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Kim, Y.J.

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Young J. Kim

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

FOREWORD

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

This paper is part of the Task's dissemination effort. It is a draft of a chapter that is to appear in a volume entitled *Migration and Settlement: A Comparative Study*. Other selected publications summarizing the work of the Migration and Settlement Task are listed at the back.

Andrei Rogers
former Chairman
of the Human Settlements
and Services Area

CONTENTS

REGIONAL FERTILITY DIFFERENTIALS
IN IIASA NATIONS

1. INTRODUCTION

Before reliable data on births for large population aggregates became available, fertility study lacked quantitative analyses. By the end of the eighteenth century, Malthus had stimulated interest in the quality of population data, but because he considered fertility levels to be essentially constant, studies of mortality were stressed throughout the nineteenth century. Only when it became obvious, at the turn of the twentieth century, that fertility levels were not constant but were actually falling in many West European countries, did serious interest in the study of fertility begin, developing into a science that has come to receive enormous attention from demographers in recent years.

We begin this paper with a discussion of several commonly used measures of fertility, the most basic of which is the *crude birth rate* (CBR): the ratio of the number of births in a year to the average population in thousands (or more exactly, thousand person-years of exposure) during that year. Using this measure for a comparison of fertility levels within a country over time or of various countries at a given time, however, would confound the effects of the age and sex compositions of the respective populations with differences in their fertility. In an effort to refine the denominator (the average population) more closely so that it represents the population at risk of giving birth, the *general fertility rate* (GFR)—the ratio of the number of births in a year to the number of thousand person-years of females in the childbearing ages, usually 15-44—is often used instead. And since the risk of childbearing varies greatly by age even within the childbearing years, this idea may be further extended to define the *age-specific fertility rate* (ASFR): the ratio of the number of births to a mother in a given age group (usually a 5-year age interval) to the number of thousand person-years of females in that age group. Although these female rates are widely accepted because of their convenience, they are rather arbitrary in the sense that each birth occurs to both parents, who are not generally of the same age. Reducing the six or seven values of age-specific rates into a single fertility index involves the assignment of proper weights to each age group. The *total fertility rate* (TFR) is obtained by assigning equal weights of unity to each age group. This measure represents a mean parity of a cohort of women at the end of its childbearing age, assuming that the childbearing years are unaffected by mortality and that the cohort experiences given age-specific fertility rates at each age. A modification of the total fertility rate to include only female births produces the *gross reproduction rate* (GRR), a measure of replacement for a female population under the assumption of no mortality.

Similarity in the pattern of age-specific fertility rates in various populations has led researchers to search for a simple model that describes patterns using only a small number of parameters. There have been essentially two approaches presented in this endeavor. The first fits probability density functions, such as gamma, beta, and Hadwiger functions, to a fertility curve (for example, see Hoem et al. 1981). The second fits curves that are generated from observed empirical fertility patterns with a small number of parameters. The fertility model

Coale and Trussell (1974) is perhaps the best among this second group because the parameters in the model have demographic meanings. The relational Gompertz model developed by Brass (1980), however, involves only two parameters, one less than in the Coale and Trussell model, which is an important consideration when data are given in 5-year age groups rather than by single years of age.

The differences in both fertility levels and the age pattern of fertility in the National Member Organization countries of IIASA and of the regions in each country is the primary concern of this paper. Our aim is to summarize and describe observed fertility differentials but not to search for explanatory factors associated with them. Before examining differentials in fertility, in section 2, we discuss the limitations of available data and define the measures that are used in the subsequent analyses. In section 3 we make comparisons in the levels of fertility between countries and between regions within countries, without regard to differing age patterns of fertility. We then examine, in section 4, the levels and age patterns of fertility simultaneously by fitting a linear model that includes both location-effect and age-effects to the age-specific fertility rates of regional populations. This is done first for the national age-specific fertility rates, for which the country-effects and age-effects are estimated. The same analysis is next carried out using the regional age-specific fertility rates within each country. In section 5, the relational two-parameter Gompertz fertility model is fitted to the age pattern of fertility. The goodness-of-fit is examined visually by comparing a fitted curve and the observed age pattern, but a statistical test is not used to assess the quality of the fit. Finally, a summary is given in section 6.

2. DATA AND DEFINITIONS

We shall only briefly describe the available data that pertain to our fertility analysis since details of the data bases and accounting frameworks for the Comparative Migration and Settlement Study are given in Rees and Willekens (1982).

Before embarking on a comparative analysis, we must first determine how comparable the available data are. The most important discrepancies are the differences in time periods of data bases and sizes of regions among the 17 countries. The data span almost a decade, and because fertility was declining during this period, international comparisons observed at these different time periods cannot be very meaningful. This problem suggests that we should therefore put more emphasis on interregional comparisons within a country, but the degree of regional fertility disparities is also affected by the way regions are defined as well as by existing fertility differentials. The number of regions in each country and the size of population or area of these regions vary greatly. For example, the United States is divided into only 4 large regions, whereas small countries such as Czechoslovakia and Finland are divided into 10 and 12 regions, respectively, and in extreme cases, large cities such as Vienna, West Berlin, and Warsaw exist as single regions in their respective country case studies. International comparisons of regional fertility differentials should also be viewed with caution because the degree of regional disparities increases, other things being equal, as the number of regions increases and the size of each region decreases.

The second source of incomparability is more specific to birth statistics. What is included in the birth statistics and the degree to which all national births are registered varies from country to country. The definition of a live birth is not uniformly applied, even among developed countries, and in some countries live births that result in early death are routinely excluded from the birth count. Births that occur to parents temporarily out of the country are included in the birth count in some countries but not in others. Further, at the regional level, births are tabulated by place of usual residence, which is recommended and is followed in most countries but by place of occurrence in some countries. Births may also be tabulated by year of occurrence, which is recommended, or by year of registration. The degree of underregistration varies not only by region but also by age of mother. And even among registered births, when information on the age of the mother is missing and is estimated, the adopted method of allocation by age affects the age-specific measures of fertility. Since birth rates are a function of population stocks as well as birth statistics, variation in population coverage is another factor to be considered. Differing degrees of underenumeration in census counts and differing degrees of accuracy in the post-censal estimates of population for off census years produce biased rates. This problem is even more pronounced when the population is enumerated both by region and by age.

With these points in mind, let us examine the data that are available for our comparative analysis of fertility. Population data are enumerated in 5-year age groups and birth data are tabulated by age of mother, also in 5-year age groups, by region of each country. These data are disaggregated by sex in 9 of the 17 countries (Austria, Canada, Finland, France, the Federal Republic of Germany, Japan, Sweden, the United Kingdom, and the United States), but in the remaining 8 countries (Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Italy, the Netherlands, Poland, and the Soviet Union) only data for both sexes combined are available. The unavailability of the data by sex obviously prevents us from calculating conventional measures of fertility because the fertility measures are based on female populations (except for the crude birth rate). The crude birth rate is calculated by dividing the number of births of both sexes in a reference period, usually a year, by the number (in thousands) of persons of both sexes at the midpoint of that reference period. But, to calculate such rates as the general fertility rate or the age-specific fertility rate, population data should be disaggregated by sex as well as by age. Since we do not have such data for half of the NMO countries in our study, we must adopt an alternative strategy.

Recall that the age-specific fertility rate is the ratio of the number of births to mothers of a given age group to the number (in thousands) of females in that age group and that the sum of these rates over all ages results in the total fertility rate (TFR). The TFR represents the completed family size at the end of childbearing ages if a cohort of women experiences no mortality, and it is usually given as per woman rather than per thousand women. Paralleling these measures of replacement are those defined with female births alone: the gross maternity function (although the term "function" connotes a continuous form, we shall maintain this terminology) and the gross reproduction rate, respectively. Thus the GRR represents the number of daughters a woman would have at the end of her childbearing years if she were to live through those years. Because fertility is a component of spatial population dynamics and the model for the process is essentially a one-sex model, it is natural to introduce these single-sex measures in the analysis. Thus the measure that was called the ASFR in the series of 17 national case studies was actually the gross maternity function either for females or for both sexes combined, depending on the availability of sex-specific data.

Because births are tabulated by age of mother, the two sets of rates—females alone and both sexes combined—are not compatible with each other for a given population. The discrepancy between the two sets depends on how different the sex ratios are among births and in successive age groups. In order to see just how distorted this picture might be, we computed the age schedules of fertility for females alone, where available, and for both sexes combined. To do this, we calculated:

$$f_i^{(F)} = \frac{FB_i}{F_i} 1000$$

and

$$f_i^{(F+M)} = \frac{FB_i + MB_i}{F_i + M_i} 1000$$

where

FB_i = number of female births to mothers in age group i (i = 1,2,...,7 represent age groups 15-19, 20-24,..., 45-49)

MB_i = number of male births to mothers in age group i

F_i = number of females in age group i

M_i = number of males in age group i

and compared age patterns of $f_i^{(F)}$, the gross maternity function for females alone, and $f_i^{(F+M)}$, the function for both sexes combined. We calculated the mean, standard deviation, and skewness as well as the gross reproduction rate of the available age schedules. For the nine countries that have sex-specific data, little difference was found between the female and the both-sexes-combined schedules. Consequently, we shall use the rates for combined sexes for all countries, even for those for which sex-specific data are available. For convenience and for consistency with the earlier national case studies, we shall now call this rate $f_i^{(F+M)}$ the age-specific fertility rate. The sum of the ASFR defined in this way over all ages and multiplied by the width of the age interval (in our case 5 years), gives the gross reproduction rate

$$GRR = 5 \sum_{i=1}^{5} f_i^{(F+M)}$$

We emphasize again that the ASFR in the remainder of this paper is the gross maternity function i.e., the component of the measure of replacement of the population, and is therefore approximately half the value of the usual age-specific fertility rate.

3. COMPARISONS OF FERTILITY LEVELS

3.1 Comparison Between Countries

Although we have reservations concerning the appropriateness of comparing national fertility levels observed at different points in time, we shall go on to examine international differentials in the level of fertility among the IIASA nations for the respective reference years first. Then we shall examine the prevailing trend in fertility levels during the 1970s in these countries to account for the differences in the reference years.

We shall use the crude birth rate and the gross reproduction rate for this purpose; the CBR is examined because of its simplicity and popularity as a fertility measure, whereas the GRR is examined in order to obtain a better comparison of fertility levels without the confounding effects of differing age and sex distributions.

To do this, we shall follow the numerical and graphical procedures of explanatory data analysis introduced by Tukey (1977). In this form of analysis, the basic numbers that are easy to find and that tell something about a collection, a *batch*, of numbers as a whole are the two extremes (minimum and maximum values) and a middle value. The middle value of a batch is called the *median* and is used as a measure of location. In addition to these three numbers, the *lower* and *upper quartiles* add more information about the batch of numbers; the range between them is called the *midspread*. These numbers will be used to summarize and compare the CBRs and GRRs of the 17 IIASA countries.

Table 1 gives, for the 17 countries, values of the CBR and GRR and their respective rank orders for the reference years and values of the GRR for 1975. Let us first summarize the fertility levels in the reference years. Values of the CBR range from a low of 10.1 in the Federal Republic of Germany to a high of 19.6 in Czechoslovakia. The median value is 16.1, with a midspread of 4.7. Values of the GRR range from a low

Table 1. The crude birth rate in the reference year and gross reproduction rates in the reference year and in 1975 by country and their rank orders.

Country and reference year	CBR	Rank order	GRR[a]	Rank order	GRR in 1975[b]	Rank order
Austria 1971	14.6	8	1.09	9	0.90	9
Bulgaria 1975	16.6	10	1.10	10	1.10	13
Canada 1971	17.6	11	1.23	15	0.88	8
Czechoslovakia 1975	19.6	17	1.21	14	1.21	17
Federal Republic of Germany 1974	10.1	1	0.73	1	0.70	1
Finland 1974	13.3	4	0.79	3	0.82	4
France 1975	14.2	7	0.94	7	0.94	11
German Democratic Republic 1975	10.9	2	0.76	2	0.75	2
Hungary 1974	17.8	12	1.14	12	1.16	15
Italy 1978	12.7	3	0.91	5	1.03[c]	12
Japan 1970	18.7	15	1.05	8	0.92	10
Netherlands 1974	13.8	6	0.87	4	0.81	3
Poland 1977	19.4	16	1.11	11	1.10	14
Soviet Union 1974	18.1	13	1.33	17	1.17	16
Sweden 1974	13.4	5	0.91	6	0.87	5
United Kingdom 1970	16.1	9	1.18	13	0.87	6
United States 1970	18.4	14	1.26	16	0.88	7

[a] The GRRs and mean age of fertility schedules for each region in the study are given in Appendix A. Regional GRR differentials for the 17 countries are set out in Appendix B.

[b] Source: United Nations 1979.

[c] This value was obtained by interpolating values for 1972 and 1978.

of 0.73 in the Federal Republic of Germany to a high of 1.33 in the Soviet Union, giving a range of 0.6 (in terms of the number of babies per woman, this translates to 1.2 babies). The median value of the GRR is 1.09 and the midspread is 0.27.

Another, and perhaps better, way of displaying the distribution of a set of numbers is the box-plot. A box-plot is obtained by plotting the lower and upper quartile values of a batch of numbers by drawing a box to identify the length of the midspread. The vertical bar in the box represents the location of the median. The crosses at the end of the line drawn outwards from the lower and upper quartiles are the last data points that lie within one midspread from the quartiles. This is a modified version by McNeil (McNeil 1977) of the original rule by Tukey, who put crosses at 1.5 midspreads from the quartiles. We chose the modified rule, because when the data have a normal distribution, the proportion of numbers in the batch outside the crosses, on average, approaches the familiar level of 0.05. Numbers that lie outside these crosses are called *outliers*. The box-plots of the distribution of CBRs and GRRs among IIASA countries are given in Figure 1. Both distributions for the reference years (the first two) are skewed to the left, and there are no outliers. (Note that since the scales of the two plots are arbitrarily set, the relative lengths of the two measures should not be compared with each other.) In six countries, the Federal Republic of Germany, the German Democratic Republic, Finland, the Netherlands, Sweden, and France, in ascending order, the value of the GRR is less than unity, i.e., their fertility is below replacement level. Japan's GRR of 1.05, when combined with mortality, would also be near or below replacement level.

Because the levels of fertility have been shifting in recent years, however, to make more meaningful comparisons of national fertility levels, fertility in each country at a fixed point in time is desirable. We first examine the time trend in fertility levels in the 17 IIASA countries. Figures 2 and 3 show the time trend observed in the total fertility rate in selected West European countries plus Canada and in East Europe during the

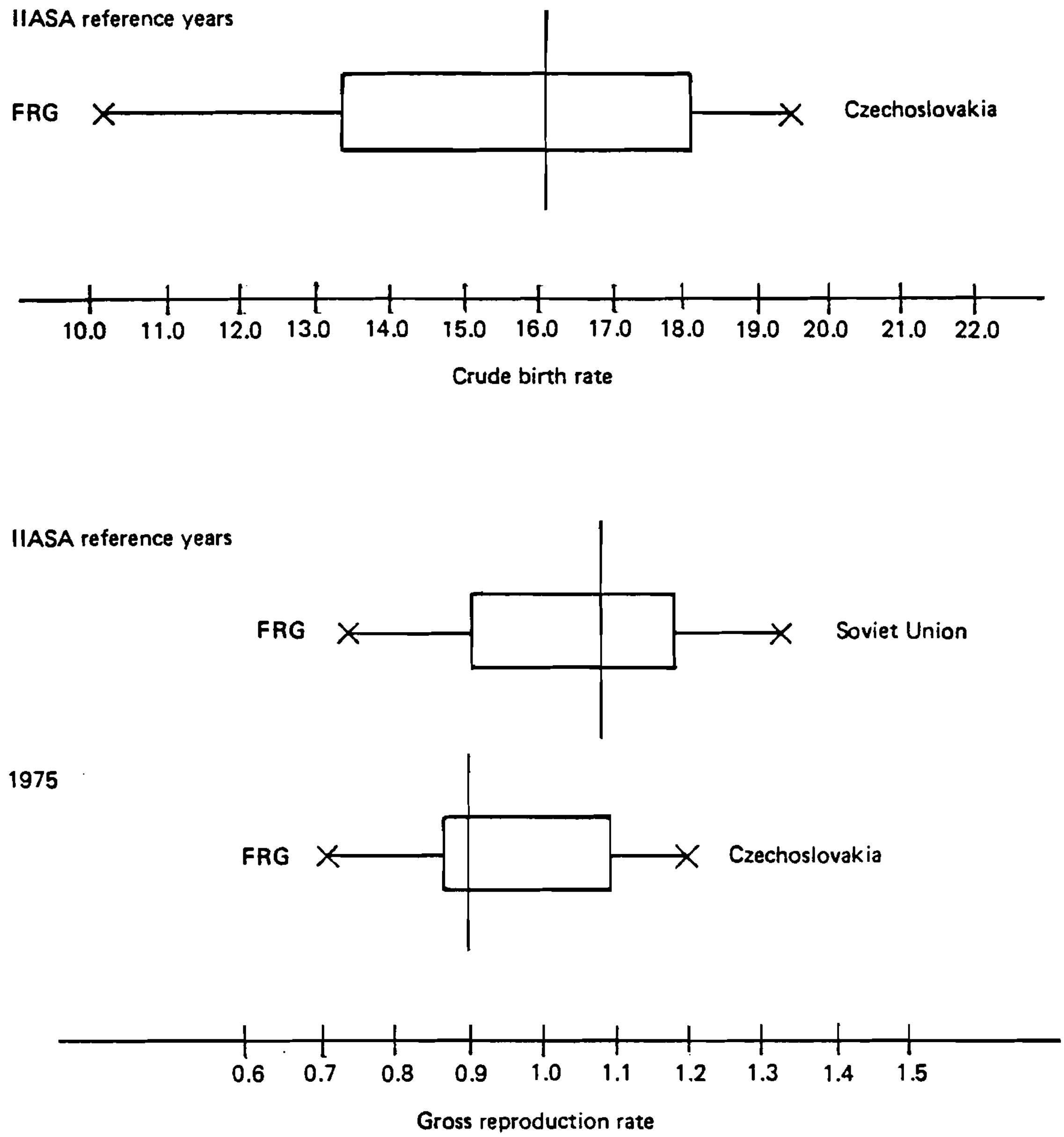

Figure 1. Box-plots of the distributions of the crude birth rates and gross reproduction rates among the 17 IIASA member countries.

