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IIASA Working Paper

WP-80-084

May 1980

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May 1980
WP-80-84

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ABOUT THE AUTHOR

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FOREWORD

Interest in human settlement systems and policies has been a central part of urban-related work at IIASA since its inception. From 1975 through 1978 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 dissemination of the Task's results and to the conclusion of its comparative study which, under the leadership of Frans Willekens, is carrying out a comparative quantitative assessment of recent migration patterns and spatial population dynamics in all of IIASA's 17 NMO countries.

This paper reviews patterns of multiregional population growth in five socialist countries in Eastern Europe. In it the author compares and contrasts a number of multiregional demographic measures that illuminate the spatial demographics that recently occurred in these countries.

Papers summarizing previous work on migration and settlement at IIASA are listed at the back of this paper.

Andrei Rogers
Chairman
Human Settlements
and Services Area

ABSTRACT

Socioeconomic changes in the Eastern European socialist countries have considerably altered demographic patterns. In order to analyze these changes, a comparative study of fertility, mortality, and migration, at the regional level has, been carried out. The method used is that of multiregional demography. It is shown that while the mortality patterns are more or less uniform in the regions of the five countries under consideration, the fertility and mortality patterns are more diverse, although they still correspond to the degree of the regional socio-economic development.

CONTENTS

MULTIREGIONAL DEMOGRAPHIC ANALYSES FOR SOME SOCIALIST COUNTRIES IN EASTERN EUROPE

1. INTRODUCTION

During the last 30 years, demographic patterns in the socialist countries of eastern Europe have been altered considerably due to modifications in the socioeconomic life. Both demographic and socioeconomic changes are dissimilar in magnitude because of the differences inherited from the past but are uniform with respect to their direction. That is, a socioeconomic or a demographic process observed in a given country should resemble the same process in other countries as well. Typical examples of such processes are industrialization and urbanization.

Given the common basis of observed changes, a comparative analysis of demographic patterns can be carried out, thus making it possible to analyze past and present demographic trends. If a demographic pattern observed in one country is not observed in another, probably it will also take place in the latter. In such a case, a comparative analysis would be of great benefit in the designing of a national social and population policy.

There are few comparative studies of this kind for this part of the world. Generally they are either parts of larger studies, or focus on a particular demographic category. A well-known investigation of fertility and population policy is the book edited by Berelson (1974) which consists of 26 chapters,each one for a separate country and written by scientists from each country. Other studies, also focusing on a particular demographic category, are those of Berent (1970) on fertility, Szabady (1973) on mortality, Sarfalvi (1970), Kowalewski (1970), Pivovarov (1972), and Compton (1976) on migration. Broader studies which focus on the joint effect of the major demographic factors are only a few: Pivovarov (1970), Valentei (1974), Szabadi et al. (1966).

The above mentioned studies have one common feature. They are all descriptive in that the demographic processes are observed predominantly with crude rates. No models are incorporated to clarify the links between different demographic variables, or to assess quantitatively the demographic processes. One study only, (Keyfitz and Flieger 1972), gives numerical results which are the outcome of up-to-date demographic models. In this book, 70 countries are studied and those of interest in this paper are also included. The numerical results are obtained by applying one methodology and one set of computer programs. The outputs allow for detailed demographic comparisons either qualitative or quantitative, but the comparing itself is left to the reader. Migrations are not considered, hence the study provides no information on spatial population distribution.

In this paper, an attempt will be made to carry out comparative demographic analyses which will comprise the major demographic components; fertility, mortality, and migration, by applying one methodology and one set of computer programs. The analysis will be by and large quantitative, with the aim being the discovery of similarities, if such exist, in the demographic structures. The discussion will be predominantly centered around the concept of "space", with respect to the three demographic components mentioned above.

The paper is based entirely on work done at the International Institute for Applied Systems Analysis (IIASA), where a comparative study for the member countries of the Institute was a part of the scientific program developed in the Migration and Settlement Task in the Human Settlements and Services Area. The latter study was focused on spatial population analysis which was based on multiregional mathematical demography (Rogers 1975a). Computer programs were created and applied to data referring to the 17 member countries.

The computer results were sent to scientists in the corresponding countries who produced reports concerning the demographic processes on a previously specified regional level. The reports on Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, and Poland were used extensively by the author of the present paper. Below is the list of scientists and their papers* (where more than one country is listed, alphabetical order is preferred throughout the whole paper):

D. Philipov - Migration and Settlement in Bulgaria (IIASA publication, RM-78-36)

K. Kühnl - Migration and Settlement in Czechoslovakia (preliminary draft)

G. Mohs - Migration and Settlement in the German Democratic Republic (IIASA publication, RR-80-6)

K. Bies and K. Tekse - Migration and Settlement in Hungary (IIASA working paper, WP-78-20)

K. Dziewonski and P. Korcelli - Migration and Settlement in Poland: Dynamics and Policies (preliminary draft)

A similar report was also done for the USSR but was not included in this paper because the demographic patterns brought about by its vast territory and multinational population cannot be observed anywhere else.

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*All these papers are expected to appear during 1980 as IIASA Research Reports.

The remaining socialist countries from eastern Europe were not included because they are not members of IIASA, hence neither data nor scientific collaboration was possible to obtain. The comparative study presented here is based on cross-sectional data. Vital-statistics data over a period of one year are used. In order to better understand what these data reveal it is necessary to consider the recent changes in the demographic patterns with respect to the socioeconomic changes which have taken place. This topic is discussed in the next section.

2. RECENT DEMOGRAPHIC CHANGES AND THEIR BACKGROUND

2.1 Background of the Demographic Changes

Since the Second World War, the countries in eastern Europe have undergone substantial changes in their social and economic development. These changes refer to socialistic industrialization, land reforms, mechanization, and collectivization (in most of the countries) of agriculture, emancipation of women, improved health care and education, etc. Closely connected with them are urbanization, development of services, etc. It is only against this background that the formation of the present-day demographic structures should be investigated.

Each of the above mentioned social or economic processes has its own features in the individual countries. The strongest effect over the demographic changes seems to be due to industrialization. The economies, being predominantly agricultural before the Second World War, turned out to be highly industrial under the conditions of central planning. The region's distribution of industrial development followed two main directions. First, the traditional industrial centers--southern parts of the GDR and Poland, the Czech republic of the CSSR, Budapest, Sofia and a few other cities in Hungary and Bulgaria--continued to grow. In addition, the industrial centers situated close to natural resources and improved transportation were enlarged, i.e, some cities along the seashore in the GDR, Poland, and Bulgaria and along the Danube to Hungary and the CSSR. Second, the socioeconomic policies in these countries facilitated the industrial development of the backward regions, in order to reach a more uniform economic growth over the whole territory. These regions included the northern parts of the GDR, the northern and central parts of Poland, the Slovak republic in the CSSR, and the peripheral regions in Bulgaria and in Hungary. An additional effect was the easing of some over-industrialized centers, such as Budapest.

In the agricultural sector, the major contribution to demographic changes was due to land reforms which brought about the mechanization and collectivization of privately owned farms. According to the land reforms, the maximum size of the private land per family was strongly decreased, so that hired workers were almost not necessary. The later collectivization into large agrarian farms made it possible to introduce high levels of mechanization in the agricultural process. These factors together contributed to a substantial decrease in the necessity of labor force in the agricultural sector.

Presently land is predominantly state-owned, with the exception of Poland, where 70 percent of the arable land is distributed into small, privately-owned farms, situated mainly in the central and northern parts of the country. Obviously, the social and political changes would not influence the spatial distribution of the agricultural activities. The traditional agricultural regions retained their significance until today.

Changes in the service sector refer mainly to the free-of-charge education (obligatory to a certain age), a free-of-charge and improved health care system, and a higher level of women emancipation. All of these changes have a definite effect on the demographic components.

Clearly, the socioeconomic changes mentioned above are the cause of a substantial spatial redistribution of the population along with essentially new demographic structures.

2.2 Fertility

During the first decade after the Second World War, the fertility level showed large fluctuations in scale and direction among the countries. In Bulgaria and Poland there was a post-war compensation period, especially long in Poland (10-12 years), and in the GDR there was a 4-5 year depression.

Later, under the influence of the new type of socioeconomic development, the fertility levels began to drop continuously. Table 1 gives some fertility measures for the five countries. These measures are not unified, but they reveal the patterns which are discussed below. The reader should be reminded that the net reproduction rate (NRR) is to be preferred to the total fertility rate (TFR), which on its side is to be preferred to the crude birth rate (CBR). (This preference is based on the definition of each rate, which are discussed in every demographic textbook.)

The decrease in the level of fertility was strongest during the beginning of the 1960's. In Bulgaria and especially in Hungary, it dropped down below the replacement level. In the CSSR, GDR, and Poland, it dropped down to a level which could barely assure replacement. By the end of the sixties and during the first years of the seventies, fertility began to increase in Bulgaria, the CSSR, and Poland, but continued to decrease in the GDR and Hungary.

The changes in fertility levels correspond to the socio-economic changes in the countries. Industrialization and the mechanization of agriculture, caused a rapid urbanization process. Women increased their social and economic participation as they became emancipated. These factors, together with the elimination of some traditional habits, such as children being additional working hands in agriculture, caused a decrease in the number of children born in a given family. Since the end of the sixties, these factors were counteracted by the population policies. Childbearing was encouraged through specially designed pronatal policies (1967 in Bulgaria, 1974 in Bulgaria). The only exception was the level of fertility in the GDR, which decreased consistently throughout the whole period.

Table 1. Levels of fertility in Bulgaria, CSSR, GDR, Hungary, and Poland.

			Year								
Country	Measure	Region	1955	1960	1965	1970	1971	1972	1973	1974	1975
Bulgaria	NRR[a]	total	--	--	0.969	1.030	0.967	0.963	1.017	1.084	1.055
CSSR*	CBR	total	20.3	15.9	16.4	15.9	16.5	17.3	18.8	19.8	19.6
		Czech republic	15.9[b]	14.4[b]	14.4[b]	15.1	15.7	16.6	18.3	19.4	19.0
GDR	CBR	total	16.3	17.0	16.5	13.9	13.8	11.8	10.6	10.8	11.6
Hungary	NRR	total	--	0.907	0.831	0.939	0.912	0.890	0.894	0.905	1.072
	TFR	total	--	2.039	1.812	1.997	--	--	--	2.304	--
	TFR	Budapest	--	1.235	1.182	1.512	--	--	--	1.797	--
	TFR	other urban	--	1.856	1.644	1.835	--	--	--	2.178	--
	TFR	rural	--	2.352	2.153	2.314	--	--	--	2.641	--
Poland	NRR	total	1.519	1.339	1.149	1.011	1.040	1.034	1.055	1.051	1.059
		Warsaw	1.228	0.759	0.580	0.585	0.580	0.580	0.599	--	--
		urban	1.366	1.098	0.879	0.794	0.810	0.807	0.805	0.805	0.826
		rural	1.675	1.601	1.487	1.315	1.370	1.369	1.449	1.458	1.484

[a] refers to the female population

[b] refers to the five-year period starting with the indicated year (1954-1959, 1960-1964, 1965-1969)

*Source: Statistical Yearbook of CSSR, 1976.

At the regional level, decreasing fertility tendencies are also observed, but the patterns of decrease vary. After the war, the population in the more industrialized regions had a considerably lower fertility level than that of the more agricultural regions. Gradually the regional differences lessened more or less over the whole territory of each country, along with planned, uniform socioeconomic development.

Differences increased, however, where the separation of urban and rural areas were concerned. Table 1 shows that the urban areas in Hungary and Poland exhibit a fertility level far below replacement, and that this has been the case since the first half of the sixties. The reason is in the joint effect of the socioeconomic conditions of life mentioned above as they are established in the urban areas. A major reason seems to be the participation of women in industrial labor. Other important reasons are the decrease of family size, delay or marriage, desire for higher education in city institutes, worsening of housing conditions.

2.3 Mortality

The level of mortality during the last 25 years or so experienced a steady decrease. Improved living conditions and health care systems have mainly brought a decrease in infant mortality which has in turn increased the expectation of life.

In Bulgaria, the life expectancy in 1956-1957 was 65.9 years for the total population; 64.2 for males and 67.7 for females. In 1973-1974, it was 68.9 for males and 73.6 for females. In Czechoslovakia, males were expected to live 60.9 years in the period 1949-1951, while in 1974 the figure was 66.8; the females increased the life expectancy from 65.5 to 73.7 during the same period of time.* In the GDR, during the 1953-1975 period, the life expectancy increased from 65 to 69 years for males and from 68 to 77 years for females.

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*Source of the data for Czechoslovakia: Statistical Survey of Czechoslovakia, Orbis, Prague (1976).

The males in Hungary were expected to live 65.2 years in 1959-1960, and 66.5 in 1969-1970. The females gained a little more: from 69.6 to 72.1 years. In Poland, the increase was from 61.8 to 66.9 for males during the 1955/1956-1976 period, and from 67.8 to 74.6 years for the females.

Although the period of measurement differs, one can notice the tendency of decreasing mortality, which causes an increase of about 4.5 years for the expectancy of life.

Unlike fertility, mortality levels seem to be much more uniform over the regions within each country. The life expectancy in 19 regions of Hungary differed at most 2.5 years for the males in 1959-1960, and this difference was the same 10 years later. For the females, the difference was three and less than two years, respectively. The division of the population of Poland by urban and rural areas shows even smaller differences--the expectation of life of an urban- or rural-born males does not differ more than one year over the 1965/1966-1976 period, and for a female the difference is also negligible (0.7 years). The uniform distribution of the level of mortality over the territory of a specific country is not a surprising result. This is a direct outcome of the socioeconomic development at the regional level during the last two to three decades.

2.4 Migration

It is very difficult to compare migration movements throughout the countries because of the differences in the definitions of such basic concepts as "migrant", "urban settlement", "community", as well as because of some changes in the territorial structure. Moreover, the magnitude of the migrations is usually defined by the crude migration rate (CMR). Recent studies of the age-specific migration curve (Rogers, Raquillet, and Castro 1977) show that its shape is usually very stable over time and space and that the CMR is strongly influenced by the age structure of the population. Consider, for example, an aging population with a peak of the migration schedule being stable at around 20-25 years of age. Obviously the CMR in this case will tend to decrease. In spite of these difficulties, some general trends can be observed in the five countries. They can generally be grouped into two processes: urbanization and a decrease in migration flows. They will be considered separately below. Note, however, that after the Second World War, large population shifts occurred with the new boundaries of the GDR and Poland. Because these shifts only lasted a decade or so, they will not be considered here.

2.4.1 Urbanization

Rapid industrialization called for an increase of the labor force in the industrial sector. The mechanization of agriculture freed a number of workers, and thus caused the movement of large amounts of the labor force to more industrialized regions. Since industry was developed predominantly in urban areas, a strong trend of urbanization took place in all five countries. Perhaps an equally important reason for urbanization was the improvement in the urban infrastructure.

The urbanization process was further strengthened by more indirect causes, such as the declaration of a city as a regional center housing the regional management and administrative bodies. These new regional centers were then able to achieve better cultural, educational, and infrastructural potentials. Another indirect cause for urbanization was socioeconomic development, which gave rise to small settlements meeting the requirements needed to be proclaimed towns. In Bulgaria, for example, such reclassification involved 283 villages during the 1945-1971 period, and 754 thousand people became citizens.

Table 2 gives some results of the urbanization process in the five countries.

Table 2. Level of urbanization in Bulgaria, Czechoslovakia, the GDR, Hungary, and Poland, during the 1965-1975 period.

Country	Population	Population in proportion to the total			
		1960	1965	1970	1975
Bulgaria	Urban	3.80	46.5	53.0	58.0
Czechoslovakia	Urban	47.6[c]	--	55.5	
GDR[b] (urban regional population)	North	--	61.0	63.1	66.3
	Middle	--	67.5	68.4	71.2
	South-west	--	65.7	66.6	67.5
	South	--	78.4	78.4	79.5
	Total urban (without Berlin)	--	73.0	73.8	75.3
Hungary	Budapest	17.90	--	19.39	19.59[b]
	Other urban	24.72	--	28.23	29.87[b]
	(County towns)	(6.00)	--	(7.23)	(7.73)[b]
	Rural	57.38	--	52.38	50.54[b]
Poland	Urban	48.3	49.7	52.3	55.7

[a] In 1961.

[b] In the GDR settlements with more than 2000 inhabitants are considered urban.

[c] Numbers refer to 1974 data.

