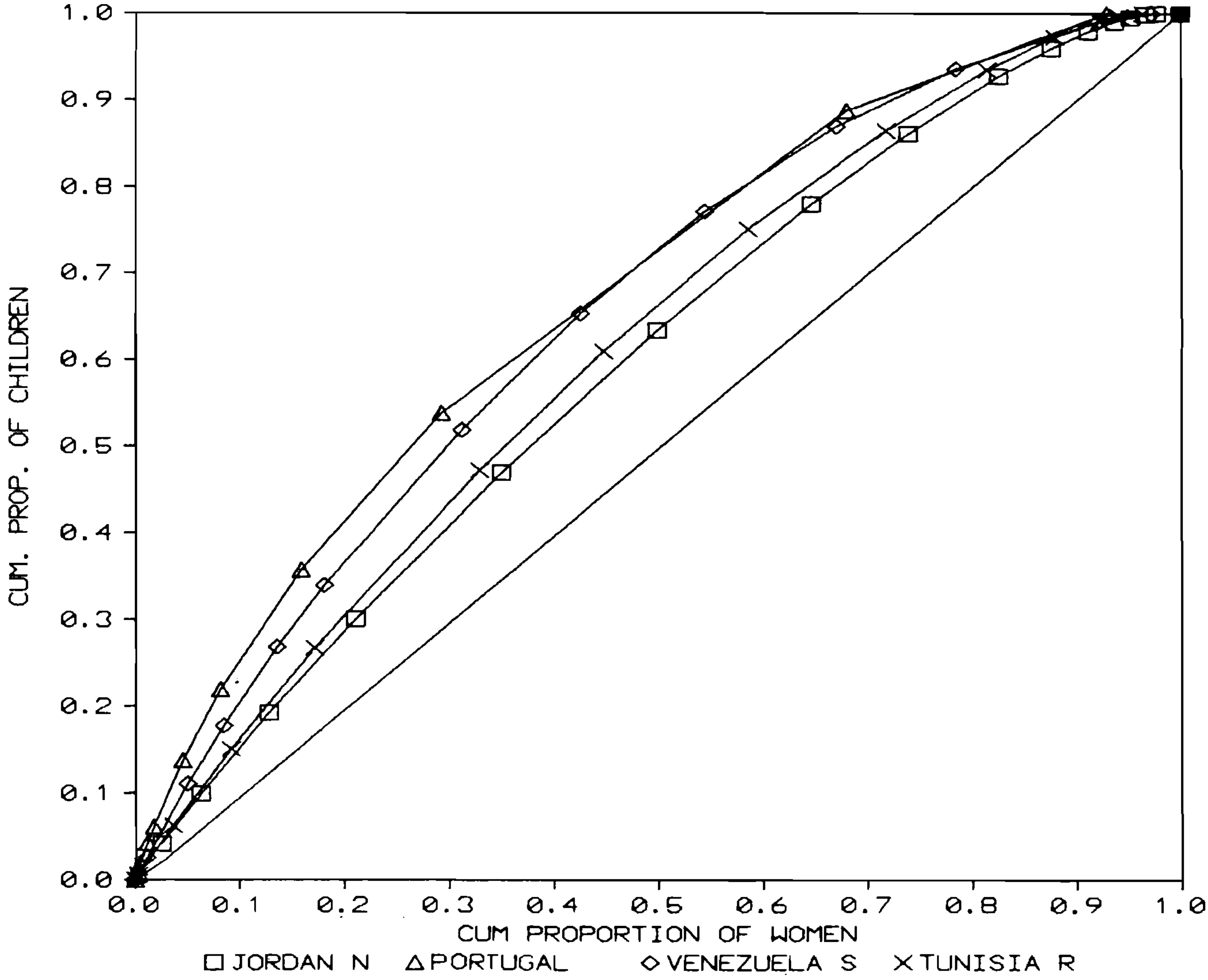
The flattest curves in Figure 15, or those closest to the diagonal, display the relatively low concentration of reproduction in Jordan and rural Tunisia. The most bowed curves, or those furthest from the diagonal, represent the relatively high concentration of reproduction in urban Portugal and among women with some schooling in Venezuela. In other words, total births are relatively evenly distributed among the females of Jordan and rural Tunisia, whereas in Portugal and Venezuela they are concentrated in a smaller portion of all women belonging to the subpopulation studied. A steep beginning of the curve, such as that for Portugal, indicates that a small fraction of high parity women accounts for a large fraction

Table 9. Mean family sizes from the women's perspective: 41 WFS countries by place of residence and education.

Country	Total	Rural	Urban	No education	Some education
Bangladesh	6.948				7.127
Benin	6.139	6.216	5.831		
Cameroon	4.905		3.884		
Colombia	6.901	7.603	6.483	7.346	5.931
Costa Rica	6.917	8.437	5.335	8.217	5.649
Dominican Republic	6.392	7.739	5.227	6.852	5.450
Ecuador	6.977	7.780	5.926	7.993	5.714
Egypt	6.639	6.968	6.219	6.805	6.356
Fiji	6.314	6.647	5.576	6.632	5.994
Ghana	6.380	6.559	5.864		5.958
Guyana	6.463	7.080	5.200	7.317	
Haiti	5.797	6.107	4.725		
Indonesia	5.246		5.302		5.637
Ivory Coast	6.781	6.834	6.490		
Jamaica	5.505	6.132	4.262		
Jordan	8.663			9.105	7.274
Kenya	7.734			67.603	8.088
Korea	5.419	6.126	4.745	5.965	4.968
Lesotho	5.217			4.998	5.322
Malaysia	6.135	6.292	5.648	6.341	5.703
Mauritania	6.008	6.024	5.932	5.909	6.046
Mexico	7.026	7.893	6.390	7.656	6.678
Morocco	7.083	7.231	6.297		
Nepal	5.644				
Nigeria	5.456				
Pakistan	6.907	6.905	6.760		
Panama	5.740	6.869	4.923	7.111	4.957
Paraguay	6.270	7.446	4.732	7.405	4.881
Peru	6.757	7.527	6.220	7.776	5.894
Portugal	2.928	3.266	2.226	3.463	2.234
Philippines	6.858	7.240	5.988	7.730	6.501
Senegal	6.925	7.023	6.686		
Sri Lanka	5.730		5.094	6.443	5.404
Sudan	5.996	5.963	6.073		
Syria	7.664	7.796	7.530		6.208
Thailand	6.362		5.001	6.349	6.274
Trinidad & Tobago	5.496	6.005	5.164	6.113	
Tunisia	6.778	6.903	6.620		
Turkey	6.084	7.053	4.805	6.990	4.491
Venezuela	6.211			7.361	5.090
Yemen	6.638				

of the births. The flattening of this concentration curve towards its end indicates a smaller relative contribution of low parity women to the number of children born as compared with the other countries. This implies a very heterogeneous population in Portugal; the concentration is mostly due to small groups of very high fer-

Figure 15. Lorenz curves for the concentration of fertility in selected WFS populations: Jordan (women without formal schooling), Portugal (all women), Venezuela (women with some schooling), and Tunisia (rural women).



tility women relative to the national fertility level.

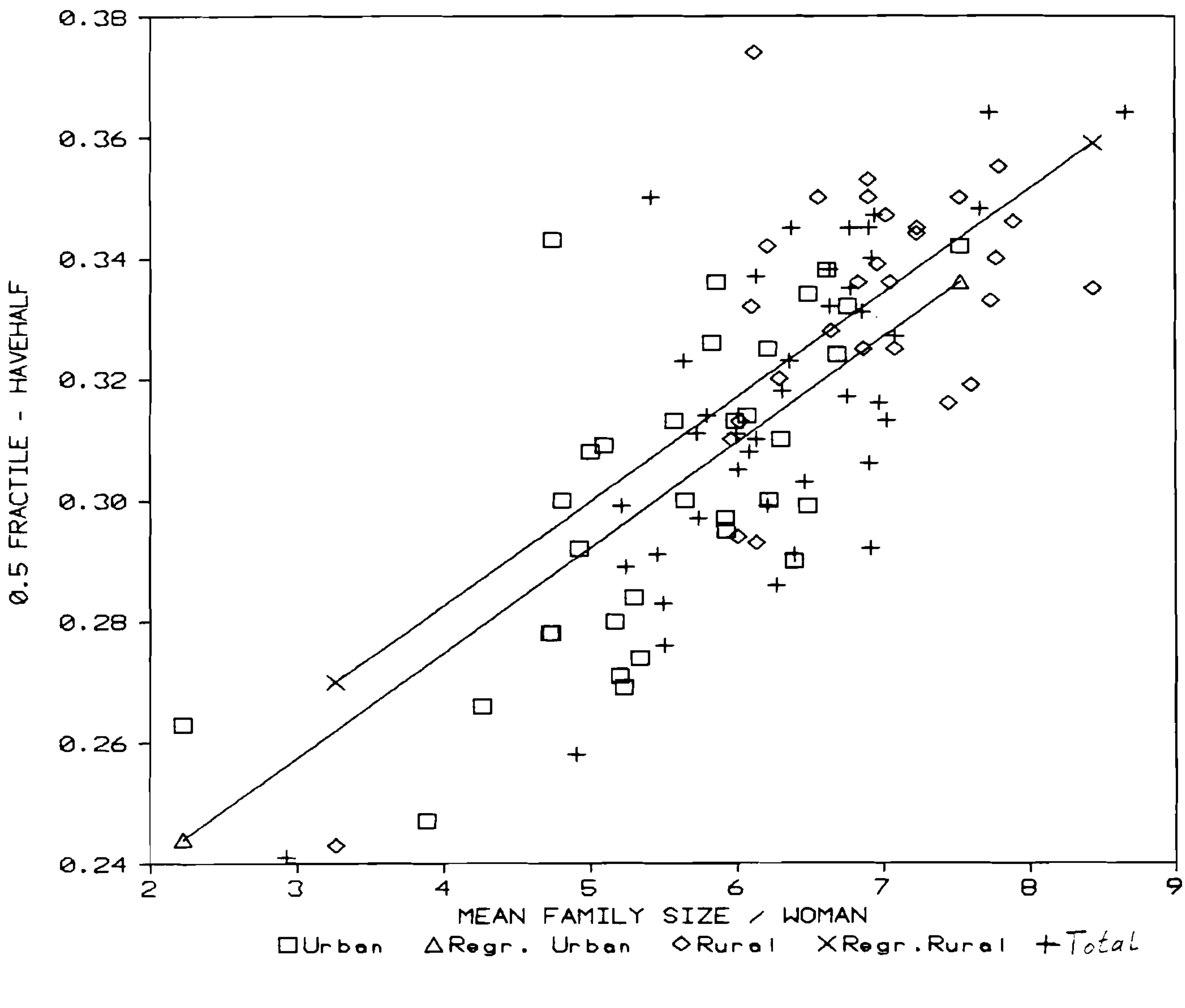
Plotting concentration, as measured by the .5 fractile, against the mean number of children per woman for the 41 less developed countries participating in the World Fertility Survey reveals a positive relationship between these two measures; the lower a country's level of fertility the higher the concentration of reproduction. The two countries with the highest mean number of children, Jordan and Kenya, show the lowest concentration. Jordan has an average of 8.7 and Kenya of 7.7 children. More than 36% of all the women have half the children in these

Table 10. Mean family sizes from the children's perspective: 41 WFS countries by place of residence and education.

Country	Total	Rural	Urban	No education	Some education
Bangladesh	8.242				8.258
Benin	7.415	7.439	7.221		
Cameroon	7.527		6.118		
Colombia	8.856	9.461	8.443	9.199	7.828
Costa Rica	9.135	10.141	7.345	9.980	7.923
Dominican Republic	8.538	9.441	7.383	8.961	7.384
Ecuador	8.714	9.237	7.714	9.375	7.456
Egypt	8.120	8.413	7.685	8.175	7.989
Fiji	8.009	8.277	7.118	8.231	7.584
Ghana	7.544	7.676	7.118		7.052
Guyana	8.477	8.791	7.412	8.851	
Haiti	7.323	7.433	6.469		
Indonesia	7.152		7.334		7.418
Ivory Coast	8.324	8.372	7.985		
Jamaica	7.800	8.321	6.118		
Jordan	9.948			10.228	8.738
Kenya	8.956			8.906	9.036
Korea	6.341	6.906	5.610	6.887	5.777
Lesotho	6.914		6.683	7.003	
Malaysia	7.830	7.884	7.310	7.965	7.374
Mauritania	7.779	7.611	7.923	7.799	7.662
Mexico	8.944	9.348	8.560	9.356	8.677
Morocco	8.920	8.779	8.251		
Nepal	7.021				
Nigeria	7.343				
Pakistan	8.267	8.157	8.326		
Panama	7.479	8.368	6.536	8.626	6.486
Paraguay	8.456	9.440	6.386	9.306	6.818
Peru	8.435	8.875	8.046	9.084	7.703
Portugal	4.597	5.025	3.296	5.246	3.231
Philippines	8.345	8.632	7.512	9.018	8.018
Senegal	8.369	8.375	8.360		
Sri Lanka	7.325		6.554	8.010	6.954
Sudan	7.829	7.842	7.780		
Syria	9.051	9.060	9.041		7.708
Thailand	7.883		6.314	7.746	7.780
Trinidad & Tobago	7.511	7.988	7.151	7.559	
Tunisia	8.062	8.081	7.984		
Turkey	7.697	8.405	6.252	8.326	5.914
Venezuela	8.042			9.004	6.661
Yemen	7.951				

countries. Obviously, if 50% had half, the distribution of offspring among women would be equal. At the other extreme, Cameroon has an average fertility of 4.9 children and a havehalf of 26% and Portugal (which is considered a less developed country by the WFS) has the highest concentration with a havehalf of 24% and the low fertility level of 2.9 children. Furthest away from the regression line lies Korea with a concentration much lower than that expected from the level of fertility, and Costa Rica with a higher concentration than the mean number of 6.9 children would imply.

