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THE ANALYSIS OF POPULATION CHANGE IN THE REPUBLICS OF THE SOVIET UNION USING MULTI-REGIONAL ACCOUNTING AND PROJECTION METHODS

PART 1. 1968-76

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Preface

This paper has been a long time in gestation (1978-80), because of the need for revising our computer analyses several times. We had originally intended to include with our historical analysis of the 1968-76 period a series of forecasts of the population of the Soviet republics. However, our analysis has been overtaken by the publication of the initial results of the 1979 Soviet Census. So that it seemed more appropriate to extend the work from 1976 to 1979 to take into account the results of the Census before carrying out any projections. This we hope to do in a second paper, a Part 2 to accompany this Part 1.

Acknowledgements

Our thanks are due to John Jenkins for his computer programming efforts (Jenkins and Rees, 1977) without which this paper would not have been possible. Dil Thomas would also like to acknowledge the support of the Social Science Research Council during this work.

Abstract

Population accounting methods developed in a United Kingdom context are applied in an analysis of the history of recent population growth among the republics of the Soviet Union. The nature of the conflict between different measures of the patterns of migration becomes much clearer when placed in an accounting framework. Multi-republic population accounts are developed for the 1968-69 period using a variety of assumptions about the reliability of the various demographic components. A careful analysis of the pattern implied by the different accounts leads to the conclusion that the migration data for 1968-69 should be regarded as a fairly reliable guide, but that the 1968, 1972, 1974 and 1976 population estimates should be revised in the light of the accounting analysis.

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1. Introduction

In terms of demographic size, the Soviet Union ranks as the third largest country in the world with an estimated population on January 1st, 1979 of 262 millions (Vestnik Statistiki, 1979), or some 6.2 per cent of the world's population of 4230 millions (our estimate extrapolated from figures given in Brown, 1976). Individual republics within the Soviet Union outrank many of the world's countries. The Russian Soviet Federated Socialist Republic (RSFSR) would come fourth; the Ukraine Socialist Soviet Republic would rank among the top fifteen countries. A study of the population geography of the republics of the Soviet Union can thus be said to have considerable significance.

This paper takes as its main theme the analysis of population change, in the recent past, among the republics making up the Soviet Union, starting in 1968 (January 1st) and continuing to 1976 (January 1st). The approach adopted is to view the populations of the republics as a multi-regional, interactive system.

The specific goals of this work are as follows.

(i) We aim to describe and to analyze the patterns of population change within the Soviet Union, at republic level.

(ii) We intend to explore the inconsistencies which occur in published Soviet population statistics and to develop a "best fit" set of population change figures that are "consistent" with the official estimates of republic populations in the period 1968-1976.

(iii) In order to produce these consistent statistics, we apply methods of representing population change developed by Rees and Wilson (1977) and Jenkins and Rees (1977). These methods involve constructing multi-regional population accounts akin to the national income accounts used in macro-economic modelling (see Stone, 1975 for a discussion of the link), each republic constituting a region in the sets of accounts.

(iv) Having developed a consistent set of multi-republic population accounts, we use the information as the basis of a set of population projections of the Soviet Union, by republic, on an all age, all sex basis. While these projections may suffer from aggregation bias, they do give a good picture of the likely future distribution of population among republics in the Soviet Union. These projections are reported in a separate paper in Part 2 of this work.

In the writing of this paper, we have chosen the Union Republics of the U.S.S.R. as our spatial units because of convenience, and since they will indicate the problems involved in an analysis of this type for the Soviet Union before going to a more refined spatial scale. We have further chosen an aggregate population for a similar reason, and because of difficulties in obtaining age/sex disaggregated data for the Soviet Union, particularly for interrepublic migration flows.

For the purpose of constructing our population accounts we have chosen the period 1968 to 1976 (January 1st to January 1st). Within this general time span we have generated accounts for two-year periods. The choice of two-year periods was conditioned by the form that the migration data in the 1970 All Union Census of Population for the U.S.S.R. takes, that is, tables of flows in the two years prior to the 15th January, 1970. Furthermore, throughout the following analysis, we take the stand that where contradictions and inconsistencies occur in the published data the source most likely to be correct is the Census, and in cases of this nature we adjust data in the pre-Censal and post-Censal periods.

Figure 1 shows, for those not familiar with the geography of the Soviet Union, the boundaries of its constituent republics. Figure 2 displays a general grouping of those republics which we use, from time to time, in the analysis. In naming the republics as "adjective applying to the republic plus SSR" (Soviet Socialist Republic) we follow the practice in the Soviet Census and other statistical volumes. The Roman script transliteration we adopt for the "adjectives" is that given in the Oxford Regional Economic Atlas of the USSR and Eastern Europe (E.I.U., 1956). There is agreement on the Roman script spelling of most republic names, excepting Azerbaydyhan SSR which is often rendered as Azerbaijan SSR, and Kirgiz SSR which is sometimes given as Kirghiz SSR.

A final comment should be made, by way of introduction, that the work reported on here is preliminary in two senses. Firstly, we would expect to extend the spatial detail of our analysis from a 15 republic basis to a 26 zone republic and economic region basis (cf. Shabad, 1977). Secondly, we would like to extend the aggregate population analysis to that for age, sex and ethnically classified populations if the right data were to become available.

Figure 1. A map of the republics of the USSR

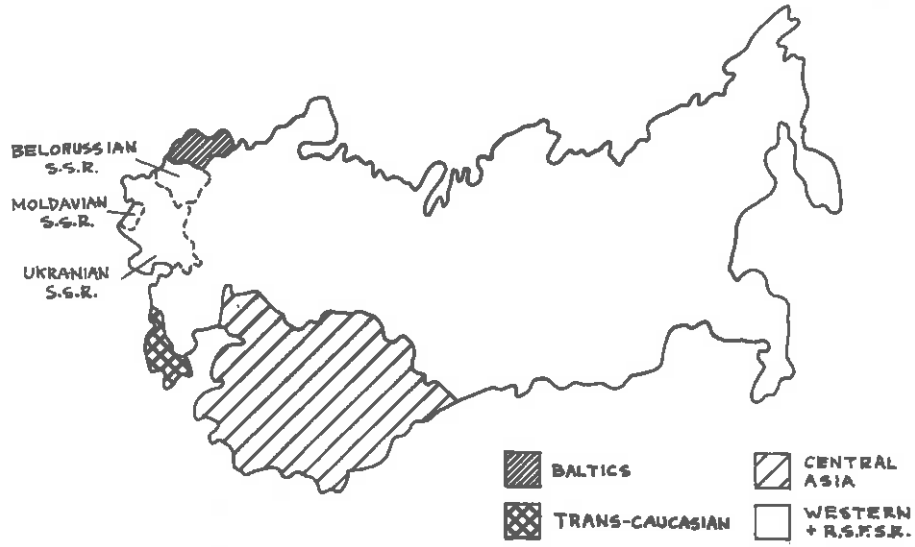


Figure 2. The republics of the USSR grouped together

2. Population change in the recent past: a brief summary

2.1 Changes in population stocks and shares

In the period under consideration, 1968-1976, the population of the Soviet Union as a whole grew by some 18.8 million persons. The Union republics grew at different rates, and also differently in absolute terms. Table 1 shows the populations of the republics at two-yearly intervals during this period, and Table 2 shows the shares of the total USSR population living in each republic. These tables highlight the size of the RSFSR when compared to the other republics. At the start of the period under consideration this republic had some 128 million inhabitants, or 54.0% of the total; the next largest republic, the Ukraine, had only 19.6% of the total. By the end of the period the RSFSR had lost a 1.3% share of the USSR population and made up 52.7% of the total. The Ukraine at this time had 19.2% of the population of the Soviet Union.

Belorussia, Moldavia and the Baltic republics maintain their modest share of the Soviet population over the period. The Transcaucasian republics increase their share modestly by 0.3% over the eight years. The largest gains are, however, in the Central Asian republics which expand their share of the USSR population by 1.5%. A shift of population, in relative terms, is therefore taking place within the Soviet Union, to peripheral, non-Russian republics. We shall examine later whether this change can be assigned to differences in natural increase rates among the republics, to net movements of population towards the periphery or to both effects.