The increase of the percentage of the urban population is clearly shown in Table 2. Because of the differences in the definition of urban settlements the data should not be compared directly. In spite of this, it can be seen that the urbanization process was strongest in Bulgaria, due mainly to the extensive growth of the capital city of Sofia. In the GDR, the urbanization process was slowest, and this can be explained by the fact that this country was already highly industrialized at the beginning of the period considered here, hence the labor force shifts were not so strong.

2.4.2 The Decrease in the Migration Flows

The urbanization process was a continuous one over the period of study. Its speed decreased, however, during recent years, in accordance with the general decline of inmigration during the sixties. During the 1960-1974 period, the CMR in Bulgaria decreased from 20.5 per thousand to 16.4 per thousand, and in Hungary from 23.9 per thousand to 23.6 per thousand (permanent migration only in Hungary; the temporary moves are also annually observed and this is the only country which provides such statistics). In Poland, the drop during the 1960-1972 period was from 42.5 per thousand to 27 per thousand. It is obvious that such large decreases cannot be explained by the aging of the population or other demographic factors only.

In Czechoslovakia the pattern is slightly different. Indeed, during the 1950-1954 period the average CMR was 48.9 per thousand, and during 1960-1964 it was 28.7 per thousand, but during the 1965-1975 period, the CMR was quite stable around the 26.4 per thousand figure. Possibly the same pattern of an increase and a consequent decrease of the CMR was observed there too, but being shifted in time.

The decrease in migration is due to a variety of reasons. First, one must consider the changes in the population at risk of migrating. This is predominantly the rural population, which has substantially decreased in numbers, and the high natural increase cannot compensate for the migration loss. Second, the intensive inflow to the industrial sector has led to the saturation of the labor force at least to some extent. Third, the restructuring of agriculture resulted in the creation of large agro-industrial farms. They became attractive to the local population, and were also a cause of decreasing outmigrations. An exception in this respect is Poland where the small privately owned farms give rise to high commuting and high seasonal migrating, which hinder temporary migrations.
Fourth, the growth of cities brings with it the rise of some problems for the citizens, the largest of which is housing:

supply is lower than demand. Last, but not least, is the effect of the population-distribution policies which began to develop around the mid-sixties. They have two main features, common among the five countries: (a) through administrative laws migration to the major cities is strongly restricted, and (b) migration to more backward regions is encouraged through salary increases and other financial measures.

The decrease of the migrations was followed by a certain change in the reasons to migrate. While during the fifties and sixties major reasons for migrating were those related to changing the place of work (getting a better job, or receiving a higher salary, etc.) in the early sixties and during the seventies new reasons came into being. Nowadays, one of the major reasons for migrating in Czechoslovakia and in Poland is housing. In the Czech republic, during the 1966-1973 period about 45 percent of the migrants are reported to have migrated because of this reason (Kühnl 1978). In the GDR and Poland another major reason for migrating is environment pollution.

The major regional migration flows are toward regions where large cities or highly industrialized areas are situated. An exception, however, is the GDR, where the southern, highly-industrialized regions have had a continuous migration loss during the last decade. As was mentioned above, such problems as environmental protection and housing have contributed to a phenomenon which may take place in the other countries as well.

Only a few regions in each country have had a positive net migration over the last two decades. Also only a few regions have had a continuous migration loss, while the majority of the regions exhibit interchangeable gains or losses over time. The continuous patterns are connected with traditional features of the regions (capital cities gain, backward regions lose). The fluctuation, i.e., changing of periods of loss and gain, can be comprised as a temporary period preceding the emergence of new patterns. For instance, regions situated at the seashore with a large urban center, were usually losing in the past but

but are gaining today (Varna and Burgas in Bulgaria, Rostock in the GDR, Gdansk in Poland, as well as some regions along the Danube in Czechoslovakia and Hungary).

3. REGIONALIZATION AND DATA

As mentioned earlier, this comparative analysis is based on the same methodology and the same data processing. Before discussing the computer outputs, the inputs will be considered, i.e., the data necessary for the study as well as the regionalization.

3.1 Regionalization

The comparative analysis is based on multiregional mathematical demography. This means that along with the traditional demographic measures, such as fertility and mortality, the spatial patterns of population changes are also considered. Spatiality is included by taking into account a given number of regions in the country, which are linked through migration.

Restrictions imposed by the size of the computer memory called for a number of regions not larger than 12 in each particular country. In order to accommodate this number, the administrative units had to be aggregated (Table 3). The pattern of aggregation was left entirely to the collaborators. In the case of the CSSR, no aggregation was done.

There is no doubt that the aggregations are not arbitrary. In all cases, the aggregation regions refer to large economic or geographic macroregions, which are generally used in regional planning. In some cases (Bulgaria, Poland), the macroregions were slightly changed in order to achieve more uniform demographic structures.

It is obvious that any aggregation will decrease the total amount of migration, because only interregional migrations are accounted for by the multiregional model. Therefore, the smaller number of aggregated regions, the smaller the migrations, hence their effect on the population change will be smaller. This is an additional reason why the magnitude of migrations should not be compared directly.

Table 3. Regional disaggregation used for multiregional analysis in Bulgaria, the CSSR, the GDR, Hungary, and Poland.

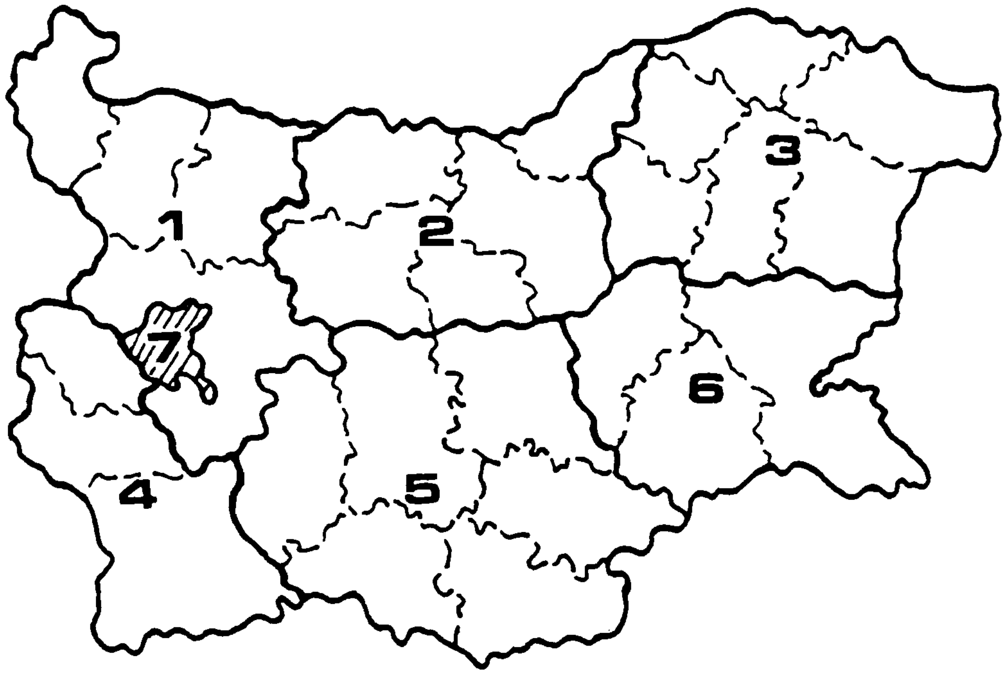
Country	Number of adm. units	Aggregated into	Year of study
Bulgaria	28 districts	7 regions	1975
CSSR	12 districts	12 regions	1975
GDR	15 bezirke	5 regions	1975
Hungary	19 counties + 5 county towns + Budapest	6 regions	1974
Poland	22 voivodships	9 regions	1973

Since the aggregated regions are in accordance with the macroregional concepts in each country, they can be thought of as being based on the same functional and structural characteristics. In the previous section, it was noted that the latter contribute to more or less the same demographic patterns. Therefore, *the international comparison of spatial demographic patterns intended here, will be based on uniform concepts of the formation of macroregions.*

Figures 1 through 5 give the regional division of each country and the aggregated regions used in this study.

3.2 Data

The data which were necessary to carry out the multiregional analysis refer to the population, births, and deaths for each region separately, and origin-destination migration flows. All data is available by five-year age groups. Disaggregation by sex was not required. The data were received from vital statistics; the year of observation can be seen on Table 3. The data for the population, births (by age of mother in all cases) and deaths were more or less in the proper form. Those referring to the migrations suited the needs of the analysis only for the GDR and Hungary, and even for Hungary the permanent, together with the temporary, migrants were considered. For the other three countries, totals of the



Region 1 North-west: Vidin, Michailovgrad, Vratza, Sofia-district (excluding Sofia-city)

Region 2 North: Pleven, Lovetch, Gabrovo, Veliko Tarnovo, Rousse

Region 3 North-east: Silistra, Razgrad, Targoviste, Shoumen, Tolbukhin, Varna

Region 4 South-west: Pernik, Kjustendil, Blagoevgrad

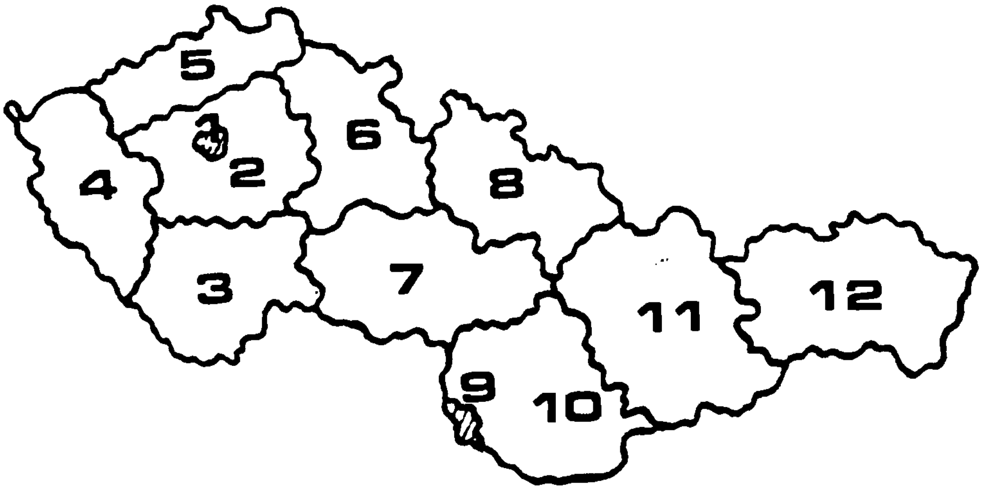
Region 5 South: Plovdiv, Pazardjik, Smoljan, Kurdjali, Haskovo, Stara Zagora

Region 6 South-east: Sliven, Jambol, Burgas

Region 7 Sofia: Sofia-city

Figure 1. Map of Bulgaria showing the 28 districts and their aggregation into 7 regions.

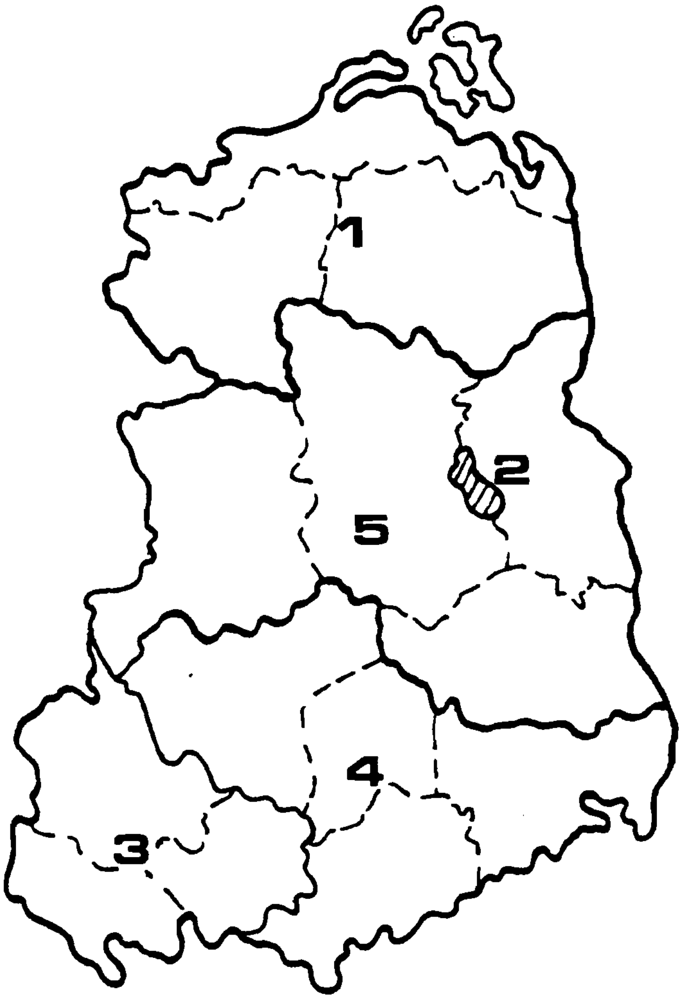
Source: Philipov (1978).



Region 1:	Prague	Bohemia
Region 2:	Central Bohemia	
Region 3:	Southern Bohemia	
Region 4:	Western Bohemia	
Region 5:	Northern Bohemia	
Region 6:	Eastern Bohemia	
Region 7:	Southern Moravia	Moravia
Region 8:	Northern Moravia	
Region 9:	Bratislava	Slovakia
Region 10:	Western Slovakia	
Region 11:	Central Slovakia	
Region 12:	Eastern Slovakia	

Figure 2. Map of Czechoslovakia showing the 12 regions of the country.

Source: Bolshaya Sovjetskaja Encyclopedia.



Region 1 North: Rostock, Neubrandenburg, Schwerin

Region 2 Berlin: Berlin

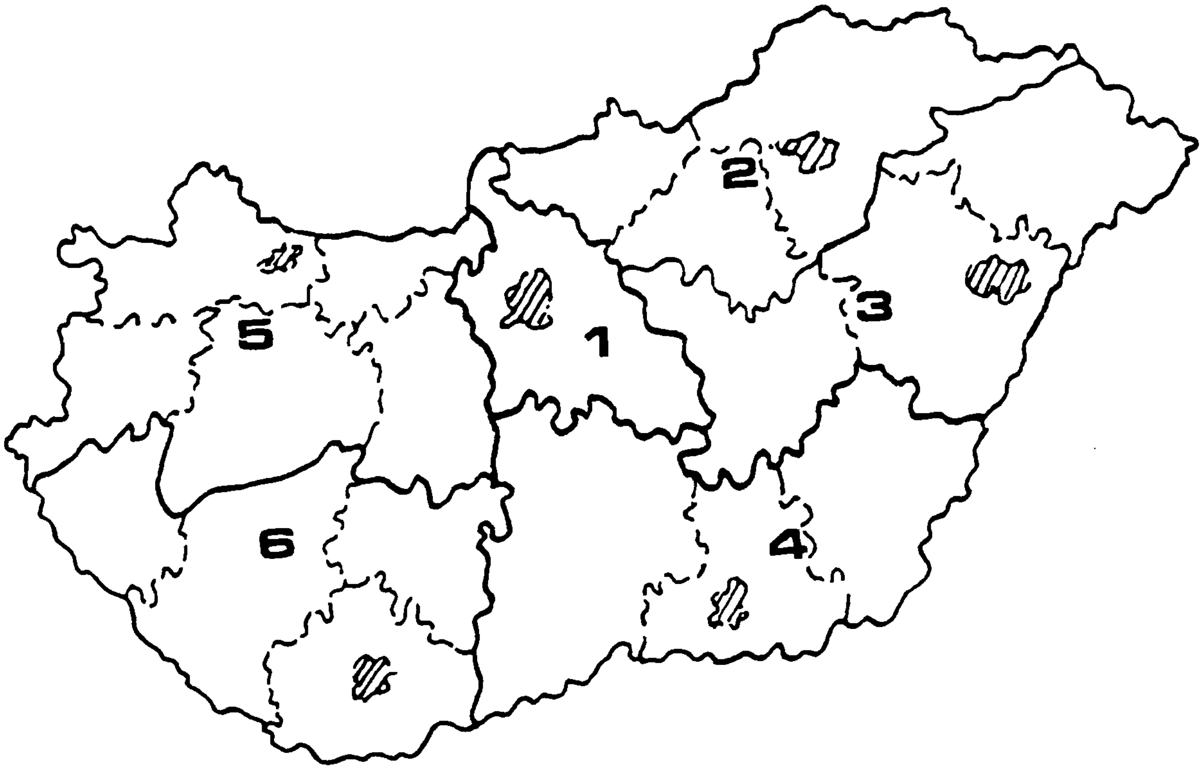
Region 3 South-west: Erfurt, Gera, Suhl

Region 4 South: Leipzig, Halle, Karl Marx Stadt, Dresden

Region 5 Middle: Cottbus, Frankfurt, Potsdam, Magdeburg

Figure 3. Map of the German Democratic Republic showing the 15 districts and their aggregation into 5 regions.