Figure 16. Relationship between mean completed family size per woman and .5 fractile for urban and rural women for WFS LDC's.



The linear relationship between the havehalf statistic and mean fertility in these countries becomes even more apparent when we look at urban and rural populations separately (see Figure 16). Urban fertility is generally lower than the

Table 11. .5 Fractiles for 41 WFS countries by place of residence and education.

Country	Total	Rural	Urban	No education	Some education
Bangladesh	0.347				0.358
Benin	0.337	0.342	0.326		
Cameroon	0.258		0.247		
Colombia	0.306	0.319	0.299	0.317	0.293
Costa Rica	0.292	0.335	0.274	0.331	0.269
Dominican Republic	0.291	0.333	0.269	0.302	0.277
Ecuador	0.316	0.340	0.297	0.345	0.296
Egypt	0.332	0.339	0.325	0.341	0.319
Fiji	0.318	0.328	0.313	0.326	0.319
Ghana	0.345	0.350	0.336		0.343
Guyana	0.303	0.325	0.271	0.335	
Haiti	0.314	0.332	0.278		
Indonesia	0.289		0.284		0.299
Ivory Coast	0.335	0.336	0.334		
Jamaica	0.276	0.293	0.266		
Jordan	0.364			0.378	0.335
Kenya	0.364			0.359	0.379
Korea	0.350	0.374	0.343	0.361	0.352
Lesotho	0.299			0.294	0.302
Malaysia	0.310	0.320	0.300	0.318	0.301
Mauritania	0.305	0.313	0.295	0.293	0.318
Mexico	0.313	0.346	0.290	0.331	0.304
Morocco	0.327	0.344	0.310		
Nepal	0.323				
Nigeria	0.291				
Pakistan	0.345	0.350	0.332		
Panama	0.297	0.325	0.292	0.328	0.296
Paraguay	0.286	0.316	0.278	0.319	0.267
Peru	0.317	0.350	0.300	0.353	0.295
Portugal	0.241	0.243	0.263	0.246	0.272
Philippines	0.331	0.345	0.313	0.360	0.324
Senegal	0.340	0.347	0.324		
Sri Lanka	0.311		0.309	0.323	0.309
Sudan	0.311	0.310	0.314		
Syria	0.348	0.355	0.342		0.323
Thailand	0.323		0.308	0.333	0.321
Trinidad & Tobago	0.283	0.294	0.280	0.326	
Tunisia	0.345	0.353	0.338		
Turkey	0.308	0.336	0.300	0.337	0.291
Venezuela	0.299			0.330	0.298
Yemen	0.338				

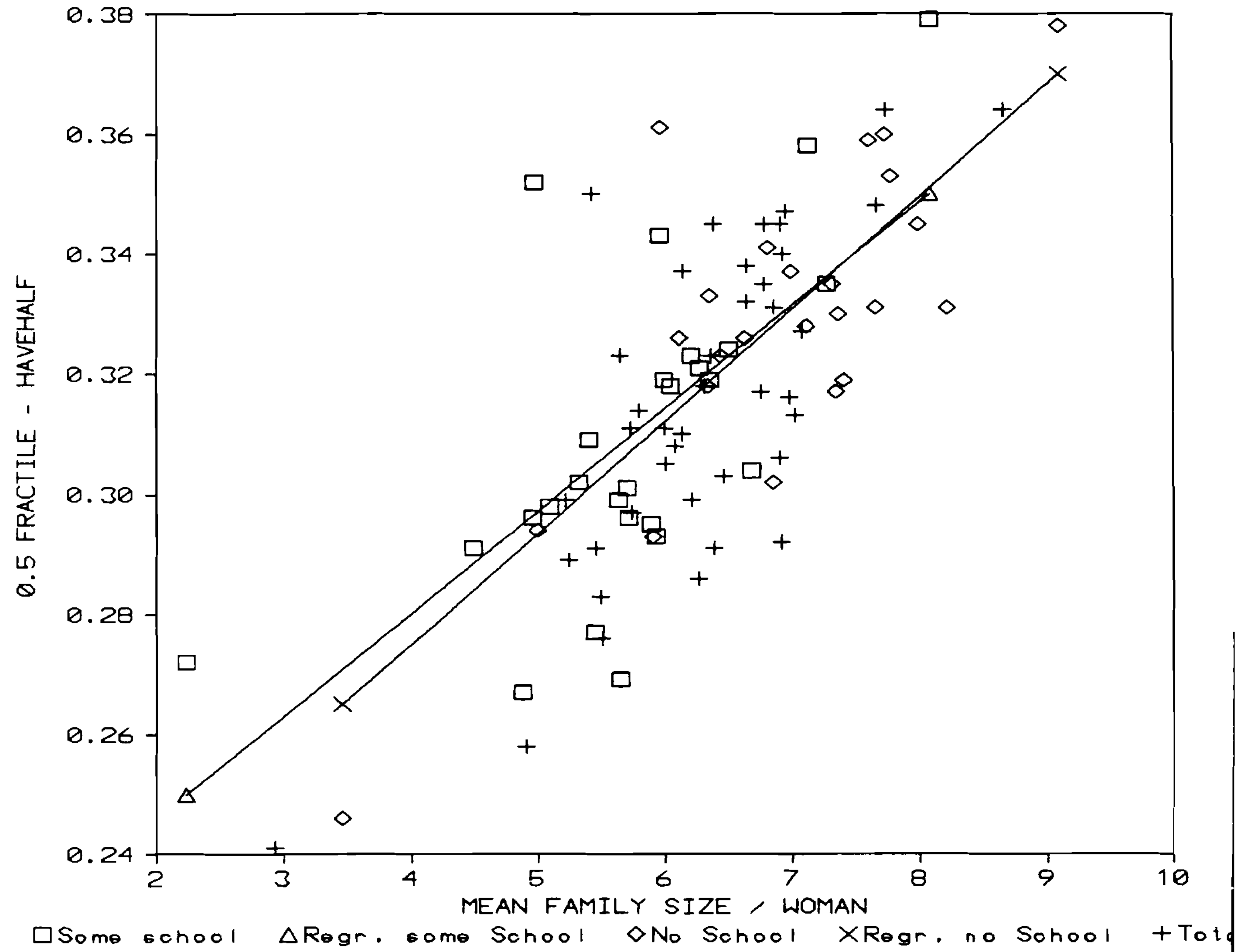
fertility of women from rural areas. It is interesting to notice that the regression lines demonstrating the relationship between the concentration and the level of fertility for rural areas is almost parallel to that for urban areas, with the urban line falling slightly below and to the left of the rural line. Country-specific characteristics seem to pertain beyond this breakdown. Korea is an outlier with the Korean rural and urban populations lying some distance above the regression line. However, urban fertility is significantly lower and more concentrated than rural and the trajectory of these two points is parallel to that of the regression line. This is also true for most urban/rural differentials within individual countries.

In all countries, except Portugal, urban concentration is higher than rural. Generally, the Latin American countries, and in particular the Caribbean countries, show the highest rural/urban differentials in respect to the concentration of reproduction. In urban areas of the Dominican Republic, for instance, 26% of the women have half the children whereas in the countryside, half of the children are borne by as many as 33% of all women. In Africa, the residential differentials in concentration are least significant; we find differences of only 1-3 percentage points.

It is worth noting that in all countries except Portugal and Sudan the concentration of reproduction in the total of the population is higher than that in the rural and urban segments separately. This deserves attention because concentration is not additive. If two rather homogeneous populations with different fertility levels were pooled together one might expect that the aggregate is more heterogeneous than any of the subpopulations. Hence, these findings indicate that family size differentials within the urban societies are greater than those between towns and the countryside. Because of this, in Portugal and Sudan the concentration of reproduction is lower for the total population than it is for either of the subpopulations.

For educational differentials a similar pattern appears. Only in Kenya, Mauritania, Lesotho, and Portugal is the concentration of reproduction higher for women without schooling. In all other countries the .5 fractiles are clearly lower for women with at least some schooling. Interesting enough, Kenya, Mauritania, and Lesotho are the only countries where the level of fertility is higher for educated women than it is for women without schooling. In Lesotho, Mauritania, Fiji and Portugal the concentration of fertility in the total population is less than that of the two subpopulations separately, in all other countries it lies inbetween those values. There is no country where the concentration of the aggregate is higher than that in any subpopulation.

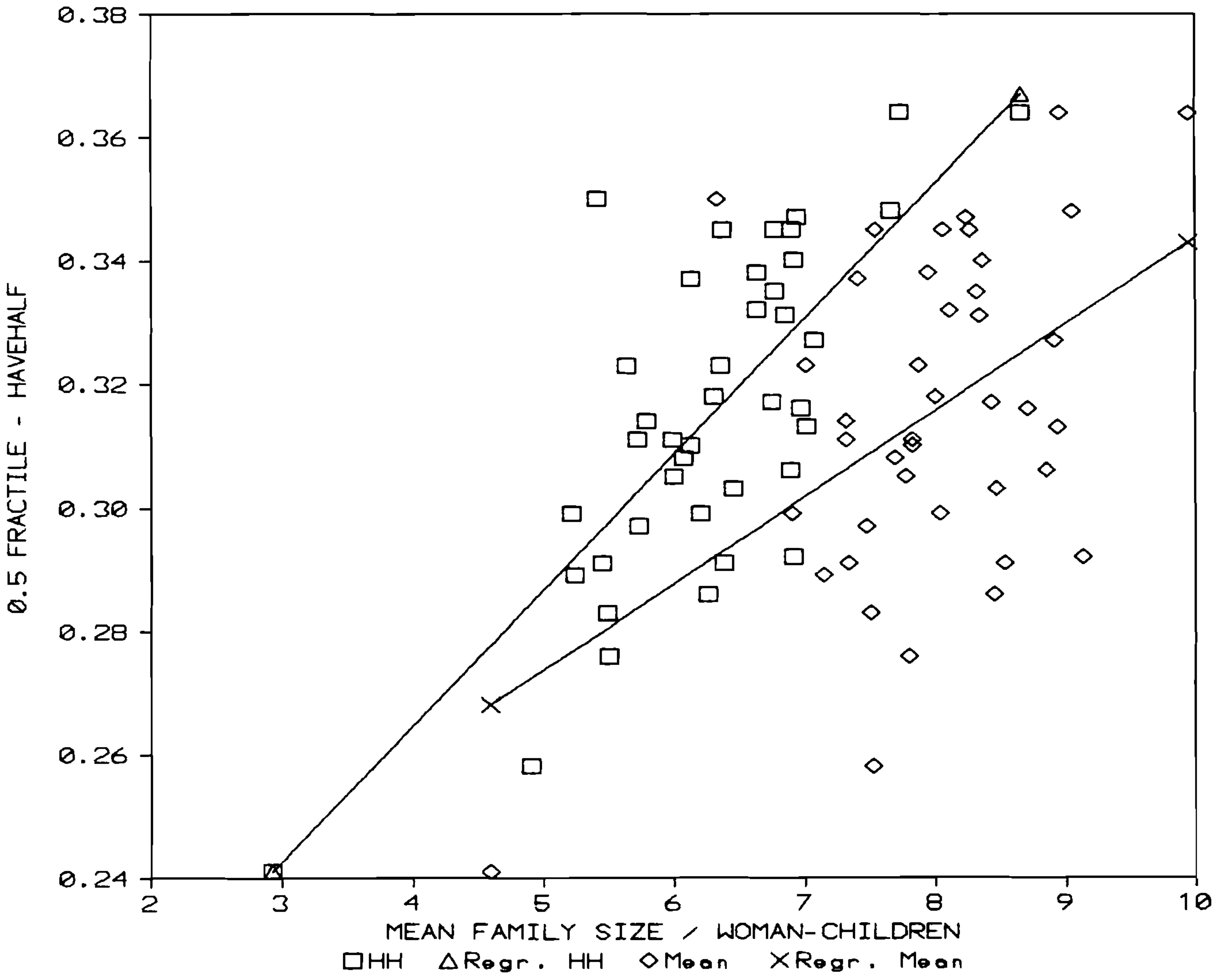
Figure 17. Relationship between mean completed family size per woman and .5 fractile for women with and without some formal education in WFS LDC's.



The above analysis showed that in almost every less developed country considered, lower fertility is associated with a higher concentration of reproduction. The slope of the regression line is around +.02, both on the aggregate level and in the subgroups. This means that one child less in the average completed family size implies a .5 fractile that is two percentage points lower.