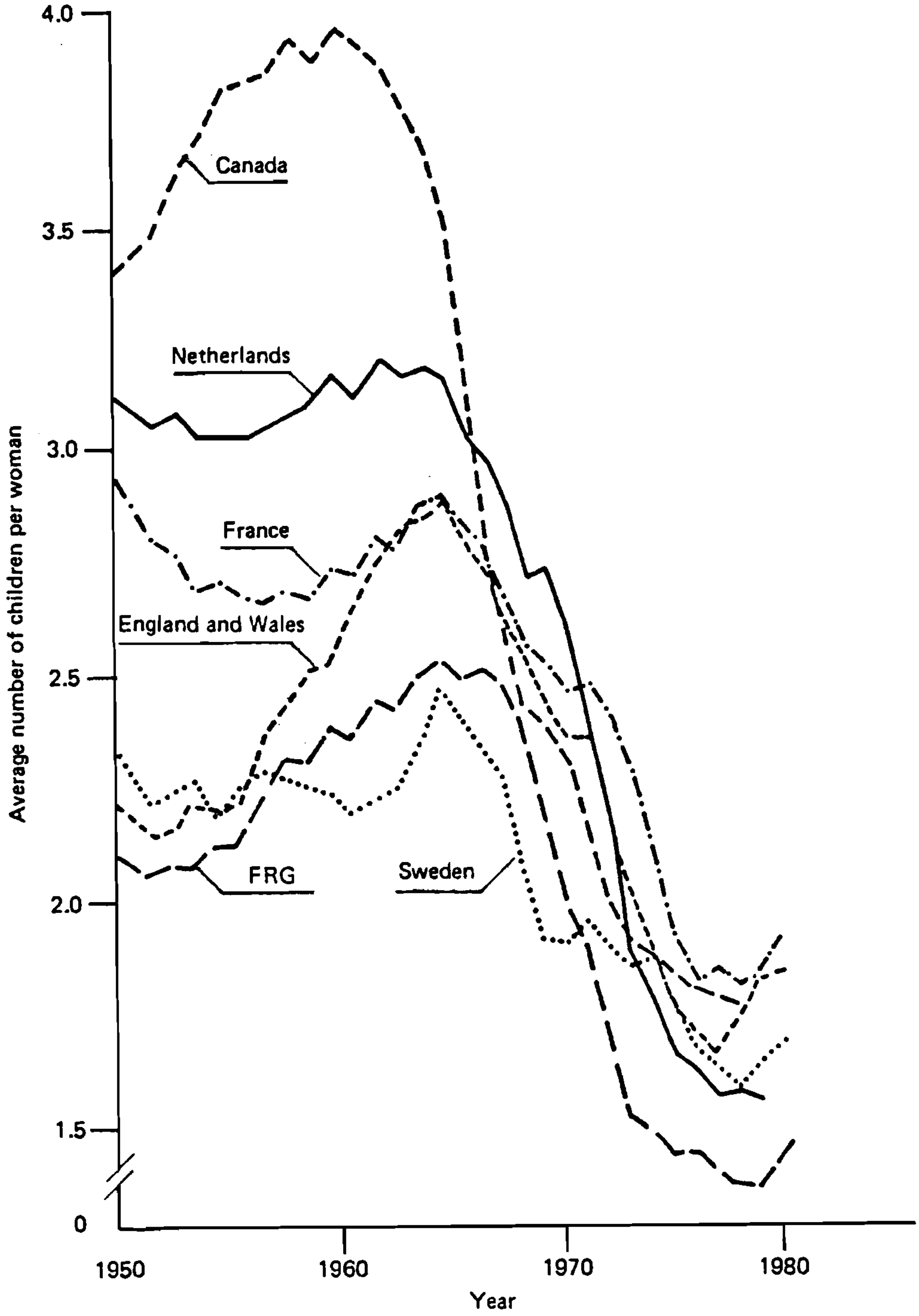

Figure 2. Trend since 1950 in the total fertility rate in selected countries of Western Europe and in Canada. (Source: reproduced with permission from Bourgeois-Pichat 1981.)

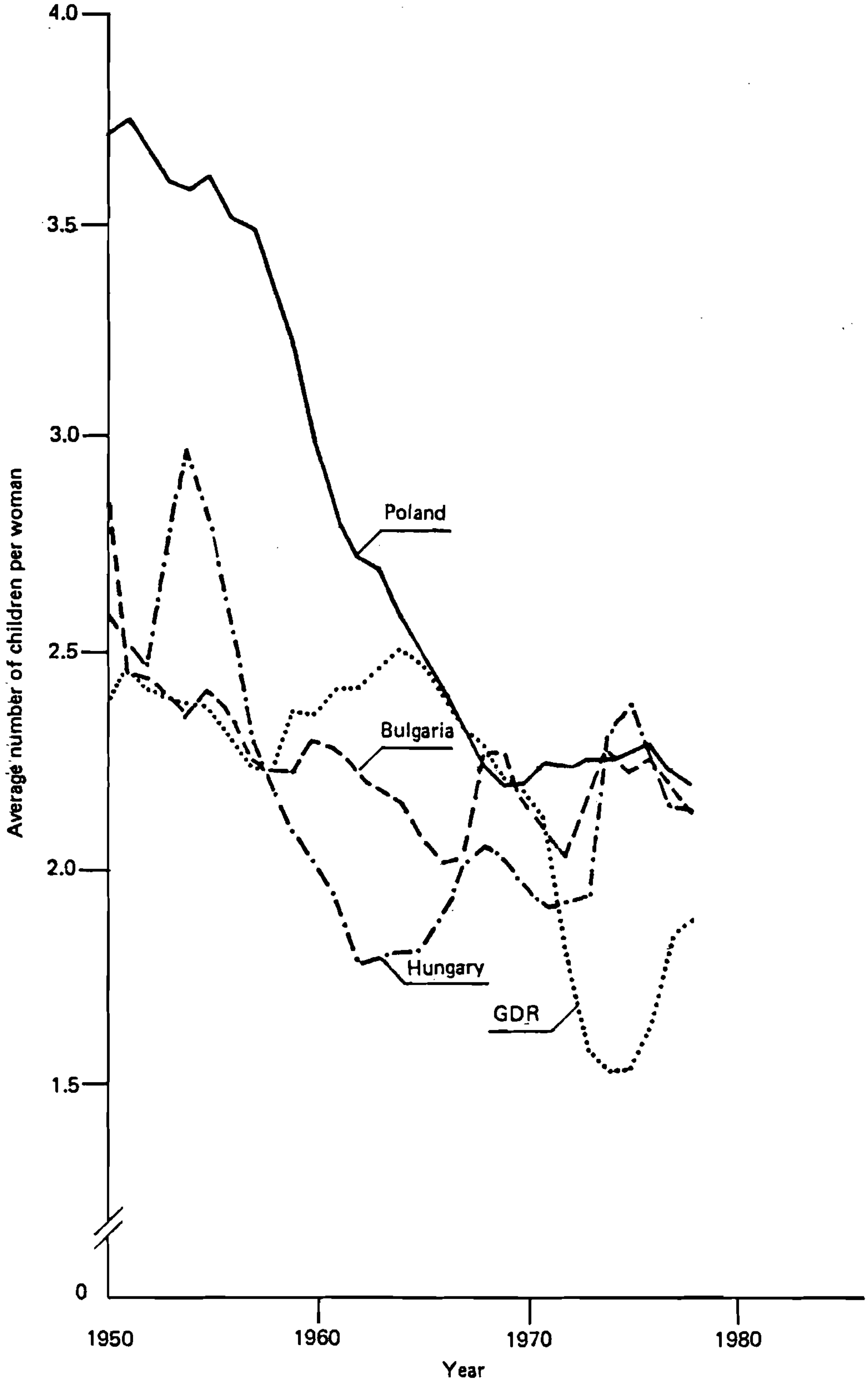

Figure 3. Trend since 1950 in the total fertility rate in selected countries of Eastern Europe. (Source: reproduced with permission from the same article as Figure 2.)

period 1950-1980, respectively (reproduced from Bourgeois-Pichat 1981). Values of the GRR for countries that are not included in Figures 2 and 3 are presented for the 1970s in Figure 4 (these values are taken from United Nations 1979).

The decline in fertility started around 1965 in West European countries and in Canada, but the trend in East Europe is less clear except for the German Democratic Republic. By noting that a TFR of 2 corresponds roughly to a GRR of 1, we see first that below-replacement fertility is the phenomenon of the 1970s, and second that there is a recent sign of increasing fertility in most West European countries and the German Democratic Republic, where the TFR fell below 2. How long these below-replacement levels of fertility will be sustained in the future is open to speculation.

To see how the comparison at a fixed point in time differs from the earlier comparison for the various reference years, values of the GRR in 1975 are also presented in Table 1, and the distribution is plotted in Figure 1. Because fertility in most countries declined between the reference years (usually in the early 1970s) and 1975, we see a decline of about 0.2 in the median value of the GRR to 0.9, and the distribution is now right-skewed on our box-plot. Canada, the United States, and Japan were the largest contributors to this shift. Eleven out of the 17 countries had a below-replacement level of GRRs in 1975.

We now examine in somewhat greater detail, country differentials in the levels of fertility as measured by the CBR and GRR. In order to see the relationship between the two indices graphically, values of the CBR are plotted against those of the GRR in a scatter diagram in Figure 5. The correlation coefficient between the two indices is 0.77, and the dispersion around the fitted line (CBR = 0.97 + 14.14 GRR) tends to be larger for countries with higher fertility. Inspection of the graph reveals the implied age distribution of a country. For example, the higher values of the CBR than might be expected from the values of the GRR in Japan and Poland are due to the effect of age

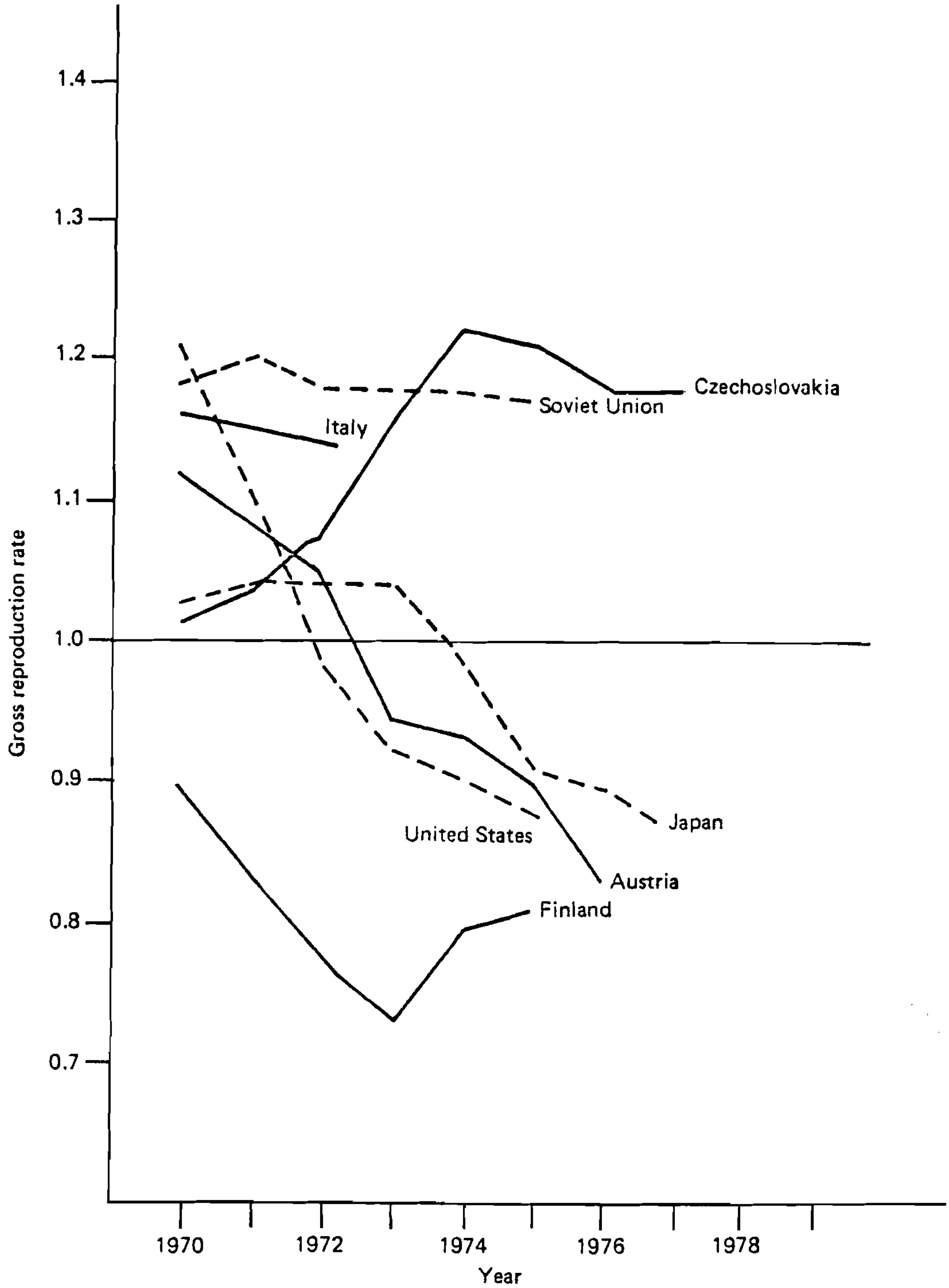

Figure 4. Trend since 1970 in the gross reproduction rate for the IIASA countries that are not included in Figures 2 and 3. (Source: UN Demographic Yearbook, Special Issue: Historical Supplement 1979.)

distributions: a relatively large proportion of females being in childbearing ages. It is the other way around in Austria and the Soviet Union.

To summarize, values of the GRR in the seven countries in their respective reference years, the Federal Republic of Germany (1974), the German Democratic Republic (1975), Finland (1974), the Netherlands (1974), Italy (1978), Sweden (1974), and France (1975), in ascending order, are below unity. At the other end, the Soviet Union (1974), the United States (1970), Canada (1971), and Czechoslovakia (1975), listed in descending order, are the countries with high fertility (the GRR is 1.2 or above). Although fertility in these countries is higher relative to the other member countries, the GRR of around 1.2 (the highest value being 1.33 for the Soviet Union) is still low compared with fertility levels prevailing in the rest of the world. Note that fertility in Canada and the United States declined to 0.88 by 1975.

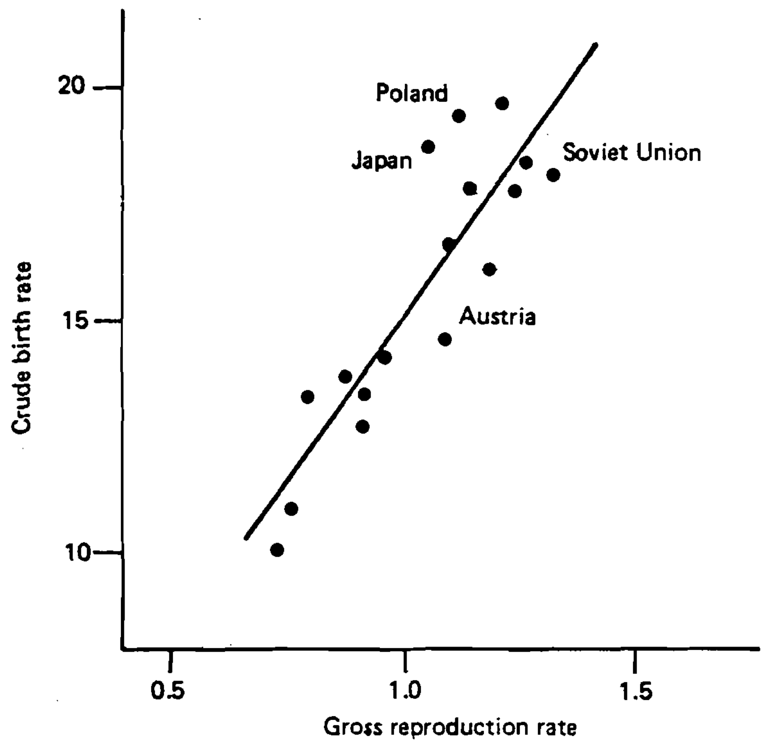

Figure 5. Values of the CBR plotted against the GRR in 17 IIASA member countries.