Table 3 shows the absolute population increase and Table 4 the relative share of population increase for each republic in the Soviet Union. Once again the size of the RSFSR makes it the most important component in the development of the population. However, Figure 3 shows this information in a somewhat more understandable form, and demonstrates that the share of the increase which belongs to the RSFSR was highest in 1968-69, and lower subsequently, whereas the share of the other republics was lower in 1968-69 and higher thereafter. Once again, however, the problem of scale when dealing with such vastly different sized areas hides some of the changes and thus it is necessary to go to a rather higher level of spatial aggregation. This is done in Figure 4: in this diagram the republics have been aggregated on the basis of spatial proximity and areal coherence. This gives us six republic groups to examine.

Table 1. Populations of the Soviet Republics, 1968-76 (in millions)

Republic group	Republic	Year (January 1st) 1968	1970*	1972	1974	1976
RSFSR	RSFSR	127.911	130.079	131.771	132.913	134.650
Western Republics	Belorussia SSR	8.820	9.002	9.171	9.268	9.371
	Ukrainian SSR	46.381	47.126	48.048	48.521	49.075
	Moldavian SSR	3.484	3.569	3.695	3.764	3.850
	Sub-total	58.685	59.697	60.914	61.553	62.296
Baltic Republics	Estonian SSR	1.304	1.356	1.395	1.418	1.438
	Latvian SSR	2.298	2.364	2.419	2.454	2.497
	Lithuanian SSR	3.064	3.128	3.219	3.262	3.315
	Sub-total	6.666	6.848	7.033	7.134	7.250
Trans-caucasian Republics	Georgian SSR	4.659	4.686	4.813	4.878	4.954
	Armenian SSR	2.306	2.492	2.635	2.728	2.834
	Azerbaydzhan SSR	4.917	5.117	5.375	5.517	5.689
	Sub-total	11.882	12.295	12.823	13.120	13.477
Central Asian Republics	Kazakh SSR	12.678	13.009	13.592	13.928	14.337
	Uzbek SSR	11.266	11.799	12.731	13.289	14.079
	Kirgiz SSR	2.836	2.933	3.110	3.219	3.368
	Tadzhik SSR	2.736	2.900	3.149	3.283	3.486
	Turkmen SSR	2.029	2.159	2.328	2.430	2.581
	Sub-total	31.545	32.799	34.910	36.149	37.851
USSR	Total	236.689	241.720	247.451	250.869	255.524

Notes:

Source: TsSU (annual), Narodnoe khozyaistvo for appropriate year.

* 1970 All Union Census.

Table 2. Relative population shares of the Soviet Republic, 1968-76

(per centages)

Republic group	Republic	Year (January 1st) 1968	1970	1972	1974	1976
RSFSR	RSFSR	54.0	53.8	53.3	53.0	52.7
Western	Belorussian SSR	3.7	3.7	3.7	3.7	3.7
Republics	Ukrainian SSR	19.6	19.5	19.4	19.3	19.2
	Moldavian SSR	1.5	1.5	1.5	1.5	1.5
	Sub-total	24.8	24.7	24.6	24.5	24.4
Baltic	Estonian SSR	0.6	0.6	0.6	0.6	0.6
Republics	Latvian SSR	1.0	1.0	1.0	1.0	1.0
	Lithuanian SSR	1.3	1.3	1.3	1.3	1.3
	Sub-total	2.8	2.8	2.8	2.8	2.8
Trans-	Georgian SSR	2.0	1.9	1.9	1.9	1.9
Caucasian	Armenian SSR	1.0	1.0	1.1	1.1	1.1
Republics	Azerbaydzhan SSR	2.1	2.1	2.2	2.2	2.2
	Sub-total	5.0	5.1	5.2	5.2	5.3
Central	Kazakh SSR	5.4	5.4	5.5	5.6	5.6
Asian	Uzbek SSR	4.8	4.9	5.1	5.3	5.5
Republics	Kirgiz SSR	1.2	1.2	1.3	1.3	1.3
	Tadzhik SSR	1.2	1.2	1.3	1.3	1.4
	Turkmen SSR	0.9	0.9	0.9	1.0	1.0
	Sub-total	13.3	13.6	14.1	14.4	14.8
USSR	Total	100.0	100.0	100.0	100.0	100.0

Source: calculated from Table 1.

Table 3. Population change, 1968-76 (millions)

Republic group	Republic	1968-70	1970-72	1972-74	1974-76
RSFSR	RSFSR	2.168	1.692	1.142	1.737
Western	Belorussian SSR	0.182	0.169	0.097	0.103
Republics	Ukrainian SSR	0.745	0.921	0.473	0.554
	Moldavian SSR	0.085	0.126	0.069	0.086
	Sub-total	1.012	1.216	0.639	0.743
Baltic	Estonian SSR	0.052	0.039	0.023	0.020
Republics	Latvian SSR	0.066	0.055	0.035	0.043
	Lithuanian SSR	0.064	0.091	0.043	0.053
	Sub-total	0.182	0.639	0.101	0.116
Trans-	Georgian SSR	0.027	0.127	0.065	0.076
Caucasian	Armenian SSR	0.186	0.143	0.093	0.106
Republics	Azerbaydzhan SSR	0.200	0.258	0.139	0.175
	Sub-total	0.413	0.528	0.297	0.357
Central	Kazakh SSR	0.331	0.583	0.336	0.409
Asian	Uzbek SSR	0.533	0.932	0.558	0.790
Republics	Kirgiz SSR	0.097	0.177	0.109	0.149
	Tadzhik SSR	0.164	0.249	0.134	0.203
	Turkmen SSR	0.130	0.169	0.102	0.151
	Sub-total	1.255	2.110	1.239	1.702
USSR	Total	5.031	5.731	3.418	4.655

Notes:

1. The population figures are in millions.

2. The periods running from January 1st in year x to January 1st in year x+1.

Source: calculated from Table 1.

Table 4. Shares of population change, 1968-76 (percentages)

Republic group	Republic	1968-69	1970-71	1972-73	1974-75
RSFSR	RSFSR	43.1	29.5	33.4	37.3
Western Republics	Belorussian SSR	3.6	2.9	2.8	2.2
	Ukraininian SSR	14.8	16.1	13.8	11.9
	Moldavian SSR	1.7	2.2	2.0	1.8
	Sub-total	20.1	21.1	18.6	15.9
Baltic Republics	Estonian SSR	1.0	0.7	0.7	0.4
	Latvian SSR	1.3	1.0	1.0	0.9
	Lithuanian SSR	1.3	1.6	1.3	1.1
	Sub-total	3.6	3.3	3.0	2.4
Trans-Caucasian Republics	Georgian SSR	0.5	2.2	1.9	1.6
	Armenian SSR	3.7	2.5	2.7	2.3
	Azerbaydzhan SSR	4.0	4.5	4.1	3.8
	Sub-total	8.2	9.2	8.7	7.7
Central Asian Republics	Kazakh SSR	6.6	10.2	9.8	8.8
	Uzbek SSR	10.6	16.3	16.3	17.0
	Kirgiz SSR	1.9	3.1	3.2	3.2
	Tadzhik SSR	3.3	4.3	3.9	4.4
	Turkmen SSR	2.6	2.9	3.0	3.2
	Sub-total	25.0	36.8	36.2	36.6
USSR	Total	100.0	100.0	100.0	100.0

Source: calculated from Table 3.