From Table 11 we see that the relative variation between mean family sizes from the children's point of view is less than between those from the women's point of view. In Portugal the mean from the children's perspective is 1.60 times the

Figure 18. Plot of mean family sizes of women and children against .5 fractile for all 41 WFS LDC's.



average parity per woman. In Jordan it is only 1.15 times greater. This is due to the fact pointed out earlier that the difference between those two means is a function of the relative variance and consequently also of the concentration of the distribution. Figure 7 plots the relationship between both means and the .5 fractile. In all cases the mean from the children's perspective is higher than that from the women's perspective because in no country is the variation in the distribution zero. And the slope of the regression line is less steep for the children's mean than for the mean from the women's perspective. The differences in the slope of the regression lines can be explained by the fact that relative variation is determining in part the mean from the children's perspective. For this reason a one percent change in the .5 fractile is not only empirically associated with a higher mean family size per woman, but on top of this the greater degree of relative variation results in an even larger change in the children's mean family size.

This strong empirical association between the level of fertility and its concentration does not hold for all less developed countries however. One very significant portion of the world population--the Chinese—experienced a very different pattern of fertility decline.

4. THE CONCENTRATION OF PERIOD FERTILITY IN CHINA 1955-1981

China recently experienced one of the most dramatic fertility declines ever observed. Within only 15 years the total fertility rate declined from 7.501 (in 1963) to 2.72 (in 1978). In urban areas this decline was even stronger than in rural communities. Before that, in 1955 to 1965, however, China's fertility had experienced another short-term decline in fertility that had brought down the TFR to a minimum of 3.29 in 1961. As the Lorenz curve in Figure 19 indicates, the concentration of reproduction in the low of 1961 was much greater than the concentration in the high fertility year of 1955 and greater than in 1981, the year of lowest fertility. Obviously the two fertility declines were of very different nature. The following analysis will give a closer look at this.

Feeney and Yu (1987) recently presented estimates for period parity progression ratios for China as a whole and for urban and rural areas for the period 1955-1981, which are based on the National One-per-Thousand Fertility Survey. The method used for estimating period parity progression ratios is based on earlier work by Feeney (1983) and shall not be discussed here.[2] We also do not want to repeat the analysis of period fertility fluctuations in China between 1955 and 1981. This research note wants to build on the given information, highlighting one aspect not mentioned by Feeney and Yu. We will also show that the Chinese trends with respect to concentration of fertility are quite distinct from most other countries in the world.

Completed parity distributions implied by the given period parity progression ratios ($p(i)$, i referring to parity) of individual years were calculated by successively applying the ratios to a radix of 1,000 women, $l(0)$, starting the process of reproduction at parity zero.[3] The proportion of women that drop out of the process of reproduction at parity i, $d(i)$, and hence have completed parity i, is calculated by

$$d(i) = l(i)*(1 - p(i)) \qquad \text{where} \qquad (8)$$

$$l(i) = l(i-1)*p(i-1) \quad .$$

[2]The parity progression ratios given by Feeney and Yu (1987) seem to refer only to married women. But since marriage is almost universal (progression to first marriage is between 0.98 and 0.99 over most of the period) this need not be of much concern and we may speak of total fertility instead of marital fertility.

[3]The notation used here comes from the model of a life table approach to parity progression where age is replaced by parity as the indexing variable (see Chiang and van den Berg (1982) and Lutz and Feichtinger (1985)).

Figure 19. Lorenz curves for the concentration of period fertility in China, 1955, 1961, and 1981.

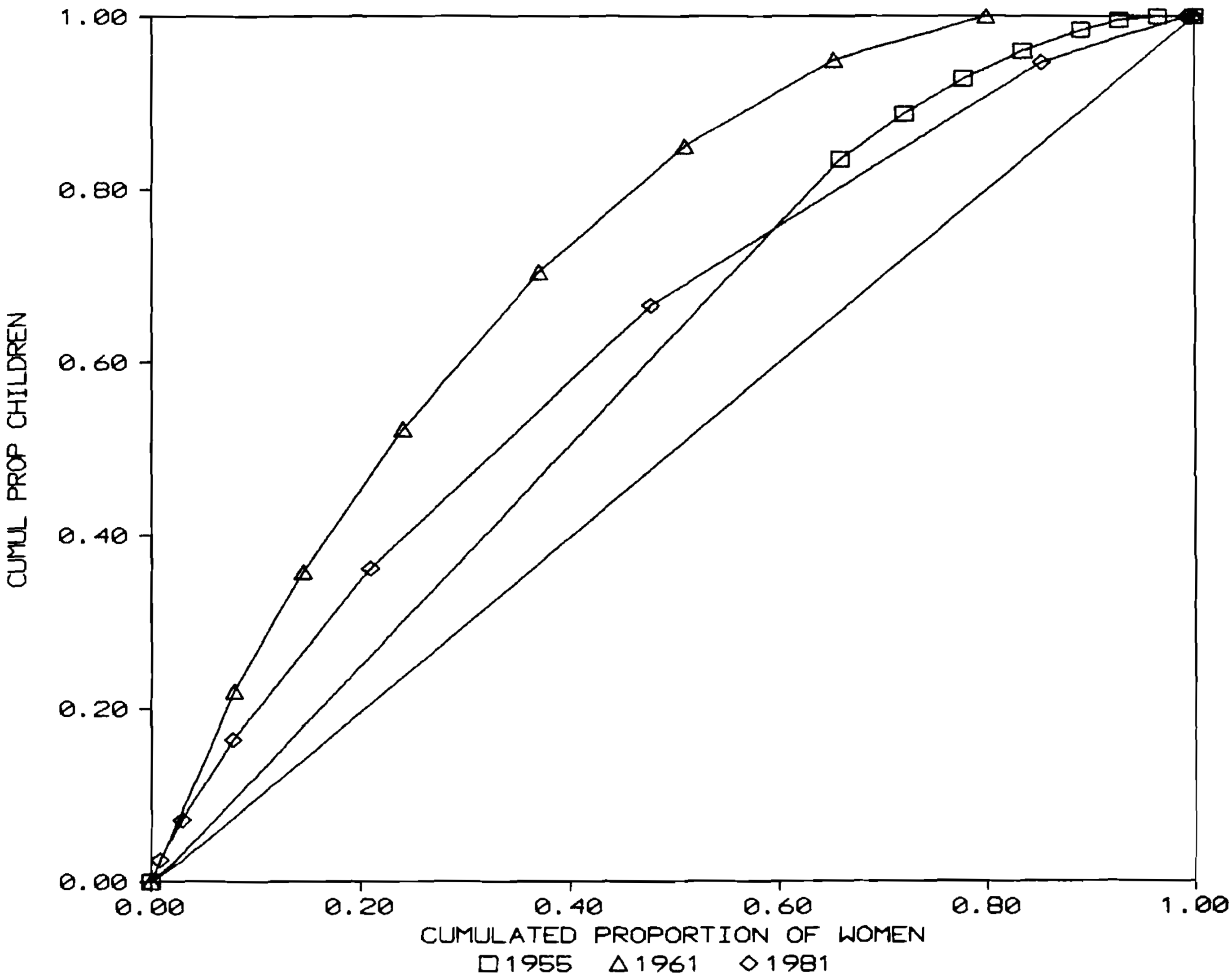
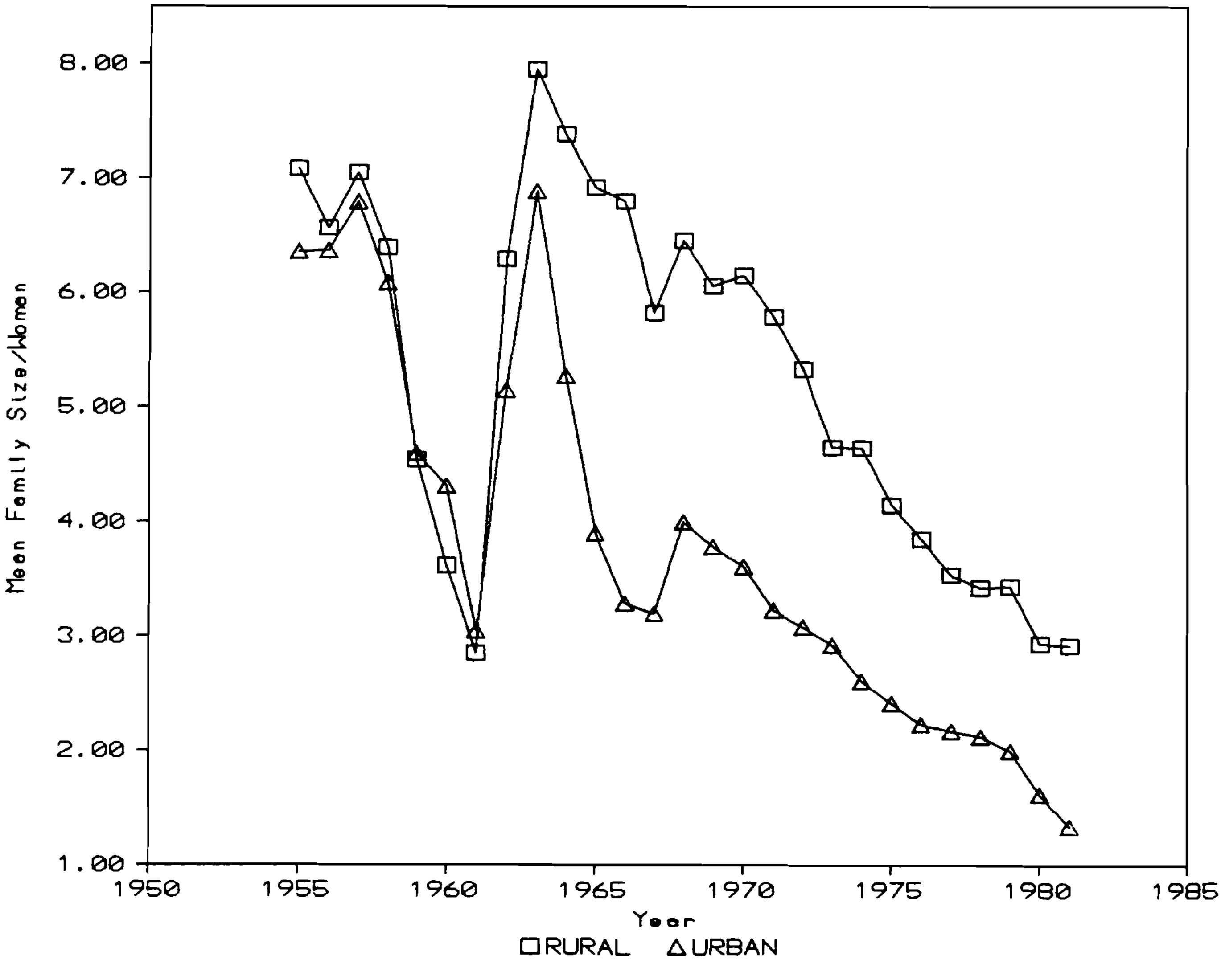


Figure 20 gives the mean family sizes of women that were calculated as a weighted average of the completed parity distributions. These averages are comparable to the total fertility rates calculated from age-specific rates in terms of giving the mean number of children of a synthetic cohort based on period observations, except for the fact that they are not exact in considering births of orders 8 and above.[4] The time series of total fertility rates and mean family sizes under a

[4]Since the parity progression ratios given by Feeney and Yu (1987) ended at parity eight, one must make adjustments for higher order births. In this paper it is assumed that women with eight or more births have, on the average, nine births.

parity-specific approach cannot be expected to be identical because one approach considers the age distribution of the population while the other is based on the parity distribution. But since age and parity are highly correlated the empirical findings should not be too different.

Figure 20. Trends in the mean family size per woman for urban and rural China, 1955-1981.



As Feeney and Yu (1987) also mention, there are two significant empirical differences between the time series of TFR's and the series of mean family sizes based on a parity-specific view: the total fertility rate is higher than the mean family size during the late 1960s and lower during the 1970s; secondly the age-specific approach implies a reversal of the long fertility decline shortly before the survey, i.e. an increase from 2.24 in 1980 to 2.63 in 1981, whereas the parity-specific approach indicates a further, although somewhat slower, decline. Which indicator should we believe? In a country where fertility is controlled in dependence on parity (such as in China) the parity-specific approach is less sensitive to period fluctuations in the timing of births (e.g. women delaying first births for some reason), and hence can be expected to give a more stable picture under a cohort point of view. The completed parity distributions implied by period fertility in 1980 and 1981 show that the relatively modest decline in mean family size was the result of two counteracting trends: the proportions of women with expected parities of two or more consistently decreased, but at the same time the expected proportion of childless women also decreased; only the proportions of women expected to have one child saw significant increases. Hence the result for 1981 does not necessarily mean a failure of recent birth control policies, but the parity-specific findings indicate that more women than ever before tend towards the one-child family.