3.2 Comparison Between Regions

As mentioned previously, each of the 17 IIASA countries in the study was disaggregated into regions by the individual authors of the national reports. Because of this, the numbers and sizes of the regions vary considerably from country to country. Keeping this in mind, we now examine the regional differentials of CBRs in each country. Table 2 presents the median and the midspread of the regional distribution of CBRs together with the extreme values. They are also set out graphically as box-plots in Figure 6. In a box-plot, a data point that lies between 1 and 1.5 times the midspread from either end of the box is denoted by an open circle (○), which will be called an *outside* value following Tukey (1977), and a data point that lies beyond 1.5 times the midspread from the box is denoted by a dark circle inside an open circle (◉) and will be called a *far-out* value. The cross (x) at the end of the line represents the last data point that lies within 1 midspread from the quartiles, as explained in subsection 3.1.

We first notice that the median CBR for each country is very close to its national CBR presented in Table 1. The median is the value around which half of the regions have larger values and half have smaller values, regardless of the size of the population in each region; the national CBR, on the other hand, is a weighted average of the regional CBRs, where the weights are the relative population sizes in each region. Considering this relationship between the median CBR and the national CBR, and the diverse manner in which the regions were defined, the closeness of the two numbers in each country is comforting. Because the national comparison was made in subsection 3.1, we shall not discuss the national levels, but instead we shall go on to compare regional fertility variations.

The regional variation of the CBR measured by the midspread (unless mentioned otherwise, the variation will always be measured by the midspread), is largest in Italy (5.6), the Soviet Union (4.7), and Japan (3.0). In the rest of the

Table 2. Summary statistics for the distribution of the crude birth rate in regions, by country.

Country and reference year	Number of regions	Crude birth rate			
		Median	Midspread	Minimum	Maximum
Austria 1971	9	15.9	2.2	10.7	19.5
Bulgaria 1975	7	17.3	2.3	13.6	18.5
Canada 1971	10	18.5	1.3	16.5	25.5
Czechoslovakia 1975	10	19.7	1.4	16.5	22.4
Federal Republic of Germany 1974	11	9.8	1.2	7.8	11.1
Finland 1974	12	12.9	1.7	11.3	15.6
France 1975	8	14.7	2.3	11.5	17.0
German Democratic Republic 1975	5	10.9	0.6	10.2	12.5
Hungary 1974	6	17.6	1.7	16.4	20.2
Italy 1978	5	11.2	5.6	10.4	16.8
Japan 1970	8	17.2	3.0	15.7	20.8
Netherlands 1974	5	14.0	0.7	12.9	15.1
Poland 1977	13	19.8	1.5	15.0	21.2
Soviet Union 1974	8	19.5	4.7	15.8	27.1
Sweden 1974	8	13.5	1.3	11.9	14.1
United Kingdom 1970	10	16.1	1.3	15.1	17.3
United States 1970	4	18.6	1.4	16.9	19.2

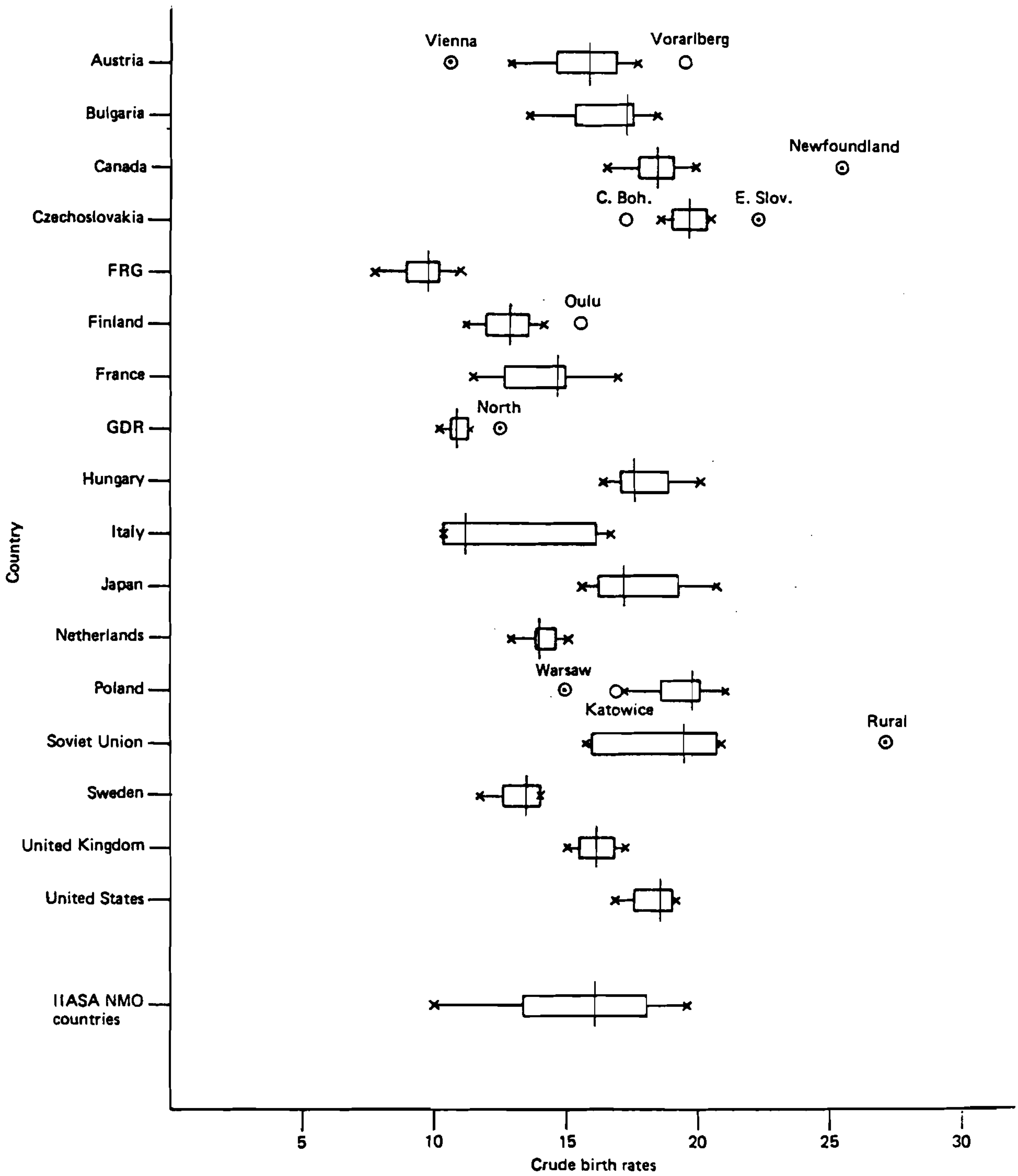

Figure 6. The box-plot of the regional distribution of the crude birth rate, by country.

countries, the regional variation in the CBR is small (on the order of 2 per thousand or less). Seven countries have outliers, however; that is, these countries have at least one region that has a CBR value that is far removed (either being very low or very high) from those for the rest of the country. Newfoundland in Canada, Eastern Slovakia in Czechoslovakia, the North Region of the German Democratic Republic, and the rural areas in the Soviet Union are high far-out values, whereas Vienna in Austria and Warsaw in Poland exhibit low far-out values. Overall, the rural areas of the Soviet Union have the highest CBR (27.1), whereas Hamburg in the FRG has the lowest CBR (7.8) among all regions in all IIASA countries.

Finally, in order to see how the magnitude of these regional variations compares with the national variation, the distribution of the national CBR plotted on the top of Figure 1 is presented at the bottom of Figure 6. It is interesting to note that the midspread for Italy is larger than the all-IIASA-countries midspread, which is about the same as that of the Soviet Union.

The same summary statistics that were given for the CBR are presented for the GRR in Table 3, and the associated boxplots are given in Figure 7. Again, the median value of the GRR for each country is extremely close to the value of the national GRR presented in Table 1. Countries with large regional variations of the GRR are the Soviet Union (0.66), Italy (0.34), and Canada (0.25). Although the regions in the Soviet Union are defined for this study in a rather unusual manner (only urban areas of seven geographic regions plus all rural areas, which is considered the eighth region), the large regional variation in the Soviet Union is not due to this disaggregation. A large variation in fertility exists between urban areas of geographic regions as well as between urban and rural areas. The GRR ranges from below one to almost two (a range of 2 children to 4 children per woman) in different regions. Regional differentials of the GRR in Canada are much smaller than those in the Soviet Union, when measured by the midspread, but the far-out value in Newfoundland makes the range almost as large

Table 3. Summary statistics for the distribution of the gross reproduction rate in regions, by country.

Country and reference year	Number of regions	Gross reproduction rate			
		Median	Midspread	Minimum	Maximum
Austria 1971	9	1.17	0.08	0.82	1.31
Bulgaria 1975	7	1.11	0.11	0.96	1.22
Canada 1971	10	1.35	0.25	1.10	1.90
Czechoslovakia 1975	10	1.21	0.05	1.08	1.39
Federal Republic of Germany 1974	11	0.72	0.07	0.58	0.81
Finland 1974	12	0.78	0.06	0.73	0.96
France 1975	8	0.93	0.16	0.83	1.12
German Democratic Republic 1975	5	0.78	0.05	0.74	0.80
Hungary 1974	6	1.18	0.05	0.99	1.36
Italy 1978	5	0.82	0.34	0.76	1.17
Japan 1970	8	1.06	0.05	1.01	1.15
Netherlands 1974	5	0.98	0.11	0.81	0.98
Poland 1977	13	1.09	0.18	0.81	1.41
Soviet Union 1974	8	1.17	0.66	0.97	1.92
Sweden 1974	8	0.93	0.06	0.86	0.97
United Kingdom 1970	10	1.20	0.11	1.11	1.26
United States 1970	4	1.26	0.05	1.22	1.30

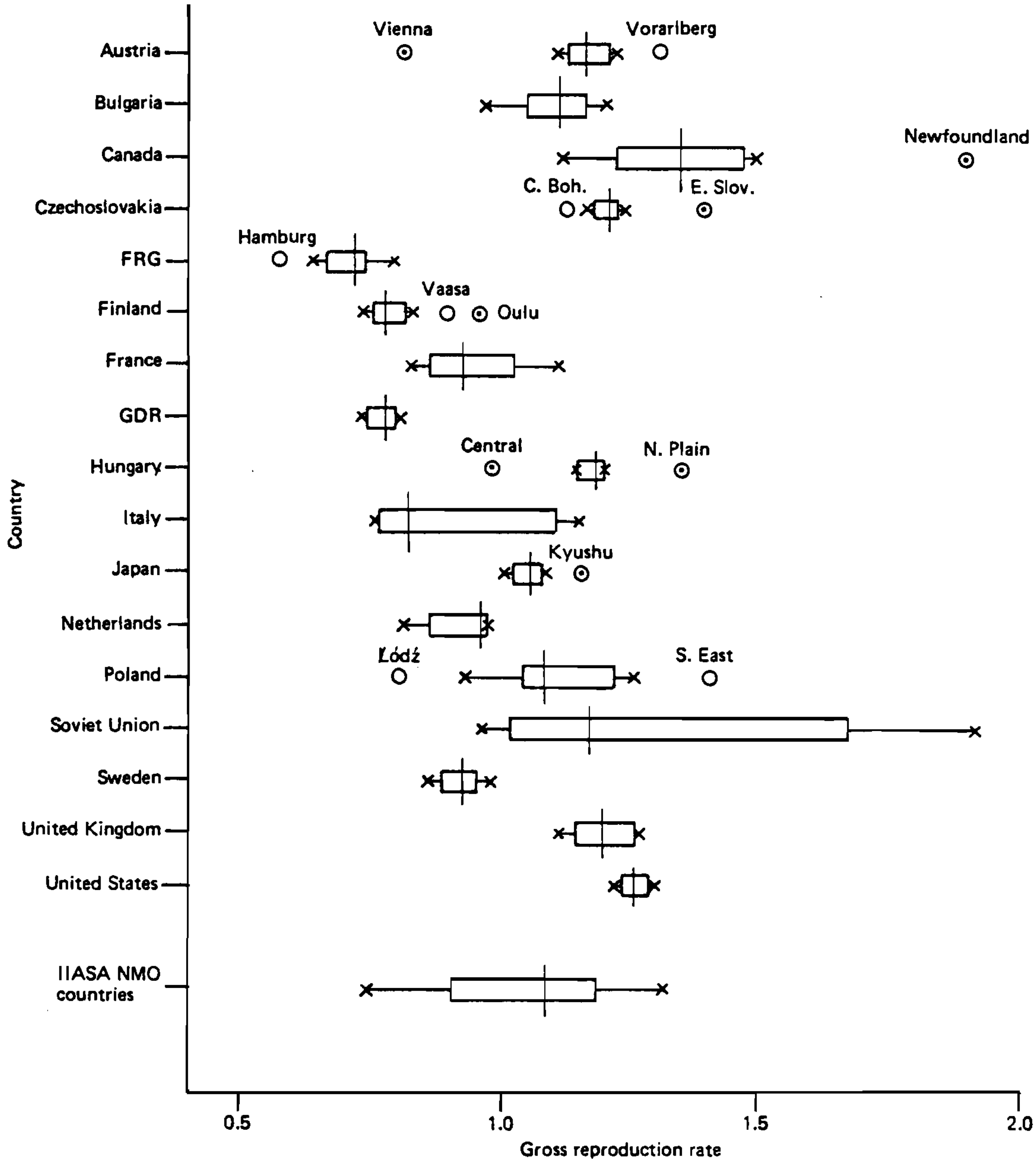

Figure 7. Box-plots of the regional distribution of the gross reproduction rate, by country.

(0.80) in the former as in the latter. Countries that have small regional variations are Czechoslovakia, Finland, the German Democratic Republic, Hungary, Japan, Sweden, and the United States, where the midspread of the GRR is 0.06 or less. Among these countries, however, Czechoslovakia, Finland, and Hungary have far-out values so that the range for these countries is larger than the range for the Netherlands and the United Kingdom, where the distances between the quartiles and extreme values are very small. When the interregional variations of fertility are compared with the international variation, we see that the interregional variations in Canada, Italy, and the Soviet Union are larger than the international variation among all IIASA countries.

When we compare the regional distributions of the CBR (Figure 6) with those of the GRR (Figure 7), we notice that there is a larger variation between countries in the regional fertility differentials when the GRR is used than when the CBR is used. For example, the regional variation of the GRR in the Soviet Union is more than 10 times that of countries with small regional variations; on the other hand, the regional variation of the CBR in the Soviet Union is only about 4 times as large as that of the countries with small regional variations. We also notice that the relative regional dispersion for a country varies greatly depending on which of the two measures of fertility is used. For example, the regional dispersion is small for the CBR but is large for the GRR in Canada, whereas the opposite is true in Japan—the relative regional dispersion is large for the CBR but extremely small for the GRR. This implies that the fertility behavior is similar but the age-sex structure of the population is different across regions in Japan, whereas in Canada the age-sex structure of regional populations somehow compensates for the differing fertility levels to produce less variable CBRs across regions.

4. A LINEAR MODEL FOR LOCATION AND AGE-SPECIFIC FERTILITY RATES

In the previous section our interest was in comparing the level of fertility without regard to the age pattern of fertility. We now examine age patterns, as well as fertility levels in different locations (country or region). When we look at the ASFR in various locations, we have a "response" arising as a function of two kinds of factors: location and age, with one of each of the factors occurring for each observation. Thus we can imagine a two-way table of responses, with ages of mother along the columns and locations along the rows. We then fit a linear model to this table using the technique of "median polish" developed by Tukey (1977). In this procedure the response in each cell of a two-way table is expressed as:

response = fit + residual

where

fit = common value + row effect + column effect

To carry out a median polish of the responses, we first remove row medians from the data and then remove column medians from the resulting residuals. The medians that are removed identify the row effects, the column effects, and the common value.

This procedure is illustrated in Table 4 by using the age-specific fertility rates in three broad age categories (15-24, 25-34, and 35-44) in three countries (the Federal Republic of Germany, Poland, and the Soviet Union). The data are presented in part (a) of Table 4. Removing row medians from the data gives the residuals in part (b), where the removed medians in the first column are separated from the second column by a vertical line. Next, removing column medians from part (b) gives part (c), where the removed medians are presented in the first row above the horizontal line. In part (c), the number 49.8 is the number taken out of every response and is therefore the effect common to all. The numbers -19.7 and 6.8 are row effects for the Federal Republic of Germany and the

Soviet Union, whereas 0.4 and -39.4 are column effects for age groups 25-34 and 35-44. Numbers in the rest of the table are the residuals. For example, the data for age group 35-44 in the Soviet Union satisfies

17.2	=	49.8	+	6.8	+	(-39.4)	+	0
data	=	common value	+	row effect	+	column effect	+	residual

Table 4. Illustrative example of a median polish: age-specific fertility rates in three age groups in three countries.