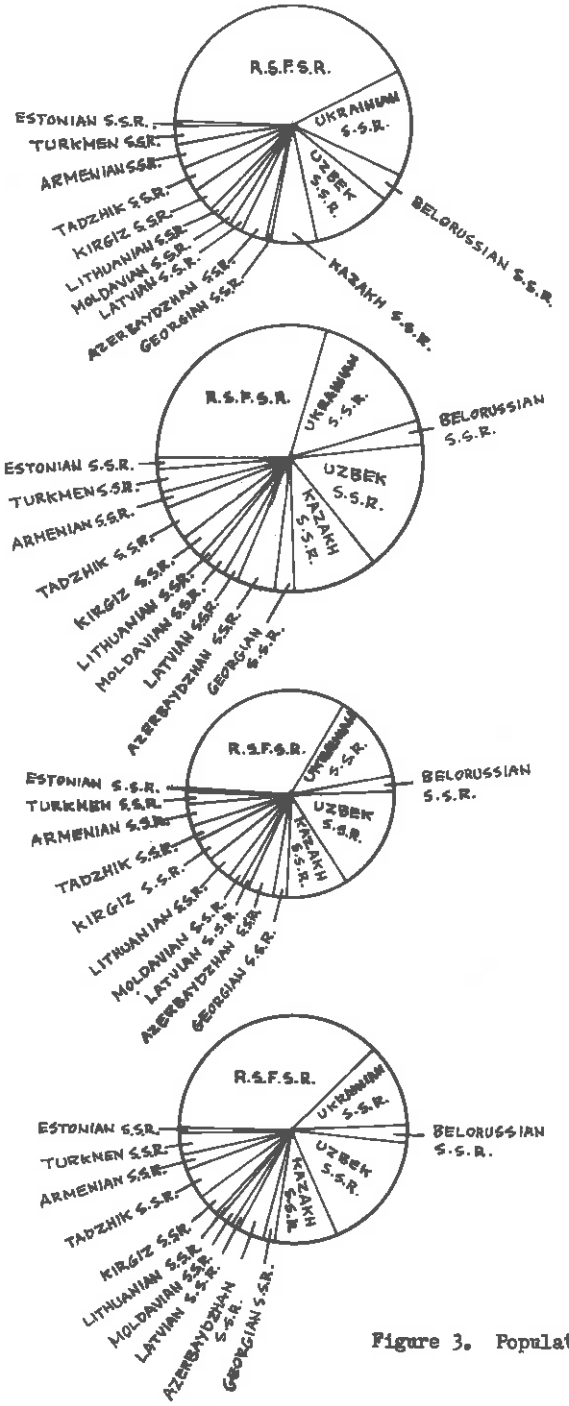
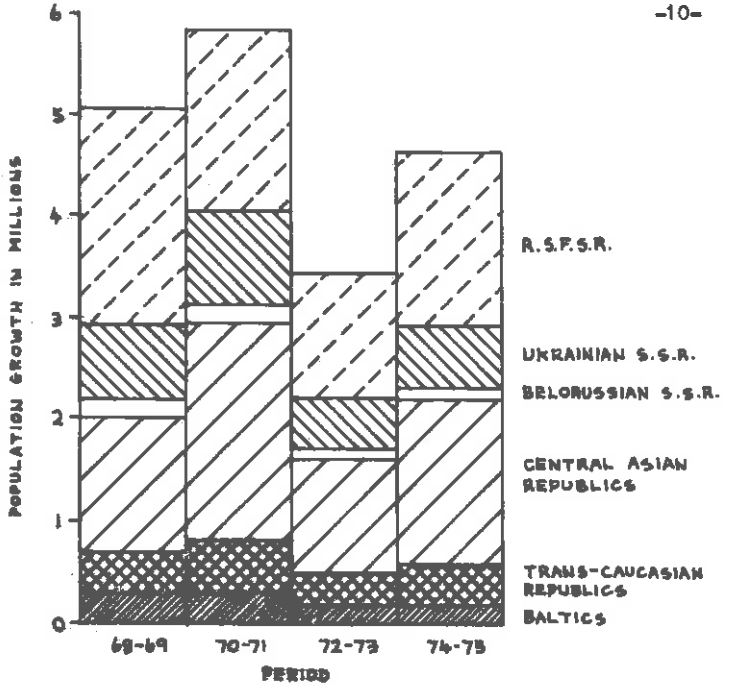


Figure 3. Population increase, 1968-76



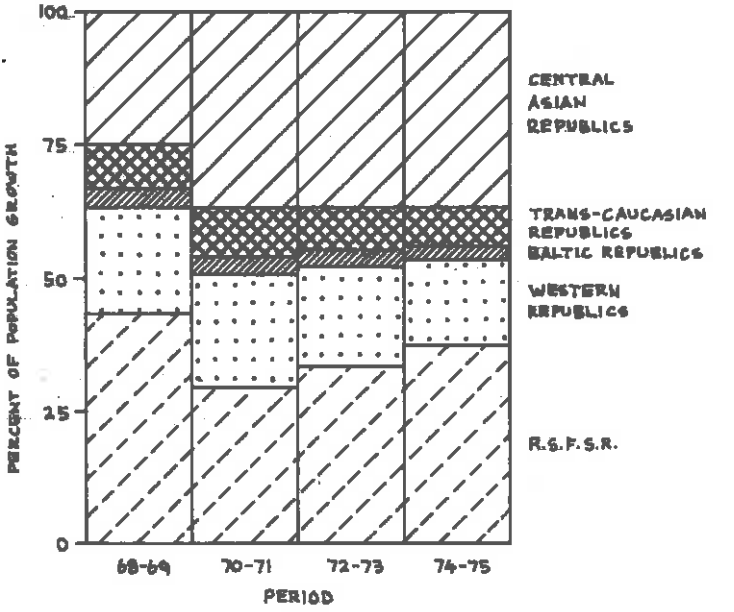


Figure 4. Shares of population growth by republic group

The diagram shows the difference in the absolute change for each of the two year periods. In the period 1970-71 the most absolute growth took place, followed by the 1972-73 period where the least growth took place. This juxtaposition may be a result of reassessment of estimates on the basis of the 1970 Census. These diagrams also show the relative positions of the different groups of Republics, once again in numerical terms the RSFSR is the largest of constituent areas but the proportion of the total which it constitutes appears to be decreasing over the period, although there is a slight recovery in the 1974-75 period.

2.2 Rates of growth

Rates of population change were derived for each republic using the following equation:

$$r^{i}_{(t,t+2)} = 1000(P^{i}_{(t+2)} - P^{i}_{(t)}) \; / \; P^{i}_{(t+1)}$$

where $r^{i}_{(t,t+2)}$ is the rate for region i in the interval of time from time t to time t+2,

and P^{i} is the regional population.

Rates of change for the republics for each two year period, and for the Soviet Union as a whole are shown in Table 5.

The striking feature of this table is that the positions in which the republics might be ranked according to this rate system differs radically to the rank which one would obtain from the absolute values. The RSFSR and the Western republics all fall relatively low down such a ranking scale, whereas the other areas, particularly the Central Asian republics, come near the higher end. Transcaucasia also ranks near the top of the scale, with the exception of Georgia, and even the Baltic republics have higher growth rates than the RSFSR and the Western republics. This indicates that the absolute values of increase previously discussed have been making a quite considerable variation in growth rates, and in these terms, giving the RSFSR a falsely high position. Thus, although in terms of absolute growth the RSFSR and Western republics house a majority of the population growth (just) in the system, in terms of the rates of growth the other republics are more important.

Table 5. Rates of change 1968-76 (per 1000 population per biennium)

Republic	Biennial period			
	1968-70	1970-72	1972-74	1974-76
RSFSR	16.9	12.9	8.6	1.3
Belorussian SSR	20.4	18.6	10.5	11.2
Ukrainian SSR	15.9	19.4	9.8	11.5
Moldavian SSR	24.0	34.8	18.5	23.1
Estonian SSR	39.6	28.3	16.4	14.2
Latvian SSR	28.5	22.9	14.4	17.6
Lithuanian SSR	20.7	28.7	13.3	16.4
Georgian SSR	5.8	26.7	13.4	15.7
Armenian SSR	78.8	56.2	34.9	39.7
Azerbaydzhan SSR	39.7	49.4	25.6	32.3
Kazakh SSR	25.7	44.6	24.5	29.8
Uzbek SSR	45.7	75.7	43.2	61.2
Kirgiz SSR	33.1	59.0	34.6	47.4
Tadzhik SSR	57.9	83.5	42.0	66.4
Turkmen SSR	62.3	76.1	43.2	63.9
USSR	21.0	23.4	13.7	18.7

Notes:

1. These are biennial rather than annual rates.

Source: calculated from Table 1.