Source: Mohs (1979).



Region 1 Central: Budapest, Pest

Region 2 Northern Hungary: Miskolc, Borsod-Abauj-Zemplén, Heves, Nógrád

Region 3 Northern Plain: Debrecen, Hajdu-Bihar, Szabolcs-Szatmár, Szolnok

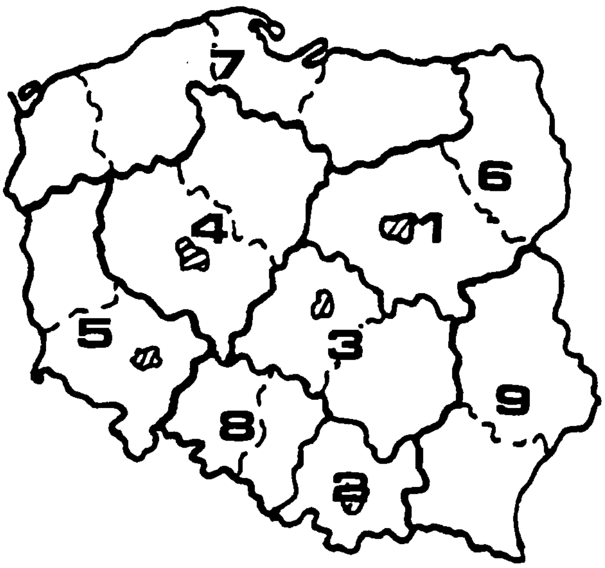
Region 4 Southern Plain: Szeged, Bács-Kiskun, Békés, Csongrád

Region 5 Northern-Trans-Danubia: Györ, Fejér, Györ-Sopron, Komárom, Vas, Veszprém

Region 6 Southern-Trans-Danubia: Pécs, Baranya, Somogy, Tolna, Zala

Figure 4. Map of Hunary showing the 19 counties, the 5 county towns, and Budapest, and their aggregation into 6 regions.

Source: Bies and Tekse (1978).



Region 1 Warsaw: Warzawa

Region 2 Cracow: Krakow, Krakowskie

Region 3 Lodz: Lodz, Kieleckie, Lodzkie

Region 4 Poznan: Poznan, Bydgoskie, Poznanskie

Region 5 Wroclaw: Wroclaw, Wroclawskie, Zielonogorskie

Region 6 Bialystock: Bialostockie, Warezawskie

Region 7 Gdansk: Gdanskie, Koszalinskie, Olsztynskie, Szezecinskie

Region 8 Katowice: Katowickie, Opolaskie

Region 9 Lublin: Lubelskie, Rzezowskie

Figure 5. Map of Poland showing the 22 voivodships and their aggregation into 9 regions.

origin-destination flows were available, not disaggregated by age, but departures from and arrivals to each region were available disaggregated by age. This required the implication of additional methods which could make it possible to deduce the necessary origin-destination flows disaggregated by age. In this case, multiproportional techniques were applied (Willekens, Por, Raquillet 1979).

For Czechoslovakia additional information was available. The origin-destination flows disaggregated by age between the two republics were available. For Bulgaria and Poland, the departures and arrivals included the intraregional moves, hence they had first to be adjusted to refer to the interregional moves only. This adjustment was made so that the age distribution of departures and arrivals were left undisturbed, thus assuming that the migration schedules of the intraregional flows were the same as those of the interregional. More details on the data preparation can be found in Philipov (1978).

The input data are not given in the present report because of their large volume. They can be found in the *Migration and Settlement* papers listed in the introduction. For convenience the national totals are represented in Table 4. Note that the migration totals refer to the flows among the aggregated regions specified above.

4. OBSERVED POPULATION CHARACTERISTICS

Observed data can be used to analyze the populations without the implementation of sophisticated models. In this way a very general description of demographic patterns can be received. Such an approach, which was until recently dominating the research in demographic work, yields results easy to understand, but very possibly inaccurate, because some special demographic features are neglected. By the application of mathematical models, one achieves better accuracy, and broadens the field of investigation, but one finds new terminology which is not always easy to understand.

Table 4. Demographic data for the five countries (national totals).

Country	Population (ooo)	Births	Deaths	Migrations[a]	Observed Crude Rates (per thousand) CBR	CDR	CMR[a]
Bulgaria	8727	144608	89945	37818	16.6	10.3	4.3
Czechoslovakia	14802	289425	169562	119281	19.6	11.5	8.1
GDR	16820	181794	240407	99809	10.8	14.3	5.9
Hungary	10448	186251	125672	711498[b]	17.8	12.0	68.1
Poland	33512	598549	277088	238998	17.9	8.3	7.1

[a]Total number of migrants among aggregated regions (see Table 3). The same number was used to compute the CMR.

[b]Permanent and temporary migrants.

In this paper, the populations of the five countries are first described directly from the observed data, and then from multiregional mathematical models. It is believed that in this way the inferences will be made accessible both to the *layman* and the specialist in the multiregional demography.

One of the most often used indicators of the schedule of an age-distributed set of demographic data is its mean age, usually estimated with the following formula

$$m = \frac{\sum_x \left(x + \frac{NY}{2}\right) R(x)}{\sum_x R(x)}$$

where NY is the width of the age group, x is the first year of the age group, and R(x) is the observed age-specific rate (Willekens and Rogers 1978). The mean ages of the births, deaths, and outmigrations for the five countries are represented in Appendix 1. The mean ages of the regional populations are given in Appendix 3, but they will be analyzed later in this paper. Note that the mean ages estimated with the above formula do not depend on the age composition of the population.

Consider first the mean age of births (of childbearing). In Bulgaria it is around 24.3 years, the number for Sofia being higher than the average. In Czechoslovakia, the difference between high and low regional mean age of births are larger. They are highest for Prague and the Slovakian regions. In the GDR there is an enormous difference between the mid-northern and the southern parts of the country. Note that the capital city again is the region with one of the highest mean ages of childbearing. In Hungary the regional distribution of this mean age is the most uniform. In Poland such uniformity can also be observed, however, Warsaw has an average mean age of childbearing and not a high one.

Where the mean age of dying is considered, uniformity over the regions is to be observed in all countries. Sofia is the only capital with a slightly higher mean age of dying.

Much larger divergences exist in the mean ages of the outmigration schedules. In Bulgaria they are around 18-20 years , but the migration flows to and from Sofia are made up of older people. In Czechoslovakia, the patterns are more complicated. The migrations to the Slovakian and to most of the Bohemian regions have younger than the average schedules, and the most aged one is to Prague. The outmigrations from Prague have also the most aged schedule, even more aged than the inmigrations. The same pattern can be observed for Bratislava, the capital of Slovakia. An interesting pattern is noted where neighboring regions are concerned: the migrants among these regions are younger than among regions situated further away. For Prague and Bratislava, however, the contrary inference can be made. Note that the same inferences hold when the two republics are compared. In the GDR, the migration curves have much more uniform mean ages. In this respect this country is an exception. The outmigrations to the Middle region seem to be slightly more aged, and those to Berlin slightly younger. The last observation also differs from those in the other four countries. In Hungary the observed patterns are much the same as in Bulgaria. Recall that Budapest is in the central region, and this is why the most aged schedules are exhibited there. Finally, in Poland the divergence is almost as big as in Czechoslovakia. The regions where the largest urban agglomerations are situated exhibit more aged migration profiles.

The discussion on mean ages of the demographic schedules shows that while the schedules of births and deaths are more or less uniformly aged over the regions (an exception being the GDR with its childbearing mean ages), those of migrations are more diverse. The common pattern is that the schedules for the migrations to and from the capital cities are more aged. Again, the capital of the GDR is an exception. Also, the less developed regions tend to have migrants whose mean age is generally younger than the average.

The mean age is too broad a measure of the migration curves. For more accurate analysis, it is better to distinguish between the two main components of the curve: its shape and its area under the curve. The first one is given on Figure 6 for each of the five countries. The area under each curve is equal to unity. In this way, the effect of the magnitude of migration is eliminated. The migration schedules on Figure 6 refer to the total number of migrants between the aggregated regions in each particular country. The five schedules have a lot of common elements. They all have a high peak around the age of 20-25 (for Bulgaria, 15-20). The second highest peak is in the 0-5 year age group for all the five countries. There is a low point on the two peaks around the 5-15 year age group. The descending slopes from the high peaks are similar and close to parallel, both between countries, and between the two slopes, Bulgaria being an exception. A third peak for the aged groups can be observed more or less for each country.

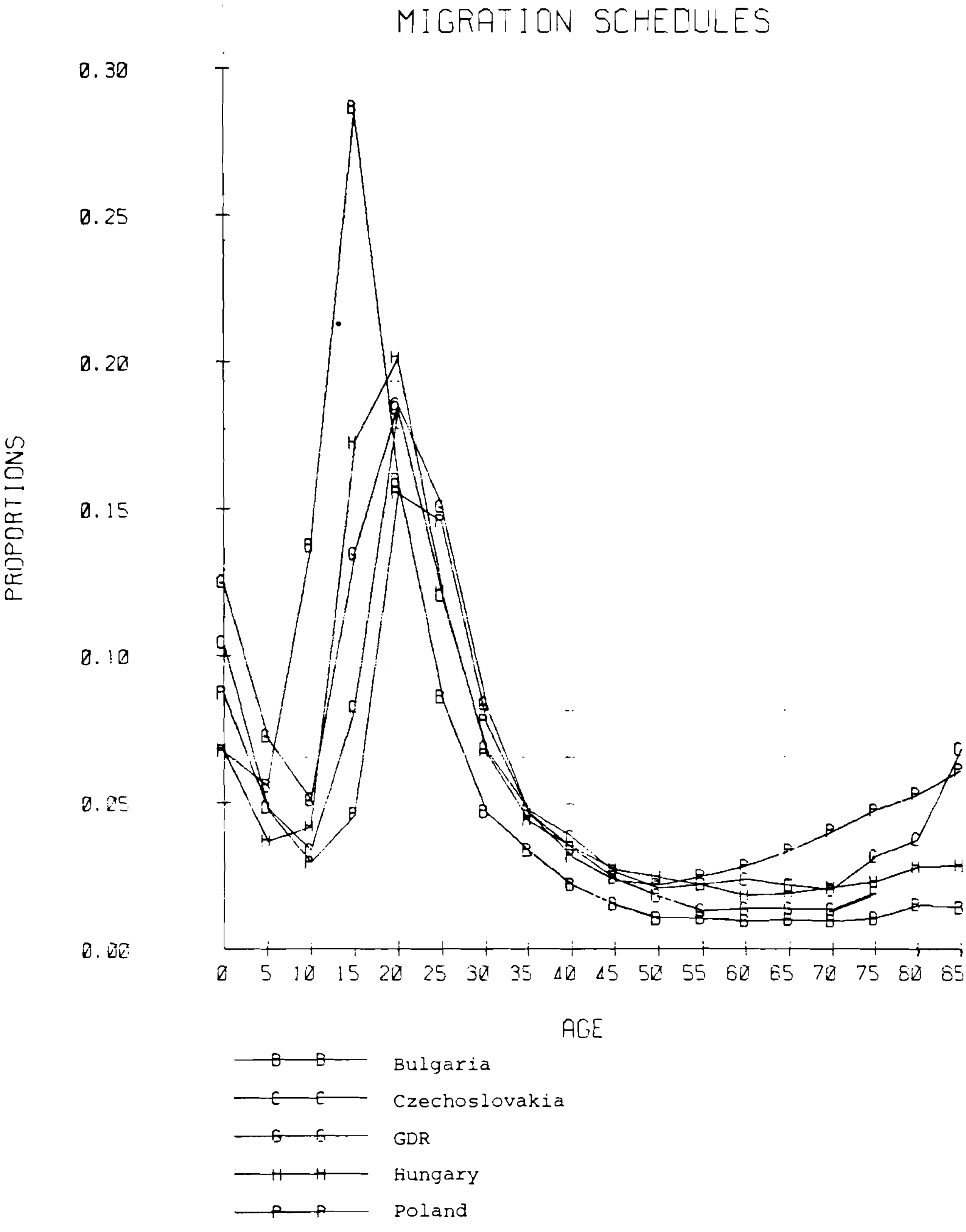


Figure 6. Migration schedules for Bulgaria, Czechoslovakia, the GDR, Hungary, and Poland.

All these similarities are common for any migration schedule, as shown by Rogers, Raquillet, and Castro (1977). The results given in this work indicate that the Bulgarian migration schedule is exceptional not only when compared with these five countries, but in any other international comparison. The reason for this lies within the concept of "migrant"--migrants in Bulgaria also include pupils who, upon finishing their primary education (14, 15, or 16 years of age), are able to continue their secondary education in a specialized school which is situated outside the settlement of dwelling. This causes higher mobility until secondary education is completed.

The highest peak is referred to as the "labor force" peak (Rogers et al. 1977), because the migrants here are moving primarily in order to find a better job (or a higher salary). Except for Bulgaria, this peak has approximately the same height in Czechoslovakia, the GDR, and Hungary, and is slightly lower in Poland. Note that in Poland the next age group is almost as high, thus the peak appears to be close to a "plateau" over the 20-30 year age group.

The "childbearing" peak is closely connected with the labor force peak, since the age distance between the two is about 20 years. Note that the second peak is highest for the GDR, and lowest for Bulgaria, and that the percentage of movers in the 20-30 year age group is highest in the GDR and lowest in Bulgaria. This shows that the "childbearing" peak is created by children moving together with parents who are predominantly 20-30 years old.

The "retirement" peak is very well depicted for Czechoslovakia and Poland. In the other three countries it is almost non-existent.

The migration schedules show also that the youngest mean ages are observed in Bulgaria, and the oldest mean ages in Poland. From the schedules it is not evident, however, why the curves for Czechoslovakia are much more aged than those of the GDR. The effect of the total number of migrants must be considered.

In order to study the magnitude of the migrations, usually the crude migration rates are used (often incorrectly referred to as the intensity of migrating). The CMRs, however, are substantially influenced by the age composition of the population at risk, and of the migrants (see Figure 6 and the analysis of the migration schedules). In instances where it is possible, one should calculate the gross migraproduction rates (GMR) (Willekens and Rogers 1978).

The same is true where fertility schedules are considered. Demographers prefer the usage of gross reproduction rates (GRR) instead of the CBRs. In the case of mortality, the expectation of life dominates over any other measures, and it will not be considered here. For example, the gross death rate is strongly influenced by the aggregation of the persons in the last age group (85+ in this case, or 70+ for the GDR).

The GRRs and the GMRs are defined as the sum of the age-specific rates multiplied by five (the division of age groups). The GMR will then depend on the kind of age-specific migration rates which are used. In this paper the latter refer to the migration flow from region i to region j, hence the GMRs will form an i by j matrix. Then ${}_iGMR_j$ is the gross migraproduction rate from region i to region j. The gross reproduction and migraproduction rates are given in Appendix 2, where again the regions are those from the aggregation previously given.

First, let us consider the GRRs. Their national totals are unaffected by the regional observations. This is one of the few demographic variables which allows for direct international comparison. Recall that the GRR can be looked upon as the number of children to be born to an individual who is not subject to dying before the end of the reproduction period (the age group 15-49 in this case). The GRR level needed for a one-to-one replacement of the individuals is around 1.05.

The magnitude of the GRR for the national population of the five countries in this study are given also in Appendix 2. They show that the reproduction level is definitely not reached in the GDR, and definitely exceeded in the other four countries. Hence, the population of the GDR is expected to decrease, at a rather high rate, in the next years. The other four national populations will increase, and the fastest increase is expected to be in Czechoslovakia, where the GRR is higher than in the remaining countries. The last inferences are subject to further refinements, which will be considered later in this paper.

Consider the values of the GRRs at the regional level. In Czechoslovakia, the GRR for Prague is 1.082, for Bratislava 1.115, and both are substantially lower than the next lowest--1.170. In Hungary the central region, where Budapest is situated, has a GRR of 0.987, and this is the only region with fertility below replacement level. Especially low is the GRR for Warsaw: 0.643. Such a low fertility level is not to be observed anywhere else throughout the five countries. The population of Sofia has a GRR equal to 0.962, thus being the only region in Bulgaria with a fertility level below replacement level. Finally, in Berlin the GRR is also lower than that for the national population, but is not the lowest.