Country	Age groups 15-24	25-34	35-44
(a)			
FRG	30.1	34.7	7.5
Poland	49.8	50.2	9.9
Soviet Union	58.9	56.6	17.2
(b)			
30.1	0	4.6	-22.6
49.8	0	0.4	-39.9
56.6	2.3	0	-39.4
(c)			
49.8	0	0.4	-39.4
-19.7	0	4.2	16.8
0	0	0	-0.5
6.8	2.3	-4.6	0

Having carried out the median polish, we may wish to see how well the row-plus-column model fits the data. Since the median of a batch of numbers minimizes the sum of absolute values of the residuals, it is clear that a median polish reduces the sum of the magnitudes of the values in Table 4. Therefore, following McNeil (1977), we compare the average size of the residuals to the average deviation of the original data from their median value. We shall call this measure G (for goodness-of-fit) and define it as

$$G = 1 - \frac{\text{sum of the absolute values of residuals}}{\text{sum of the absolute values of deviations of the data from the median}}$$

i.e., G is the proportionate reduction in the sum of the absolute deviations from the median. It represents the proportion of variation in the data accounted for by the median polish. For the example given in Table 4, the sum of the absolute values of the residuals is 28.4 and the sum of the absolute deviations of the data from their median is 150.8, thus

$$G = 1 - \frac{28.4}{150.8} = 0.81$$

i.e., 81 percent of the variation in the data is accounted for by the row-plus-column model.

To perform these calculations with fertility data, Fortran programs written by McNeil were used with one modification. We adjusted the row effects and column effects to sum to zero, following the familiar rule used in the analysis of variance.

4.1 National Age-Specific Fertility Rates

We first consider the ASFR in each country and median polish the fertility data, after setting out the countries as rows and the age groups as columns. Because the ASFR in age group 45-49 in most IIASA member countries is extremely low, this age group has been dropped from the analysis.

The results of the median polish are presented in Table 5. The country effects are shown in a column next to the country name, and the age effects are shown in a row under the age group identification. The common value is given at the upper left corner and is underlined. The rest of the table shows the pattern of residuals. The ASFR in any cell may be obtained by combining the common value, the country effect, and the row effect with the residual.

We shall first consider the fitted values of age and country effects, leaving the pattern of residuals to be examined later. As expected, the age effect accounts for most of the variation in the two-way table. The overall age pattern, which may be viewed as an average pattern for the 17 countries, shows a "typical" fertility pattern in which fertility is concentrated in the age group 20-24. The fitted age pattern is presented graphically in Figure 8. The scale on the left indicates the deviation (the set of which sum to zero) from the typical value. The largest relative age effect is 35.7 in age group 20-24, and the lowest is -30.2 in age group 40-44, giving a range of 65.9. The relative effect added to the common value of 34.1 gives the absolute value of the fitted ASFR, and this scale is indicated on the right-hand side of the graph. The height from the horizontal line at zero in absolute scale to the end of the bar in each age group depicts the visual shape of the fitted ASFR.

The country effects range from a low of -6.7 in the Federal Republic of Germany to a high of 8.2 in the Soviet Union, giving a range of 14.9. Since the country effect is expected to represent the relative level of fertility in each country, the country effect from the median polish is plotted against the value of the GRR in Figure 9. The data points fall around a straight line (country effect = -22.81 + 22.02 GRR) except for a few outliers. The most notable outlier is Bulgaria. The correlation coefficient between the country effect and the GRR is 0.70. Because the deviations of the data points from the expected line seem to be related to the pattern of residuals in the median polish, we shall examine the residuals next, and then come back to the discussion of the deviations of the country effect from the regression line.

Table 5. Common value, country effects, and age effects[a] from the median polish of national ASFRs, with the pattern of residuals.

Country and reference year	Country effect	Age 15-19	20-24	25-29	30-34	35-39	40-44
	34.1	-15.6	35.7	30.9	-0.7	-20.1	-30.2
Austria 1971	3.3	•	•	-	•	•	•
Bulgaria 1975	-5.0	++	+++	•	•	•	•
Canada 1971	7.8	•	•	•	•	•	•
Czechoslovakia 1975	1.1	•	+++	•	•	•	•
Federal Republic of Germany 1974	-6.7	•	--	-	•	•	•
Finland 1974	-5.4	•	-	•	•	•	•
France 1975	-2.0	•	•	•	•	•	•
German Democratic Republic 1975	-5.8	+	•	--	-	•	•
Hungary 1974	-1.3	+	++	•	•	•	•
Italy 1978	-0.9	•	--	•	•	•	•
Japan 1970	-3.2	-	--	+++	+	•	•
Netherlands 1974	-2.6	•	--	•	•	•	•
Poland 1977	1.4	•	+	•	•	•	•
Soviet Union 1974	8.2	•	++	+	-	•	•
Sweden 1974	-1.2	•	-	•	•	•	•
United Kingdom 1970	5.8	•	•	•	•	•	•
United States 1970	6.5	•	+	•	•	•	•

[a]
• residual that lies within 1 midspread away from the quartiles
+,- residual that lies between 1 and 1.5 times the midspread away from the quartiles
++,-- residual that lies between 1.5 and 3 times the midspread away from the quartiles
+++,--- residual that lies beyond 3 times the midspread away from the quartiles

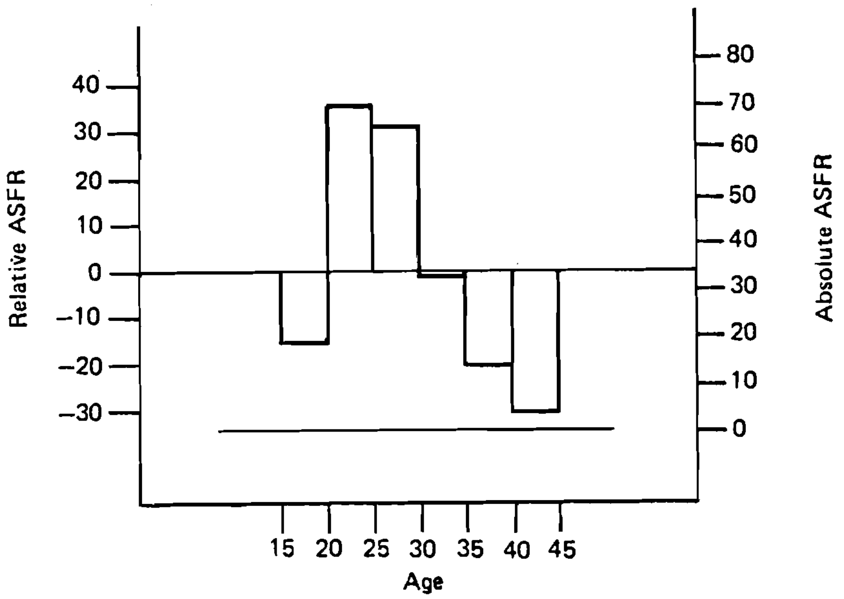

Figure 8. Relative and absolute age effects of the national ASFR obtained by a median polish.

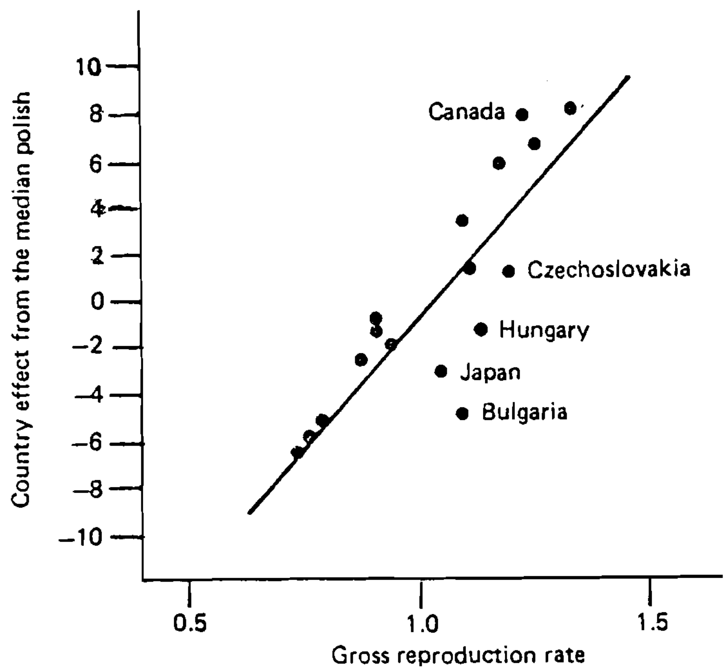

Figure 9. The country effect from the median polish of the national ASFR plotted against the GRR.

Before examining the residuals, however, let us first determine how much variation in the country ASFRs is accounted for by the row-plus-column model. As was explained before, a median polish minimizes the sum of the absolute deviations of the residuals from the median. The procedure was iterated until the improvement in the sum of the magnitudes of the residuals was less than 1 percent. The sum of the absolute deviations of the 102 original fertility rates (6 ages in 17 countries) from their median is 2334.0 and, after 3 iterations, the sum of the absolute value of the residuals (since the median of the residuals is zero) is reduced to 658.9. Thus the reduction in the residual size is

$$G = 1 - \frac{658.9}{2334.0} = 0.72$$

or 72 percent. Therefore about three-quarters of the variation in the country ASFR is accounted for by the linear model of country effect-plus-age effect.

Having examined the overall fit of the model, we now inspect the pattern of its residuals in Table 5. The median of the residuals is zero, as mentioned above, and the midspread is 7.13. The distribution of the residuals is symmetric, except for a few large positive outliers. Residuals that lie within a width of one midspread away from either quartile are represented by a • and residuals that lie between 1 and 1.5 times the width of the midspread from the quartile are represented by a - if they are located below the lower quartile or by a + if they are located above the upper quartile to depict the magnitude as well as the sign. Residuals that lie between 1.5 and 3 times the width of the midspread away from the lower or upper quartile are denoted by -- or ++, and outliers more than 3 times the width of the midspread away from the quartiles are denoted by --- and +++. The three largest outlier residuals are all positive and are associated with Bulgaria, Czechoslovakia, and Japan. Among these countries, Bulgaria and Czechoslovakia have a large residual in age group 20-24, whereas Japan exhibits it in age group 25-29. In addition, Hungary and the Soviet Union also show a large positive residual in age group 20-24, indicating more concentrated fertility in this age group. In Bulgaria and Hungary, fertility in age group 15-19 is also elevated, implying high fertility in early ages. The structure of residuals in the German Democratic Republic with a positive residual in age group 15-19 and negative residuals in age groups 25-29 and 30-34 reveals a highly skewed age pattern of childbearing concentrated at early ages. On the other hand, Japan's peak fertility appears in age group 25-29, with negative residuals in early age groups 15-19 and 20-24. This implies that Japan's fertility is extremely concentrated in age group 25-29 and has a very narrow spread. On the other hand, the Federal Republic of Germany, Finland, Italy, the Netherlands, and Sweden have a negative residual in age group 20-24, which implies a flatter age pattern in these countries than the overall age pattern shown in Figure 8.

Going back to the relative country effect, it is now clear from an inspection of Figure 9 that four of the five countries having large positive residuals (Bulgaria, Czechoslovakia, Japan, and Hungary) have lower country effects in the median polish than would be predicted by their GRR. In retrospect, this could have been expected because the GRR is the sum of the ASFR over all ages in a country, whereas in the median polish the country effect and the residual together are components of the ASFR. Why the country effect for Canada is larger than expected in the absence of any large negative residuals is not clear.

4.2 Regional Age-Specific Fertility Rates

Setting regions out as rows and age groups as columns, we now examine the regional ASFRs within each country by median polishing them. The results of the 17 separate median polishes are summarized in Table 6. The first and second columns of the table identify the country's name and reference year and the number of regions specified in the study. The third column

Table 6. The typical value, age effects, and the regional effects from a median polish of the regional ASFRs by country.

Country and reference year	Number of regions	Typical value	Age effect						Regional effect		Goodness-of-fit
			15-19	20-24	25-29	30-34	35-39	40-44	Midspread	Range	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Austria 1971	9	38.0	-12.5	38.6	21.7	1.9	-17.0	-32.7	3.4	17.0	0.84
Bulgaria 1975	7	37.5	- 1.3	65.6	19.3	-17.3	-31.0	-35.2	2.5	4.7	0.91
Canada 1971	10	45.9	-19.7	40.0	34.4	1.9	-20.1	-36.5	7.6	26.3	0.88
Czechoslovakia 1975	10	40.6	-13.0	65.5	27.5	-11.1	-30.7	-38.2	2.2	6.8	0.88
Fed. Rep. of Germany 1974	11	23.6	- 8.8	23.3	20.6	- 0.7	-13.6	-20.8	2.5	6.6	0.91
Finland 1974	12	26.9	-13.7	24.5	26.2	1.8	-15.0	-23.6	1.8	9.3	0.91
France 1975	8	31.0	-18.4	29.8	30.1	1.6	-16.6	-26.7	3.4	6.7	0.91
German Demo. Rep. 1975	5	25.2	- 1.6	43.8	12.1	-10.4	-20.1	-23.8	0.8	1.2	0.94
Hungary 1974	6	39.8	- 6.6	58.6	24.7	- 9.7	-29.7	-37.2	1.2	8.1	0.91
Italy 1978	5	30.9	-13.5	19.4	26.9	5.7	-14.9	-23.7	11.0	14.1	0.89
Japan 1970	8	35.4	-33.0	20.5	69.8	3.8	-27.2	-34.0	0.5	3.3	0.92
Netherlands 1974	5	30.3	-21.6	23.5	42.2	1.4	-18.6	-27.0	2.4	4.1	0.92
Poland 1977	13	36.0	-18.9	47.0	26.5	- 1.8	-21.2	-31.6	5.2	18.0	0.85
Soviet Union 1974	8	44.0	-23.1	47.2	43.8	-15.3	-17.4	-35.2	16.8	34.3	0.80
Sweden 1974	8	30.9	-19.8	25.6	34.0	6.1	-18.0	-27.9	1.2	2.3	0.94
United Kingdom 1970	10	39.7	-14.1	39.2	35.5	- 2.0	-23.0	-35.6	2.6	4.6	0.93
United States 1970	4	41.9	- 9.3	44.9	32.5	- 4.5	-25.8	-37.8	1.4	1.8	0.90

presents the common value derived from the median polish, denoted here as the "typical" ASFR value for the country. One can see from the table that the Federal Republic of Germany has the lowest typical value, followed by the German Democratic Republic and Finland. The highest typical value is in Canada, followed by the Soviet Union. Since the typical ASFR value represents an average fertility for the country, we may compare it with the value of the GRR by plotting the two values on a graph (Figure 10). The correlation between the two measures is very high, yielding a correlation coefficient of 0.96. As was the case with the country effect, Canada's typical value again deviates from the straight line (typical value = -1.25 + 35.14 GRR). A comparison of Figures 9 and 10 suggests that the typical value for each country from the median polish of *regional* ASFRs represents the relative level of fertility far more accurately than the country effect obtained from the median polish performed on the *national* ASFRs.

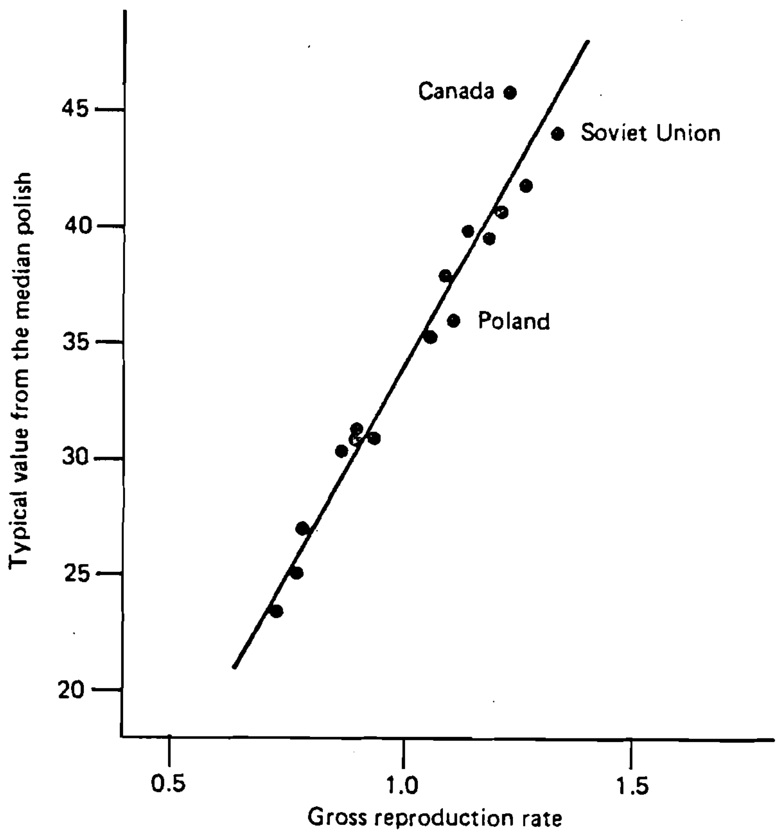

Figure 10. The typical value from the median polish of the regional ASFR in each country plotted against the GRR.