The rates derived for each of the two year periods are shown in Table 5. The general distribution across the republics has already been described but is shown more clearly in Figure 5, which compares the rate of each republic to the rate for the USSR as a whole. From this the following points arise.

(1) The growth rates of the three Western republics are consistently below the national average.

(2) The Baltic republics have generally low rates of growth, which approach the national average, Estonia and Latvia tend to be above the average, and the rate for Estonia has markedly fallen off over the period in question. Lithuania tends to be slightly below the national growth rate and to show very little change throughout the period 1968-76.

(3) The Transcaucasian republics are an area of extremely fluctuating growth rates and are difficult to typify in terms of a general hypothesis. Armenia has an extremely high growth rate in the 1968-69 period, but this tends to fall off towards the end of the total period, this high rate of increase is attributed to the largely Moslem heritage of the population, and is generally seen as a result of high natural increase. Azerbaydzhan is in the middle range of the values and remains fairly consistent throughout the period, although this republic shows a tendency for the growth rate to decline towards the end of the period. Georgia, on the other hand, is consistently low in its rate of growth, and is below the national rate for three out of four periods. Thus, Transcaucasia is somewhat anomalous as an aggregate area, since its constituent republics show markedly different patterns of growth.

(4) The republics of Central Asia show consistently high rates of growth, which show little tendency to decline, except in the period 1972-73, when all the growth rates decline, and even then they maintain their relatively high position. In particular, the rate of growth of Uzbekistan seems actually to increase over the period in relation to the other republics. The other republics are fairly consistent in their position, although there is a slight tendency to decrease in absolute increase in relative terms they remain high.

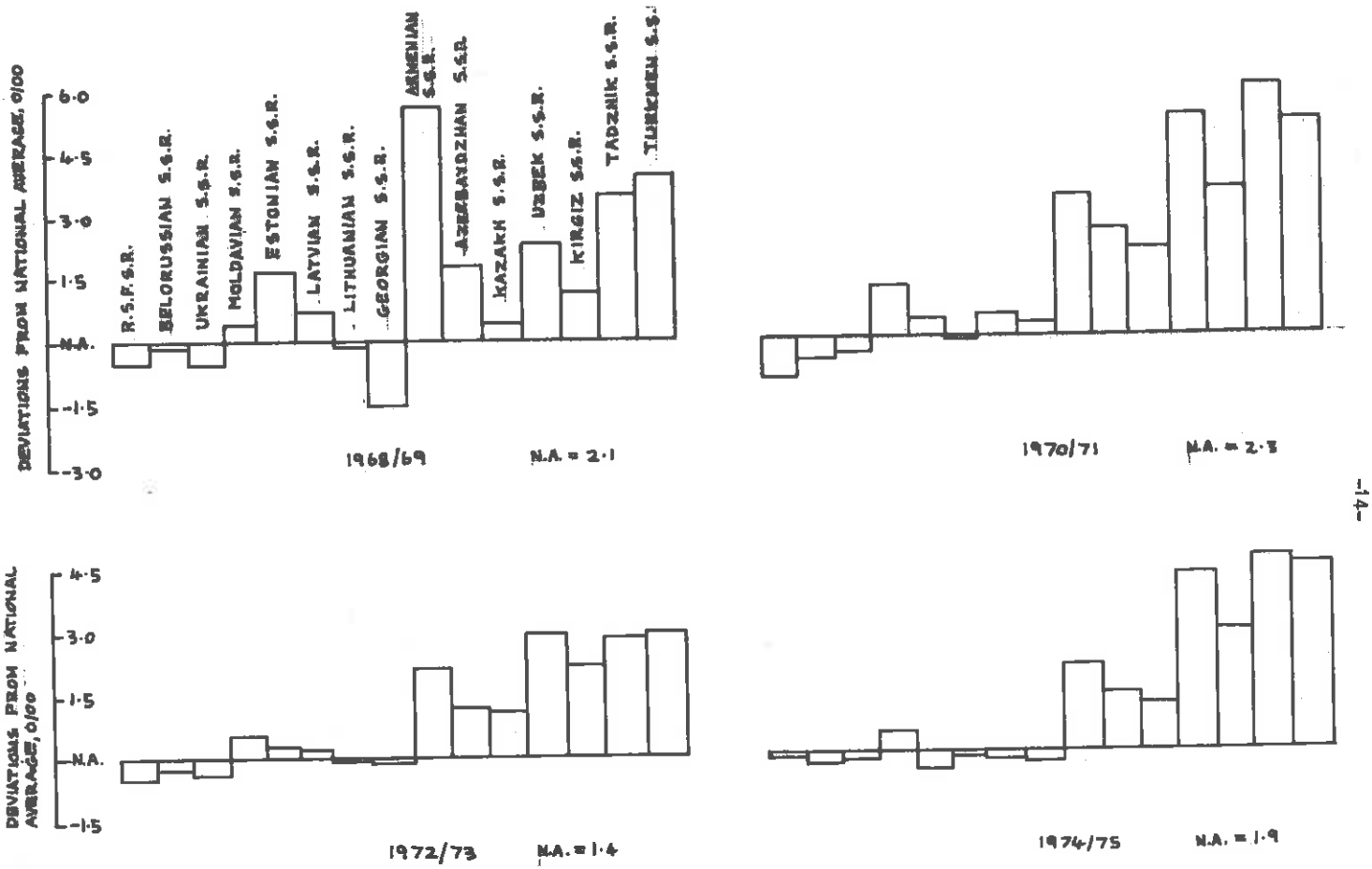


Figure 5. Deviation of republic growth rates from national average, 1968-76

(5) Moldavia is something of an anomaly in that it exhibits consistently high growth rates, but is situated in the western part of the USSR.

(6) The above points are based on the relation between the rates for republics and the national rate of growth; to return to Table 5 for a moment, it is worth making the point at this time that the general trend for this period is somewhat unclear, since it rises over the first two two-year periods, falls markedly in the third, and then recovers in the last period, although not reaching previous levels. However, within this pattern it is possible to discern clear spatial patterns of the growth of population.

The spatial distribution of these rates is shown on Figures 6a-6d, and once again the pattern is distinctive. Discounting the variations in rates with time which were discussed above and concentrating simply on the spatial pattern we are left with the following picture.

(1) A central core of republics with low growth rates, consisting of the RSFSR, the Ukraine, and to a lesser extent Belorussia.

(2) A secondary ring of republics with medium range growth rates, consisting of the Baltic republics, Kazakhstan, Moldavia and in some cases Belorussia.

(3) A final ring of republics with growth rates which are relatively high, consisting of the southern fringe of Transcaucasia and Central Asia.

Although the actual figures vary from time period to period the pattern which the rates generate remains constant. The one republic which falls outside this categorisation is Georgia which exhibits rates lower than one would expect from its spatial location. The general trend of this pattern is for growth rates to increase with distance from some hypothetical centroid in the western RSFSR, a useful test of this would be to do a similar analysis of growth rates for the eastern regions of the RSFSR, but this is outside the scope of the present paper.