Figure 21 plots the trends in the coefficient of concentration chosen for this study, the .5 fractile or ***havehalf***, from 1955 to 1981 for rural and urban areas. Although the level of fertility, at least since 1963, has been substantially higher in rural areas than in the cities of China, the extent of concentration in the distribution of period completed parity distributions has not differed much. Generally, about 35 percent of all women have had half the children since 1961. This percentage is much higher, i.e. the concentration is much lower, than in most other countries with controlled fertility. In industrialized countries with total fertility rates between 2.0 and 3.0 usually 22% to 26% of all women have half the children (see the following sections).

Table 12 and Figure 21 also indicate the fertility declines China experienced between 1957 and 1961, and that since 1963 are of a very different nature. The first decline, which led to a minimum of 2.88 children per mother in 1961, was highly selective and did not affect all women. The period parity progression ratios of 1961 imply that 20% of the women would remain childless under the observed rates, whereas other portions of the female population had still rather high fertility. As a consequence of this unevenness the concentration of reproduction increased rapidly during that period. In 1980 and 1981 the overall level of fertility was lower than in 1961 but concentration had not increased. This means that the relative

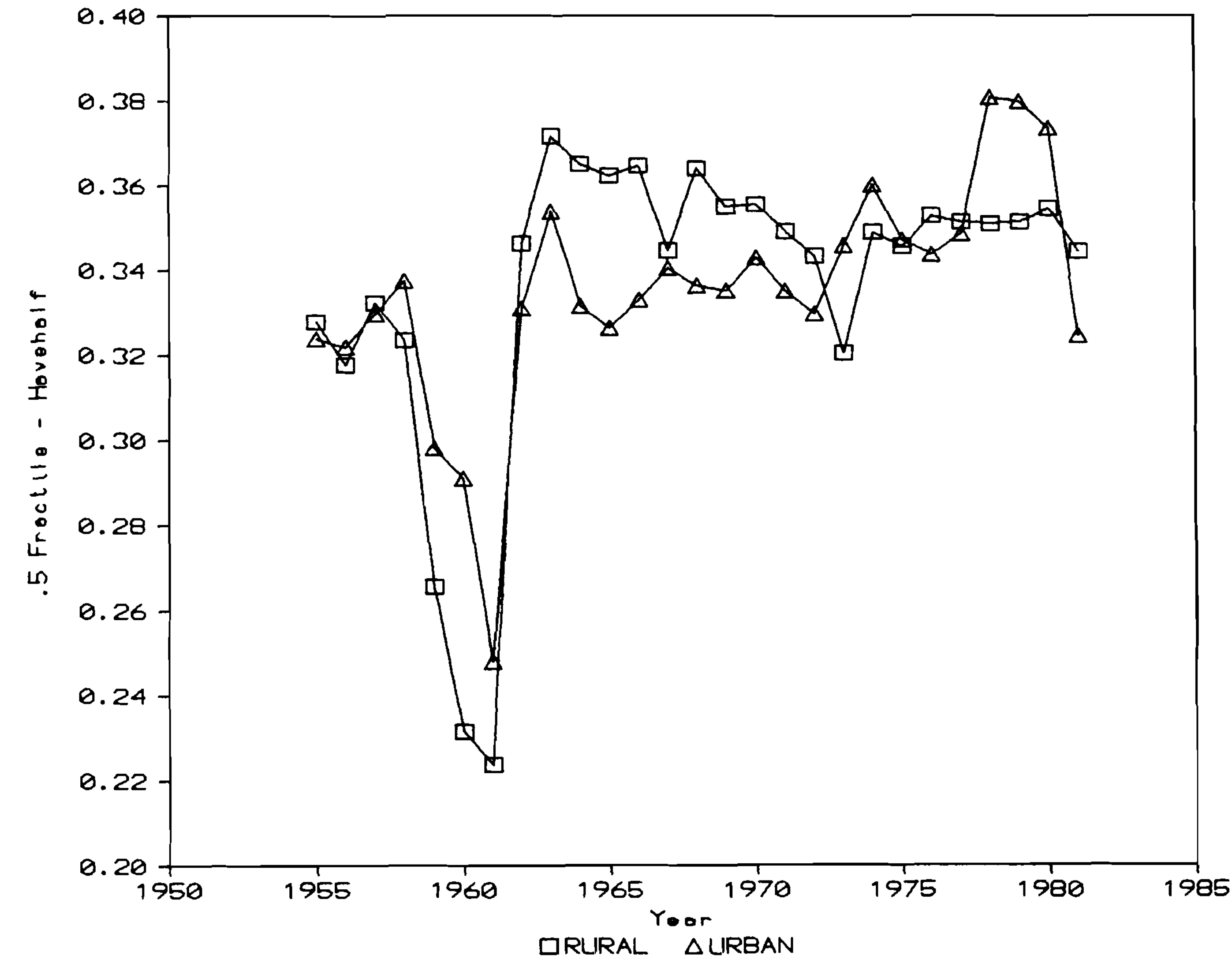
Table 12. Mean family sizes and concentration of fertility in China, 1955-1981.

	Total			Rural			Urban		
Year	Mean/ Woman	Mean/ Child	Havehalf	Mean/ Woman	Mean/ Child	Havehalf	Mean/ Woman	Mean/ Child	Havehalf
1955	6.99	8.14	0.33	7.08	8.19	0.33	6.36	7.70	0.32
1956	6.53	7.92	0.32	6.56	7.94	0.32	6.36	7.74	0.32
1957	7.02	8.08	0.33	7.04	8.11	0.33	6.79	7.89	0.33
1958	6.35	7.65	0.33	6.39	7.71	0.32	6.09	7.29	0.34
1959	4.57	6.54	0.27	4.55	6.62	0.27	4.60	6.10	0.30
1960	3.77	5.94	0.24	3.62	5.94	0.23	4.31	5.80	0.29
1961	2.88	4.86	0.23	2.86	4.88	0.22	3.05	4.74	0.25
1962	6.12	7.19	0.34	6.30	7.34	0.35	5.16	6.24	0.33
1963	7.83	8.27	0.37	7.95	8.34	0.37	6.89	7.77	0.35
1964	7.13	7.88	0.36	7.38	8.02	0.36	5.28	6.32	0.33
1965	6.37	7.33	0.35	6.92	7.72	0.36	3.91	4.77	0.33
1966	6.11	7.07	0.35	6.80	7.57	0.36	3.29	4.05	0.33
1967	5.20	6.30	0.35	5.83	6.84	0.34	3.20	3.83	0.34
1968	5.95	6.86	0.35	6.45	7.24	0.36	4.00	4.77	0.34
1969	5.64	6.62	0.34	6.06	6.94	0.35	3.79	4.59	0.34
1970	5.72	6.71	0.34	6.15	7.04	0.36	3.61	4.33	0.34
1971	5.36	6.39	0.34	5.79	6.72	0.35	3.23	3.90	0.34
1972	4.93	5.97	0.33	5.33	6.29	0.34	3.09	3.73	0.33
1973	4.57	5.55	0.33	4.66	5.80	0.32	2.93	3.45	0.35
1974	4.28	5.10	0.34	4.65	5.43	0.35	2.61	3.03	0.36
1975	3.83	4.59	0.34	4.15	4.88	0.35	2.41	2.84	0.35
1976	3.55	4.23	0.34	3.85	4.49	0.35	2.23	2.63	0.34
1977	3.29	3.92	0.34	3.53	4.14	0.35	2.17	2.55	0.35
1978	3.21	3.79	0.34	3.43	3.99	0.35	2.12	2.42	0.38
1979	3.22	3.81	0.34	3.43	4.00	0.35	2.00	2.31	0.38
1980	2.72	3.23	0.35	2.93	3.41	0.35	1.62	1.89	0.37
1981	2.66	3.25	0.33	2.92	3.47	0.34	1.62	1.89	0.37

variation in the distribution remained almost stable or, in other words, that the fertility decline affected practically all Chinese women and not only certain segments of the population as it is usually observed in less developed countries (see next section).

Another consequence of the observed trends in concentration is that the mean *sibship*, i.e. the mean family size from the child's perspective, declined even more strongly than the mean from the women's perspective, from 8.14 in 1955 to 3.23 in 1980. Only during the extraordinary fertility decline of 1959-1961 did the mean from the children's perspective decline much less than from the women's perspective because of simultaneously increasing concentration. By 1981 the mean family size from the children's perspective had declined to the very low value of 1.57 in the cities of China. This is probably the lowest value of any sizable population in

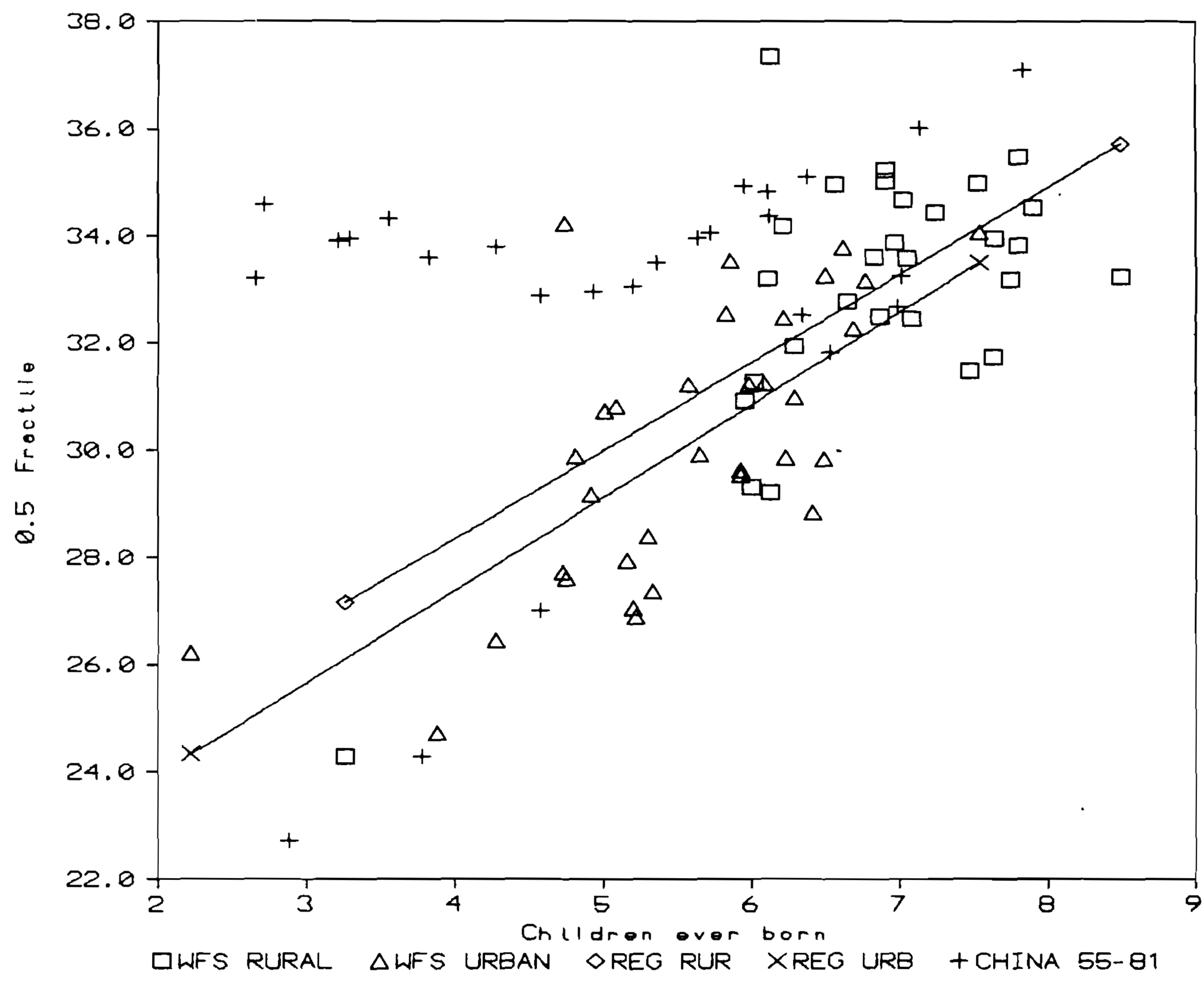
Figure 21. Trends in the concentration of fertility for urban and rural China, 1955-1981.



the whole world including the very low fertility cities of Western Germany. The reason for this record is that even in a modern industrialized city where the total fertility rate might be lower than in Chinese cities, the mean family size from the children's perspective is greater because of higher concentration: this is mainly a consequence of high proportions of women expected to remain childless (generally more than 30%) in European cities. In sharp contrast to this the parity-specific fertility pattern of urban China in 1981 implies that only 1.4% of all women remain childless.

How does the Chinese experience relate to patterns of demographic transitions described in the previous section? Figure 22 shows the association between the average level of fertility and concentration for urban and rural populations in the WFS countries (such as in Figure 16) and superimposes the same relationship for China for 1955-1981.

Figure 22. Relationship between mean completed family size and the concentration of fertility for a cross-section of LDC's and China, 1955-1981.