Columns 4-9 in Table 6 give the age effects obtained from the median polish of the regional ASFRs in each country. These age effects represent the relative age pattern of fertility for the country from the regional data, i.e., they are deviations from their respective typical values. Figure 11 shows these age patterns graphically, where the zero line represents the typical ASFR value for each country. As was shown in Figure 8, a visual shape of the fitted absolute ASFR may be obtained by connecting the end of the bar in each age group from the horizontal line drawn near the end of the bar for the last age group. This line represents the absolute level of zero for each country. The bar graphs in Figure 11 illustrate, therefore, the level as well as the age pattern of fertility.

Among the 17 IIASA countries, the highest fertility in early ages (age groups 15-19 and 20-24) is shown in Bulgaria; it is one of the two countries where the level of fertility in age group 15-19 is as high as the average level of fertility for the country (the other being the German Democratic Republic). In addition, Czechoslovakia, the German Democratic Republic, and Hungary also show high fertility at early ages. (Note that although the German Democratic Republic follows this age pattern of early fertility, its fertility level is low.) Contrary to this pattern, Italy, Japan, the Netherlands, and Sweden have the highest fertility in age group 25-29. In addition to these countries, the Federal Republic of Germany, Finland, France, the Soviet Union, and the United Kingdom exhibit a flat age pattern, where the fertility levels in age groups 20-24 and 25-29 are about equal. We notice that these results are consistent with the observation inferred from the structure of residuals of the country-plus-age model fitted to the country ASFRs.

Let us next examine the regional effects in each country. Because the numbers and sizes of regions vary widely from country to country as noted earlier, and because our interest is in international comparison of the degree of interregional variation within a country, we shall focus on summary statistics of the variation; the midspread and range of the regional effects are

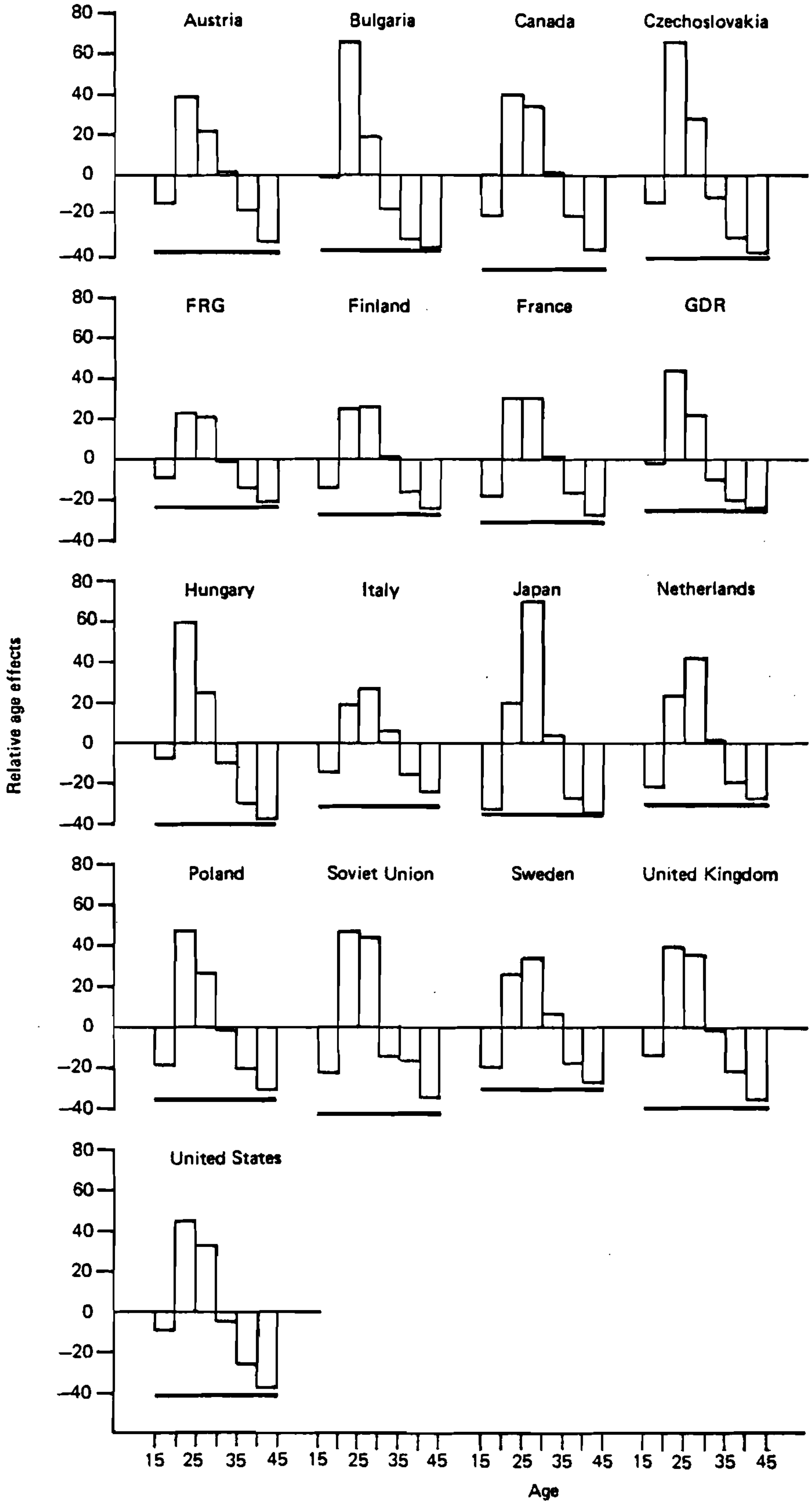

Figure 11. The relative age effects for the six age groups from the median polish of the regional ASFR, by country.

presented in columns 10 and 11 of Table 6. The highest regional variation measured by the range is to be found in the Soviet Union, which shows a range of 34.3; this is followed by Canada, Poland, Austria, and Italy. In terms of the midspread, the Soviet Union and Italy continue to have large relative values, but the relative values for Austria, Poland, and Canada are much less prominent. Large ranges of variation in these countries in the latter group were caused by extreme levels of fertility in just one or two regions relative to the rest of their respective countries, whereas countries in the former group have large overall fertility differentials between regions. Countries that show the smallest interregional variation in the level of fertility are the German Democratic Republic, the United States, and Sweden. The small regional variation in the United States might be due to the country being divided into only 4 vast regions. Again, these results are consistent with the observations made in terms of the regional distribution of the GRR in each country presented in Figure 7.

Finally, we shall examine the goodness-of-fit of the regional-plus-age model for each country. Each of the 17 median polishes produced the structure of residuals similar to those presented in Table 5. Because it is impractical to set out 17 such tables, they are not presented here. Instead, the measure G, which represents the proportion of interregional variation explained by the model and, hence, summarizes the degree of regional uniformity in the age pattern of fertility, is presented in the last column of Table 6. The value of G in most countries hovers around 0.90; the highest value is 0.94 for Sweden and the German Democratic Republic, which indicates a small regional variation in age patterns of fertility, and the lowest value is about 0.8 for the Soviet Union, which is a negative outlier, indicating a large regional variation in age patterns of fertility. Austria and Poland also show high variations, although they are not as high as those in the Soviet Union.

The last two points of the above discussion deal with interregional variation in fertility levels and age patterns of childbearing. Variation in levels is summarized by the midspread or range of the regional effects, whereas variation in age patterns is summarized by the measure G. We notice that a country with large (small) variation in levels also tend to exhibit large (small) variation in age patterns of childbearing. Because fertility decline usually results from decline in young ages (through later age at marriage or postponing first birth after marriage) or in old ages (by limiting family size), the decline in overall level accompanies shifts in the age pattern of childbearing. Sweden and the German Democratic Republic have extremely small interregional variations in both levels and age patterns. Although the United States has a comparably small variation in fertility levels, age pattern differentiation is larger than those in the above two countries. The United Kingdom, Japan, and the Netherlands also show small interregional variations. At the other end of the scale, the Soviet Union has by far the largest interregional variation in fertility, both in level and age pattern. High variability among the rest of the countries is shown in Austria and Poland but, as noted earlier, it is mainly due to the outlier regions in these countries. Canada shows relatively higher variability in level than in age pattern.

5. A RELATIONAL GOMPERTZ FERTILITY MODEL

In this section we shall be interested only in the age pattern of childbearing, without regard to differing levels of fertility. Hence in this part of the analysis the ASFRs are adjusted for the value of GRR, so that when the age distribution is cumulated to the end of childbearing ages, the cumulated value at the end is always unity. Therefore, terms like age pattern or age distribution in this section refer to density functions.

It has been pointed out in the literature (see Brass 1980) that the cumulative distribution function of the ASFR closely follows a Gompertz curve, with a fit that is good over the central part of childbearing ages but is less satisfactory over the tails. If a cumulative distribution function F(x) obeys the Gompertz function

$$F(x) = e^{-e^{-(a+bx)}}$$

where a and b are constants, then there exists a linearizing transformation $\phi(\cdot)$ of F(x)

$$\phi[F(x)] = -\log[-\log F(x)] = a + bx$$

Since the linear transformation of a linear function is again linear, the transformation $\phi(\cdot)$ of any distribution that belongs to the Gompertz family is related linearly. The relational Gompertz model is a generalization of this. Namely, even when the distribution functions do not obey the Gompertz function exactly, if they deviate from it in much the same way, then the transformed nonlinear functions still may be related linearly. For example, the nonlinear transformation Y(x) given by

$$Y(x) = -\log[-\log F(x)]$$

is related linearly to the transformation $Y_s(x)$ of a standard distribution function $F_s(x)$ that belongs to the same family by the expression

$$Y(x) = \alpha + \beta\, Y_s(x)$$

where α and β are constants. The standard function presented by Brass (1980) is used as our standard $Y_s(x)$ in this analysis, and the parameters α and β are estimated for each age pattern using the method of least squares. The cumulative distribution function is obtained by the inverse transformation

$$F(x) = e^{-e^{-Y(x)}}$$

and the density function is obtained by differencing the cumulative values at adjacent ages,

$$f(x) = F(x) - F(x-1)$$

The standard density function generated this way from the standard function $Y_s(x)$ had a dip at age 39; it was corrected to give a smooth curve. Increasing the value of α in the linear transformation shifts the age distribution to earlier ages, whereas increasing the value of β decreases the spread of the age pattern, when $Y(x)$ is linear. If the function $Y(x)$ is non-linear, in addition to the above effects, changes in α and β also affect the skewness of the distribution, as shown graphically in Figures 12 and 13.

In applying the relational model to our fertility data in 5-year age groups, cumulated fertility rates at ages 20, 25, 30, 35, 40, and 45 are used (the value at age 50 being unity by definition). Because of the low fertility rate in age group 45-49, however, the cumulated value at age 45 is nearly 1, which makes $Y(45)$ unstable. Therefore, the cumulative value at age 45 is excluded and only 5 values up to age 40 are used in the analysis.

5.1 Patterns of National Age-Specific Fertility Rates

Before fitting the relational Gompertz model, whose parameters are not familiar to most of us, more familiar measures are calculated for the purpose of easy reference. The mean, standard deviation, and skewness of the ASFR for each country are presented in Table 7. The mean age at childbearing ranges from a low of 24.5 years in Bulgaria to a high of 27.9 years in Japan, giving a spread of 3.5 years. The range of the standard deviation of the childbearing pattern is 2 years, from a low of 4.3 years in Japan to a high of 6.4 years in Austria. In general, early mean age is associated with large standard deviation and skewness, but there are irregularities. Next,

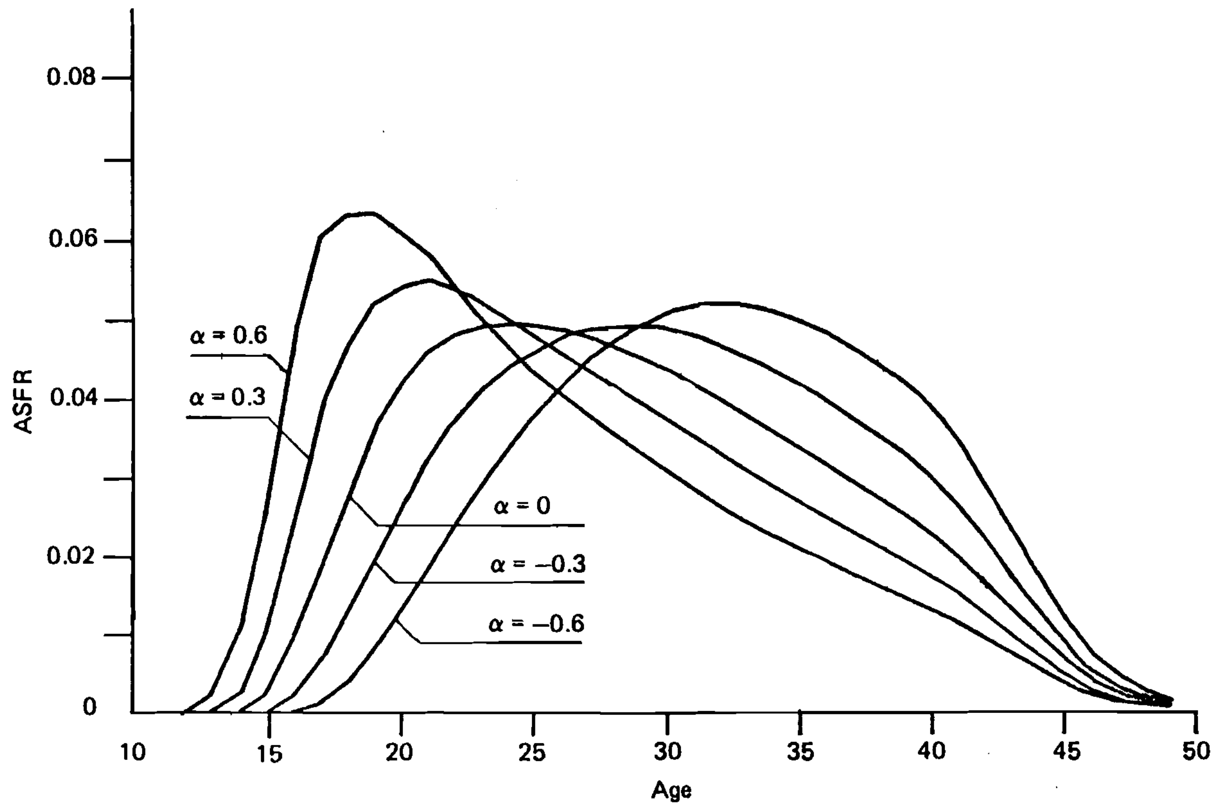

Figure 12. Standard age-specific fertility pattern (α = 0), and patterns for selected values of α in the relational model.

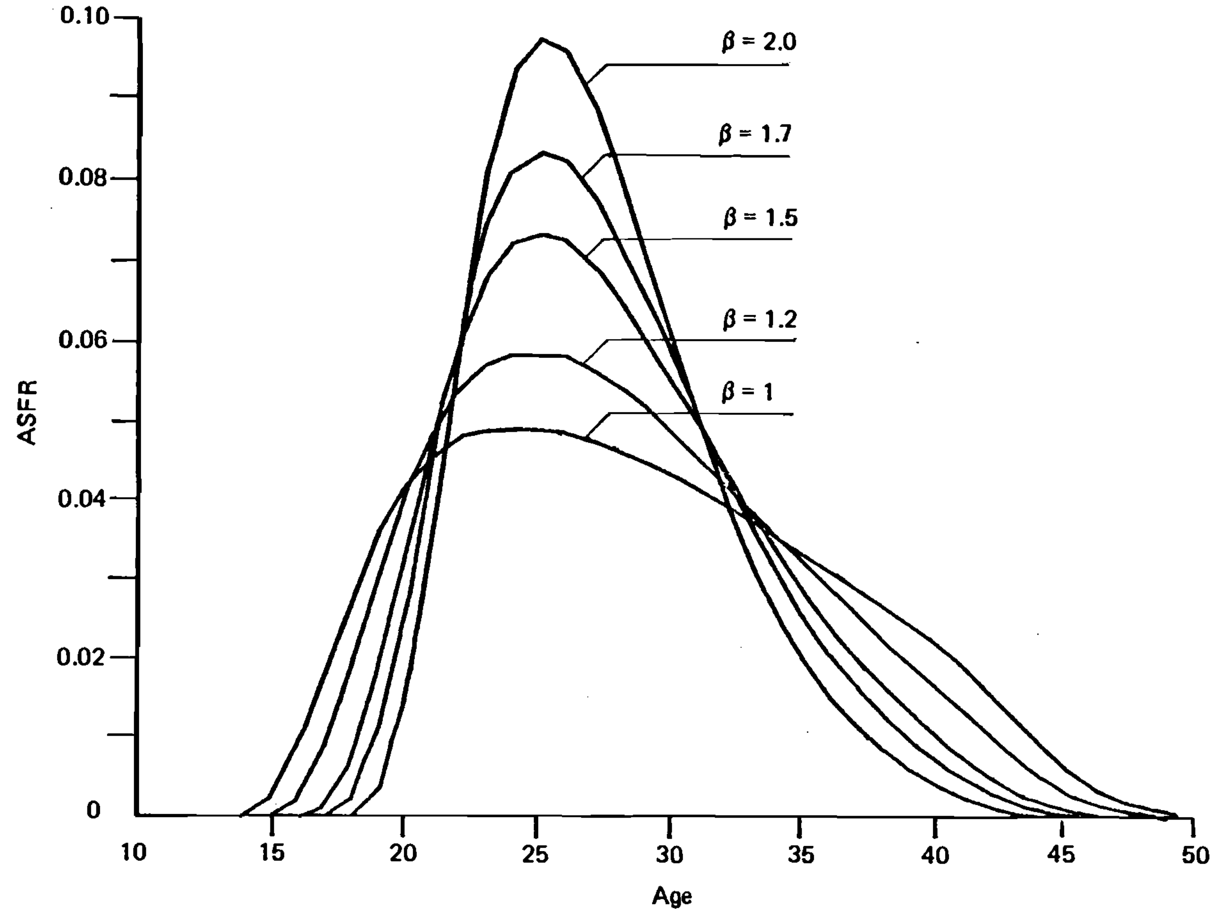

Figure 13. Standard age-specific fertility pattern (β = 1), and patterns for selected values of β in the relational model.

each of the 17 national age patterns of fertility are fitted by the relational Gompertz model, and the estimated parameters α and β in the relational model will be compared with the mean and standard deviation of the age schedule of fertility. Estimated values of α and β are presented in Table 8 together with values of R^2 (proportion of variance explained by the linear fit). We note extremely high values of R^2 for all countries, but will see later that the almost perfect linear fit (e.g., R^2 = 0.999) of $Y(x)$ to $Y_s(x)$ does not necessarily generate a good fit of the density function.