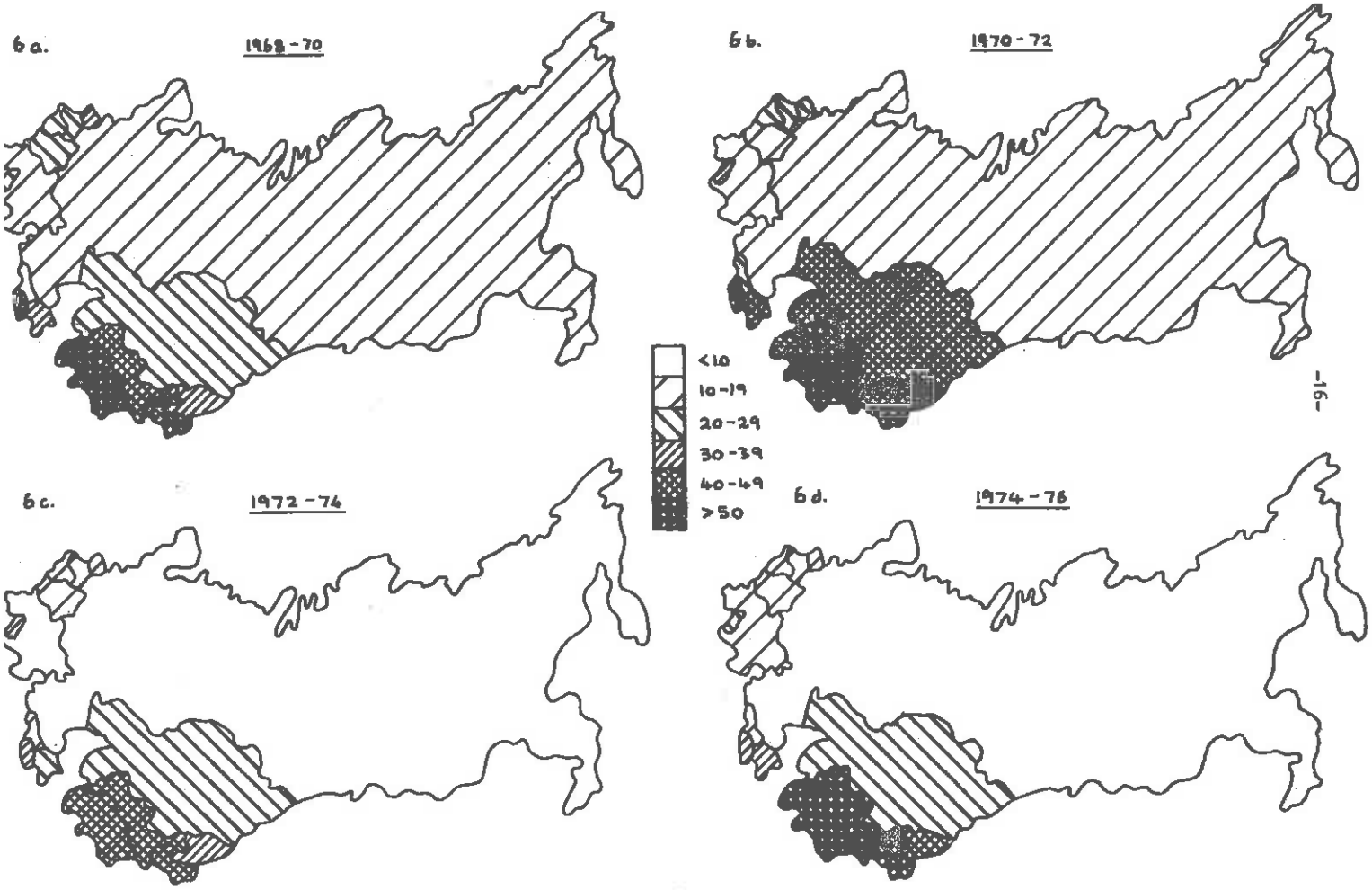


Figure 6. Two year growth rates for the populations of the Soviet republics, 1968-69 to 1974-75

2.3 The components of growth

Thus far in this section of the paper we have discussed only total population change. We now examine the way total change is composed of the two components of natural increase and net migration for the two year period 1968-69. The absolute numbers and rates involved for the 15 republics are set out in Table 6.

Natural increase is defined as the simple difference between the numbers of births in a republic and the number of deaths. The natural increase rate is computed by dividing the natural increase number by the population at risk, which is here defined to be the January 1st 1968 population. The rate is expressed per 1000 population. Natural increase has been positive for all the Soviet republics in the recent past.

Net migration can be defined as either the difference between the total of in-migrants to a republic and the total of out-migrants from a republic or as the difference between total change and natural increase. Thus, net migration can be computed from migrant figures given in the All-Union census or from population, births and deaths figures. We discuss the results of variants of these two methods in the next section. The net migration figures in Table 6 represent our best estimate of net migration using an accounts based compromise between the direct and residual methods. The net migration rate is computed by dividing the net migration figures by the same populations at risk as were used for natural increase. The rates can be negative or positive.

The spatial pattern of natural increase rates are shown in Figure 7. There are two broad groups of republics, those falling below the national average and those above it. Spatially these republics can be grouped together and a general hypothesis might be that republics to the west of the RSFSR have generally low increase rates, whereas those to the south have generally high rates. In the first category fall the Ukraine, Belorussia, the Baltic republics and the RSFSR itself, with Moldavia as the exception to the general trend. In the latter category are the Central Asian and Transcaucasian republics. The implications of this pattern are very interesting. The question which must be asked is are these republics growing at a rate fast enough to overcome the absolute numerical dominance of the Western republics as a whole and the RSFSR in particular.

Table 6. Components of growth, 1968-69

Republic	Components of growth: numbers (1000's)			Components of growth: rates (per 1000 per 2 years)		
	Natural increase	Net migration	Total change	Natural increase	Net migration	Total change
RSFSR	1519.0	312.9	1832.0	11.8 (5.9)	2.4 (1.2)	14.2 (7.1)
Belorussian SSR	159.3	-0.1	159.2	18.0 (9.0)	-0.0 (-0.0)	18.0 (9.0)
Ukrainian SSR	607.5	16.2	623.7	13.0 (6.5)	0.4 (0.2)	13.4 (6.7)
Moldavian SSR	87.1	-11.3	75.7	25.0(12.5)	-3.2 (-1.6)	21.6(10.8)
Estonian SSR	11.0	37.7	48.6	8.4 (4.2)	28.8 (14.4)	37.6(18.6)
Latvian SSR	14.2	45.9	60.1	6.2 (3.1)	20.0 (10.0)	26.0(13.0)
Lithuanian SSR	55.8	0.4	56.2	18.2 (9.1)	0.2 (0.1)	18.2 (9.1)
Georgian SSR	109.7	-94.6	15.1	23.4(11.7)	-20.2(-10.1)	3.2 (1.6)
Armenian SSR	88.7	91.1	179.8	38.4(19.2)	39.4 (19.7)	77.8(38.9)
Azerbaydzhan SSR	240.7	-53.6	187.2	48.8(24.4)	-10.8 (-5.4)	38.0(19.0)
Kazakh SSR	447.0	-149.5	297.5	35.2(17.6)	-11.8 (-5.9)	23.4(11.7)
Uzbek SSR	648.7	-145.0	503.7	57.4(28.7)	-12.8 (-6.4)	44.6(22.3)
Kirgiz SSR	134.4	-45.1	89.3	47.2(23.6)	-15.8 (-7.9)	31.4(15.7)
Tadzhik SSR	168.0	-11.7	156.4	61.2(30.6)	-4.2 (-2.1)	51.0(28.5)
Turkmen SSR	117.8	6.8	124.6	57.8(28.9)	3.4 (1.7)	61.2(30.6)
USSR	4408.9	0.1	4409.2	18.6 (9.3)	0.0 (0.0)	18.6 (9.3)

Source: Constrained accounts described in section 3.7.
The rates are calculated by dividing the components of growth by the initial population. The annual equivalent rates are given in brackets.