In order to find other patterns in the spatial distribution of the fertility level, as depicted by the GRR, it is necessary to recall the changes in the socioeconomic life which are the causes of the recent changes in the levels of fertility, as briefly discussed in the second section of this paper. It was pointed out there that the process of urbanization, together with lower levels of fertility in the urban areas, has brought about a decrease of fertility in countries as a whole, and that the more backward regions exhibit higher fertility levels. These patterns are more or less valid during the year of observation in this analysis, with the exception of Bulgaria and Hungary where pronatal policies have caused a general increase in fertility.

The GDR is the only exception from the above patterns. It seems that in this country, fertility in the more backward regions has dropped below that of the most developed regions. Since the more developed regions have a larger urban population, their higher level of fertility might be due to the urban life style. It becomes clear that different explanations are possible, therefore, a more thorough analysis is necessary, which is beyond the scope of this paper.

The regional GRRs do not indicate what will happen with the regional population in the long run--will it increase or decrease? This is because migration may contribute to a complete change in the regional population growth. That is why some measure of the moves in a multiregional population must be considered. Directly from the observed data, it is possible to estimate the ${}_{i}GMR_{j}$, as it was mentioned above. Note that ${}_{i}GRM_{j}$ refers to the particular migration flow from region i to region j. For the inmigration flows GMRs are not computed. The migration flow ${}_{j}GMR_{i}$ is considered instead (recall that the difference in the estimation of in- and outmigration rates is in defining the population at risk.

The value of ${}_{i}GMR_{j}$ can be interpreted as the number of moves from region i to region j which the person is expected to make during his life, if he is not subject to dying (in such a case the length of life may be defined as the last age group during which positive migration rates are observed and if the regime of migrating remains unchanged). Then, the totals ${}_{i}GMR.$ give the total number of moves out of region i, per person from the same region. Finally, .GMR is the total number of moves a person from the country is expected to make. Neither of these three types of GMRs allows for international comparisons, but the values for ${}_{i}GMR$ and ${}_{i}GMR_{j}$ can be used to observe patterns of migration in each country and compare them between the countries. The values for the totals, .GMR., will not be compared in this study, unlike the total GRRs. They can be compared with time-series data only.

The GMRs estimated at the regional level can be used in three different ways. First, ${}_i\text{GMR}_.$ can be used; second, the ${}_i\text{GMR}_j$ for different j can be directly compared to show which is the preferred region of destination for outmigrants from region i; and third, the values of the GMRs for two counter-flows, i.e., ${}_i\text{GMR}_j$ and ${}_j\text{GMR}_i$ can be compared, to show preference between two regions.

In Bulgaria, the highest ${}_i\text{GMR}_.$ is observed in the North-west region, while the lowest is in the South region. The first region is predominatly agricultural, the second predominantly industrial. For Sofia the value of ${}_i\text{GMR}_.$ is around the average. A comparison for the maximum of ${}_i\text{GMR}_j$ for each j, for different regions i shows that the most preferred region is usually one of the neighboring regions. This is more evident where i denotes a peripheral region. Comparing the values of ${}_i\text{GMR}_j$ and ${}_j\text{GMR}_i$ will show that ${}_j\text{GMR}_4 < {}_4\text{GMR}_j$, i.e., the South-west region is the most unattractive one, while Sofia and the South regions are most attractive.

In Czechoslovakia, ${}_i\text{GMR}_.$ is high for the Bohemian regions, and its value for Prague is higher than the average ($.\text{GMR}. = 0.618$). Substantially lower are the ${}_i\text{GMR}_.$ for the Moravian and Slovakian regions, with the exception of Bratislava. The maximum values of ${}_i\text{GMR}_j$ over j show that the geographic situation of the regions underlines heavily the most preferred direction of a move. Three geographic areas can be delineated--Bohemia, Moravia, Slovakia (see Figure 2). Especially low are the migration links between the republic of Slovakia and the rest of the country (the Czech republic). By comparing the values for ${}_i\text{GMR}_j$ and ${}_j\text{GMR}_i$, it can be seen that a person born in Prague is expected to make a smaller number of moves to a given region than a person from the same region to Prague. On the contrary, however, is the region least preferred by its inhabitants, at least during 1975.

In the GDR, the highest ${}_{i}GMR_{.}$ is observed for the North region. Low values are observed in the South and South-west regions of the country, but altogether each value is close to the average (${}_{.}GMR_{.}$ = 0.437). The maximum values of ${}_{i}GMR_{j}$ for each j show that the inhabitants of the North region and of Berlin heavily prefer the Middle region; the south-born persons prefer to move most often to the South-west; and a person from the Middle region shares his preference between the South region and Berlin. Surprisingly, Berlin is not the most preferred region. The ${}_{i}GMR_{j}$ and ${}_{j}GMR_{i}$ comparison would point to the South region as the largest "gainer", and the North region as the largest "loser".

In Hungary, the CMRs have very high values because temporary migrants are included in the study. The highest number of moves outside the region is expected to be made by a person from the Northern-Plain region. This figure is higher than the average for the Central region where Budapest is situated, and is lower for the Southern and the two Trans-Danubian region (the latter two are less developed). The Central region is by far the most preferred one to move to for a person born elsewhere, and the persons from this region give a preference to the Northern-Plain region. Note that if the moves to the Central regions are extracted, the number of moves to be made would substantially diminish. Finally, the comparison of the ${}_{i}GMR_{j}$ and ${}_{j}GMR_{i}$ shows that the Central region is most preferred, while the Northern-Hungary region is least preferred, but not strongly.

In Poland the ${}_{i}GMR_{.}$ are highest for the regions Wroclaw and Bialystok, followed by Gdansk. By far the lowest ${}_{i}GMR$ is for Warsaw, in which this capital differs from the other four. The maximums of ${}_{i}GMR_{j}$ over j show again that an individual from region i would prefer to move to a neighboring region, thus the distance is once again an important factor in choosing the region of destination. The people of Warsaw prefer the less developed but neighboring region of Bialystok and the remaining number of moves out of Warsaw are close to zero. A person from Katowice does not have a determined regional preference, but would wish least to move to Warsaw. The last inference holds also for a person from the Lublin region. The ${}_{i}GMR_{j}$ versus ${}_{j}GMR_{i}$ comparison for the regions of Poland shows that the region of Katowice and Warsaw are the "gainers" although the GMRs to and from Warsaw are very low. The "losers" are Wroclaw, with a high expected number of moves to the western and central regions of the country, and Lublin.

The study of migration with the help of the GMRs shows that only one pattern is common for the five countries, and this is the significance-of-distance factor. Neighboring regions are preferred to more remote ones. This is especially important in Czechoslovakia, where migration within each one of the three areas: Chechia, Moravia, and Slovakia, are dominating over migration between the areas.

Considering the capital cities only, Berlin and Warsaw seem to be exceptions from the pattern of the other three, the latter being the most preferred region. Since in the regionalization discussed here only the capitals give some information about the urbanization process during the year of observation, it can be deduced that this process is weaker in the GDR and in Poland, but still exists in the other countries, as far as this is shown by the most preferred regions.

Finally, the pattern of migration from less-developed to more developed regions is observed in the five countries, but exceptions exist in the GDR and partially in Poland. Everywhere the population of the more-developed regions is generally more mobile.

In the discussion of the GMRs it must be taken into consideration that their usages are based on the assumption that the individual is not subject to dying until positive migrations are observed. Besides, the GMRs treat migrations as a recurrent event and give no information on the duration of stay. That is why migration must be studied in more detail. This can be done by applying multiregional methods. These are the topics of discussion in the next section.

5. THE MULTIREGIONAL DEMOGRAPHIC MODELS

The multiregional approach to demography is based on the existence of a multiregional population. For example, a national population is divided into several groups which correspond to some geographical regions covering the territory of the country. The construction of the model is based on the interactions of these subpopulations through migration. Therefore, the single-region demographic variables (basically fertility and mortality) will be influenced by the migrations and will no longer be single-region. It may be concluded then that the multiregional models are an extension of the single-regional ones, in that space is introduced into their construction. Detailed descriptions of these models can be found in Rogers (1975a) and Willekens and Rogers (1978). The basic outputs of the multiregional approach are the multiregional life tables and the multiregional population projections, which will be studied in this paper.

5.1 The Multiregional Life Table

The multiregional life table describes the life history of hypothetical cohorts, each one of which consists of individuals born at the same moment in time in the same region. The life history of the cohorts are described separately from each other. The size of each initial cohort may be arbitrarily chosen, in this case each one being equal to 100,000.

The construction of a multiregional life table is based on the derivation of the probabilities of dying and outmigrating. The latter are estimated with the following matrix equation:

$$\underset{\sim}{P}(x) = \left(\underset{\sim}{I} + \frac{5}{2}\,\underset{\sim}{M}(x)\right)^{-1} \left(\underset{\sim}{I} - \frac{5}{2}\,\underset{\sim}{M}(x)\right)$$

where $\underset{\sim}{I}$ is the identity matrix, x denotes the age, and $\underset{\sim}{M}(x)$ is a specially arranged matrix of the age-specific outmigration and death rates.

A typical element of the matrix $\underset{\sim}{P}(x)$ is $p_{ij}(x)$ which denotes the probability that an individual at exact age x in region i will survive in region j to exact age x+5. By applying these probabilities to the initial cohorts, one receives the regional distribution of the survivors at exact age x, given that they have been born at the same moment in time in the same region.

As an example, consider the cohort born in Berlin, one of the five regions in the GDR. At age 20, there will be 97,538 survivors out of the initial 100,000 and 81,599 of them will be in their region of birth: Berlin. The remaining 15,939 will be in the other four regions: 2,455 in the North, 1,561 in the South-west, 3,673 in the South, and 8,250 in the Middle. Obviously, the Middle region is most attractive to the Berliners at this age. If the cohort originates from the Middle region however, 97,331 will reach exact age 20 and 78,797 will remain in the region. In the Berlin region, 5,593 persons will reach the age 20 out of the 100,000 born in the Middle region. The complete results at exact age 20 are shown in Table 5.

Table 5. Expected number of survivors at exact age 20 in five regions of the GDR, 1975.

	Region of Destination at Exact Age 20						
	Region	North	Berlin	S. West	South	Middle	Total
Initial Region of Cohort	North	82117	2673	2022	4222	6227	97261
	Berlin	2455	81599	1561	3673	8250	97538
	S. West	1581	1522	85251	5924	3030	97307
	South	2126	2045	3254	84873	5305	97603
	Middle	3879	5593	2306	6756	78797	97331

The probabilities of dying and outmigrating and the survivors at exact age x can further be used to derive other elements of the multiregional life table. Such are, for instance, the survivorship proportions $s_{ij}(x)$, which denote that an individual aged x to x+4 in region i will survive in region j to be included in the population aged x+5 to x+9. Then the multiregional stationary population can be computed. The above described life-table characteristics are not presented numerically in this paper because of their large volume. They are mentioned in order to show that the multiregional life table, as an extension of the single-region one, will have as its elements the same life-table characteristics.

The expectation of life is the most important characteristic of the life table. In the multiregional case, it is distributed among the regions. Consequently, it is a measure not only of the duration of life, but also of its spatial distribution. The expectations of life at birth for the five countries are given in Appendix 3.

Consider an individual who was born in Sofia (Appendix 3). Altogether, he is expected to live 70.62 years, of which almost 60 are in the region of birth. The remaining 10.62 years he will spend in the other six regions of Bulgaria, preferring mostly the North-west region--3.8 years. If the individual was born in the North-west, however, he is expected to live 8.6 years in Sofia out of a total of 71.39 years.

An analysis of this kind is used to assess quantitatively the migrations between the regions of each separate country. The totals of the life expectancies can be used to compare the mortality levels between the regions, keeping in mind that the individual is exposed to the level of mortality in the region where he is living. Therefore, his total duration of life will be like a "weighted" sum of the mortality levels in the different regions, the "weights" being the duration of life in each region provided by the migrations. That is why a regional total life expectancy will be closer to the average for the whole country, hence the amplitude of the life expectancy will be smaller in the multiregional case than in the single-region case.

In Bulgaria, the regional expectations of life (e_0) are on the average 70.74 years, the North-east region being the lowest--70.09 years. The maximum difference is 1.30 years. In Czechoslovakia, e_0 is 70.40 years, the maximum difference being 1.89 years. The corresponding values in the GDR are 71.58 and less than 1 year; in Hungary--68.96 and 1.29 years; in Poland--71.16 and 2.01 years. These numbers show that the levels of mortality are the same in all the countries, the lowest being in Hungary and the highest in the GDR and Poland.

The evaluation of the multiregional life expectancies includes the effect of migration as mentioned earlier. Comparing them with the single-region life expectancies shows how migration influences the individual's duration of life. In Hungary, the largest difference between a multiregional and a single-region expectation of life is bound to be found for the Southern Plain, +0.16. This is obviously a very small value and can be neglected. The plus sign indicates that due to migration, an individual born in this region will live 0.16 years longer. In the GDR the largest difference is +0.35 for Berlin. Therefore, the Berlin-born persons prolong their life by a third of a year, by spending some part of their life outside of the city. Such small quantities were observed for the remaining three countries also, and this allows for the conclusion that the migrations do not change the length of life. The reader is reminded that the results given here are statistical averages for the total population (which is homogeneous with respect to the migration moves). Consider the differences among the magnitudes of the multiregional life expectancies at the regional level in each country. It can be seen that they are also small, especially in Bulgaria, Hungary, and the GDR. In Czechoslovakia and Poland they are slightly larger because of the higher values in the Southern Moravia and Warsaw regions.

A comparison of e_0 for the capitals of the countries shows that in the city of Warsaw the level of mortality is lower than that in the remaining regions of Poland, while this level in the remaining capitals is slightly higher than the average for the country. The latter result is what should be expected for an urbanized area, hence Warsaw is an exception in this respect. It is difficult to give a straightforward explanation of this fact.

When the regional distribution of e_0 is measured with percentages, an overall view of the levels of migration, usually denoted by ${}_i\theta_j$ (Rogers 1975b) can be seen. These are presented for the five countries in Appendix 3. The main diagonal of each table contains the level of stayers in region of birth, while the off-diagonal elements give the level of migration from region i to region j.

The discussion of the migration levels ${}_i\theta_j$ can be carried out in the same manner as for the GMRs from the preceding section. The major difference between the two demographic indicators is that the former is measuring the durability of the migrations, while the latter measures its frequencies. Both measure preferences to move to a particular region, but are such that they complement each other.

Consider first the values of ${}_i\theta_i$. In Czechoslovakia its highest value is for Eastern Slovakia, 0.817, and lowest for Central Bohemia, 0.606. The Bohemian regions are less preferred by their inhabitants. A person born in Prague is expected to spend 70 percent of his life in this city, and a person born in Bratislava is expected to spend 73 percent of his life there. Note that the GMRs were not used to derive information concerning the preference to leave the region of birth. Now the values of ${}_i\theta_i$ show that Bratislava is not so "disliked" as was shown by the GMRs. It may be stated that its inhabitants are less mobile than those of Bohemia and Prague. To complete the picture for Bratislava, consider the symmetry of elements

$_i\theta_9$ and $_9\theta_i$ in Appendix 3 (Czechoslovakia). The duration of stay of a Bratislava-born person in percentages is higher than that for an individual born in another region and having arrived in Bratislava, except for the region of Eastern Slovenia. The latter region is "the loser" in this respect. The comparison of the off-diagonal elements gives a very clear picture of the migration levels in Czechoslovakia. It shows that the migrations between the two republics are very small. For example, a person born in Prague is expected to spend less than 2 percent of his life in Slovenia, and almost 28 percent in the Czech part of the country.

An analysis of this kind can be done for the remaining countries as well. It can be seen that the off-diagonal elements of each table generally confirm the inferences based on the GMRs. Here only the immobility, as is given by the main-diagonal elements $_i\theta_i$, will be discussed.

In Bulgaria the difference in the levels of immobility (hence of mobility) are not very large: the highest is 87 percent (South region) and the lowest is 74 percent (North-west). The immobility of Sofian citizens is slightly above the average.

In the GDR, the difference is still smaller: only 8 percent. The more developed southern parts of the country tend to be more attractive to their own natives, than the rest of the country. The Berliners have quite a low immobility level.

In Hungary, the temporary migrants are the cause for the low immobility levels. Its highest value is observed in the highly industrialized Central region, which includes Budapest. The difference in the levels of immobility reaches 17 percent (Appendix 3) which is higher than in Bulgaria and the GDR.

In Poland the patterns of immobility are different among the regions also. The citizens of Warsaw almost never migrate --they prefer to spend 91.5 percent of their lives in Warsaw. The immobility level of the inhabitants of the more developed southern regions of Katowice and Cracow is high. The immobile citizens of Warsaw contribute to the largest difference in immobility levels, 24 percent.