As discussed above, for the cross-section of less developed countries at different stages of their demographic transition the association is clearly negative: the lower the level of fertility the higher the concentration in the distribution of children. This pattern holds for urban populations and rural populations independently. When the Chinese experience is superimposed to this pattern (as it is done in Figure 22 by the "+" symbols) it becomes clear that the development up to around 1970 follows pretty much the general pattern but then deviates greatly from it: The Chinese experience of the late 1950s fits well into the pattern of rural high fertility societies. Even the very steep fertility decline of 1959-1961 (the "+"s in the lower left corner of Figure 22) followed the cross-sectional pattern of countries that had entered their secular fertility declines. Between 1962 and around 1970 the Chinese association between fertility levels and concentration lies close to the bulk of other countries and slightly above them, i.e. has somewhat lower concentration for the given level of fertility. After 1970, however, the decline in Chinese fertility levels is not associated with increased concentration and the trend (in the upper left corner of Figure 22) deviates grossly from the general cross-sectionally observed pattern. It also deviates significantly from the time-series of some other countries discussed above.

Why is the Chinese pattern of parity-specific fertility decline so completely different from that observed in any other population? A strictly demographic answer would be that relative variation in the distribution did not increase because the decline affected all segments of the population to a similar extent. The fact that the decline was not strictly proportional (in that case concentration would remain unchanged) was counteracted by the fact that in the Chinese culture every woman seems to want at least one child and childlessness remained extremely low. More generally, it might be said that this extraordinary development was clearly a consequence of the Chinese policy of birth control, a policy that despite its problems seems to have been very successful and brought about a surprisingly egalitarian fertility pattern.

5. CONCENTRATION OF MARITAL FERTILITY IN EUROPE AND THE USA IN THE 1970s: A WFS PERSPECTIVE

5.1. Socio-Economic Differential Concentration

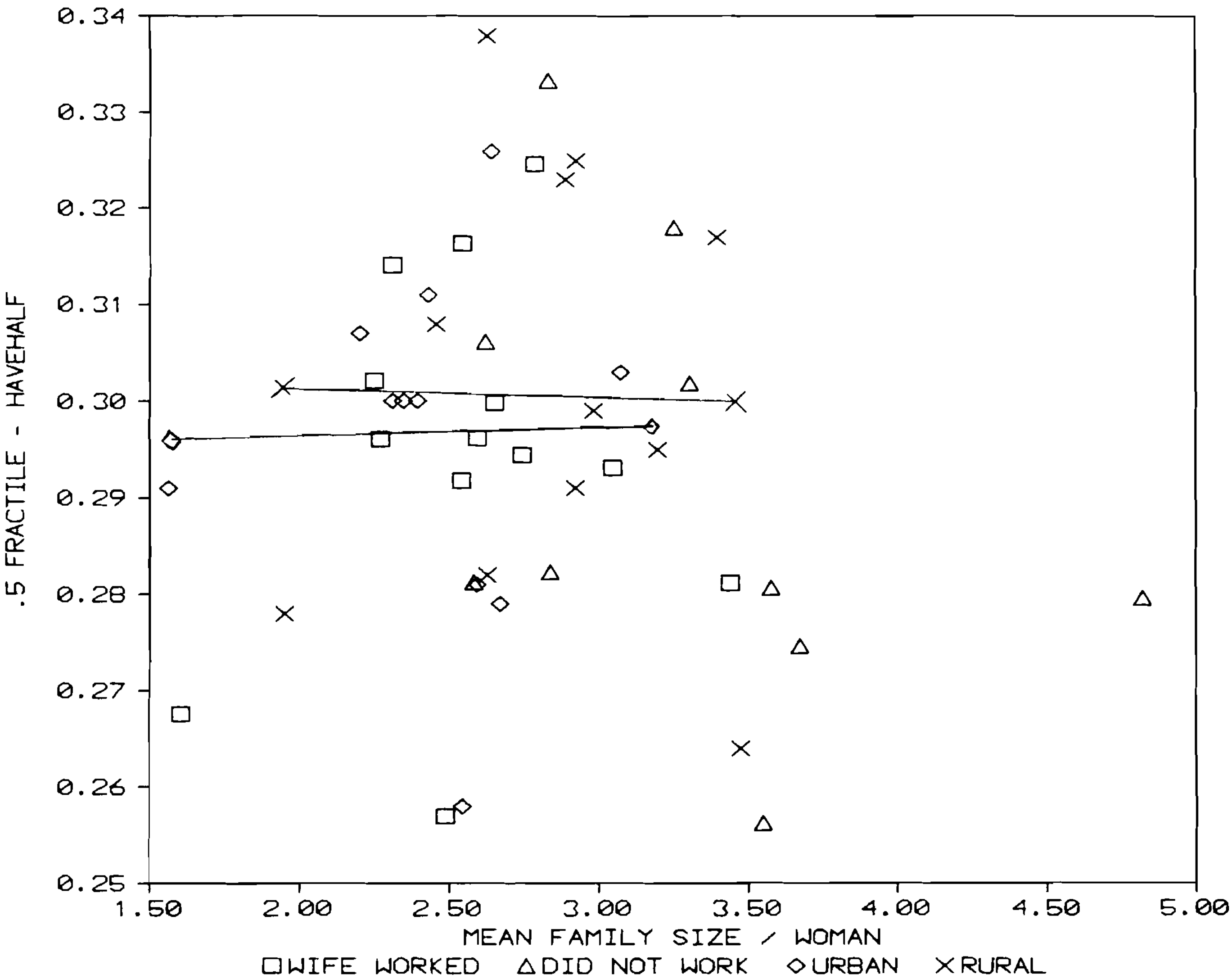
For countries that have essentially completed their demographic transition the pattern of differentials in the concentration of reproduction may be expected to differ from those in natural fertility societies or populations in the process of the fertility transition. In section 3 we already saw a reversal of the otherwise consistent positive association between the .5 fractile and the level of fertility for urban/rural differentials in Portugal. This was a first hint to a possibly different pattern in low fertility countries. In modern contraceptive societies, differential fecundability plays only a minor role in causing variation in the distribution of children ever born. When—at least theoretically—everybody has access to relatively convenient methods of birth control, the determinants of unevenness in the distribution lie in differential intentions and desires.

In most cases the European World Fertility Surveys[5] included only ever-married women in their samples. This is important to be kept in mind because in Europe the proportion of women that do not marry is high (up to around 30%) and despite the high incidence of non-marital fertility average fertility of unmarried women is still much lower than that of married women. Especially the proportion childless is expected to be very high among unmarried women. On the other hand, the distribution of reproduction among married couples is relatively even for the cohorts observed in the European World Fertility Surveys. On the average, concentration analysis shows that about 30% of all married women had half the number of children ever-born to all married women beyond age 40.

Despite the seemingly weak heterogeneity among married couples in European countries and the US after the post-World War II baby boom, socio-economic differentials in fertility patterns may be detected: with respect to the woman's place of residence it appears that for all countries considered, the average family size per woman is higher in rural areas than in cities. The differentials range from more than one child difference in Poland to less than .1 in Belgium (see Table 13b). From the children's perspective (Table 14b) in Belgium, the mean family size be-

[5]This study is based on data extracted from the standard recode files at ECE in Geneva. The author is grateful for the permission to use those data.

Figure 23. Relationship between mean family size per woman and .5 fractile for ever-married women aged 40-44 in 143 WFS countries by place of residence and work status.



comes even larger in urban areas than in rural villages. The reason for this inverse relationship lies again in the differential extent of concentration in the distribution of completed parities. In all countries except for Yugoslavia, Norway, and the Netherlands rural concentration is lower than urban. In contrast to the negative association between the level of fertility and its distribution during the demographic transition in most countries, Figure 23 shows that for Europe in the mid-1970s the regression line is almost horizontal for urban and rural populations.

Table 13a. Mean family sizes per woman for ever-married women aged 40-44 in 13 WFS countries by highest completed education.

Country	Incomplete elementary	Complete elementary	Low secondary	High secondary	Post secondary
Belgium		2.52	2.77	2.10	2.44
Czechoslovakia	4.25	2.56	2.49	2.01	1.81
Denmark		2.62	2.52	2.19	2.84
Finland	3.87	2.90	2.41	2.36	2.08
France	3.42	2.57	2.43	2.38	2.16
Great Britain	3.33	2.79	2.52	2.46	2.52
Italy	3.08	2.29	2.09	1.92	1.87
Netherlands		1.85	1.65	1.40	1.75
Norway		3.16	2.68	2.59	2.69
Poland	3.80	2.96	2.53	2.11	1.77
Spain	3.22	2.90	3.24	3.03	3.39
United States	4.32	4.08	3.24	3.33	2.92
Yugoslavia	3.29	2.39		1.97	1.59

Table 13b. Mean family sizes per woman for ever-married women aged 40-44 in 13 WFS countries by place of residence and work status.

Country	Rural	Urban	Ever worked	Never worked
Belgium	2.63	2.54	2.49	2.84
Czechoslovakia	2.63	2.20	2.31	
Denmark	2.93	2.43	2.54	2.58
Finland	2.99	2.40	2.65	3.55
France	2.92	2.59	2.54	3.58
Great Britain			2.60	2.83
Italy	2.46	2.31	2.25	2.62
Netherlands	1.95	1.56	1.61	
Norway	2.89	2.64	2.79	
Poland	3.40	2.35	2.75	3.31
Spain	3.20	3.07	3.05	3.26
United States			3.44	4.82
Yugoslavia	3.48	2.67	2.27	3.67

For female work status the appearing pattern is similar to that of place of residence. If a woman had never worked in her life her mean family size is likely to be above average in all countries considered. The causal relationship underlying this association is not always clear: it may be that some women are oriented towards being housewives and have more children because of this or that women who have many children cannot work even if they would like to do so. This pattern also varies greatly from one country to another. In Finland, for instance, where almost all women ever-worked, the differential is highest because the group of not work-

Table 14a. Mean family sizes from children's perspective in 13 WFS countries born to ever-married women aged 40-44 by highest completed education.

Country	Incomplete elementary	Complete elementary	Low secondary	High secondary	Post secondary
Belgium		3.75	3.84	3.10	3.40
Czechoslovakia	5.59	3.28	3.10	2.45	2.23
Denmark		3.45	3.32	2.50	3.33
Finland	4.76	3.92	3.11	3.11	2.69
France	4.82	3.45	3.37	2.99	2.71
Great Britain	4.20	3.67	3.41	3.30	3.23
Italy	4.16	2.99	2.58	2.45	2.58
Netherlands		2.63	2.45	2.14	2.43
Norway		3.94	3.26	3.26	3.21
Poland	4.79	3.82	3.24	2.68	2.27
Spain	4.26	3.69	4.17	3.83	4.05
United States	6.24	5.67	5.31	4.39	3.67
Yugoslavia	4.62	3.17		2.43	1.94

Table 14b. Mean family sizes from children's perspective in 13 WFS countries born to ever-married women aged 40-44 by place of residence and work status.

Country	Rural	Urban	Ever worked	Never worked
Belgium	3.53	3.87	3.81	3.85
Czechoslovakia	3.21	2.88	2.96	
Denmark	3.64	3.18	3.29	3.68
Finland	3.64	3.26	3.57	5.08
France	3.92	3.66	3.48	4.85
Great Britain			3.50	3.41
Italy	3.26	3.14	2.97	3.56
Netherlands	2.90	2.26	2.40	
Norway	3.56	3.33	3.46	
Poland	4.27	3.16	3.71	4.39
Spain	4.25	4.04	4.11	4.14
United States			4.82	6.45
Yugoslavia	4.88	3.76	3.04	5.01

ing women is highly selective.[6] In other countries—like Spain—where great proportions of women are housewives, the differentials between the groups of women are much less. The pattern of concentration with respect to female work status is also quite uneven across countries. In Denmark and Yugoslavia concentration among

[6]In some countries the number of women in the "never worked" category was so small that no reasonable figures could be achieved. Those cases are omitted from the table.

Table 15a. .5 fractile (*Havehalf*) for ever-married women aged 40-44 in 13 WFS countries by highest completed education.