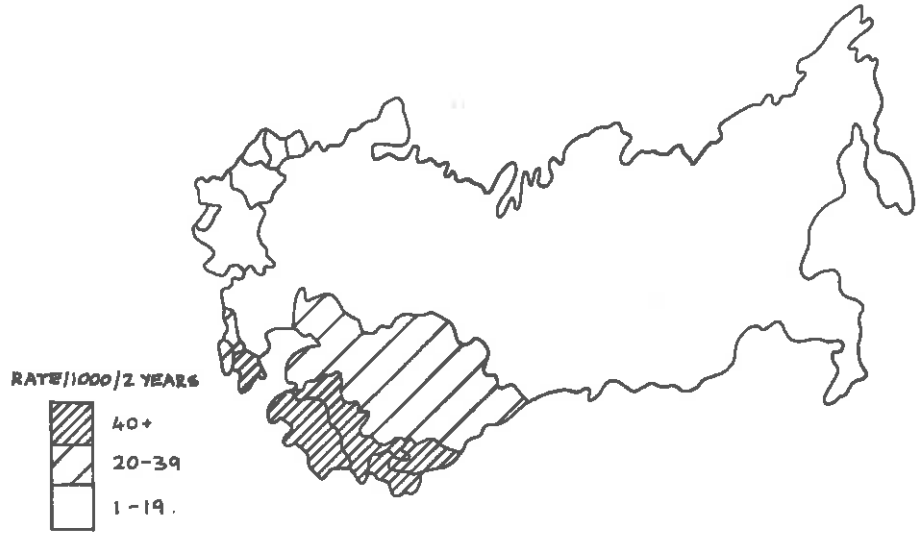


Figure 7. The spatial pattern of natural increase, 1968-69

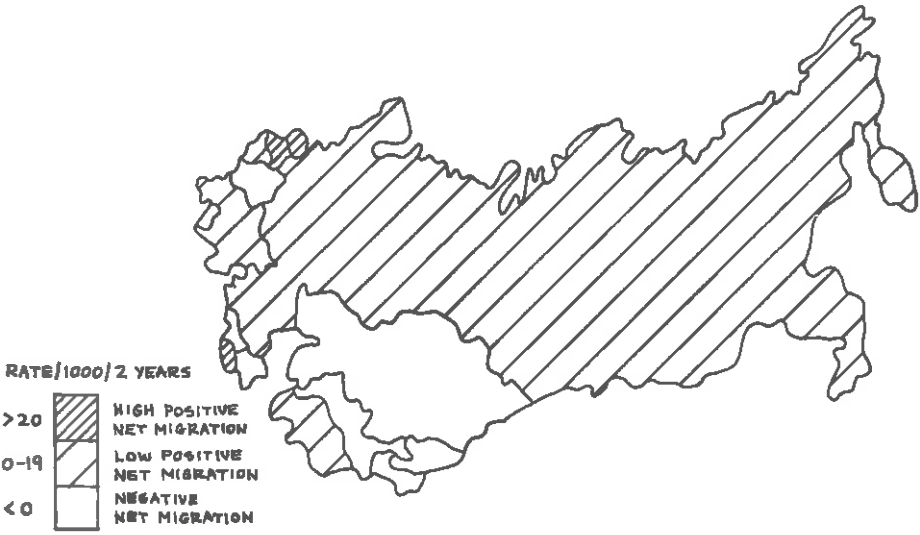


Figure 8. The spatial pattern of net migration, 1968-69

Figure 8 shows the spatial pattern of net migration rates for the republics using the figures given in Table 6. The map indicates that the republics of the Western USSR are experiencing net inflows, whereas the Central Asian and Transcaucasian republics suffer net outflows. As we shall see in the next sub-section of the paper, this pattern differs from the longer term pattern between the 1959 and 1970 censuses. There are, however, exceptions to the general division of the country into two portions. Moldavia and Belorussia are Western republics with net out-migration; Armenia is a Transcaucasian republic which experiences a high net in-migration rate; and Turkmenistan is a Central Asian republic experiencing a low net in-migration rate. Shabad (1977) also comments on the Moldavia anomaly, explaining it as

> "a temporary trend fostered by the recruiting of labour for settlement in the Eastern regions of the USSR."

The Belorussian rate, although negative, is very close to a zero balance. The Armenian and Turkmen rates are rather a puzzle, however. They may be an artefact of our estimation methods, although the direct census method also gives net in-migration for the Armenian SSR.

To obtain an idea of how the two components are related and how the variation of total change is related to the two components, the natural increase rates, the net migration rates and total change rates for the republics are plotted on a series of graphs in Figure 9. The first graph shows natural increase plotted against net migration. Of the 8 divisions in Webb's original classification of the components of change, only three are represented among the Russian republics. Latvia and Estonia stand apart as republics for which the net migration rate (positive) exceeds the natural increase rate. Five republics (RSFSR, Ukraine, Lithuania, Turkmenstan, Armenia) occupy positions in the graph where both natural increase and net migration are positive, and where natural increase exceeds net migration. Three - Lithuania, the Ukraine and the RSFSR - form a tight cluster with natural increase rates between 15 and 20/1000 and net migration rates of just above zero, and Belorussia is very close to this cluster. Armenia occupies an isolated position and Turkmenistan is close to the other Central Asian republics in the positive natural increase-negative but smaller net migration sector of the graph. The Tadzhik, Uzbek, Azerbaydzhani, Kirgiz and Kazakh SSRs fall in this sector of the graph with the Moldavian SSR close to the Western republic cluster and the Georgian SSR experiencing heavy out-migration.

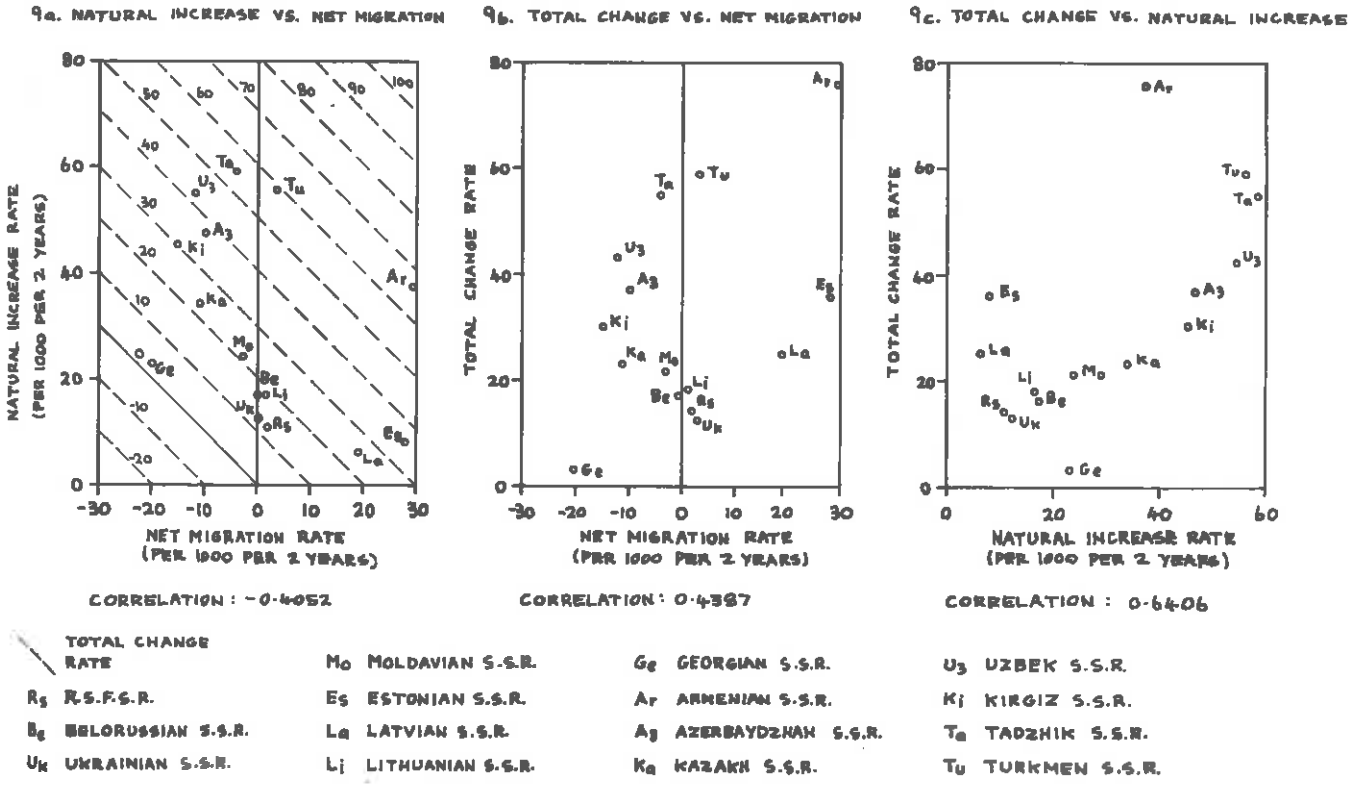


Figure 9. Graphs of natural increase rate, net migration rate and total change rate for Soviet republics, 1968-69

The second and third graphs in Figure 9 show how good each component of growth is as a predictor of the variation in total growth. The simple correlation of net migration with total growth is only 0.44 whereas that of natural increase is 0.64. Natural increase is a good deal more important in explaining the variation in total change rates among the republics than is net migration. This contrasts sharply with the situation in the U.K. where net migration is the dominant component in explaining the pattern of regional growth rates (Rees, 1979).