Table 7. The mean, standard deviation, and skewness of the age pattern of fertility, by country.

Country and reference year	Mean	Standard deviation	Skewness
Austria 1971	26.7	6.4	0.55
Bulgaria 1975	24.5	5.1	0.80
Canada 1971	27.3	6.1	0.53
Czechoslovakia 1975	25.4	5.2	0.71
Fed. Rep. of Germany 1974	26.9	5.9	0.55
Finland 1974	27.0	5.7	0.52
France 1975	27.1	5.7	0.60
German Dem. Rep. 1975	24.6	5.1	0.84
Hungary 1974	25.4	5.4	0.64
Italy 1978	27.5	6.0	0.40
Japan 1970	27.9	4.3	0.51
Netherlands 1974	27.4	5.2	0.58
Poland 1977	26.7	5.7	0.70
Soviet Union 1974	27.0	6.0	0.81
Sweden 1974	27.3	5.4	0.43
United Kingdom 1970	26.7	5.8	0.52
United States 1970	26.1	5.9	0.58

Table 8. The estimated coefficients in the relational model fitted to the national fertility age pattern, by country.

Country and reference year	Parameter α	β	R^2
Austria 1971	0.190	1.276	0.9998
Bulgaria 1975	0.671	1.683	0.9969
Canada 1971	0.060	1.310	0.9991
Czechoslovakia 1975	0.428	1.678	0.9995
Fed. Rep. of Germany 1974	0.132	1.391	0.9987
Finland 1974	0.109	1.467	0.9993
France 1975	0.061	1.436	0.9981
German Dem. Rep. 1975	0.636	1.636	0.9970
Hungary 1974	0.438	1.592	0.9995
Italy 1978	0.032	1.380	0.9989
Japan 1970	-0.216	1.993	0.9974
Netherlands 1974	-0.016	1.585	0.9962
Poland 1977	0.156	1.432	0.9972
Soviet Union 1974	0.103	1.324	0.9897
Sweden 1974	0.027	1.581	0.9993
United Kingdom 1970	0.171	1.441	0.9995
United States 1970	0.300	1.434	0.9996

We shall first examine the estimated values of α and β in each country. The values of α range from a low of -0.22 to a high of 0.67. Bulgaria, the German Democratic Republic, Hungary, and Czechoslovakia have high values of α, whereas Japan has by far the lowest value of -0.22. In addition to Japan, the Netherlands also has a negative value of α. As mentioned earlier, a high (low) value of α shifts the age distribution to younger (older) ages and, hence, implies higher (lower) fertility at early ages. The estimated value of α reflects our earlier observation of the national age pattern; child-bearing is high at young ages, with consequently a low mean age of childbearing, in such East European countries as Bulgaria, Czechoslovakia, the German Democratic Republic, and Hungary, whereas childbearing at young ages is low in Japan, Italy, and the Netherlands. In order to see how well the estimated α in the relational model depicts the timing of childbearing more systematically, values of α are plotted against the mean ages (μ) of the ASFR in Figure 14. There is an almost perfect linear relationship between the two measures ($\alpha = 6.267 - 0.229\mu$; $R^2 = 0.979$). The only point that deviates from the regression line at the bottom right depicts the values for Japan.

The estimated value of β ranges from a minimum of 1.28 in Austria to a maximum of 1.99 in Japan. We notice that the values of β in all 17 IIASA countries are larger than 1, indicating that the age pattern in these countries has a smaller variance than the variance of the adopted standard age pattern. To confirm the seemingly good indication of β representing the spread of the ASFRs, values of β are plotted against standard deviations of the age-specific schedules in Figure 15. Again, the parameter β is almost perfectly linearly related to the standard deviation σ ($\beta = 3.456 - 0.349\sigma$; $R^2 = 0.967$). We note that the point at the upper left represents Japan, which has an extremely narrow spread in the age schedule of childbearing as noted earlier.

Having established that the estimated parameters α and β correspond closely to the mean and standard deviation of the age pattern of fertility, we shall examine α and β for a country simultaneously. Inspection of the estimated parameters α and β simultaneously reveals that, except for Japan, countries with a high value of α tend also to have a high value of β. The value of β is plotted against that of α in Figure 16. The one outstanding point at the top left represents Japan with its unusual fertility pattern of a late beginning and a small spread. Points at the upper right represent Bulgaria, Czechoslovakia, the German Democratic Republic, and Hungary. In these countries, value of both α and β are high, characterizing high fertility in the first two age groups with much reduced fertility in subsequent

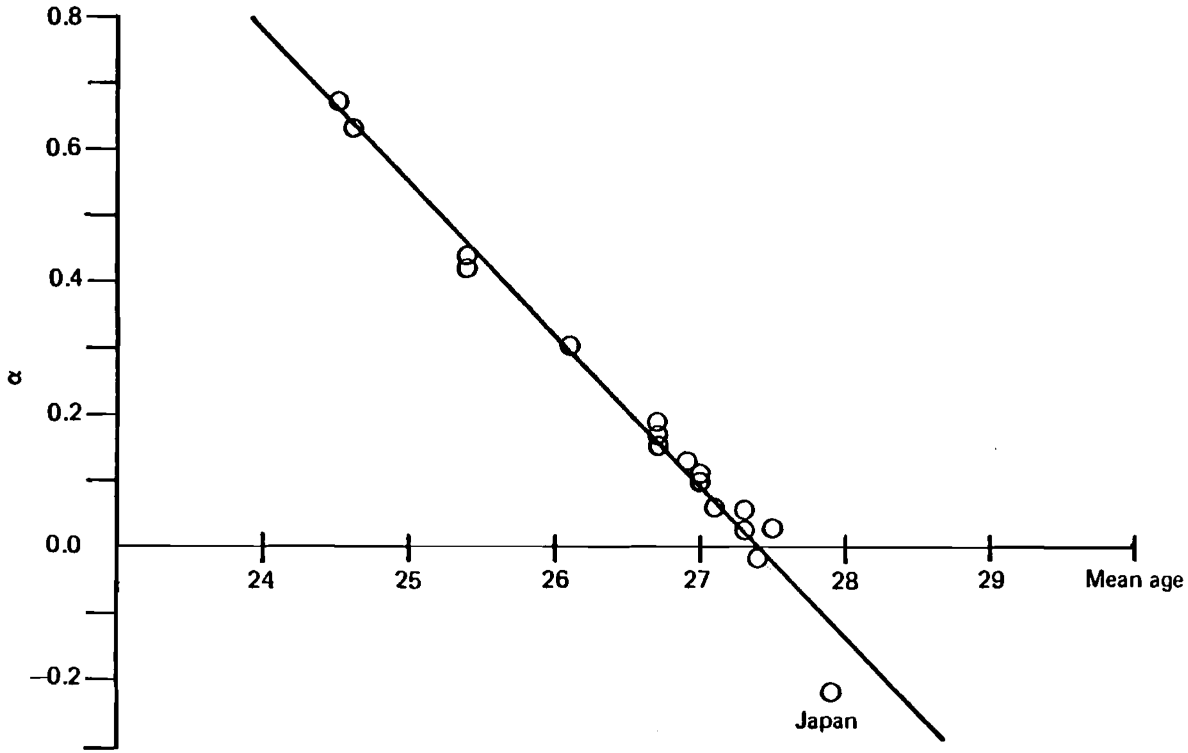

Figure 14. Estimated coefficient α in the relational model plotted against the mean of the age schedule of fertility.

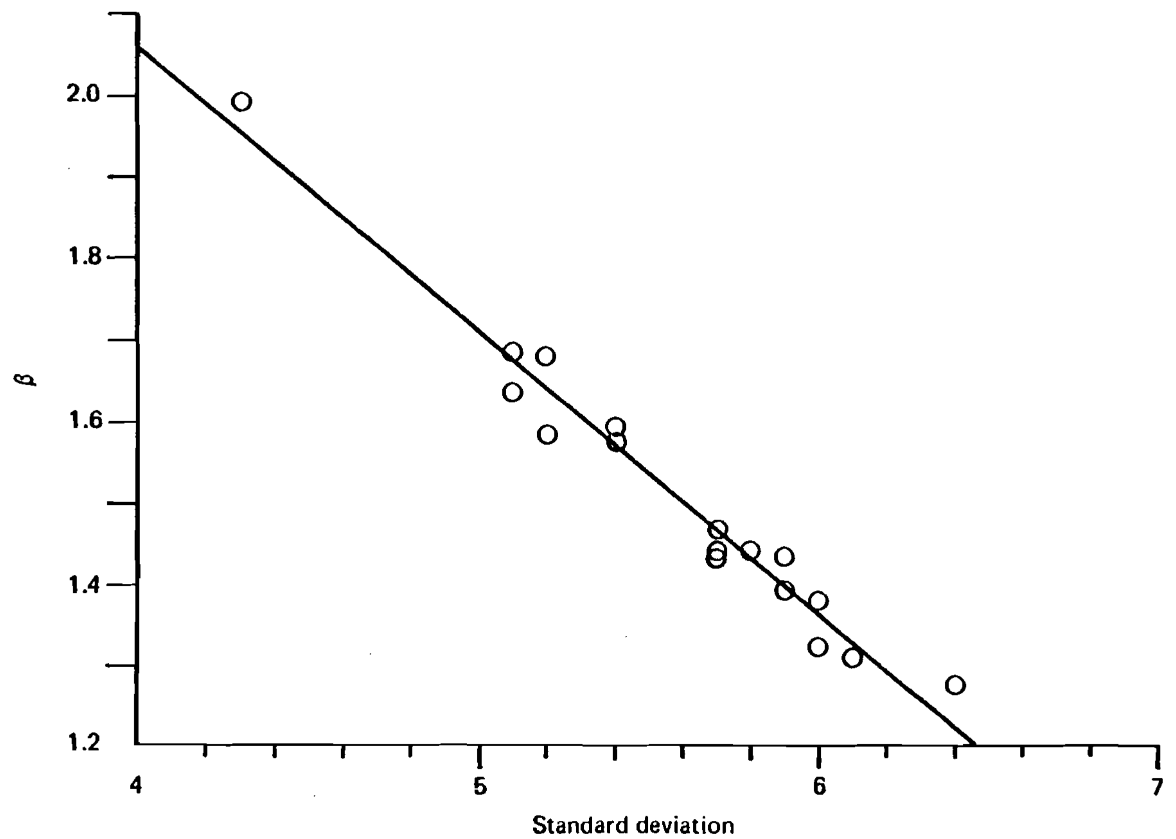

Figure 15. Estimated coefficient β in the relational model plotted against the standard deviation of the age schedule of fertility.

age groups. Among these four countries, Bulgaria and the German Democratic Republic are depicted by the right-most points, indicating an early age of childbearing. The remaining countries form the rest of the group, two points of which are somewhat removed to the upper left. These represent the Netherlands and Sweden, where childbearing starts relatively late and ends early. The lowest point on the plot reflects Austria's largest age variance in fertility among all IIASA countries.

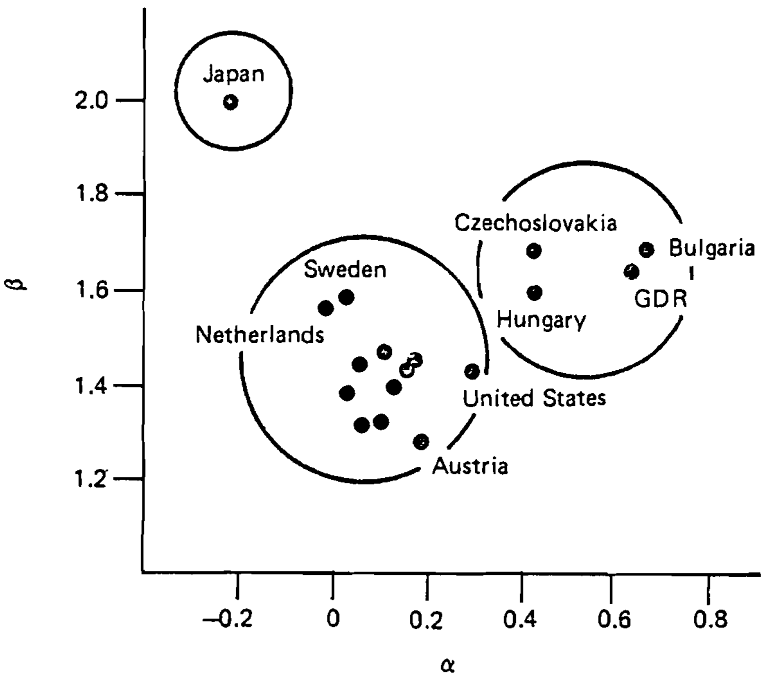

Figure 16. The value of β plotted against the value of α in the relational Gompertz model.

In summary, the horizontal position in Figure 16 represents the timing of childbearing (earlier childbearing as one moves to the right), whereas the vertical position represents the age variation of childbearing (larger age variability as one moves downward).

Next, using the estimated α and β for each country, the cumulative distribution function F(x) is generated by the double exponential transformation; finally the density function f(x) is generated by differencing F(x). Figure 17 represents both the original data (country ASFR normalized to unit area) and the density curve generated by the relational model. Tests of the goodness-of-fit are not performed; instead observations are made by visual inspection of the fit using the comparability of the area under the curve and the area occupied by the bar in each 5-year age interval as a criterion for a good fit. The fits seem remarkably good, especially for the West European countries, Canada, and the United States, but they are less satisfactory for the East European countries and Japan. This is due to the particular pattern of the standard curve used, which depicts an age pattern with the highest fertility in age group 20-24 and slowly declining fertility thereafter. (Recall the curve with $\alpha = 0$ in Figure 12 or $\beta = 1$ in Figure 13). Considering that fertility data in 5-year age groups (cumulative values at only five points) are used with only one standard age pattern, the results are encouraging. The two parameters α and β of the relational Gompertz model clearly highlight the characteristics of a given age pattern and reproduce a continuous age pattern associated with it from only five data points.

5.2 Patterns of Regional Age-Specific Fertility Rates

Before summarizing the regional distributions of α and β of the relative Gompertz model, the regional distributions of the mean and standard deviation of the ASFRs summarized by the midspread and range are presented in Table 9.