Country	Incomplete elementary	Complete elementary	Low secondary	High secondary	Post secondary
Belgium		0.26	0.28	0.27	0.28
Czechoslovakia	0.31	0.32	0.32	0.35	0.35
Denmark		0.31	0.31	0.36	0.33
Finland	0.32	0.29	0.32	0.31	0.31
France	0.27	0.29	0.30	0.33	0.34
Great Britain	0.33	0.29	0.30	0.31	0.31
Italy	0.29	0.31	0.33	0.32	0.29
Netherlands		0.27	0.26	0.28	0.31
Norway		0.32	0.33	0.32	0.34
Poland	0.31	0.30	0.32	0.33	0.34
Spain	0.30	0.32	0.31	0.31	0.34
United States	0.25	0.28	0.28	0.30	0.32
Yugoslavia	0.27	0.31		0.35	0.38

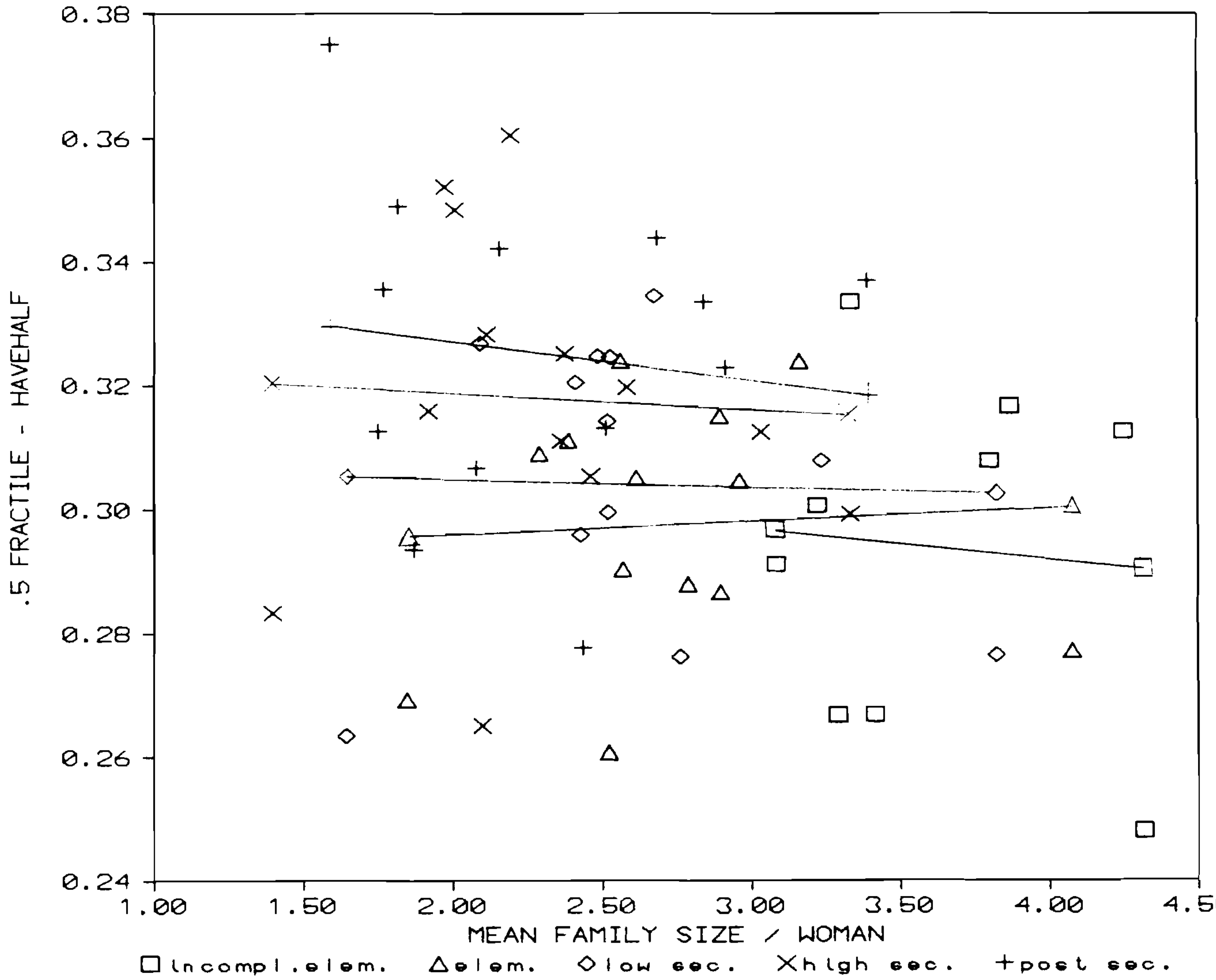
Table 15b. .5 fractile (*Havehalf*) for ever-married women aged 40-44 in 13 WFS countries by place of residence and work status.

Country	Rural	Urban	Ever worked	Never worked
Belgium	0.28	0.26	0.26	0.28
Czechoslovakia	0.34	0.31	0.31	
Denmark	0.32	0.31	0.32	0.28
Finland	0.30	0.30	0.30	0.26
France	0.29	0.28	0.29	0.28
Great Britain			0.30	0.33
Italy	0.31	0.30	0.30	0.31
Netherlands	0.28	0.29	0.27	
Norway	0.32	0.33	0.32	
Poland	0.32	0.30	0.29	0.30
Spain	0.30	0.30	0.29	0.32
United States			0.28	0.28
Yugoslavia	0.26	0.28	0.30	0.27

never-working women is highest, whereas in Belgium and Great Britain it is higher among women that had once been working. We may assume that these differentials are largely a function of differential selectivity to the respective groups in various countries.

For educational differentials the pattern is much clearer (see Tables 13a-15a and Figure 24). Generally, the higher the mean family size per woman, the lower the educational category. For several countries, however, the highest educational

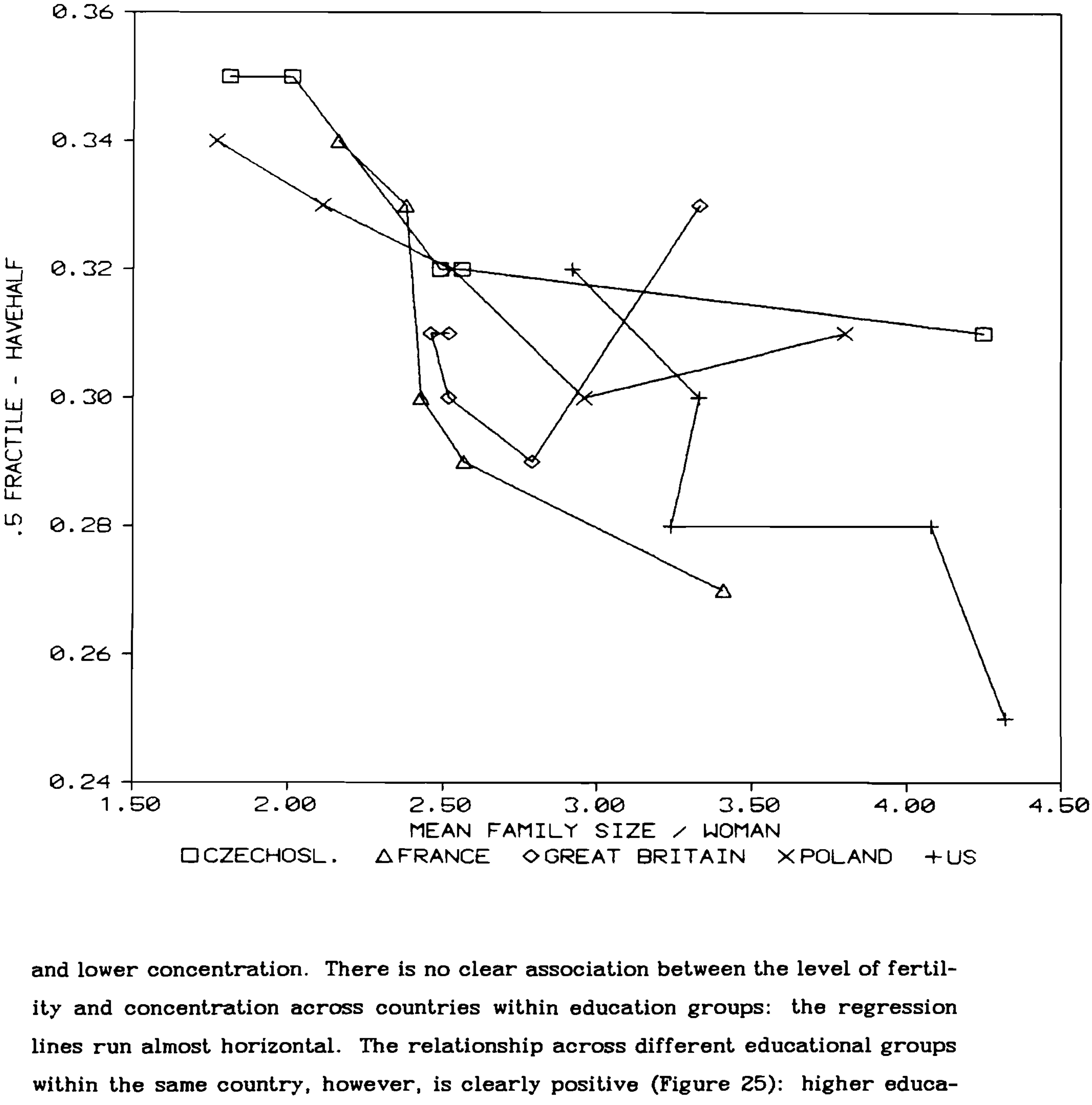
Figure 24. Relationship between mean family size per woman and .5 fractile for ever-married women aged 40-44 in 143 WFS countries by highest completed education.



category—women with post-secondary training—exhibits again increasing fertility levels. This U-shape of the mean family size with respect to education appears in Belgium, Denmark, Great Britain, the Netherlands, Norway, and Spain. From the children's point of view this U-shape disappears or is greatly reduced for most of the countries mentioned because generally the variation is somewhat less in the highest educational categories than in lower educational groups.

Again, the pattern is very different for each country, but on the average Figure 24 brings out some clear patterns: the regression lines indicate that on the average higher education means lower family size (except for the highest group)

Figure 25. Relationship between mean family size per woman and .5 fractile for different educational groups within Czechoslovakia, France, Great Britain, Poland, and the US.



and lower concentration. There is no clear association between the level of fertility and concentration across countries within education groups: the regression lines run almost horizontal. The relationship across different educational groups within the same country, however, is clearly positive (Figure 25): higher education associated with lower average family size results in lower concentration. This pattern is very clear in France and Czechoslovakia, but is also approximated by most other countries. This observed relationship means a reversal of the clear negative association between concentration and the level of fertility observed for populations in the process of the secular fertility transition.

Why, in a modern society with good availability of contraceptive methods, does lower fertility also mean lower relative variance in the distribution? In the following section we will approach this question by focusing on the question of differential use and efficiency of contraception and its consequence on the concentration of reproduction.

5.2. Birth Control and Concentration

It was already hinted that the key to the understanding of socio-economic differentials in the variation of the distribution of completed family size might be found in differential use of contraception. This brings us down to the level of proximate fertility determinants. There is no doubt that at the level of proximate determinants, besides the effect of differential fecundability and marriage, all variation in the distribution of children ever born is due to differential use of contraception or abortion. The problem is to measure birth control in a way that is relevant to the explanation of completed parity. This turns out to be a very difficult task because it is strongly related to the timing of births. A few short periods without contraception during the long potentially reproductive span of a woman are enough to produce a few births regardless of current use or ever-use of specific methods measured by a survey. Hence, the two usually measured indicators of contraceptive use, ever-use and current use, can only partly explain the *how*, and to an even much lesser extent, the *why* of the resulting completed parity distribution.

5.2.1. Concentration and Current Use of Contraception in Spain and Po-Poland

Data from the European World Fertility Survey make it possible to focus explicitly on the effect of contraceptive use on the distribution of reproduction. The data refer to ever-married women up to age 45. The three categories of contraceptive use predefined by WFS are: efficient methods, inefficient methods, and no methods. For most of the countries this information is available for current use of contraception as well as for ever-use.

When studying the relationship between contraceptive use and concentration of fertility, the idea is that the female population is broken down into subpopulations that might differ from the total in terms of the concentration of reproduction. For less developed countries the expectation--based on the previous analysis—is that the subpopulation of women that does not use contraception has higher average fertility and shows a lower degree of concentration than the total. For the users of modern contraceptive methods the result is expected to depend largely on the distribution of desired family sizes.

Table 16. Concentration and current use of contraception in Poland and Spain (only women with no additional children expected).

Method	Age group	n	Mean number of children ever born	0.5 fractile (*Havehalf*)
		Poland		
Efficient method	40-44	(361)	2.43	0.32
Inefficient method	40-44	(851)	2.85	0.32
No method	40-44	(417)	3.04	0.27
Efficient method	35-39	(400)	2.49	0.34
Inefficient method	35-39	(828)	2.75	0.34
No method	35-39	(282)	2.85	0.28
		Spain		
Efficient method	40-44	(150)	3.51	0.34
Inefficient method	40-44	(410)	2.30	0.26
No method	40-44	(583)	3.01	0.30
Efficient method	35-39	(171)	2.23	0.28
Inefficient method	35-39	(354)	1.95	0.28
No method	35-39	(345)	2.74	0.31

For the analysis of current use of contraception we have to be cautious about including women that otherwise use efficient methods but at the time of the survey were trying to become pregnant. To avoid problems of this kind we restrict the analysis to women that do not want additional children. Table 16 presents data for Poland and Spain for women aged 40-44 and 35-39 at the time of the survey. These two countries were selected because both have relatively high proportions of women using no method or inefficient methods but exhibit quite different fertility patterns.

At first sight it seems counterintuitive that in Spain women using efficient contraceptive methods have, on the average, higher fertility than all other women. This pattern also appears for a number of other countries. A possible explanation for this paradox is that the difference in fertility levels is not so much caused by unwanted pregnancies but by differentials in the desire for children. Since in Spain only 12% of the women aged 40-44 used efficient methods we might assume that this is some kind of elite that also wanted more children than other strata of the population. These women also show the lowest concentration of fertility indicating a rather small proportion of childless women and few women with very high fertility. This again indicates planned fertility. In Spain the highest concentration of fertility is found among women that use inefficient methods.