This concludes the discussion of the multiregional life table. It has very important implications which will be discussed further.

5.2 The Multiregional Population Projection

The most important implementation of the multiregional life table is in the projection of the multiregional population. Analogous to the single-region case, this projection is described using the following equation:

$$\{\kappa(t+1)\} = \underset{\sim}{G}\{\kappa(t)\} \quad , \quad \text{given } \{\kappa(0)\}$$

where $\{\kappa(0)\}$ is the population-vector (population distributed by age and regions) at time t, and $\underset{\sim}{G}$ is the generalized Leslie matrix [or the multiregional growth operator, depending on the arrangement of the matrix elements; for more details see Rogers (1975a)]. The elements of $\underset{\sim}{G}$ are computed by applying the multiregional life table. For the population projection the elements of $\underset{\sim}{G}$ are held fixed, i.e., they are independent of the time t. Therefore, the projection is not a forecast. It must be used only for the analysis of the observed population.

Among the numerous characteristics which yield the projection of a multiregional population, the following will be discussed in this paper: total number, mean ages, regional shares to the national population, and the growth ratio λ (the ratio between the totals of a regional population estimated at the end and at the beginning of a time-period used for the projection). They are given in Appendix 4, for the initial population, for the 50-year projection, and for its stable equivalent. The reader is reminded that the stable equivalent is the stable population, which in the long run will give the same results as the observed one, if both are projected with the observed constant rates of fertility, mortality, and migration.

5.2.1 Mean Ages

The changes in the mean ages during the process of projection of a multiregional population are due to the joint effect of the demographic factors studied here--fertility, mortality, and migration. The initial population age structure influences future changes also. Demographic factors contribute to the changes through two lines--the schedules and the level. Here the mortality schedules and levels will not be considered because they were already shown to be uniform throughout the regions of each country.

The effect of the initial age structure is strongest when the population is aged, because the proportion of aged persons is expected to decrease. High fertility levels would also favor the decrease of the mean age. The fertility schedules are usually not very different with respect to their mean age (see Appendix 1); but even where they are different, they still favor a decrease of the population's mean age.

The effect of the migration levels and schedules is much more complicated. Consider at first a migration schedule like the one for Bulgaria (Figure 6) whose mean age is roughly 20-22 years. Such a schedule will obviously contribute to an increase in the mean age of the population at the region of origin, and a decrease in the mean age of the population at the region of destination. The larger the number of migrants, the stronger this effect will be.

Consider now migration schedules with a high mean age, for example, ones for the migrants from Cracow or from Wroclaw to Warsaw (48.06 and 49.15). Their effect on the regions of origin and the region of destination will be just the opposite. Next, consider a "young" *out*migration schedule and an "aged" *in*migration schedule. Such a combination of migration schedules will result in a rapid aging of the regional population, provided the number of migrants is large enough. Finally, consider an outmigration and an inmigration schedule of a similar shape. Then the number of migrants is going to have an influence on the changes in mean ages. A lot more examples of the effect of the migrations on the age structure of the population can be given.

In Bulgaria the observed populations of the North-west and North regions have a mean age substantially higher than that for the rest of the country. During the projection process, these two populations will get younger, while the populations of the other regions will age. The South-west region, on the other hand, will age rapidly because outmigrants substantially exceed inmigrants. Both migration schedules are young hence the regional population will age. The process of aging is strengthened also by the fact that the number of persons is decreased in the age of highest reproduction, hence the total number of births will also decrease.

For Sofia, the migrations cause aging through a different pattern. Hence the number of inmigrants exceeds the number of outmigrants, but their mean age is higher (see Appendix 1). The level of fertility in Sofia is below replacement level, therefore also contributing to the aging process.

The aging patterns of the Bulgarian population may be observed more or less in the other countries, too. In the GDR, the enormous increase of the mean ages is due primarily to the low level of fertility in this country. Migration is not contributing to any specific pattern. In Hungary, the changes in the mean ages are very small. In Poland, however, the changes in the mean ages are large, especially in the regions of Warsaw, Wroclaw, Gdansk, and Katowice. The major reason for the aging of the Polish population is the unfavorable age structure of the observed population (see Figure 3e). The proportion of the population aged 10-25 is high in this country. The inferences made for Sofia are also valid for Warsaw. The other regions cited above behave much like the South-west Bulgarian regions.

The mean ages of the Czechoslovakian regions do not change considerably, but some patterns are easily observed. In Slovakia the population is aging, while in Czechia it becomes younger, if any change is to be observed. The largest changes are observed in Prague, Central, and Eastern Bohemia. The migrations to Prague are much younger than the outmigrations, and this is causing the decrease in the mean age. In the other two regions, the in- and outmigrants are of approximately the same age and there are more inmigrants, but their mean age is lower than the region's population. The opposite is observed in the Slovakian regions, that is why the high level of fertility does not bring about a decrease of the mean age.

It should be noted that in all the regions in any country, the mean age, 50 years after the year of observation, is very close to that of the stable equivalent population. In Hungary, it is even the observed population in 1974 which is close to stability in this respect. If this fact reflects stability of the observed or the projected age structure for 50 years, it is not evident, but possible.

5.2.2 Regional Shares

Consider the 50 years projection in Bulgaria. Three regions will increase their population with respect to the total country's population, the largest being the increase in Sofia. There the level of fertility is low, but the inmigration flow is high. In the North-east region it is just the opposite--net inmigration is negative, but is compensated for by a high fertility level. In the South region both are positive, and bring about a relative increase. In the North-west and North regions, the regional shares decrease because of the aged population, and because of the considerable outmigration. At stability, the changes in the two eastern and the two western regions are much more pronounced. The other three shares being approximately equal to those in 2025, it seems that the above mentioned four regions contribute to the redistribution of the population in the long run.

In Czechoslovakia, the regional share of the Slovakian regions exhibit larger changes. Altogether, they will increase their share by 4 percent, which is due to the higher levels of fertility. Note that the Central Slovakia region at first increases its share, but later becomes a loser. This is obviously due to a favorable age structure of the observed population.

In the GDR, the South region decreases substantially its share, on account of the sharp increase of the share of Berlin. At stability, Berlin is joined by the South-west region.

In Hungary, the changes in the regional shares are negligible, even in the long run, making this country unique.

Finally, in Poland, the changes in the regional shares of the population are substantial. Especially high is the growth of the region Lublin in the long run, while the change is negligible in the 50-year projection period. Here the high regional fertility level should be recalled. The low level of fertility in Warsaw does not contribute to a substantial decrease of its share, because of the higher inmigration. The same is true for the region of Katowice. In this country it can be observed that the long-run projection causes further and very large changes in the population shares. This fact is caused predominantly by the large differences in the fertility levels, combined of course with the effect of migration.

5.2.3 Growth Ratios and Stability

The growth ratio λ is defined as the ratio of the total regional population at two points in time: the years t+5 and t. When $\lambda > 1$, the population will be increasing, and vice versa. The growth ratio defines the growth rate r through the formula:

$$r = \frac{1}{5} \ln \lambda$$

The rate of natural increase is the single-region equivalent of r, whose value in the multiregional case is determined also by the number of migrations.

The growth ratio, 50 years after the initial year, is less than unity for all regions of the GDR. This means that the regional populations are decreasing, at least during these particular five years. In the long run, however, the regional growth ratios equalize to yield the same value denoted again by λ. It is, in fact, the dominant eigenvalue of the multiregional growth matrix (or operator). For the GDR, this value of λ is equal to 0.9537 which yields $r = -9.5$ per thousand. This shows that the population of each region will extinguish in the long run, and the rate of the decrease is high. This λ is lower than any of the regional growth ratios at the year 2025, hence 50 years after the initial time period, the population will still decrease slowly. The reasons for this process can be found by examining the observed age and regional distribution which may have caused some population waves. The GDR is the only country whose population will extinguish in the long run and is decreasing over a period of 50 years.

Hungary and Czechoslovakia are on the opposite end of the spectrum. Their multiregional populations increase right from the beginning until stability is reached (except once for the Hungarian Southern-Plain region). (The data for this are not exhibited in this paper.) The rates of growth for these two populations at stability are correspondingly, $r = 3.0$ per thousand and $r = 6.3$ per thousand.

In Bulgaria and in Poland the populations of some regions will increase continuously, but other regions will initially decrease--Wroclaw in Poland, and South-west and South-east in Bulgaria. Since at stability the growth ratios are larger than unity, these three regional populations will later begin to grow. Recall that Wroclaw is a region with one of the lowest fertility levels and is the least attractive for migrants. Therefore, its population at risk to outmigrate will decrease enough to cause the number of inmigrants to be larger than the natural and outmigration decrease, because the fertility, mortality, and outmigration rates are kept constant. Hence, the population will begin to increase. Note that for Warsaw, Sofia, and the Central region in Hungary, this process takes place from the beginning, because the high inmigration compensates for the negative natural growth rates and outmigration. The same explanation is valid for the Bulgarian regions, although the fertility there is high. These two countries' rates of growth at stability are r = 2.4 per thousand for Bulgaria, and r = 3.0 per thousand for Poland. Recalling that the other three countries' values for r shows that the intrinsic rate of growth (at stability) of Czechoslovakia is much higher than the other, and that the GDR's r is the only one negative in magnitude. The rate of growth at stability for the other three countries are approximately equal.

The properties of the stable population which results from the observed one were discussed briefly with the mean ages, regional shares, and growth ratios. These three characteristics are common for the stable and the stable equivalent population. They are different, however, where the initial and the stable equivalent populations are compared. This difference is due to certain "discrepancies" in the age- and spatial composition of the initial multiregional population, which have appeared because of post changes in fertility, mortality, and migration. The stable equivalent to the observed population is not influenced by the past, hence it describes the demographic patterns during the year of observation. The differences in the characteristics of the two populations then are a measure of the effect of the past changes.

Consider first the total number of the two kinds of populations. They are represented also in Appendix 4. In the GDR either the national, or any of the regional observed populations are smaller in size than the corresponding stable equivalent population. This means that the decrease of the observed population will be slower in the beginning and will accelerate later during the projection process. The difference between the two totals measures the effect of the observed age and spatial distribution over the short and middle run projection processes. It is largest for the South-west and South regions. Comparing the changes in the mean ages (as an indicator of the age distribution) and in the regional shares (as an indicator of the spatial distribution) one can infer that the latter dominates in the effect on the observed structures. Such inferences are thought too general; they can be improved, but this will lead to details which are out of the scope of this paper.

In Bulgaria, the national totals are almost equal, but this is not the case for the regional ones. The projections for the seven regional populations are diverse throughout the whole process, but are in accordance with inferences made earlier in the paper. It will only be noted that the observed population of Sofia is expected to grow at the beginning of the process more quickly than its stable equivalent.

The population of Warsaw has to grow slightly slower at the beginning in order to reach the rates of growth of its stable equivalent. The high fertility level of the Lublin region is the reason for the initial rapid growth of its population, while the spatial distribution favors the growth of the Cracow region, and cannot compensate for the higher fertility in Bialostok. The total of the observed national population is slightly higher, which reflects higher levels of fertility in the past. Also, this means that the growth of the total Polish population will accelerate in the future. Note that the level of fertility indirectly effects the spatial distribution.

This kind of discussion is easy for Hungary. There, the two types of national and regional totals are so close that the observed population may be treated as having no internal forces. In this respect it is unique when compared to the five countries studied here.

In Czechoslovakia, the compared totals show analogy with Poland. It is to be noted that the Slovakian regions project differently, while the Moravian or the Bohemian regions project with quite the same pattern.

Figure 7 gives the age distributions of the national observed and stable equivalent population totals, such that the area under each curve is equal to unity. It is to be noted that all the observed age structures have gaps around the ages of 30 and 35, obviously caused by the two World Wars. Another common feature is the relatively low number of persons in the first one or two age groups, resulting both from the recent low levels of fertility, and from the effect of the population waves, namely that the persons exposed to the highest risk of giving a birth are less in number (the first of the above mentioned gaps).

The above mentioned gaps and the consequences which they have caused explain the differences in the observed and stable age structures. The stable age structures are quite similar among the five countries, with the exception of the GDR, which has an age structure typical of a decreasing population.

The stable age structures of a regional population may substantially differ from the ones in Figure 7. In Figure 8, the age structure for the region of Sofia is shown. The curve is typical for a region with a low fertility level and a high inmigration level; or high fertility level and a high outmigration level.

This concludes the analysis of the population projection process and its properties at stability. It was found that similarities exist only in certain aspects and that they are not common for all the countries. This is what should be expected because the projection is combining the effects of three major demographic components considered here, together with the observed age and spatial distribution of the population.

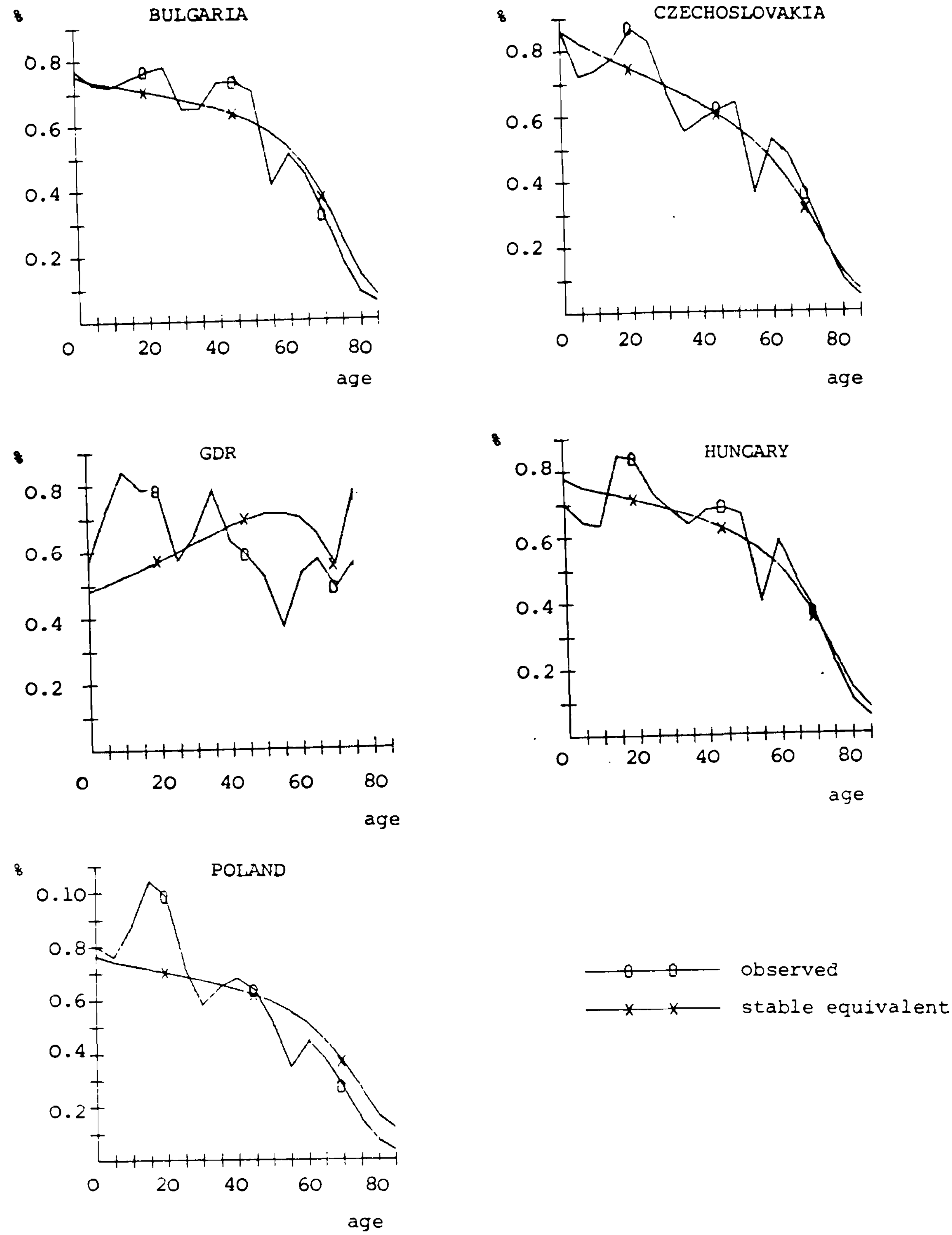


Figure 7. Percentage distribution of the observed national population and its stable equivalent for Bulgaria, Czechoslovakia, the GDR, Hungary, and Poland.