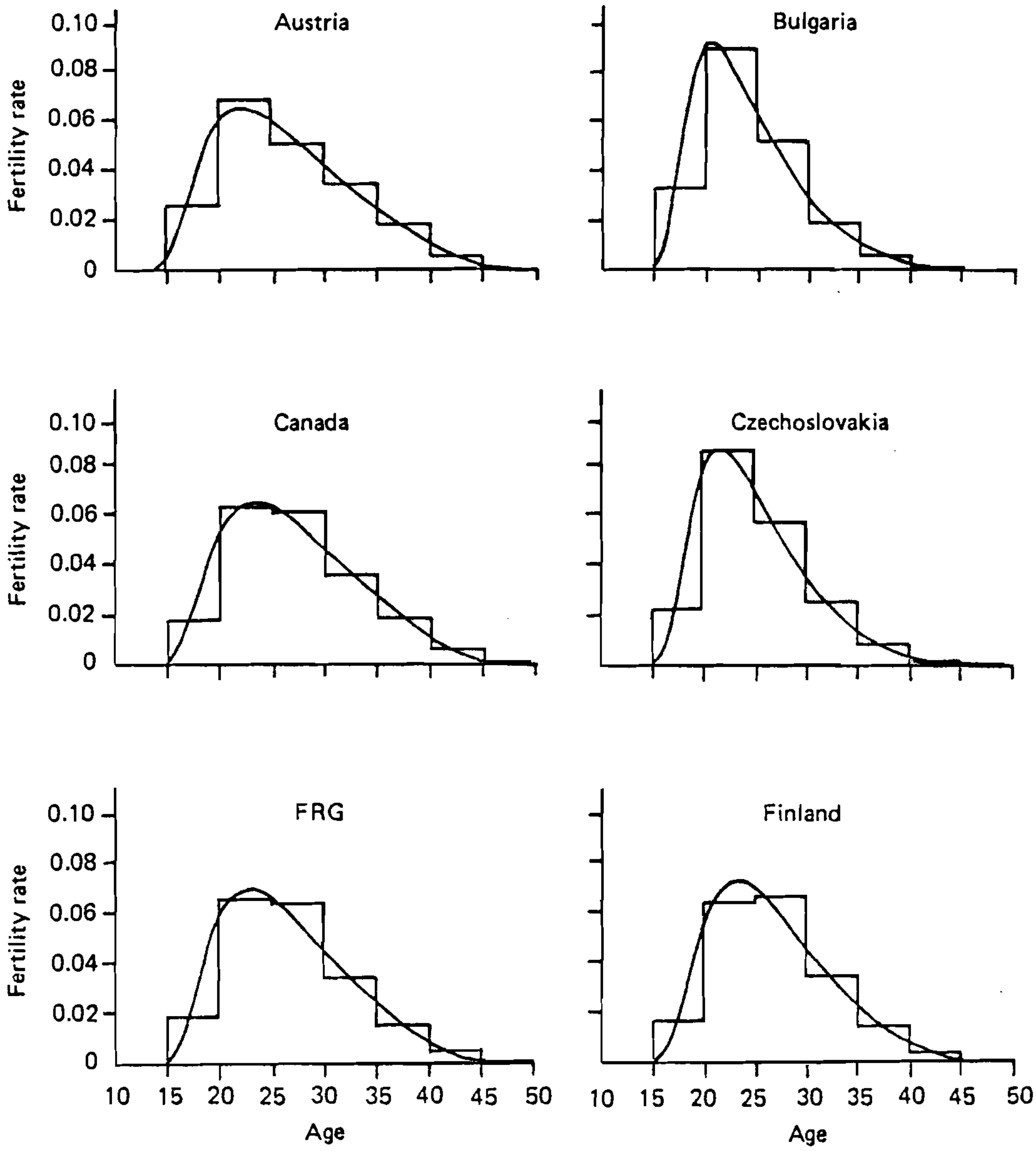

Figure 17. The age-specific fertility rates and the relational fit, by country.

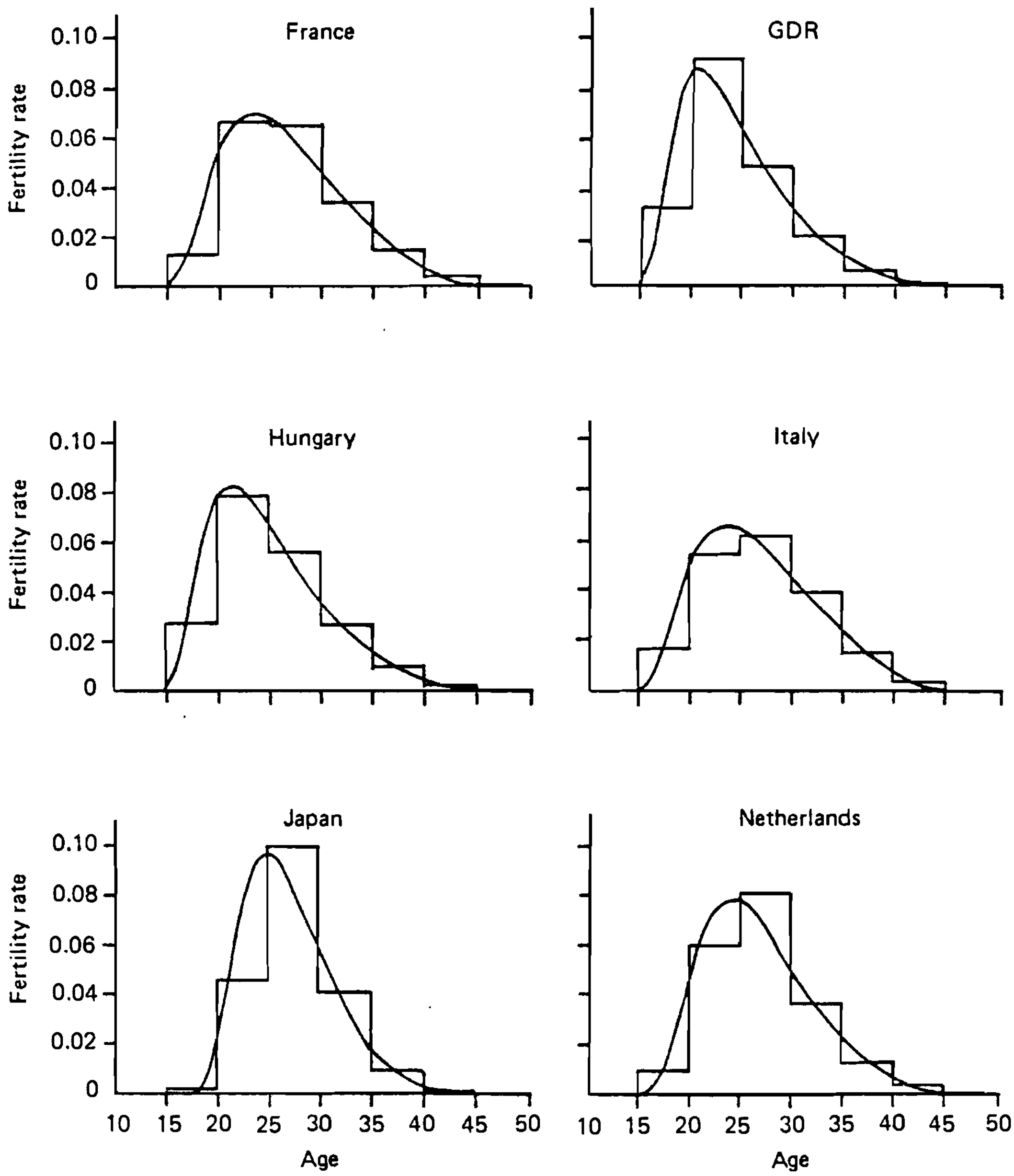

Figure 17. Continued.

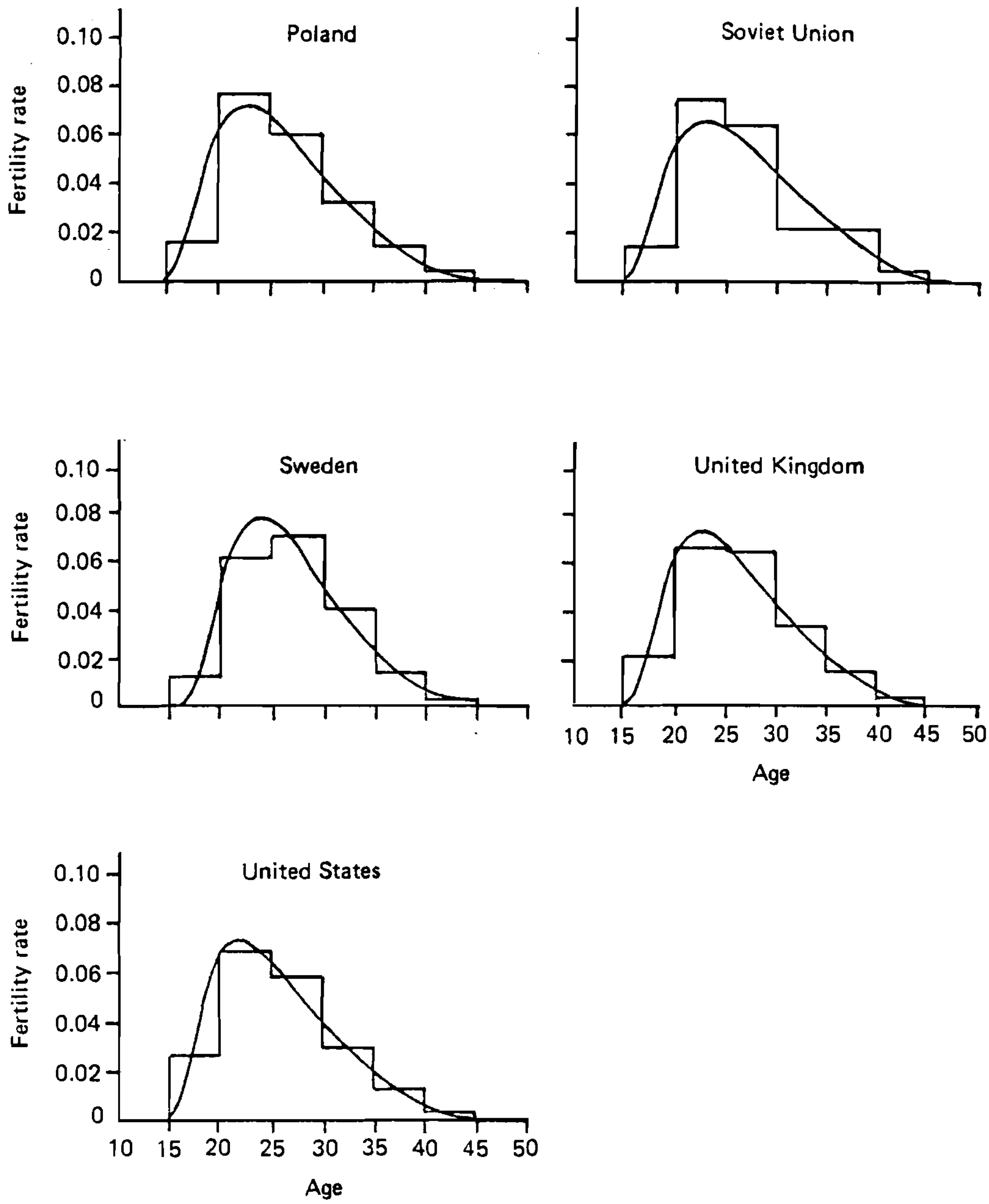

Figure 17. Continued.

Table 9. The midspread and range of the mean and standard deviation of the regional age pattern of fertility, by country.

Country and reference year	Mean: Midspread	Mean: Range	Standard deviation: Midspread	Standard deviation: Range
Austria 1971	0.8	2.1	0.2	0.6
Bulgaria 1975	0.2	1.5	0.2	0.5
Canada 1971	1.0	1.7	0.4	0.5
Czechoslovakia 1975	0.9	1.6	0.2	0.6
Federal Republic of Germany 1974	0.4	1.0	0.2	0.4
Finland 1974	0.7	1.1	0.2	0.7
France 1975	0.2	0.5	0.2	0.4
German Democratic Republic 1975	0.4	0.5	0.1	0.4
Hungary 1974	0.4	0.9	0.2	0.4
Italy 1978	0.7	0.8	0.5	0.7
Japan 1970	0.6	1.2	0.2	0.3
Netherlands 1974	0.2	0.7	0.2	0.2
Poland 1977	0.5	1.9	0.1	0.5
Soviet Union 1974	0.9	2.1	0.7	1.1
Sweden 1974	0.3	0.6	0.1	0.2
United Kingdom 1970	0.4	0.7	0.2	0.3
United States 1970	0.6	1.0	0.1	0.2

In Austria, Canada, Czechoslovakia, and the Soviet Union, there are large regional variations in the mean age at childbearing (ranges of about 2 years, and midspreads of about a year). In Bulgaria and Poland, regional variation in timing of childbearing is large when measured by the range (almost 2 years) but is small when measured by the midspread. The regional variation in the standard deviation of age at childbearing is large in the Soviet Union, Italy, and Canada. Thus the age pattern of childbearing varies markedly in the Soviet Union in terms of both the timing and spread, whereas only the timing varies in Austria and Czechoslovakia, while only the spread in age pattern varies widely in Italy.

The relational Gompertz model, using the same standard as the one used for the national patterns, is then fitted to the regional ASFRs in each country. As in section 4.2, instead of presenting all values for each region in each country, which would be too cumbersome for any meaningful comparison, the results are summarized in Table 10. To examine the regional variations in estimated α and β within each country, the midspread and range of the regional values are presented.

The regional variation in α, which summarizes timing of childbearing, is large in Austria, Canada, Czechoslovakia, and the Soviet Union; the regional variation in β, which summarizes age spread of childbearing, is large in Czechoslovakia, Italy, and the Soviet Union. We notice that if the variation of α is large for a country, the variation of β is also large in general, but this pattern is not regular. For example, Austria has an extremely small variation of β without having a corresponding small variation of α, whereas Italy has a large variation of β without a large variation of α. It is suspected that a relatively large variation in β in Japan, in the light of its small variation in the standard deviation of the age pattern, is an artifact due to the poor fit of the Japanese age pattern to the standard chosen for this study. Because the estimated values of α and β in a region are not independent of each other, they perhaps should be compared as a pair rather than separately as

Table 10. The midspread and range of the estimated regional parameters of the relational Gompertz model, by country.

Country and reference year	Number of regions	α Midspread	α Range	β Midspread	β Range
Austria 1971	9	0.16	0.40	0.05	0.20
Bulgaria 1975	7	0.06	0.38	0.06	0.18
Canada 1971	10	0.17	0.33	0.10	0.21
Czechoslovakia 1975	10	0.23	0.38	0.19	0.36
Federal Republic of Germany 1974	11	0.08	0.20	0.08	0.18
Finalnd 1974	12	0.14	0.20	0.12	0.27
France 1975	8	0.06	0.14	0.08	0.12
German Democratic Republic 1975	5	0.09	0.13	0.01	0.09
Hungary 1974	6	0.09	0.21	0.05	0.17
Italy 1978	5	0.07	0.12	0.17	0.22
Japan 1970	8	0.14	0.28	0.14	0.21
Netherlands 1974	5	0.05	0.14	0.09	0.11
Poland 1977	13	0.10	0.41	0.06	0.25
Soviet Union 1974	8	0.15	0.38	0.29	0.43
Sweden 1974	8	0.05	0.12	0.03	0.14
United Kingdom 1970	10	0.07	0.14	0.05	0.10
United States 1970	4	0.13	0.23	0.04	0.07

two numbers. The midspreads and ranges of α and β for a country nevertheless reflect differing degrees of regional variation (as well as do mean and variance), and they identify countries with large or small regional variations in the age pattern of childbearing that are consistent with both Table 9 and the results of section 4.2. Finally, we note that a "large" regional variation in fertility age patterns refers to a dispersion of about one year in midspread or two years in range for the mean age and about half of those for the standard deviation.

6. SUMMARY

Fertility differentials between IIASA countries are studied systematically in this paper. However, it should be kept in mind that observations made here are contingent upon the data that were used in the analyses. Some problems with the data include differing reference years for each country when fertility was shifting rather rapidly and differing ways in which regions were defined in each country.

Comparisons are made at two levels throughout the paper. The first involves international comparison of national measures and the second involves two steps: interregional comparison of regional measures in each country and international comparison of the degree of interregional variation. The midspread and range of the distribution are used as measures of variation of the distribution. We are interested in two aspects—overall level and age pattern—of fertility differentials.

As a first step, only the level of fertility is considered without regard to differing age patterns in section 3. Although parallel comparisons are made with regard to both CBRs and GRRs, emphasis is given to the GRR as a measure of fertility level. The GRR in the reference years is below unity in seven countries, including, in ascending order, the Federal Republic of Germany 1974, the German Democratic Republic 1975, Finland 1974, the Netherlands 1974, Italy 1978, Sweden 1974, and France 1975; at the other end of the scale, it is highest in the Soviet Union

1974 with GRR = 1.3. The effect of rather dramatic fertility decline in the Western countries since around 1965 is reflected in the comparatively high fertility levels for Canada 1971, the United Kingdom 1970, and the United States 1970, in contrast to data in other countries that describe conditions around 1975. Collectively, the median value of the GRR is 1.1 with a midspread of 0.2, so that fertility levels in the 17 countries is much lower than those prevailing in the rest of the world. When we examine the fertility data for 1975 for all IIASA countries to account for the effect of the difference in the reference years, the GRR in Austria, Canada, the United Kingdom, and the United States all went down to below one, while Italy's GRR went up to above one (because Italy's reference year was 1978). Thus 11 out of 17 of the IIASA member countries had a GRR value less than one in 1975 with the median value among the 17 of 0.9.

Interrregional variation in the GRR, as measured by the midspread of the regional distribution, is by far the largest in the Soviet Union (0.66). Countries that show small regional variations are Czechoslovakia, the Federal Republic of Germany, Finland, the German Democratic Republic, Hungary, Japan, Sweden, and the United States, where the midspread is 0.07 or less. This large variation between countries in regional fertility differentials of the GRR (more than 10-fold) is much reduced when the regional differentials of the CBR are compared between countries (Figures 6 and 7).