The Spanish picture is quite different from the Polish one, where the highest concentration is found among women that use no contraception. An answer to this discrepancy might be found in selectivity. In Spain more than half of the women were in the group using no method, whereas in Poland it is only a quarter. Comparative analysis of subfecundability also shows that when the group of non-users in a society becomes smaller, the proportion of women in that group that do not use contraception (because of subfecundability or sterility) increases. Hence the group of non-*contraceptors* tends to become increasingly heterogeneous as it shrinks: some women have very high fertility because they do not limit their family size and others have very low fertility because they are subfecund. Other problems arise when analyzing the number of children ever-born to women currently using efficient methods. These women might have started the use of efficient methods fairly recently because the availability and social acceptance of such methods changed in recent years. If we study ever-use of contraception instead of current use, the differentials should, to a lesser extent, be affected by selectivity.

5.2.2. Ever-Use of Contraception in Eight European Countries

Since it is not influcnced by current circumstances, ever-use is a better indicator of a woman's attitude towards birth control at a time when it was relevant for her level of fertility. For eight European countries we have the distribution of children ever-born by age groups of ever-married women and by ever-use of contraception. The mean completed family sizes (for women aged 40-44) range from 1.92 in the Netherlands to 2.32 in Spain. The other countries, namely Belgium, Great Britain, Hungary, Italy, Norway, and Poland have mean completed family sizes between 2.5 and 2.9.

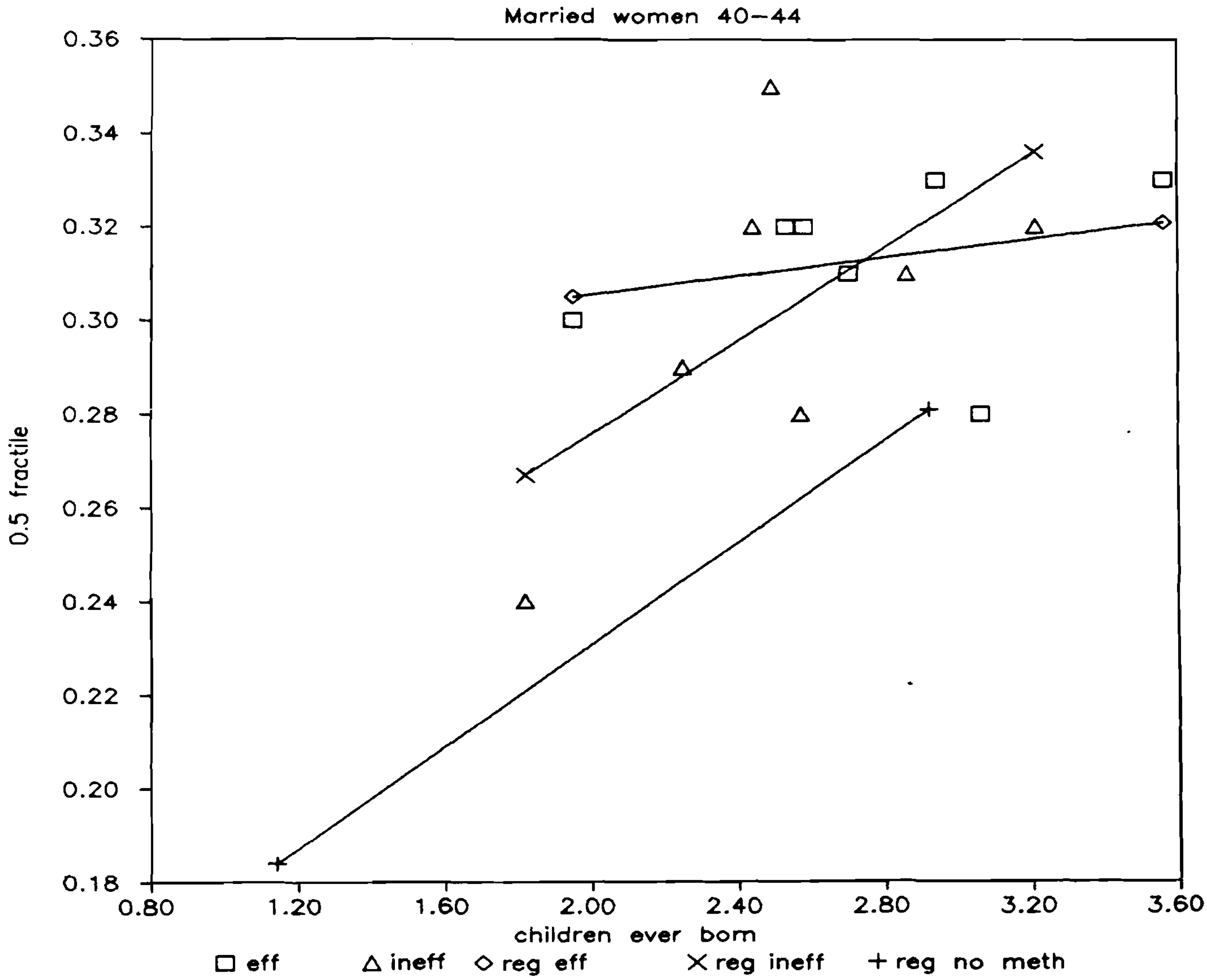
Figure 26 shows the relationship between the mean number of children ever-born and the .5 fractile in the distribution of children for women aged 40-44 (the oldest age group in the European WFS surveys) in all countries except Hungary (which has no data for age group 40-44). The three lines indicate the regression lines for the bivariate relationships of women using efficient, inefficient, or no contraception. Again, the group of women without any use of contraception is the highest concentrated one, for the reasons discussed above. The international comparison suggests that the lower the proportion of women that do not use contraception, the higher the proportion of subfecund women among them, which results in a lower level of average fertility and higher concentration. This is most extreme in Belgium.

It is interesting to notice that the regression line for women using inefficient methods is parallel to that of women using no methods whereas the line for women that had ever used efficient methods in their life is almost horizontal. In other words, for the population of women that used modern means of contraception changes in the average level of fertility do not bring about any significant change in the extent of concentration. The main reason for this is that the range of completed parities is much smaller for these "modern" women than for women using traditional methods. This corresponds to the finding (see Gisser et al. 1985) that the distribution of desired family sizes shows much less variance than the distribution of actual family sizes. And for women that use efficient contraceptive methods actual family size is more likely to correspond to desired family size.

5.3. The Distribution of Expected Family Size

Looking at the distribution of expected family size differs from the previous study of completed cohort fertility in two important aspects: it includes the women's own intention making it an indicator of higher psychological interest but at the same time making it not necessarily congruent with reality; secondly, the analysis of completed cohort fertility so far had the disadvantage that women had to be beyond a certain critical age (at least age 40 in our study) and hence the bulk of children studied here was born more than 20 years before the survey, which in the case of WFS means even before the peak of the baby boom in most countries. For this reason it seems desirable to use models that allow us to study the fertility of more recent cohorts. One such method that will be applied in the

Figure 26. Relationship between the mean number of children ever born and the concentration of the distribution for women ever using efficient, inefficient, or no methods in Belgium, Great Britain, Italy, the Netherlands, Norway, Poland, and Spain.



next section is to estimate completed parity distributions for synthetic cohorts. Another way is to stick to the analysis of real cohorts and estimate the still incomplete reproductive performance up to the age of 45 or 49. Yet another approach that is only viable in surveys, is to take the women's own statement on expected family sizes as an estimator of future fertility. The analysis in Figure 27 is based on this approach.

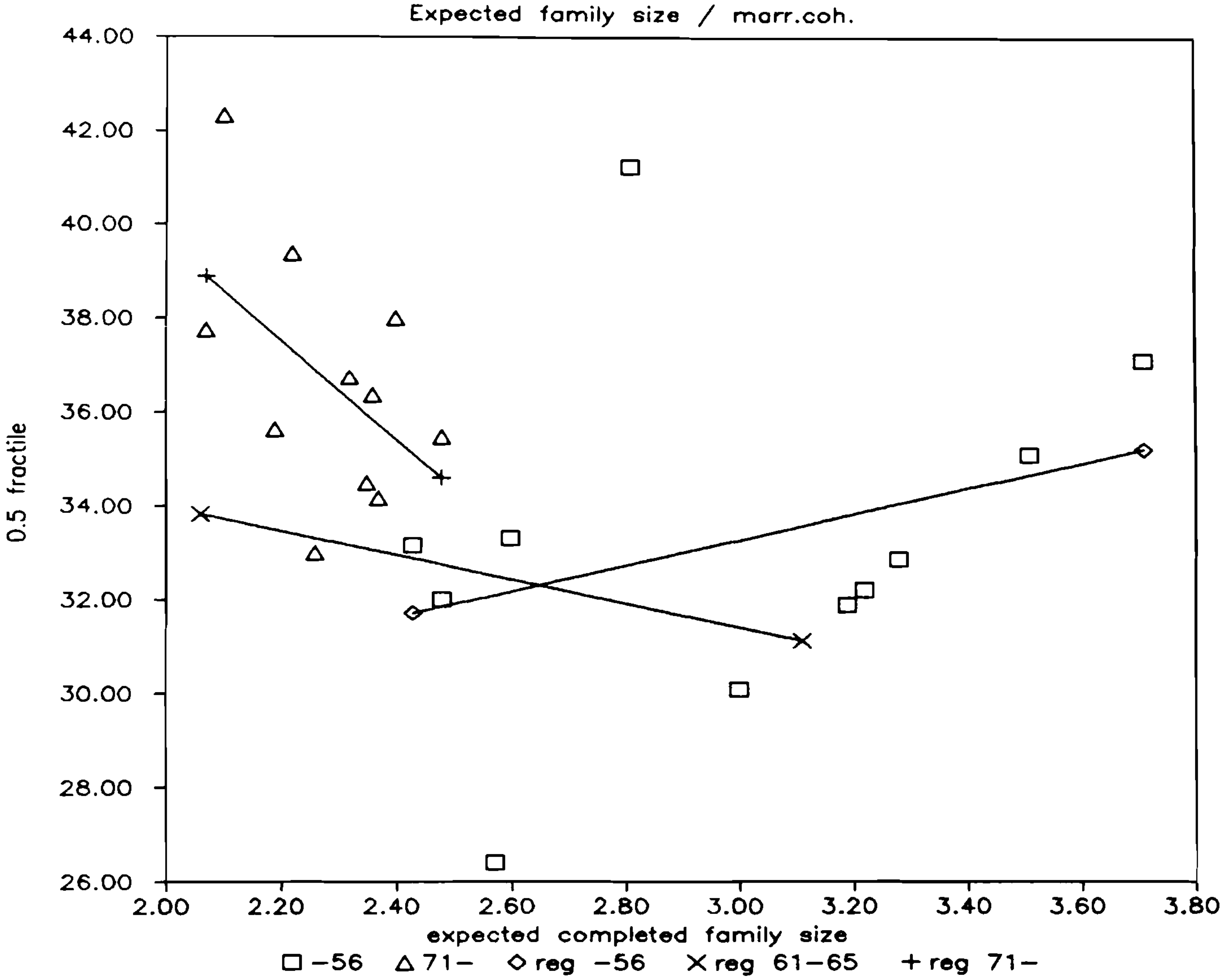
Table 17. Mean family sizes and concentration of parity distribution for women aged 40-44 in 7 European countries by ever-use of contraception.

	Country	Mean/mother	Mean/child	.5 fractile
Wife ever-used efficient method	Belgium	3.06	4.29	0.28
	Great Britain	2.70	3.50	0.31
	Italy	2.58	3.34	0.32
	Netherlands	1.95	2.55	0.30
	Norway	2.94	3.56	0.33
	Poland	2.53	3.24	0.32
	Spain	3.56	4.39	0.33
Wife ever-used inefficient method	Belgium	2.25	3.24	0.29
	Great Britain	2.57	3.70	0.28
	Italy	2.44	3.12	0.32
	Netherlands	1.82	2.70	0.24
	Norway	2.49	2.96	0.35
	Poland	2.86	3.66	0.31
	Spain	3.21	4.02	0.32
All women together (incl. no use)	Belgium	2.55	3.82	0.26
	Great Britain	2.60	3.50	0.30
	Italy	2.38	3.19	0.30
	Netherlands	1.69	2.46	0.27
	Norway	2.78	3.46	0.32
	Poland	2.78	3.76	0.29
	Spain	3.12	4.12	0.30

Like Figures 25 and 26, Figure 27 plots the relationship between average completed family size and the coefficient of concentration, the .5 fractile. The analysis is based on expected family size distributions for ten European WFS countries and three selected marriage cohorts: women who married before 1956, between 1961 and 1965, and after 1971.

As has been mentioned above, expected family size distributions tend to be much more even than actual empirical distributions. This is because almost no married couples want to remain childless and very few want to have more than four children. Consequently the concentration figures are very low, ranging from 30% to 43% of all women having half the children. Figure 27 also reveals a clear change in the structure of the relationship over time. For the earlier marriage cohorts the negative association between fertility and concentration appears which we found before in the case of completed cohort fertility. But already for women married after 1960 the association is reversed. This trend continues and for women married after 1971 the cross-sectional pattern shows lower concentration associ-

Figure 27. Relationship between average expected family size and concentration for cohorts of women that married before 1956, 1961-1965, and after 1971 in 10 European WFS countries.



ated with lower fertility. For younger cohorts the range of expected family sizes seems to have become smaller.