These two sections give us a picture of the system which we are attempting to model. The path of population change that the system has followed since 1968 has been examined and components of growth for the period which we intend to use as the base for future work have been described. There remain, however, certain inconsistencies in this picture which we discuss in the next section.

2.4 Inconsistencies in published data

Two kinds of inconsistency can be discerned in Soviet demographic statistics on migration. The first kind is the difference between the pattern exhibited over the eleven years between recent Soviet Census, 1959-70, and the pattern exhibited in the two year period prior to the census in 1970. The second kind of inconsistency is between different estimates of net migration in the 1968-70 period: the several estimates differ substantially in degree though not markedly in size. These inconsistencies have been noted by other authors - Grandstaff (1974), Newth (1976) and Shabad (1977) - although the issues have not been stated very clearly.

We can attempt to do this by drawing up a table of the various net migration estimates (Table 7). The first column of figures in Table 7A gives the net migration flows derived as a residual from the following equation:

$$NM^i(1959,1970) = P^i(1970) - P^i(1959) - B^i(1959,1970) + D^i(1959,1970) \quad (1)$$

where $NM^i(1959,1970)$ is the net migration into republic i in the period between the date of the 1959 Census and the date of the 1970 Census in the USSR, $P^i(1970)$ is the population of the republic at the latter date, $P^i(1959)$ is the population at the earlier date and $B^i(1959,1970)$ and $D^i(1959,1970)$ are the births and deaths in the republic in the intervening period.

Table 7. Net migration statistics for Soviet republics, 1959-69, 1959-67, 1968-69 as estimated by various authorities

7A. Figures from the literature (in 1000's)

Republic	1959-69 Residual figures (Shabad)[1] (1)	1968-69 Residual figures (Grandstaff)[2] (2)	1968-69 Census figures (Shabad)[3] (3)	1968-69 Census figures (Grandstaff)[4] (4)
RSFSR	-1,704	-156	176	176.0
Belorussian SSR	-286	1	2	2.5
Ukrainian SSR	462	98	37	36.9
Moldavian SSR	65	-1	-10	-9.5
Estonian SSR	92	24	16	15.6
Latvian SSR	156	26	14	14.3
Lithuanian SSR	50	10	3	2.6
Georgian SSR	-92	-23	-36	-36.4
Armenian SSR	146	34	6	5.6
Azerbaydzhan SSR	-58	-14	-28	-28.4
Kazakh SSR	685	-31	-22	-21.7
Uzbek SSR	360	81	-83	-82.6
Kirgiz SSR	70	21	-15	-14.7
Tadzhik SSR	69	15	-19	-18.5
Turkmen SSR	40	6	-11	-10.8
TOTALS				
Net in-migration sum	2,195	316	254	253.5
Net out-migration sum	2,140	225	224	222.6
Net migration sum	55	91	30	30.9
Absolute value sum	4,335	541	478	476.1

Sources:

1. Shabad (1977), Table 9.6, p.185: "1959-70 figures are the author's estimates" (based on 1959 and 1970 Census populations and intervening birth and death figures).
2. Grandstaff (1977), Table 2, p.37, quoting Newth (1972), p.206.
3. Shabad (1977), Table 9.6, p.185: "1968-69 data from Volume 7 of the 1970 Census".
4. Grandstaff (1977), Table 1, p.34: "Vestnik statistiki, 1973:2, p.86".

Table 7B. The census figures re-worked

Republic	Total internal in-migration (1)	Total internal out-migration (2)	Net internal migration (3)	Immigrants (4)	"Balance" (5)
RSFSR	1168166	1005121	163045	12924	175969
Belorussian SSR	134479	133545	934	1511	2445
Ukrainian SSR	583207	552953	30254	6715	36969
Moldavian SSR	49870	59988	-10118	605	-9513
Estonian SSR	35159	19687	15472	128	15600
Latvian SSR	44933	31047	13886	331	14217
Lithuanian SSR	27547	25132	2415	138	2553
Georgian SSR	21030	57766	-36736	413	-36323
Armenian SSR	20676	20692	-16	5646	5630
Azerbaydzhan SSR	26618	55545	-28927	432	-28495
Kazakh SSR	421907	444474	-22567	845	-21722
Uzbek SSR	120230	203437	-83207	554	-82653
Kirgiz SSR	72265	87169	-14904	278	-14626
Tadzhik SSR	36859	55473	-18614	104	-18510
Turkmen SSR	30887	41804	-10917	82	-10835
Total	2793833	2793833	0	30706	30706

Source: TsSU (1972), Table 1, Soviet Census 1970, Volume 7, p.7.

Table 7C. Net migration statistics from the different accounts, 1968-69

Republic	Unconstrained accounts (1)	Constrained accounts (2)	Backcast unconstrained (3)	Backcast constrained (4)
RSFSR	176080	312926	176016	445780
Belorussian SSR	865	-122	863	2902
Ukrainian SSR	32378	16169	32364	42751
Moldavian SSR	-10614	-11340	-10611	-9821
Estonian SSR	16009	37665	16004	16307
Latvian SSR	14424	45876	14422	14947
Lithuanian SSR	2430	407	2430	3122
Georgian SSR	-37761	-94628	-37770	-36701
Armenian SSR	-118	91111	-99	405
Azerbaydzhan SSR	-30440	-53586	-30444	-29318
Kazakh SSR	-26335	-149501	-26241	-264418
Uzbek SSR	-88724	-145012	-88743	-139515
Kirgiz SSR	-16259	-45100	-16283	-14571
Tadzhik SSR	-20064	-11650	-20051	-20466
Turkmen SSR	-11871	6785	-11857	-11404
Net in-migration sum	242186	510939	242099	526214
Net out-migration sum	242186	510939	242099	526214
Net migration sum	0	0	0	0
Absolute value sum	484372	1021878	484198	1052428

Source: the analyses described in section 3 of this paper.

The same method is used with 1968 estimates and 1970 Census populations to generate the net migration flows over the 1968-69 period. These are given in column (2). If we subtract the column (2) figures from the column (1) figures we obtain the net migration movements for the period 1959-68. The contrast between the two periods is pronounced, as earlier observers have noted. The negative flows for the RSFSR and Belorussia SSR in the 1959-68 period become positive flows in the 1968-70 period. The earlier positive flows into the Moldavian SSR, Azerbaydzhani SSR, Kazakh SSR, Uzbek SSR, Kirgiz SSR and Tadzhik SSR become negative flows in the latter period. The flows for the Ukraine, the Baltic republics, Armenia and Turkemnia remain positive in both periods; those for the Georgian SSR remain negative.

Clearly, there has been a massive shift in the pattern of net flows between the early and middle sixties on the one hand and the late sixties on the other. Tentatively, the following explanation might be offered. The earlier period saw the completion of the russification and industrialization drive in the Transcaucasian and Central Asian republics, accomplished through a migration of Great Russians to those areas. Once those republics had been fully integrated into the Soviet system the pattern changed to one of flows from labour surplus to labour deficit areas. Because of the differences in natural increase between the republics that we have already noted this new pattern is likely to persist for some time to come.