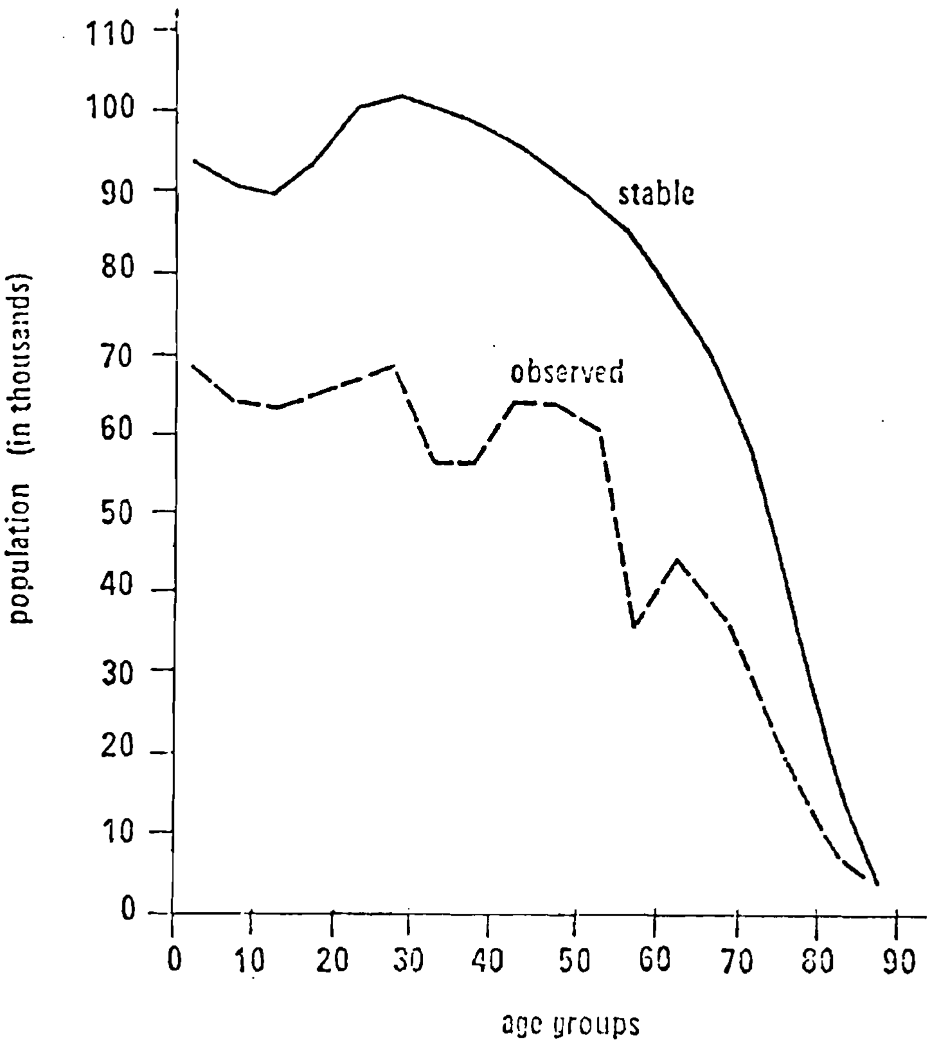


Figure 8. Number of people in each age group of the observed and the stable equivalent populations in the Sofia region, 1975.

5.3 Spatial Net Reproduction Rates

It was pointed out that fertility and migration are dominating factors in the formation of a country's demographic structure. The interactions between these two factors, however, have been considered here. The impact of fertility on migration is directly determined through changes in the population age structure, which lead to changes in the population at risk. The impact of migration on fertility is more complex, because the changes of the population at risk lead to the spatial transfer of future births. While the descriptive explanation of these interactions is not difficult, their quantitative assessment needs specific demographic measures which are only recently available; i.e., spatial net reproduction rates (Rogers 1975b).

The spatial net reproduction rate is estimated by the following formula:

$$_{i}NRR_{j} = \sum_{x} {}_{i}L_{j}(x)\ F_{j}(x)$$

where $F_j(x)$ is the observed age-specific fertility rate in region j, and $_{i}L_{j}(x)$ is the stationary population from the multiregional life table. It is to be interpreted as the number of babies born in region j to an individual born in region i, and exposed to the multiregional regime of mortality and migration.

The sum of $_{i}NRR_{j}$ over j, $_{i}NRR.$, gives the total number of births for the same individual, independent of where the births take place. This is not the same as the conventional, single-region NRR, because the individuals are subjected to different levels of fertility and mortality in the different regions.

Analogous to the estimation of the migration levels from life expectancies, net reproduction allocations may be estimated from the spatial NRR's, according to the formula:

$$_{i}\rho_{j} = {}_{i}NRR_{j}/{}_{i}NRR$$

The values for the $_{i}NRR_{j}$ and $_{i}\rho_{j}$ are given in Appendix 5. The totals in Bulgaria indicate that individuals from two regions, North and Sofia, cannot reach the reproduction level, in spite of the fact that for a certain part of their lives they are exposed to the higher fertility levels in the other regions (the single region fertility levels are indicated by the GRRs in Appendix 2). The highest total was obtained again for the North-east region, in spite of the dominating outmigration flow from this region.

The elements from the main diagonal show the number of births in the region of origin. The lowest intraregional reproduction level* is observed for the North-east; it is also low for Sofia. All the values are below unity, hence the migrations are strong enough to cause such a change of the births, that the fertility of the native regional population is below reproduction. The off-diagonal elements show that the most preferred region for childbearing, if not the region of origin, is a neighboring one. The regional distribution of the NRR is better assessed with the ${}_i\rho_j$, but their values for Bulgaria show the same pattern as the ones pointed out above.

The ${}_i$NRR. totals for Czechoslovakia are all larger than unity. They are lowest for the two capitals, and highest for Eastern Slovakia, which is analogous to the single-region case. Eastern Slovakia is the only region in the country where the intraregional reproduction is assured, and this is because of its high fertility rate. Note that intraregional reproduction is very low in the Bohemian region and Bratislava.

The allocations of the NRRs show that Bratislava is favored by citizens born in this city: 75 percent will remain in the same region. This percentage is lower in almost all Bohemian regions. The allocations show other interesting results. The exchange of births is smaller between the Bohemian and the Slovakian regions than between the Moravian and Slovakian regions, i.e., the differences here are not between the republics, as was the case with the previously studied characteristics. Also, the regions of Prague and Central Bohemia exchange a larger number of people. If the two regions

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*The intraregional reproduction level here refers to an individual born in the same region. Recall that ${}_i\mathrm{NRR}_i$ is a cohort measure.

were aggregated, the intraregional birth percentage would be high. Finally, 14 percent of the births to a Bratislavian citizen will take place in Western Slovakia, this being the highest interregional birth preference in the country. It has no feedback, however.

In the GDR, it is not surprising to find spatial net reproduction rates far below unity. Migration, however, shows a completely different pattern in comparison to the single-region case (see the GRRs in Appendix 2), having again in mind the negligible interregional mortality difference. Compare the GRR and the ${}_1$NRR of the North region, whose GRR ranks third, while the ${}_1$NRR. ranks first. The two values are equal; hence the effect of mortality (included in ${}_1$NRR, but not included in GRR) has been compensated for by certain changes in the level of fertility. This takes place through migration to regions of higher fertility: the South-west and the South. On the other hand, the dominating outmigration flow is directed to the Middle region which has the lowest fertility level in the country. The GMRs for the outmigration of the North region show that, on the average, one should expect a decrease in its fertility level, instead of an increase. In a case like this it is then necessary to consider the age distribution of the populations ${}_1L_j(x)$ which is out of the scope of this paper. The latter is, in fact, causing this unexpected result. For the remaining regions, the changes in the fertility levles are more straightforward.

The diagonal elements of the net reproduction allocations show that in the southern regions of the GDR having a child in the region of origin is more preferable. The differences are not large however. The off-diagonal numbers indicate that the Middle region is the most preferred region for having a child after the region of origin (except for the South-western inhabitants). Perhaps this is because of the fact that it neighbors all the regions (except the South-west).

In Hungary the values for ${}_iNRR.$ are indicating fertility above the reproduction level. Their regional distributions are highly influenced by the inclusion of the temporary migrations, hence the absolute numbers do not reflect a real-world picture. Note that the temporary migrant usually migrates for a short period of time and is highly unlikely to give birth during this period. For the same reasons it is difficult to assess the rise in the reproduction level for individuals from the Central region.

The relative comparison is indicative of some patterns, which are revealed by the values for ${}_i\rho_j$. One can see that the Central region is the most preferred for childbearing, after the region of origin. This is obviously due to the city of Budapest and its surroundings. The region of origin is more preferred for the Trans-Danubian and Southern Plain inhabitants.

In Poland, the totals ${}_iNRR.$ reveal the same patterns as the GRRs. The Warsaw population achieves higher reproduction levels through migration to the Bialystok and Gdansk regions. Intraregional reproduction is positive for the Lublin region only, but in Cracow is close to replacement. The off-diagonal elements follow the same patterns as the GMRs.

The net reproduction allocations show that the people of Warsaw prefer their own region for giving birth more than do the inhabitants of any other region. Wroclaw is just the opposite. Here the low preference is unique for the country. Both results correspond to the magnitude of the outmigration flows, as measured with the ${}_iGMR.$. Also in accordance with the ${}_iGMR_j$ are the off-diagonal allocations.

The study of the spatial NRRs for the five countries shows that these patterns more or less correspond to the outmigration patterns of the GMRs. An exception is the GDR and to some extent Czechoslovakia.

A common feature for all the countries is the low intra-regional reproduction level. Only two regions, one in Czechoslovakia, and one in Poland, have a reproduction level higher than unity. Both of them are less developed regions. The populations of the more developed regions have a reproduction level usually lower than in the other regions, but it tends to increase through migration.

6. POPULATION POLICY

The analysis of the multiregional characteristics from the previous sections, although brief, indicates a number of similarities and diversities in demographic patterns. In almost all cases these patterns were in direct relationship to the particular stage of spatial socioeconomic development, and to the demographic consequences which this development has caused (urbanization, etc., as discussed in the first two sections). The diversities are due predominantly to the variations in the stages of overall national development (GDR), or to geographic factors (Czechoslovakia). While the latter are unique for each country, the former allows for the inference of important results. When a country is at a certain stage of socioeconomic development, it may be expected that the demographic changes will follow the patterns indicated by a country which presently is at a higher stage of development. In such a case, if the demographic changes are undesirable, the population policy may be especially designed in order to prevent or decrease the effect of their appearance. A brief discussion of possible population policies follows.

A population policy for fertility can be described in one word: pronatal. It is desirable that the population growth be as low as possible, but positive, which can come about by a fertility level barely above replacement. The tools for applying this policy are numerous, but they center around the mother--longer paid leaves, high premiums, health consultations, etc. Young families are also given certain advantages, for instance, in their demand for housing. Abortions are usually not prohibited, but are undesirable. And, of course, there is a desire for a decrease of infant mortality.

The only concept with respect to mortality is the increase in the expectation of life. For this purpose, medical care is by far more effective than any social policy. For this reason the population policy, being a part of the social one, is not centered heavily on the problem. Infant mortality is the exception, but the efforts for its decreasing have reached the highest possible level, and its decrease is a problem of life style and tradition, rather than medicine.

Some strong migration flows, like urbanization, have caused problems both in the region of origin and in the region of destination and have brought about substantial disproportions in the spatial population distribution. These flows are hindered through a number of direct and indirect policy measures. Inmigration to most attractive places, like cities, is administratively restricted; in the less attractive regions the population is attracted through salary increases, better housing conditions, better job opportunities, etc.

Generally, migrations are thought of as undesirable, and therefore they should be decreased to a certain minimum. In this respect policy tools are not well defined, except for certain small sized dwellings. It is obvious also that the policy instruments mentioned in the above paragraph may induce larger counter-flows, thus being contradictory to the ones mentioned here. The achievement of a proportional population distribution is the dominating aim, however.

This short description of a population policy indicates that while its essence, tools, and direction are well defined, the intensity of their implementation must be thoroughly studied. Such studies are necessary in order to understand what the consequences of a certain policy will be. Suppose that the policy is aimed at the spontaneous increase of the fertility level in a certain region. The multiregional population projection showed that the population waves cause substantial changes in the age and spatial structure, hence this increase is likely to cause some problems in the years to come, not only in this same region but because of migration in other regions also. Thus, an increase of fertility in the Northwest region of Bulgaria will cause an increase in the population of Sofia. The multiregional population projection can be used then to assess quantitatively the two increases, and to design properly the policy. Or, consider a population policy aimed at decreasing the migration flow to a certain region, say Warsaw. The low level of fertility is compensated for by the inmigration stream. Thus, the decrease of the latter will cause a stronger decrease of the proportion of youngsters, hence the population will age.

Note that the above mentioned consequences may take place not only when the inmigrations to Warsaw are decreased, but also when these migrants are directed to another region, which has become more attractive for some reasons. For instance, Warsaw gains migrants predominantly from Bialystok. Make this region much more attractive, or redirect the migrants to Gdansk, say, and the growth of Warsaw will become negative.

In this way a comparative policy analysis can also be carried out. For instance, problems of pollution were reported to decrease the attractiveness of the more developed Southern regions in the GDR and Poland. The same may be expected to take place in the Bulgarian regions South and Sofia, or in the Hungarian Central region. A simulated multiregional population which incorporates these changes can be carried out, in order to help the policymakers, to identify what investments are necessary to decrease the pollution, in order to avoid undesired population changes.

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APPENDIX 1: MEAN AGES OF CHILDBEARING, DYING, AND OUTMIGRATING DURING THE OBSERVED YEAR, FOR BULGARIA, CZECHOSLOVAKIA, THE GDR, HUNGARY, AND POLAND (estimated according to the formula on page 22 in the text)

BULGARIA

N	region	births	deaths	outmigration to: 1	2	3	4	5	6	7
1	n.west	24.06	77.89	-	18.65	18.96	17.12	19.72	17.93	24.62
2	north	24.25	78.44	20.01	-	20.12	16.89	21.70	19.06	31.21
3	n.east	24.43	78.72	20.56	21.64	-	17.47	23.48	19.94	33.42
4	s.west	24.60	79.11	18.60	18.61	18.41	-	20.05	17.69	28.11
5	south	24.45	79.18	21.04	21.70	21.55	17.81	-	20.28	32.60
6	s.east	24.36	78.88	19.84	21.05	20.87	17.39	22.49	-	32.02
7	sofia	25.44	80.04	27.66	29.20	27.04	22.93	31.81	26.13	-

CZECHOSLOVAKIA

No	region	births	deaths	outmigration to: 1	2	3	4	5	6	7	8	9	10	11	12
1	prague	26.05	78.77	-	38.02	36.74	39.73	42.80	42.46	37.94	40.47	42.06	35.65	37.83	37.88
2	c.boh	24.77	78.82	34.48	-	29.77	31.82	34.40	33.73	31.35	33.09	28.53	29.36	30.87	31.66
3	s.boh	25.11	78.89	33.73	30.19	-	30.56	34.17	32.98	30.31	31.83	27.56	26.05	27.10	27.31
4	w.boh	24.87	78.88	36.26	32.18	31.33	-	36.17	35.39	32.28	33.81	29.95	29.23	30.67	32.40
5	n.boh	24.72	78.47	38.93	35.03	33.95	36.35	-	38.90	35.64	37.20	33.41	32.26	28.82	35.77
6	e.boh	24.93	78.95	36.22	32.40	31.88	34.13	36.43	-	32.56	34.52	28.64	29.19	31.76	31.85
7	s.mor	25.26	79.10	36.11	32.62	31.33	33.44	36.13	35.81	-	34.15	34.34	29.92	29.78	31.58
8	n.mor	25.08	78.87	37.15	32.64	31.62	34.77	37.07	36.49	33.11	-	30.22	29.28	31.61	32.41
9	brat	26.22	78.19	46.18	23.32	22.13	30.50	35.92	30.02	43.29	47.16	-	43.32	44.96	47.28
10	w.slov	25.77	78.49	33.35	29.97	29.71	30.27	31.82	32.04	29.05	30.96	35.36	-	31.47	32.82
11	c.slov	25.94	78.56	36.09	31.95	25.23	33.55	35.38	34.17	31.33	32.13	38.05	32.95	-	34.61
12	e.slov	26.32	78.55	35.60	31.44	31.87	33.64	33.87	33.43	30.52	32.87	37.22	33.32	33.71	-

G.D.R.