6. THE CONCENTRATION OF OVERALL FERTILITY IN AUSTRIA

So far the analysis has focused on marital fertility. This was mainly determined by the design of WFS which did not include unmarried women. The major difference between unmarried and married women with respect to concentration analysis is that the prevalence of completed parity zero is much higher among unmarried women. For this reason any analysis of overall fertility tends to result in higher concentration coefficients than for marital fertility.

Table 18a presents fertility and concentration measure for cohorts of Austrian women born between 1921 and 1945. Because the survey was taken in 1981 only births up to age 35 could be considered. To make the figures comparable across cohorts this age limit was kept for all birth cohorts. For these 25 years which in general cover the period from immediately after the war to shortly after the peak of the baby boom, the concentration of reproduction decreased significantly. One major reason for this was the strong decrease in childlessness. Almost a quarter of all women born 1921-1925 remained childless up to age 35, whereas for the cohort born 1941-1945 the comparable figure is only 12%. This phenomenon has been observed throughout Europe, and in all countries studied the baby boom had been accompanied by a more even distribution of fertility and hence lower concentration.

Table 18b refers to more recent fertility experience by constructing completed parity distributions for synthetic cohorts based on parity-specific fertility rates. The estimation was done by the means of a fertility table based on parity (see Lutz and Feichtinger 1985). The rates were calculated from a retrospective survey and pertain to the average of the years 1977 to 1980. For all Austrian women the estimates of completed parity distributions under the assumption of constant parity-specific behavior indicate that 28% of the women will remain childless and about one third will end up with two children. Only less than one percent of all women will have six or more children.

This distribution results in a mean number of children per woman of 1.62 and a 0.5 fractile of 0.23, i.e. a proportion of 23% of all women having half the children. This degree of concentration is significantly higher than that for cohorts participating in the baby boom. Our estimation shows that the concentration of completed parity implied by the behavior of 1977-1980 will be equivalent to that of the birth cohorts born in 1926-1930 although the distributions are quite different: for the 1926-1930 cohort the relative variance originated to a higher extent from women with larger families than for current period fertility where the high proportion of

Table 18a. Concentration of fertility for cohorts of Austrian women (married and unmarried) born in 1921-1925 to 1941-1945 (births up to age 35).

Cohorts born	Mean number of children per woman	Percentage of childless women	0.5 fractile (*Havehalf*)
1921-1925	1.65	24.1	0.21
1926-1930	1.82	20.4	0.23
1931-1935	2.01	16.2	0.26
1936-1940	2.15	12.2	0.28
1941-1945	2.03	12.0	0.27

Source of data: Haslinger (1985).

Table 18b. Concentration of fertility by educational groups for synthetic cohorts of Austrian women, 1977-1980. Estimates based on period parity-specific fertility rates.

	Mean number of children per woman	Percentage of childless women	0.5 fractile (*Havehalf*)
Austria total	1.62	27.9	0.23
Highest education:			
Primary school	1.62	33.6	0.22
Vocational school	1.62	20.6	0.27
Secondary school	1.52	28.2	0.22
University	1.95	34.0	0.19

Source of data: Lutz (1985).

childless women plays a crucial role.

Breakdowns of the Austrian female population by the highest completed education reveal an interesting pattern. Fertility is least concentrated for women that went to a vocational school because of the relatively low proportion (20%) of childless women in that group. It is most concentrated among women with university degrees. Although we have to be cautious because of the small number of such women in the sample (n = 252), we find that women with university training show an almost dichotomous behavior: on the one hand, they have the highest percentage of childlessness (34%) among all groups; on the other hand, once they decide to have children, they have significantly more than average. This results in a concentration coefficient indicating that 19% of all women have half the children.

The results for overall period fertility in Austria hence may lead to the assumption that recent fertility patterns, again, show a somewhat higher degree of concentration than during the time of the post-World War II baby boom. This increase in relative variance is not due to some segments of the population with increased fertility but it is a consequence of greater proportions of childless women.

7. CONCLUSIONS

We found that until a certain late stage of the demographic transition process, lower fertility is associated with a higher degree of concentration of reproduction among women. The most likely explanation for this empirical finding is that the introduction of birth control into a fertility regime that used to be determined mainly by fecundability tends to increase the relative variance in the distribution. All of the 41 WFS countries studied in section 3 seem to follow a trend towards the case of Portugal that has the lowest fertility and the highest concentration. But already in Portugal rural/urban differentials indicate a reversal of the otherwise consistent positive association between the *havehalf* and the mean number of children per woman.

Portugal already shows the "new" pattern that is found in all modern European societies. In our societies the distribution of family size desires has gained a leading role in determinating concentration. And since the distribution of desire of family sizes is typically rather even in modern societies, this tends to result in lower concentration if desire and reality are not too far apart. Hence contraception still plays an important instrumental role. Without contraception (and possibly abortion as another means of birth control) actual fertility would deviate substantially from the rather homogeneous desired family size distribution. In other words, birth control in certain segments of society leads first to increased concentration, but once contraception becomes almost universal and highly efficient concentration tends to decline because of an approximation of actual family size to desired family size, at least from the side of excess fertility. Subfecundity and involuntary childlessness--further reasons for increased concentration--on the other hand, are not directly linked to contraception. Hence, the future trend of concentration in reproduction will largely depend on two factors: the prevalence of voluntary and involuntary childlessness.

What are the consequences of concentration of reproduction among women on individuals and the society as a whole? We may distinguish between demographic and non-demographic consequences. As discussed above, under a demographic perspective higher concentration leads to a higher difference between mean family sizes for mothers and mean family sizes for children. The mean size of the *sibship* from which children come is always greater than or equal to the mean number of children per mother because large families get greater weight when calculating the mean *sibship* and childless women are not counted at all. If we assume that the size of one's family of origin has implications for one's socialization, the consequences of concentration become far reaching. In the field of demographic consequences the assumption that mothers' and daughters' family sizes are positively correlated leads to the conclusion that a higher degree of concentration in the mothers' generation *ceteris paribus* should result in a higher mean fertility in the daughter's generation. This is because higher concentration at a given average level of fertility indicates that more girls come from larger families and hence their own fertility tends to be higher. This point is treated more extensively in Lutz and Wolf (1987).

Other non-demographic consequences of higher concentration and therefore different socialization in the family of origin reach all aspects of society and culture. It might well influence basic attitudes such as whether the majority of a generation will tend towards individualism or collectivism, etc. The distribution of reproduction at a given fertility level also has immediate consequences on the kind of housing demanded, on the usage of social benefits, on the distribution of wealth, and on the question of family support for the elderly. In the care for elderly it makes a tremendous difference if every woman had a certain number of children or if some women had all the children and others had none. This also has consequences for the flow of wealth from one generation to another and on the opportunities for upward social mobility if different social strata reproduce at different rates.

REFERENCES

Allison, P.D. (1978) Measures of Inequality. *American Sociological Review* 43:865-880.

Bruckmann, G. (1969) Einige Bemerkungen zur statistischen Messung der Konzentration. *Metrika* 14:183-213.

Bruckmann, G. (1981) Kapitel 26: Konzentrationsmessung. Pages 185-190 in *Statistik für Wirtschaftswissenschaftler*, 2nd edition, edited by J. Bleymüller, G. Gehlert, and H. Gülicher. Munich: Verlag Franz Vahlen.

Chiang, C.L. and B.J. van den Berg (1982) A Fertility Table for the Analysis of Human Reproduction. *Mathematical Biosciences* 62:237-251.

Cleland, J. and J. Hobcraft (eds.) (1985) *Reproductive Change in Developing Countries: Insights from the World Fertility Survey*. New York: Oxford University Press.

Crow, J.F. (1958) Some Possibilities for Measuring Selection Intensities in Man. *Human Biology* 30:1-13.

Easterlin, R. (1978) The Economics and Sociology of Fertility: A Synthesis. Pages 57-133 in *Historical Studies of Changing Fertility*, edited by Ch. Tilly. Princeton University Press.

Feeney, G. (1983) Population Dynamics based on Birth Intervals and Parity Progression. *Population Studies* 37(1):75-89.

Feeney, G. and J. Yu (1987) Period Parity Progression Measures of Fertility in China. *Population Studies* 41(1):77-102.

Foster, J.E. (1985) Inequality Measurement. In *Fair Allocation*, edited by H.P. Young. *Proceedings of Symposia in Applied Mathematics*, vol. 33, American Math. Society.

Gisser, R., W. Lutz, and R. Münz (1985) Kinderwunsch und Kinderzahl. Pages 33-94 in *Leben mit Kindern*, edited by R. Münz. Vienna.

Goodman, L., N. Keyfitz, and T. Pullum (1975) Addendum: Family Formation and The Frequency of Various Kinship Relationships. *Theoretical Population Biology* 8:376-381.

Goodwin, D., W. Lutz, and J. Vaupel (1986) Concentration and the Level of Fertility. Unpublished draft paper. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Goodwin, D. and J. Vaupel (1985) *Concentration Curves and Have-Statistics for Ecological Analysis of Diversity: Part III: Comparison of Measures of Diversity*. WP-85-91. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Haslinger, A. (1985) Fruchtbarkeitsentwicklung nach Heiratsjahrgängen: Ein Vergleich des Mikrozensus Juni 1981 mit der Longitudinalerhebung. Pages 227-291 in *Leben mit Kindern*, edited by R. Münz. Vienna.

Henry, L. (1961) Some Data on Natural Fertility. *Eugenics Quarterly* 18(2):81-91.

Herfindahl, O. (1950) Concentration in the Steel Industry. Dissertation, Columbia University.

Hobcraft, J. and J.B. Casterline (1983) Speed of Reproduction. *WFS Comparative Studies* No. 25. Voorburg, Netherlands: International Statistical Institute.

Lorenz, M.O. (1905) Methods of Measuring the Concentration of Wealth. *Journal of American Statistical Association*, Vol. 9.

Lutz, W. (1984) Die Entwicklung paritätsspezifischer Fruchtbarkeitskontrolle. *Zeitschrift für Bevölkerungswissenschaft* 10(4):449-462.

Lutz, W. (1985) Heiraten, Scheidungen und Kinderzahl. Demografische Tafeln zum Familien--Lebenszyklus in Osterreich (Marriage, Divorce, and the Number of Children. A Life Table Approach to the Analysis of the Family Life Cycle in Austria). Pages 3-21 in: *Demografische Informationen.*

Lutz, W. (1987) Birth Control and the Concentration of Fertility: A Study of Eleven European Countries. Paper prepared for the European Population Conference 1987 in Jyväskylä, Finland (submitted for publication in *European Journal of Population*).

Lutz, W. and G. Feichtinger (1985) A Life Table Approach to Parity Progression and Marital Status Transitions. Contributed paper to the IUSSP General Conference (Session F.13) in Florence, 1985.

Lutz, W. and D. Wolf (1987) Fertility and Marital Status Changes over the Life Cycle: A Comparative Study of Finland and Austria. Paper prepared for the European Population Conference 1987 in Jyväskylä, Finland.

Lutz, W. and A. Yashin (1987) *Comparative Anatomy of Fertility Trends: The Aging of the Baby Boom.* WP-87-12. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Münzner, H. (1963) Probleme der Konzentrationsmessung. *Allg. Stat. Archiv* 47:1-9.

Page, H. (1977) Patterns Underlying Fertility Schedules: A Decomposition by Both Age and Marital Duration. *Population Studies* 3(1).

Piesch, W. (1975) *Statistische Konzentrationsmasse: Formale Eigenschaften und Verteilungstheoretische Zusammenhänge.* Tübingen: J.C.B. Mohr.

Preston, S. (1976) Family Sizes of Children and Family Sizes of Women. *Demography* 13(1):105-114.

Rantakallio, P. (1971) The Effect of a Northern Climate on Seasonality of Births and the Outcome of Pregnancies. *Acta Paediatrica Scandinavica*, Supplement 218. Oulu, Finland: Kirjapaino Osakeyhitiö Kaleva.

Rosenbluth, G. (1955) Measures of Concentration. Pages 57-99 in *Business Concentration and Price Policy.* National Bureau of Economic Research, Special Conference Series Nr. 5. Princeton.

Spree, R. (1982) The German Petite Bourgeoisie and the Decline of Fertility: Some Statistical Evidence from the Late 19th and Early 20th Centuries. In: *Historical Social Research - Quantum Information* 22:15-49.

Spree, R. (1984) Der Geburtenrückgang in Deutschland vor 1939: Verlauf und schichtspezifische Ausprägung. *Demographische Informationen 1984*, pages 49-68.

United Nations (1973) *The Determinants and Consequences of Population Trends*, Vol. 1. New York.

United Nations (1981) *UN Demographic Yearbook.* New York: United Nations.

United Nations (1985) *World Population Prospects: Estimates and Projections as Assessed in 1982.* ST/ESA/SER.A/86. New York: Department of International Economic and Social Affairs, United Nations.

Vaupel, J. and D. Goodwin (1986) A Division of Labor: The Concentration of Reproduction Among U.S. Women, 1917-1980. Submitted to *Demography* as a Research Note.