To investigate the level and age pattern of fertility simultaneously, the ASFRs in different locations (countries in case of international comparison, and regions in case of interregional comparison) are considered as a two-way table in section 4. The age effects and location effects in the linear model are estimated by Tukey's median polish together with the magnitude and pattern of residuals. Seventy-two percent of variation in the national ASFRs is accounted for by the age-plus-country effect model, in which age effects attribute to about four times as much variation as country effects. The relative country effects represent relative levels of fertility studied in section 3, whereas the relative age effects present the overall age pattern of childbearing in all 17 IIASA countries. The magnitude and pattern of residuals in each country represent a departure of that country's age pattern from the overall pattern, thus indicating a difference in national age patterns. The distinct age pattern in Japan, where fertility is concentrated in age group 25-29, as well as the East European pattern, in which fertility is high at early ages (in age groups 15-19 and 20-24) in Bulgaria, Czechoslovakia, the German Democratic Republic, and Hungary) is separated out from the rest of the countries. It is interesting to note that very different fertility patterns appear in the Federal Republic of Germany than the German Democratic Republic; the former exhibits a typically Western pattern and the latter shows a typically East European pattern.

From the median polish of the regional ASFRs in each country, we obtain the typical value that summarizes the overall country level, the age effects that represent an average age pattern for that country, and the regional effects that give relative levels of fertility in each region. The magnitude and pattern of residuals in the resultant table represent the degree of interregional variation in the age pattern of childbearing: the measure G of goodness-of-fit of the model summarizes this. We find that the typical value for a country from the analysis of regional ASFRs correlates better with the GRR than does the country effect from the analysis of national ASFRs. The relative magnitude of interregional variation in the fertility level in each country obtained from this analysis is consistent with the results in section 3; small in Sweden, the German Democratic Republic, and the United States, and large in Canada, Italy, Austria, and Poland with the largest in the Soviet Union. Differing national age patterns of childbearing, which were suggested by the structure of residuals in the median polish of national ASFRs, are confirmed by the estimated age effects in this analysis. Finally, interregional variation in the age pattern (measured by G) is small in Sweden, the German Democratic Republic, and the United Kingdom, large in Austria and Poland,

and largest in the Soviet Union. Thus countries that have large interregional variations in fertility levels tend also to have large interregional variations in their age patterns of fertility.

Finally, after adjusting for differing levels, the age pattern of fertility is studied in more detail, taking both the timing and age dispersion into account, in section 5. The fertility age distribution is fitted by the Brass's relational Gompertz fertility model. Estimated values of the parameters α and β in the model characterize the timing and age spread that are consistent with the mean and standard deviation of the ASFRs in five-year age groups. Parameters from the national age pattern distinctly differentiate the early childbearing East European pattern, late childbearing and centrally concentrated Japanese pattern, and the more typical Western pattern. In general, early age at childbearing is associated with a small spread of the age distribution, but Japan is an exception. When the single year age distribution is generated using the estimated parameters α and β, the fit of the generated curve to the 5-year ASFRs is more satisfactory for the Western pattern than for the East European pattern or for Japan. This is because the standard age pattern of fertility used in this analysis is similar to the Western pattern.

Interregional variation in the age pattern of fertility is obtained by fitting the regional age patterns and comparing the estimated regional parameters of timing (α) and age spread (β). Interregional variation in the timing is large in Austria, Canada, Czechoslovakia, and the Soviet Union, and small in France, the German Democratic Republic, Italy, the Netherlands, Sweden, and the United Kingdom. On the other hand, interregional variation in age dispersion is large in Czechoslovakia, Italy, Japan, and the Soviet Union, and small in the German Democratic Republic, Sweden, the United Kingdom, and the United States. We note here that large (small) interreginal variation in timing of childbearing is usually accompanied by a corresponding large (small) interregional variation in age dispersion, but the correspondence is not regular. It is suspected that when the chosen standard fits poorly to the given age schedule, the estimated β is less reliable as a measure of the spread of the age distribution.

To summarize, a country with a high fertility level tends to have a large interregional variation in fertility levels, which is also accompanied by a large interregional variation in age schedules of fertility, again in terms of both the timing and age dispersion. The Soviet Union exhibits by far the largest variations, followed by Canada and Italy. Countries with the lowest and most uniform fertility include Sweden and the German Democratic Republic. Countries with outlier regions (e.g., Austria) present conflicting pictures depending on whether the midspread or range is used as a criterion. Countries that are not mentioned specifically in the discussion fall into middle-of-the-roaders by implication.

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APPENDIX A: THE GROSS REPRODUCTION RATES (TOTAL, UNDER 30 AND OVER 30 YEARS OF AGE) AND THE MEAN AGE OF FERTILITY SCHEDULE FOR EACH REGION IN THE COMPARATIVE MIGRATION AND SETTLEMENT STUDY

Country (reference year) and region	Population (1)	Fertility: GRR (2)	Fertility: Mean age of fert.sched. (3)	Fertility: GRR(<30) (4)	Fertility: GRR(>30) (5)
Austria (1971)					
Burgenland	272119.	1.16	25.96	0.882	0.274
Carinthia	525728.	1.22	27.12	0.853	0.363
Lower Austria	1414161.	1.10	26.34	0.810	0.293
Upper Austria	1223444.	1.19	27.00	0.832	0.359
Salzburg	401766.	1.17	26.96	0.823	0.344
Styria	1192100.	1.13	26.77	0.806	0.329
Tyrol	540771.	1.23	27.94	0.792	0.437
Vorarlberg	271473.	1.31	27.66	0.888	0.423
Vienna	1614841.	0.82	25.77	0.618	0.199
Austria	7456403.	1.09	26.72	0.776	0.312
Bulgaria (1975)					
North West	1042803.	1.10	24.06	0.977	0.119
North	1400117.	1.01	24.25	0.888	0.123
North East	1486719.	1.20	24.43	1.050	0.154
South West	696466.	1.11	24.60	0.959	0.153
South	2164076.	1.13	24.45	0.989	0.141
South East	866834.	1.22	24.36	1.065	0.152
Sofia	1069975.	0.96	25.44	0.780	0.182
Bulgaria	8726990.	1.10	24.49	0.957	0.146
Canada (1971)					
Newfoundland	507750.	1.90	28.01	1.258	0.643
Prince Edward Island	110085.	1.51	28.13	0.981	0.524
Nova Scotia	772500.	1.33	27.16	0.935	0.392
New Brunswick	625674.	1.41	27.49	0.965	0.443
Quebec	5904307.	1.10	28.16	0.728	0.373
Ontario	7331987.	1.22	26.99	0.881	0.344
Manitoba	975655.	1.33	27.33	0.932	0.397
Saskatchewan	940790.	1.47	27.30	1.036	0.438
Alberta	1545537.	1.37	26.79	1.002	0.368
British Columbia	2029147.	1.19	26.54	0.886	0.301
Canada	20743436.	1.23	27.33	0.866	0.367
Czechoslovakia (1975)					
Central Bohemia	2300705.	1.13	25.37	0.937	0.198
Southern Bohemia	667998.	1.17	25.11	0.991	0.179
Western Bohemia	872796.	1.20	24.87	1.014	0.184
Northern Bohemia	1135800.	1.21	24.72	1.028	0.185
Eastern Bohemia	1224599.	1.21	24.93	1.034	0.180
Southern Moravia	1985174.	1.22	25.26	1.021	0.200
Northern Moravia	1875294.	1.21	25.08	1.023	0.192
Western Slovakia	1966889.	1.18	25.84	0.953	0.231
Central Slovakia	1455491.	1.25	25.94	0.996	0.251
Eastern Slovakia	1316921.	1.39	26.32	1.081	0.313
Czechoslovakia	14801667.	1.21	25.41	0.998	0.212

Country (reference year) and region	Population (1)	Fertility GRR (2)	Mean age of fert.sched. (3)	GRR(<30) (4)	GRR(>30) (5)
Fed.Rep.of Germany(1974)					
Schleswig-Holstein	2584343.	0.73	26.52	0.552	0.176
Hamburg	1733802.	0.58	26.61	0.432	0.145
Lower Saxony	7265539.	0.81	27.25	0.575	0.232
Bremen	723990.	0.68	26.23	0.521	0.156
N. Rhine-Westphalia	17218626.	0.72	26.81	0.534	0.186
Hessen	5576082.	0.70	26.76	0.516	0.180
Rhineland-Palatinate	3687561.	0.73	26.62	0.553	0.180
Baden-Wuerttemberg	9226239.	0.77	26.98	0.559	0.212
Bavaria	10849123.	0.75	27.23	0.532	0.215
Saarland	1103325.	0.65	26.51	0.490	0.164
West Berlin	2034366.	0.65	26.34	0.490	0.161
Fed.Rep. of Germany	62002996.	0.73	26.91	0.537	0.196
Finland (1974)					
Uusimaa	1073485.	0.76	26.76	0.568	0.195
Turku and Pori	691672.	0.76	26.54	0.581	0.182
Ahvenanmaa	22009.	0.80	26.60	0.618	0.184
Hame	657049.	0.75	26.64	0.566	0.187
Kymi	345985.	0.73	26.64	0.553	0.176
Mikkeli	212200.	0.75	27.41	0.540	0.212
Pohjois-Karjala	177870.	0.79	27.57	0.535	0.251
Kuopio	251320.	0.77	27.27	0.550	0.219
Keski-Suomi	238814.	0.80	27.31	0.568	0.230
Vaasa	423043.	0.90	27.25	0.644	0.253
Oulu	400853.	0.96	27.57	0.667	0.293
Lappi	196232.	0.83	27.25	0.589	0.241
Finland	4690532.	0.79	26.96	0.581	0.211
France (1975)					
Paris Region	9876665.	0.88	27.28	0.630	0.250
Paris Basin	9647540.	0.99	26.86	0.734	0.253
North	3913250.	1.12	27.08	0.815	0.303
East	4905810.	0.94	27.13	0.681	0.258
West	6889705.	1.06	27.14	0.777	0.280
Southwest	5553655.	0.84	27.20	0.614	0.227
Middle East	6129105.	0.91	27.44	0.654	0.260
Mediterranean	5464635.	0.83	27.34	0.594	0.231
France	52380364.	0.94	27.15	0.686	0.255
German Dem.Rep.(1975)					
North	2085383.	0.79	24.50	0.684	0.110
Berlin	1098174.	0.80	24.85	0.686	0.111
Southwest	2529805.	0.78	24.97	0.636	0.141
South	7134846.	0.74	24.54	0.635	0.101
Middle	3972041.	0.74	24.50	0.646	0.097
German Dem.Rep.	16820250.	0.76	24.61	0.648	0.108

Country (reference year) and region	Population (1)	Fertility: GRR (2)	Fertility: Mean age of fert.sched. (3)	Fertility: GRR(<30) (4)	Fertility: GRR(>30) (5)
Hungary (1974)					
Central	2968109.	0.99	25.80	0.776	0.210
North Hungary	1357973.	1.20	25.15	0.989	0.208
North Plain	1543604.	1.36	25.53	1.087	0.269
South Plain	1451260.	1.15	25.30	0.939	0.210
North Trans-Danubia	1823844.	1.19	25.40	0.980	0.214
South Trans-Danubia	1303694.	1.17	24.90	0.984	0.183
Hungary	10448484.	1.14	25.42	0.929	0.216
Italy (1978)					
North West	15424582.	0.77	27.22	0.546	0.221
North East	10394756.	0.76	27.31	0.531	0.227
Center	10790837.	0.82	27.25	0.582	0.239
South	13471822.	1.17	28.03	0.750	0.420
Islands	6518288.	1.11	27.90	0.714	0.398
Italy	56600292.	0.91	27.47	0.625	0.286
Japan (1970)					
Hokkaido	5184287.	1.01	27.24	0.800	0.213
Tohoku	11392179.	1.08	27.38	0.840	0.242
Kanto	30257930.	1.02	28.43	0.705	0.319
Chubu	17401128.	1.07	27.44	0.832	0.234
Kinki	16511391.	1.03	27.90	0.764	0.271
Chugoku	6996961.	1.05	27.26	0.837	0.215
Shikoku	3904014.	1.06	27.17	0.842	0.219
Kyushu	13017290.	1.15	27.92	0.842	0.313
Japan	104665176.	1.05	27.85	0.777	0.273
Netherlands (1974)					
North	1473611.	0.98	27.18	0.728	0.248
East	2592786.	0.98	27.61	0.713	0.268
West	6150477.	0.81	27.35	0.598	0.209
South-West	322891.	0.98	26.94	0.749	0.227
South	2948600.	0.86	27.41	0.645	0.218
Netherlands	13488365.	0.87	27.39	0.647	0.227
Poland (1977)					
Warsaw	2207161.	0.83	26.41	0.640	0.195
Lodz	1099132.	0.81	25.86	0.644	0.163
Gdansk	1287689.	1.04	26.70	0.778	0.267
Katowice	3557261.	0.92	25.77	0.737	0.187
Cracow	1143864.	0.94	26.68	0.691	0.248
East-Central	2930837.	1.22	26.71	0.923	0.297
Northeast	2398497.	1.27	27.18	0.921	0.346
Northwest	2106814.	1.09	26.19	0.846	0.240
South	2505722.	1.11	26.74	0.832	0.283
Southeast	4208485.	1.41	27.74	0.975	0.432
East	2479828.	1.25	26.99	0.926	0.327
West-Central	4712562.	1.14	26.76	0.850	0.288
West	4059724.	1.05	26.25	0.813	0.238
Poland	34697580.	1.10	26.69	0.826	0.275

Country (reference year) and region	Population (1)	Fertility GRR (2)	Mean age of fert.sched. (3)	GRR(<30) (4)	GRR(>30) (5)
Soviet Union (1974)					
Urban areas of the:					
RSFSR	88230272.	1.00	26.07	0.830	0.172
Ukrainian+Mold.SSRs	29527222.	1.03	26.08	0.833	0.200
Byelorussian SSR	4549020.	1.08	26.56	0.865	0.220
Central Asian Rep.s	8681624.	1.92	28.33	1.318	0.604
Kazakh SSR	7348350.	1.26	27.14	0.955	0.300
Caucasian Republics	6918171.	1.47	27.09	1.146	0.326
Baltic Republics	4334008.	0.97	26.75	0.724	0.241
Rural areas of USSR	101280288.	1.88	27.40	1.375	0.510
Soviet Union	250868944.	1.33	27.00	1.014	0.320
Sweden (1974)					
Stockholm	1486821.	0.86	27.52	0.599	0.260
East Middle	1397129.	0.95	26.96	0.694	0.252
South Middle	763793.	0.97	27.38	0.695	0.278
South	1157556.	0.92	27.31	0.660	0.262
West	1603323.	0.93	27.32	0.670	0.263
North Middle	853655.	0.89	26.95	0.651	0.243
Lower North	400292.	0.90	27.35	0.631	0.266
Upper North	494569.	0.96	27.41	0.679	0.286
Sweden	8157138.	0.92	27.26	0.658	0.262
United Kingdom (1970)					
North	3359700.	1.16	26.40	0.881	0.278
Yorkshire + Humbers.	4811900.	1.26	26.41	0.953	0.306
North West	6788700.	1.26	26.61	0.938	0.324
East Midlands	3362800.	1.21	26.45	0.923	0.286
West Midlands	5178000.	1.21	26.82	0.891	0.324
East Anglia	1673500.	1.11	26.43	0.853	0.256
South East	17315502.	1.12	26.91	0.822	0.298
South West	3763700.	1.15	26.49	0.878	0.271
Wales	2733900.	1.19	26.42	0.900	0.285
Scotland	5199100.	1.26	27.07	0.907	0.358
United Kingdom	54186800.	1.18	26.70	0.881	0.304
United States (1970)					
Northeast	49040708.	1.24	26.64	0.926	0.316
North Central	56571668.	1.30	26.15	0.999	0.298
South	62795372.	1.27	25.60	1.003	0.272
West	34804200.	1.22	26.02	0.946	0.277
United States	203211920.	1.26	26.07	0.974	0.290

APPENDIX B: REGIONAL DIFFERENTIALS IN GROSS REPRODUCTION RATES

Country and reference year	National (N)	Lowest	Highest	MAD[a]	MAD/N %[b]
Austria 1971	1.09	0.82	1.31	0.12	10.8
Bulgaria 1975	1.10	0.96	1.22	0.07	6.4
Canada 1971	1.23	1.10	1.90	0.19	15.4
Czechoslovakia 1975	1.21	1.13	1.39	0.04	3.2
Fed. Rep. of Germany 1974	0.73	0.58	0.81	0.05	6.7
Finland 1974	0.79	0.73	0.96	0.05	5.9
France 1975	0.94	0.83	1.12	0.08	8.6
German Demo. Republic 1975	0.76	0.74	0.80	0.03	3.4
Hungary 1974	1.14	0.99	1.36	0.09	7.6
Italy 1978	0.91	0.76	1.17	0.17	18.5
Japan 1970	1.05	1.01	1.15	0.03	3.0
Netherlands 1974	0.87	0.81	0.98	0.08	9.2
Poland 1977	1.10	0.81	1.41	0.14	12.7
Soviet Union 1974	1.33	0.97	1.92	0.32	24.3
Sweden 1974	0.92	0.86	0.97	0.03	3.3
United Kingdom 1970	1.18	1.11	1.26	0.05	4.2
United States 1970	1.26	1.22	1.30	0.03	2.2

[a]MAD is the mean absolute deviation of a regional value from the national figure.

[b]MAD/N % expresses the mean absolute deviation as a percentage of the national value.

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