No	region	births	deaths	outmigration to: 1	2	3	4	5
1	north	24.50	69.67	-	26.02	24.54	24.79	26.18
2	berlin	29.62	69.95	25.15	-	23.63	25.74	26.92
3	s.west	29.33	69.98	24.75	25.44	-	25.37	25.32
4	south	29.28	69.89	24.31	24.95	25.01	-	24.97
5	middle	24.48	69.74	24.12	26.78	25.10	25.27	-

HUNGARY

No	region	births	deaths	1	outmigration to: 2	3	4	5	6
1	central	25.80	77.76	-	31.48	29.85	35.25	35.26	34.13
2	n.hung.	25.15	78.21	32.39	-	30.12	29.89	30.06	33.45
3	n.plain	25.53	78.20	31.02	31.28	-	29.19	31.22	31.60
4	s.plain	25.30	78.28	34.95	30.65	28.16	-	32.28	32.76
5	n.t-danu	25.40	78.43	37.20	32.23	32.09	31.99	-	31.60
6	s.t-danu	24.90	78.35	36.01	31.86	31.04	32.26	31.47	-

POLAND

No	region	births	deaths	outmigration to:								
				1	2	3	4	5	6	7	8	9
1	warsaw	26.82	77.57	-	44.35	44.80	42.64	40.01	43.55	39.55	39.02	42.21
2	cracow	27.83	78.13	48.06	-	40.77	40.35	36.47	39.80	36.74	35.53	37.95
3	lodz	26.81	77.92	43.62	39.66	-	37.71	35.79	37.46	35.02	34.91	37.26
4	poznan	27.12	78.63	44.74	40.59	40.77	-	36.83	39.93	36.48	36.80	39.06
5	wroclaw	26.60	77.32	49.15	42.45	44.26	43.02	-	44.07	39.09	40.22	42.45
6	bialyst	27.18	78.20	41.76	38.27	38.05	37.50	36.16	-	34.99	36.12	37.33
7	gdansk	26.95	77.74	47.04	42.50	44.02	42.80	40.25	43.02	-	39.75	42.65
8	katowice	26.52	78.09	45.42	39.09	40.42	39.73	37.56	40.42	36.24	-	38.95
9	lublin	27.60	78.11	44.43	39.18	39.91	39.09	36.90	39.23	36.09	36.29	-

APPENDIX 2: GROSS MIGRAPRODUCTION RATES FOR BULGARIA, CZECHOSLOVAKIA, THE GDR, HUNGARY, AND POLAND (the ${}_{i}GMR_{j}$ is defined as the multiplied-by-five sum of the age-specific migration rates from region i to region j)

BULGARIA

	region of residence	GMR region of birth 1	2	3	4	5	6	7	GRR
1	n.west	-	0.056	0.018	0.050	0.038	0.021	0.106	1.096
2	north	0.089	-	0.125	0.027	0.043	0.044	0.048	1.011
3	n.east	0.036	0.082	-	0.020	0.030	0.078	0.031	1.204
4	s.west	0.020	0.008	0.005	-	0.009	0.005	0.020	1.112
5	south	0.065	0.059	0.035	0.077	-	0.198	0.068	1.130
6	s.east	0.008	0.013	0.022	0.009	0.027	-	0.016	1.217
7	sofia	0.244	0.080	0.042	0.201	0.075	0.074	-	0.962
	total	0.461	0.298	0.248	0.385	0.221	0.420	0.290	1.104

CZECHOSLOVAKIA

	region of residence	GMR region of birth 1	2	3	4	5	6	7	8	9	10	11	12	GRR
1	prague	-	0.436	0.160	0.150	0.170	0.125	0.051	0.047	0.036	0.010	0.014	0.015	1.082
2	c.boh	0.382	-	0.117	0.156	0.196	0.124	0.027	0.027	0.005	0.012	0.014	0.021	1.174
3	s.boh	0.069	0.081	-	0.117	0.068	0.036	0.043	0.020	0.006	0.009	0.008	0.012	1.170
4	w.boh	0.075	0.104	0.091	-	0.125	0.043	0.029	0.028	0.008	0.011	0.011	0.025	1.198
5	n.boh	0.114	0.176	0.062	0.157	-	0.113	0.032	0.028	0.006	0.013	0.014	0.029	1.213
6	e.boh	0.083	0.133	0.070	0.068	0.126	-	0.057	0.043	0.005	0.017	0.015	0.019	1.213
7	s.mor	0.045	0.045	0.123	0.095	0.055	0.106	-	0.172	0.032	0.036	0.025	0.021	1.222
8	n.mor	0.036	0.033	0.044	0.053	0.048	0.070	0.146	-	0.024	0.032	0.055	0.043	1.215
9	brat	0.006	0.003	0.004	0.005	0.004	0.002	0.007	0.005	-	0.198	0.075	0.049	1.115
10	w.slov	0.007	0.012	0.013	0.028	0.022	0.020	0.027	0.023	0.474	-	0.177	0.058	1.197
11	c.slov	0.007	0.014	0.011	0.020	0.013	0.013	0.014	0.030	0.125	0.139	-	0.087	1.247
12	e.slov	0.006	0.010	0.006	0.017	0.015	0.011	0.007	0.015	0.059	0.036	0.084	-	1.394
	total	0.832	1.046	0.701	0.866	0.842	0.662	0.442	0.437	0.780	0.513	0.491	0.379	1.211

G.D.R.

	region of residence	GMR: region of birth 1	2	3	4	5	GRR
1	north	-	0.070	0.048	0.058	0.100	0.794
2	berlin	0.098	-	0.051	0.060	0.169	0.776
3	s.west	0.063	0.040	-	0.096	0.058	0.842
4	south	0.140	0.111	0.191	-	0.183	0.816
5	middle	0.228	0.277	0.096	0.160	-	0.739
	total	0.529	0.498	0.386	0.375	0.510	0.810

HUNGARY

	region of residence	GMR: region of birth 1	2	3	4	5	6	GRR
1	centr	-	1.364	2.135	1.035	0.938	0.843	0.987
2	n.hung	0.530	-	0.440	0.131	0.133	0.088	1.197
3	n.plain	0.952	0.472	-	0.276	0.178	0.104	1.355
4	s.plain	0.447	0.135	0.273	-	0.166	0.230	1.148
5	n.tr-d	0.513	0.210	0.252	0.252	-	0.570	1.194
6	s.tr-d	0.323	0.089	0.090	0.215	0.356	-	1.167
	total	2.765	2.270	3.189	1.908	1.770	1.836	1.144

POLAND

	region of residence	GMR region of birth 1	2	3	4	5	6	7	8	9	GRR
1	warsaw	-	0.014	0.040	0.016	0.023	0.362	0.027	0.011	0.025	0.643
2	cracow	0.009	-	0.050	0.014	0.063	0.016	0.023	0.068	0.070	1.197
3	lodz	0.021	0.039	-	0.050	0.123	0.069	0.079	0.073	0.056	1.118
4	poznan	0.010	0.020	0.054	-	0.185	0.053	0.180	0.034	0.039	1.160
5	wroclaw	0.012	0.052	0.080	0.109	-	0.049	0.097	0.082	0.079	1.001
6	bialyst	0.105	0.016	0.082	0.037	0.069	-	0.162	0.024	0.075	1.238
7	gdansk	0.027	0.030	0.079	0.167	0.127	0.208	-	0.035	0.093	1.117
8	katowice	0.011	0.188	0.176	0.060	0.215	0.061	0.067	-	0.118	0.910
9	lublin	0.012	0.060	0.042	0.020	0.084	0.051	0.067	0.035	-	1.344
	total	0.207	0.419	0.603	0.474	0.888	0.867	0.703	0.362	0.554	1.097

APPENDIX 3: MULTIREGIONAL EXPECTATIONS OF LIFE AND MIGRATION LEVELS FOR BULGARIA, CZECHOSLOVAKIA, THE GDR, HUNGARY, AND POLAND

BULGARIA

expectations of life

	n.west	north	n.east	s.west	south	s.east	sofia
n.west	52.97	2.32	0.92	2.27	1.64	1.06	3.80
north	3.83	58.57	5.19	1.45	1.98	2.08	2.01
n.east	1.70	3.46	59.37	1.06	1.38	3.18	1.30
s.west	0.87	0.38	0.26	54.98	0.40	0.26	0.79
south	2.97	2.69	1.69	3.44	61.24	7.71	2.60
s.east	0.43	0.60	0.92	0.47	1.11	53.43	0.63
sofia	8.62	3.16	1.74	7.22	2.88	2.80	59.49
total	71.39	71.19	70.09	70.90	70.63	70.52	70.62
average	70.74						

migration levels

	n.west	north	n.east	s.west	south	s.east	sofia
n.west	0.742	0.033	0.013	0.032	0.023	0.015	0.054
north	0.054	0.823	0.074	0.021	0.028	0.030	0.028
n.east	0.024	0.049	0.847	0.015	0.020	0.045	0.018
s.west	0.012	0.005	0.004	0.775	0.006	0.004	0.011
south	0.042	0.038	0.024	0.049	0.867	0.109	0.037
s.east	0.006	0.008	0.013	0.007	0.016	0.758	0.009
sofia	0.121	0.044	0.025	0.102	0.041	0.040	0.842
total	1.000	1.000	1.000	1.000	1.000	1.000	1.000

CZECHOSLOVAKIA

expectations of life

	prague	c.boh	s.boh	w.boh	n.boh	e.boh	s.mor	n.mor	brat	w.slov	c.slov	e.slov
prague	49.28	9.90	4.74	4.43	4.67	3.82	1.77	1.59	0.84	0.55	0.60	0.71
c.boh	7.89	42.51	3.48	4.18	4.76	3.47	1.07	1.01	0.33	0.47	0.52	0.73
s.boh	2.00	2.47	48.52	3.24	2.02	1.28	1.38	0.77	0.28	0.35	0.35	0.46
w.boh	1.97	2.78	2.57	44.92	2.98	1.38	0.93	0.87	0.32	0.40	0.39	0.75
n.boh	2.79	4.26	1.96	3.80	46.28	2.94	1.04	0.90	0.28	0.48	0.47	0.90
e.boh	2.30	3.61	2.25	2.17	3.20	50.61	1.75	1.36	0.29	0.62	0.56	0.68
s.mor	1.59	1.84	3.97	3.09	1.94	3.40	56.70	5.32	0.99	1.38	1.04	0.93
n.mor	1.15	1.27	1.63	1.79	1.52	2.22	4.39	55.90	0.74	1.19	1.81	1.47
brat	0.18	0.16	0.21	0.25	0.19	0.16	0.31	0.25	51.37	5.25	2.24	1.46
w.slov	0.34	0.51	0.59	0.99	0.74	0.73	0.99	0.88	10.31	54.09	5.31	2.03
c.slov	0.31	0.52	0.46	0.72	0.53	0.51	0.59	1.01	3.16	4.33	54.57	2.68
e.slov	0.25	0.37	0.28	0.58	0.49	0.40	0.32	0.54	1.44	1.30	2.53	57.03
total	70.07	70.17	70.66	70.15	69.33	70.93	71.22	70.40	70.34	70.41	70.38	69.82

average 70.40

migration levels

	prague	c.boh	s.boh	w.boh	n.boh	e.boh	s.mor	n.mor	brat	w.slov	c.slov	e.slov
prague	0.703	0.141	0.067	0.063	0.067	0.054	0.025	0.023	0.012	0.008	0.009	0.010
c.boh	0.113	0.606	0.049	0.060	0.069	0.049	0.015	0.014	0.005	0.007	0.007	0.010
s.boh	0.029	0.035	0.687	0.046	0.029	0.018	0.019	0.011	0.004	0.005	0.005	0.007
w.boh	0.028	0.040	0.036	0.640	0.043	0.020	0.013	0.012	0.004	0.006	0.005	0.011
n.boh	0.040	0.061	0.028	0.054	0.668	0.041	0.015	0.013	0.004	0.007	0.007	0.013
e.boh	0.033	0.051	0.032	0.031	0.046	0.714	0.025	0.019	0.004	0.009	0.008	0.010
s.mor	0.023	0.026	0.056	0.044	0.028	0.048	0.796	0.076	0.014	0.020	0.015	0.013
n.mor	0.016	0.018	0.023	0.025	0.022	0.031	0.062	0.794	0.010	0.017	0.026	0.021
brat	0.003	0.002	0.003	0.004	0.003	0.002	0.004	0.004	0.730	0.075	0.032	0.021
w.slov	0.005	0.007	0.008	0.014	0.011	0.010	0.014	0.012	0.147	0.768	0.076	0.029
c.slov	0.004	0.007	0.007	0.010	0.008	0.007	0.008	0.014	0.045	0.061	0.775	0.038
e.slov	0.004	0.005	0.004	0.008	0.007	0.006	0.004	0.008	0.020	0.018	0.036	0.817
total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

G.D.R.

expectations of life

	north	berlin	s.west	south	middle
north	51.67	2.67	1.91	2.30	3.54
berlin	3.65	52.85	2.15	2.54	5.49
s.west	2.56	1.81	56.49	3.60	2.37
south	5.63	4.67	7.17	57.61	6.83
middle	7.79	9.12	3.97	5.96	53.17
total	71.31	71.13	71.69	72.01	71.39
average	71.58				

migration levels

	north	berlin	s.west	south	middle
north	0.725	0.038	0.027	0.032	0.050
berlin	0.051	0.743	0.030	0.035	0.077
s.west	0.036	0.026	0.788	0.050	0.033
south	0.079	0.066	0.100	0.800	0.096
middle	0.109	0.128	0.055	0.083	0.745
total	1.000	1.000	1.000	1.000	1.000

HUNGARY

expectations of life

	central	n.hung.	n.plain	s.plain	n.t-danu	s.t-danu
central	33.40	17.08	19.26	14.99	13.89	13.11
n.hung.	6.75	29.33	6.96	4.55	4.25	3.74
n.plain	8.76	7.76	25.74	6.28	5.23	4.62
s.plain	6.34	4.75	6.08	31.81	4.65	5.16
n.t-danu	8.03	6.46	7.02	6.69	35.32	9.84
s.t-danu	5.11	3.68	4.07	4.82	6.33	32.39
total	68.38	69.06	69.13	69.13	69.67	68.85
average	68.96					

migration levels

	central	n.hung.	n.plain	s.plain	n.t-danu	s.t-danu
central	0.488	0.247	0.279	0.217	0.199	0.190
n.hung.	0.099	0.425	0.101	0.066	0.061	0.054
n.plain	0.128	0.112	0.372	0.091	0.075	0.067
s.plain	0.093	0.069	0.088	0.460	0.067	0.075
n.t-danu	0.117	0.094	0.102	0.097	0.507	0.143
s.t-danu	0.075	0.053	0.059	0.070	0.091	0.470
total	1.000	1.000	1.000	1.000	1.000	1.000

POLAND

expectations of life

	warsaw	cracow	lodz	poznan	wroclav	bialyst	gdansk	katowice	lublin
warsaw	66.20	0.48	1.34	0.65	0.80	8.66	1.16	0.46	0.96
cracow	0.28	58.00	1.47	0.54	1.63	0.58	0.72	1.98	1.96
lodz	0.61	1.18	52.45	1.49	2.76	1.89	1.97	2.01	1.62
poznan	0.40	0.77	1.77	56.70	4.33	1.75	4.37	1.17	1.36
wroclav	0.42	1.57	2.26	2.93	48.49	1.45	2.44	2.24	2.17
bialyst	2.55	0.55	2.13	1.17	1.63	48.14	3.48	0.76	1.93
gdansk	0.97	1.05	2.47	4.68	3.40	5.40	52.73	1.26	2.77
katowice	0.49	5.82	5.34	2.15	5.60	2.04	2.25	59.32	3.74
lublin	0.40	1.74	1.29	0.74	2.01	1.44	1.69	1.10	54.67
total	72.32	71.18	70.51	71.05	70.66	71.36	70.81	70.31	71.18
average	71.16								

migration levels

	warsaw	cracow	lodz	poznan	wroclav	bialyst	gdansk	katowice	lublin
warsaw	0.915	0.007	0.019	0.009	0.011	0.121	0.016	0.007	0.013
cracow	0.004	0.815	0.021	0.008	0.023	0.008	0.010	0.028	0.027
lodz	0.008	0.017	0.744	0.021	0.039	0.026	0.028	0.029	0.023
poznan	0.006	0.011	0.025	0.798	0.061	0.025	0.062	0.017	0.019
wroclav	0.006	0.022	0.032	0.041	0.686	0.020	0.034	0.032	0.031
bialyst	0.035	0.008	0.030	0.017	0.023	0.675	0.049	0.011	0.027
gdansk	0.013	0.015	0.035	0.066	0.048	0.076	0.745	0.018	0.039
katowice	0.007	0.082	0.076	0.030	0.079	0.029	0.032	0.844	0.053
lublin	0.006	0.024	0.018	0.010	0.029	0.020	0.024	0.016	0.768
total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

APPENDIX 4: ABSOLUTE NUMBERS (IN THOUSANDS), MEAN AGES, REGIONAL SHARES, AND GROWTH RATIOS* AT THE YEAR OF OBSERVATION, 50 YEARS LATER, AND AT STABILITY, FOR THE MULTIREGIONAL POPULATIONS OF BULGARIA, CZECHOSLOVAKIA, THE GDR, HUNGARY, AND POLAND

* The growth ratio is defined as the ratio of the total number of a regional (or national) population, to the same population 5 years ago, and is denoted by λ. It is not defined for the initial year.

BULGARIA

	population	total	n.west	north	n.east	s.west	south	s.east	sofia
abs.	1975	8727.	1043.	1400.	1487.	696.	2164.	867.	1070.
num.	2025	10108.	981.	1492.	1873.	653.	2718.	881.	1510.
(th.)	stab eq.	8748.	741.	1355.	2122.	247.	2333.	559.	1389.
mean	1975	35.18	38.97	37.87	33.81	34.19	33.60	34.33	34.37
age	2025	36.55	37.81	37.68	35.19	38.13	35.89	36.37	36.88
	stab eq.	36.42	37.37	37.46	35.51	36.36	36.09	35.51	37.23
	1975	100.00	11.95	16.04	17.04	7.98	24.80	9.93	12.26
share	2025	100.00	9.71	14.76	18.53	6.46	26.89	8.71	14.94
	stab eq.	100.00	8.47	15.49	24.26	2.83	26.67	6.39	15.88
lam	2025	1.0105	1.0006	1.0081	1.0184	0.9837	1.0155	0.9963	1.0212
	stab eq.	1.0119	1.0119	1.0119	1.0119	1.0119	1.0119	1.0119	1.0119

CZECHOSLOVAKIA

	population	total	prague	c.boh	s.boh	w.boh	n.boh	e.boh	s.mor	n.mor	brat	w.slov	c.slov	e.slov
abs	1975	14802.	1164.	1136.	668.	873.	1136.	1225.	1985.	1875.	337.	1630.	1455.	1317.
num	2025	20122.	1547.	1378.	917.	1054.	1413.	1535.	2708.	2570.	699.	2172.	2051.	2077.
(th)	stab eq.	13915.	1094.	923.	642.	650.	879.	997.	1993.	1728.	564.	1302.	1250.	1893.
mean	1975	34.61	39.24	37.19	35.85	34.44	33.89	36.20	35.80	33.49	33.83	33.35	32.35	30.98
ages	2025	34.51	36.70	34.61	34.67	34.32	33.97	34.76	34.48	34.26	35.76	34.83	34.30	32.80
	stab eq.	34.29	36.47	34.29	34.56	33.79	33.54	34.42	34.36	34.02	36.16	34.54	34.13	32.94
	1975	100.00	7.87	7.68	4.51	5.90	7.67	8.27	13.41	12.67	2.28	11.01	9.83	8.90
share	2025	100.00	7.69	6.85	4.56	5.24	7.02	7.63	13.46	12.77	3.47	10.79	10.19	10.32
	stab eq.	100.00	7.86	6.63	4.62	4.67	6.32	7.16	14.32	12.42	4.05	9.36	8.99	13.60
lam	2025	1.0305	1.0327	1.0278	1.0336	1.0212	1.0232	1.0273	1.0341	1.0292	1.0520	1.0254	1.0283	1.0392
	stab eq.	1.0320	1.0320	1.0320	1.0320	1.0320	1.0320	1.0320	1.0320	1.0320	1.0320	1.0320	1.0320	1.0320

G. D. R.

	population	total	north	berlin	s.west	south	middle
abs.	1975	16820.	2085.	1098.	2530.	7135.	3972.
num.	2025	13981.	1785.	1411.	2267.	5246.	3272.
(th)	stab eq.	22454.	2439.	3353.	4411.	7530.	4721.
mean	1975	37.03	34.56	37.12	36.69	38.36	36.15
age	2025	41.95	42.09	40.13	40.97	42.16	43.01
	stab eq.	42.41	42.40	42.01	41.80	42.36	43.33
	1975	100.00	12.40	6.53	15.04	42.42	23.61
share	2025	100.00	12.76	10.09	16.22	37.52	23.40
	stab eq.	100.00	10.86	14.93	19.64	33.54	21.02
lam	2025	0.9642	0.9636	0.9926	0.9751	0.9556	0.9591
	stab eq.	0.9536	0.9536	0.9536	0.9536	0.9536	0.9536

HUNGARY

	population	total	centr	n.hung	n.plain	s.plain	n.tr-d	s.tr-d
abs.	1974	10448.	2968.	1358.	1544.	1451.	1824.	1304.
num.	2024	11977.	3513.	1489.	1735.	1554.	2253.	1434.
(th)	stab eq.	10245.	3001.	1262.	1480.	1318.	1958.	1226.
mean	1974	36.15	37.60	35.28	34.52	37.11	34.84	36.45
age	2024	36.27	37.55	36.02	34.93	36.45	35.40	36.21
	stab eq.	35.94	37.23	35.64	34.59	36.05	35.15	35.87
	1974	100.00	28.41	13.00	14.77	13.89	17.46	12.48
share	2024	100.00	29.33	12.43	14.48	12.98	18.81	11.97
	stab eq.	100.00	29.29	12.32	14.44	12.87	19.11	11.97
lam	2024	1.0113	1.0118	1.0087	1.0108	1.0095	1.0143	1.0107
	stab eq.	1.0151	1.0151	1.0151	1.0151	1.0151	1.0151	1.0151

POLAND

	population	total	warsaw	cracow	lodz	poznan	wroclaw	bialyst	gdansk	katowice	lublin
abs.	1973	33512.	1388.	2851.	4357.	4698.	3484.	3732.	4307.	4947.	3750.
num.	2023	44641.	2079.	4059.	4937.	6506.	4191.	4513.	6438.	6671.	5247.
(th)	stab eq.	31747.	1236.	3705.	2527.	4201.	2268.	2827.	4358.	4090.	6536.
mean	1973	32.37	36.52	32.40	34.00	32.44	30.57	32.78	29.76	32.56	32.87
age	2023	36.96	44.53	35.72	37.24	36.28	38.14	35.50	36.29	39.04	34.03
	stab eq.	36.52	44.38	35.86	36.97	36.34	37.57	35.45	36.35	38.69	34.19
	1973	100.00	4.14	8.51	13.00	14.02	10.40	11.14	12.85	14.76	11.19
share	2023	100.00	4.66	9.09	11.06	14.57	9.39	10.11	14.42	14.94	11.75
	stab eq.	100.00	3.89	11.67	7.96	13.23	7.14	8.90	13.73	12.88	20.59
lam	1973	1.0133	1.0100	1.0226	1.0032	1.0185	0.9980	1.0104	1.0178	1.0077	1.0274
	stab eq.	1.0149	1.0149	1.0149	1.0149	1.0149	1.0149	1.0149	1.0149	1.0149	1.0149

APPENDIX 5: SPATIAL NET REPRODUCTION RATES AND THEIR ALLOCATIONS FOR BULGARIA, CZECHOSLOVAKIA, THE GDR, HUNGARY, AND POLAND

BULGARIA

net reproduction rate

	n.west	north	n.east	s.west	south	s.east	sofia
n.west	0.778	0.034	0.013	0.034	0.023	0.015	0.044
north	0.054	0.798	0.074	0.020	0.027	0.028	0.023
n.east	0.028	0.058	0.972	0.018	0.022	0.053	0.017
s.west	0.015	0.006	0.004	0.820	0.006	0.004	0.011
south	0.046	0.042	0.026	0.056	0.945	0.123	0.032
s.east	0.007	0.010	0.016	0.008	0.018	0.881	0.008
sofia	0.118	0.041	0.023	0.099	0.037	0.036	0.804
total	1.045	0.990	1.127	1.054	1.078	1.140	0.938
average	1.060						

net reproduction allocations

	n.west	north	n.east	s.west	south	s.east	sofia
n.west	0.744	0.035	0.012	0.032	0.021	0.013	0.046
north	0.052	0.806	0.065	0.019	0.025	0.025	0.024
n.east	0.027	0.059	0.862	0.017	0.020	0.046	0.018
s.west	0.014	0.006	0.004	0.778	0.006	0.004	0.012
south	0.044	0.043	0.023	0.053	0.876	0.108	0.034
s.east	0.007	0.010	0.014	0.007	0.017	0.772	0.009
sofia	0.113	0.042	0.020	0.094	0.034	0.032	0.857
total	1.000	1.000	1.000	1.000	1.000	1.000	1.000

CZECHOSLOVAKIA

net reproduction rate

	prague	c.boh	s.boh	w.boh	n.boh	e.boh	s.mor	n.mor	brat	w.slov	c.slov	e.slov
prague	0.750	0.132	0.059	0.053	0.056	0.047	0.021	0.018	0.010	0.006	0.007	0.008
c.boh	0.119	0.740	0.050	0.061	0.069	0.050	0.014	0.013	0.004	0.006	0.007	0.010
s.boh	0.028	0.036	0.822	0.047	0.028	0.017	0.019	0.010	0.004	0.005	0.005	0.006
w.boh	0.029	0.044	0.040	0.802	0.046	0.020	0.013	0.013	0.004	0.006	0.005	0.011
n.boh	0.040	0.067	0.028	0.058	0.839	0.044	0.015	0.012	0.004	0.007	0.007	0.013
e.boh	0.032	0.054	0.032	0.030	0.046	0.884	0.025	0.019	0.004	0.009	0.008	0.009
s.mor	0.021	0.025	0.058	0.044	0.026	0.049	0.976	0.076	0.014	0.020	0.014	0.013
n.mor	0.016	0.018	0.023	0.026	0.021	0.032	0.065	0.971	0.010	0.017	0.026	0.021
brat	0.002	0.002	0.003	0.003	0.002	0.002	0.004	0.003	0.806	0.070	0.028	0.018
w.slov	0.004	0.007	0.008	0.014	0.011	0.011	0.014	0.012	0.150	0.918	0.077	0.028
c.slov	0.004	0.008	0.007	0.011	0.008	0.008	0.009	0.015	0.046	0.067	0.962	0.040
e.slov	0.004	0.006	0.004	0.010	0.008	0.007	0.005	0.009	0.023	0.021	0.042	1.108
total	1.049	1.139	1.134	1.159	1.161	1.171	1.178	1.172	1.078	1.152	1.187	1.285

average 1.175

net reproduction allocations

	prague	c.boh	s.boh	w.boh	n.boh	e.boh	s.mor	n.mor	brat	w.slov	c.slov	e.slov
prague	0.715	0.116	0.052	0.046	0.048	0.040	0.018	0.016	0.009	0.005	0.006	0.006
c.boh	0.113	0.650	0.044	0.052	0.060	0.043	0.012	0.011	0.004	0.006	0.006	0.008
s.boh	0.027	0.032	0.725	0.041	0.024	0.015	0.016	0.009	0.003	0.004	0.004	0.005
w.boh	0.028	0.038	0.035	0.692	0.039	0.017	0.011	0.011	0.004	0.005	0.005	0.009
n.boh	0.038	0.059	0.025	0.050	0.723	0.038	0.012	0.011	0.003	0.006	0.006	0.010
e.boh	0.030	0.047	0.028	0.026	0.039	0.755	0.021	0.016	0.003	0.008	0.006	0.007
s.mor	0.020	0.022	0.051	0.038	0.023	0.042	0.828	0.065	0.013	0.017	0.012	0.010
n.mor	0.015	0.016	0.020	0.022	0.018	0.028	0.055	0.828	0.009	0.015	0.022	0.017
brat	0.002	0.002	0.002	0.003	0.002	0.001	0.003	0.002	0.748	0.061	0.023	0.014
w.slov	0.004	0.006	0.007	0.012	0.009	0.009	0.012	0.011	0.139	0.797	0.064	0.022
c.slov	0.004	0.007	0.006	0.009	0.007	0.006	0.007	0.013	0.042	0.058	0.810	0.031
e.slov	0.004	0.005	0.004	0.008	0.007	0.006	0.004	0.008	0.021	0.019	0.036	0.862
total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

G.D.R.

net reproduction rate

	north	berlin	s.west	south	middle
north	0.593	0.025	0.017	0.021	0.035
berlin	0.041	0.552	0.024	0.028	0.062
s.west	0.030	0.022	0.631	0.043	0.028
south	0.064	0.053	0.083	0.622	0.078
middle	0.066	0.078	0.033	0.052	0.554
total	0.794	0.729	0.787	0.766	0.756
average	0.766				

net reproduction allocations

	north	berlin	s.west	south	middle
north	0.746	0.035	0.022	0.028	0.046
berlin	0.051	0.757	0.030	0.037	0.081
s.west	0.038	0.030	0.801	0.056	0.037
south	0.081	0.072	0.105	0.812	0.103
middle	0.083	0.107	0.042	0.067	0.732
total	1.000	1.000	1.000	1.000	1.000

HUNGARY

net reproduction rate

	central	n.hung.	n.plain	s.plain	n.t-danu	s.t-danu
central	0.416	0.259	0.315	0.214	0.192	0.180
n.hung.	0.117	0.475	0.117	0.066	0.060	0.051
n.plain	0.190	0.149	0.415	0.117	0.088	0.075
s.plain	0.102	0.066	0.095	0.510	0.066	0.077
n.t-danu	0.131	0.097	0.107	0.101	0.591	0.170
s.t-danu	0.078	0.048	0.054	0.071	0.102	0.539
total	1.035	1.095	1.103	1.079	1.099	1.092
average	1.079					

net reproduction allocations

	central	n.hung.	n.plain	s.plain	n.t-danu	s.t-danu
central	0.402	0.236	0.285	0.198	0.175	0.165
n.hung.	0.113	0.434	0.106	0.061	0.055	0.046
n.plain	0.184	0.137	0.376	0.109	0.080	0.069
s.plain	0.098	0.061	0.086	0.473	0.060	0.070
n.t-danu	0.126	0.088	0.097	0.094	0.537	0.156
s.t-danu	0.076	0.044	0.049	0.066	0.093	0.494
total	1.000	1.000	1.000	1.000	1.000	1.000

POLAND

net reproduction rate

	warsaw	cracow	lodz	poznan	wroclav	bialyst	gdansk	katowice	lublin
warsaw	0.577	0.002	0.008	0.003	0.004	0.057	0.006	0.002	0.005
cracow	0.003	0.959	0.021	0.007	0.023	0.008	0.009	0.028	0.027
lodz	0.007	0.014	0.826	0.018	0.035	0.025	0.024	0.026	0.020
poznan	0.004	0.009	0.024	0.914	0.059	0.023	0.059	0.015	0.017
wroclav	0.004	0.019	0.028	0.036	0.701	0.017	0.029	0.027	0.026
bialyst	0.034	0.008	0.033	0.016	0.024	0.846	0.052	0.011	0.029
gdansk	0.011	0.013	0.033	0.063	0.046	0.077	0.833	0.016	0.037
katowice	0.004	0.060	0.057	0.021	0.059	0.021	0.022	0.758	0.038
lublin	0.006	0.027	0.021	0.011	0.032	0.024	0.026	0.017	1.018
total	0.651	1.112	1.049	1.089	0.982	1.097	1.062	0.899	1.218
average	1.084								

net reproduction allocations

	warsaw	cracow	lodz	poznan	wroclav	bialyst	gdansk	katowice	lublin
warsaw	0.887	0.002	0.007	0.003	0.004	0.052	0.006	0.003	0.004
cracow	0.005	0.863	0.020	0.006	0.023	0.007	0.009	0.031	0.022
lodz	0.010	0.013	0.787	0.017	0.036	0.023	0.023	0.028	0.017
poznan	0.007	0.008	0.022	0.840	0.060	0.021	0.055	0.017	0.014
wroclav	0.007	0.017	0.027	0.033	0.714	0.016	0.027	0.030	0.021
bialyst	0.052	0.007	0.032	0.015	0.024	0.771	0.049	0.012	0.024
gdansk	0.018	0.012	0.032	0.058	0.047	0.070	0.785	0.018	0.030
katowice	0.007	0.054	0.054	0.019	0.060	0.019	0.021	0.843	0.031
lublin	0.008	0.024	0.020	0.010	0.032	0.022	0.025	0.019	0.836
total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

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