The second kind of inconsistency concerning the net migration figures for 1968-69 earns such a label more properly. Firstly, an analysis of the census migration table for inter-republic flows in Table 7B reveals that the "balance" flows (or the column totals less the row totals of the table) are not total net migration figures but rather the sum of "net internal migration" plus "immigrants" from abroad. Emigration flows are unavailable.

The various estimates of net migration in Table 7C, which derive from the population accounts described later in the paper, are predicated on the assumptions that the net external migration balance is zero and that the external migration flows can be ignored. Rather different estimates of net migration result from applying in columns (2) and (4) or from not

applying in columns (1) and (3) population constraints at both ends of the 1968-69 period to the accounts. The unconstrained net migration estimates are fairly close to the net internal migration figures (column 3 of Table 7B) but the constrained figures show some substantial differences.

Although none of the 1968-69 estimates can be regarded as wholly satisfactory the Table 7C, column (3) figures are selected as the most probable: they employ the census migration figures as input to the accounts and adjust the 1968 populations to be consistent with the census populations.

In section 3 of the paper we outline the methods used to derive the population accounts and to select the "best fitting" set.

3. The construction of a set of multi-republic population accounts

3.1 Introduction

The previous section has been concerned with a brief description of the gross changes in population stocks in the republics of the Soviet Union since 1968 in order to set the scene for the more detailed analysis that follows. This analysis is an attempt to develop a set of population accounts, for the same regions, which are consistent with these gross shifts but which go into considerably more detail about the interactive nature of the system. In all cases the accounts are kept consistent with the broad constraints imposed in section 2, and in some cases this necessitates an adjustment to the figures which are input to the model. The second part of this section of the paper consists of the theoretical framework within which this work has been set. The theory of population accounting is briefly described and facets of the accounting model not previously described are outlined. The sections that follow consist of a presentation of the accounts which have been derived from the model, the ideas which underlie their construction and an analysis of their accuracy. These accounts are analysed and a "best-fit" series developed which are most consistent with the observed changes in official Soviet population estimates from 1970 to 1976. These "best-fit" accounts are then used as the basis for a projection series for the USSR by republic which will be presented in the Part 2 of this paper.

3.2 Population accounting theory

3.2.1 History

Population accounts were initially developed by Richard Stone in order to analyse the demographic dynamics of the national education system (Stone, 1971). The accounts were later generalized to multi-regional systems by Rees and Wilson (1973, 1975) and Wilson and Rees (1974). The principles governing the construction of accounts and the models used to fill out accounts matrices are systematically set out in Rees and Wilson (1977) and Illingworth (1976). Here we summarize the essential features of population accounting theory.

The accounts that are constructed are for the aggregate or all age and sex population. The requisite data are available only on this

basis for all the input components in published Soviet materials*. The computer program used to estimate the account tables is described in Jenkins and Rees (1977).

3.2.2 Definitions

A population accounts matrix is a two dimensional array whose elements show the population flows between origin lifestates and regions on the one hand and destination lifestates and regions on the other. An accounts table consists of an accounts matrix with row and column totals added. An accounts based model is a model that estimates the accounts matrix from information on some of its terms and from some of its row and column totals.

The notation for aggregate accounts is very simple. The letter K is used to indicate a population flow or stock, and $\underline{K}$ is a matrix of such terms. To the variable are attached various superscripts indicating origin and destination states. Origin lifestates are generally designated by an α, and are of two kinds, ε indicating existence at the start of a time interval, or β, indicating birth during a time interval. Destination lifestates are generally designated ω and are also of two kinds, σ indicating survival at the end of a time interval, or δ indicating death at some time during the time interval. Attached (in parentheses) to each lifestate superscript is a regional label, either i for initial region or j for final region. There are N regions, divided into two sets, I and O, referring to regions inside the system of interest or outside the system of interest. Normally the set of regions will include at least one region, a rest of the world region, in set O, unless it can be reasonably assumed that external flows are so negligible that they can safely be ignored. This is an assumption we make in the case of the Soviet Union. Time is designated by the points in time to which stocks refer, t for the start of a time period, t+T for the end where T is length of the time interval in years. For population flows two time labels are used to indicate the span of time over which the movements occur. Time labels are generally omitted when they are implicitly clear from the variable context.

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* The intention of the first author, D. Thomas, was to visit the USSR to investigate the availability of age-sex disaggregated data, but permission to spend some time in the Soviet Union came too late to be taken up.

The accounts matrix, $\underline{K}$, consists of four submatrices,

$$\underline{K} = \begin{bmatrix} \underline{K}_{ES} & \underline{K}_{ED} \\ \underline{K}_{BS} & \underline{K}_{BD} \end{bmatrix} \qquad (2)$$

where E refers to existence, S to survival, D to death and B to birth. The typical elements of the submatrices making up the accounts are:

$$\underline{K} = \begin{bmatrix} K^{\varepsilon(i)\sigma(j)} & K^{\varepsilon(i)\delta(j)} \\ K^{\beta(i)\sigma(j)} & K^{\beta(i)\delta(j)} \end{bmatrix} \qquad (3)$$

where $K^{\varepsilon(i)\sigma(j)}$ are persons in existence in region i at the start of a period who survive in region j at the end of the time interval, where $K^{\varepsilon(i)\delta(j)}$ are persons alive in region i at the start of a period who subsequently die in region j, where $K^{\beta(i)\sigma(j)}$ are the infants born in region i who survive in region j at the end of the period, and where $K^{\beta(i)\delta(j)}$ are infants born in region i who subseuqnetly die in the time interval in region j. When j does not equal i the terms are those of migrants, whereas when j equals i the terms refer to stayers.

3.2.3 Accounts tables

Figure 10 sets out an accounts table in general form for the Russian republics. Thus, in Figure 10 the variable $K^{\varepsilon(2)\sigma(15)}$ refers to surviving migrants from Belorussia to Turkmenistan, for example. The row and column totals are indicated by asterisks in the position of the superscript that has been summed. For example, the initial population stocks are designated as

$$K^{\varepsilon(i)*(*)} = \sum_{\omega}\sum_{j} K^{\varepsilon(i)\omega(j)}$$

$$= \sum_{j} K^{\varepsilon(i)\sigma(j)} + \sum_{j} K^{\varepsilon(i)\delta(j)} \qquad (4)$$

Figure 11 indicates the elements in the accounts table that are available from census or vital registration sources. Initial population stocks for January 1st 1968 derive from the Soviet population estimate series

Figure 10. An accounts table for the Soviet republics, 1968-70 displaying the algebraic variables

Origin states \ Destination states		Survival, Jan. 1, 1970				Death 1968, 1969				Totals
		1. RSFSR	2. Belorussian SSR	...	15. Turkmen SSR	1. RSFSR	2. Belorussian SSR	...	15. Turkmen SSR	
Existence, Jan. 1, 1968	1. RSFSR	$K^{\varepsilon(1)\sigma(1)}$	$K^{\varepsilon(1)\sigma(2)}$	...	$K^{\varepsilon(1)\sigma(15)}$	$K^{\varepsilon(1)\delta(1)}$	$K^{\varepsilon(1)\delta(2)}$	...	$K^{\varepsilon(1)\delta(15)}$	$K^{\varepsilon(1)*(*)}$
	2. Belorussian SSR	$K^{\varepsilon(2)\sigma(1)}$	$K^{\varepsilon(2)\sigma(2)}$	...	$K^{\varepsilon(2)\sigma(15)}$	$K^{\varepsilon(2)\delta(1)}$	$K^{\varepsilon(2)\delta(2)}$	...	$K^{\varepsilon(2)\delta(15)}$	$K^{\varepsilon(2)*(*)}$
	⋮	⋮	⋮		⋮	⋮	⋮		⋮	⋮
	15. Turkmen SSR	$K^{\varepsilon(15)\sigma(1)}$	$K^{\varepsilon(15)\sigma(2)}$	...	$K^{\varepsilon(15)\sigma(15)}$	$K^{\varepsilon(15)\delta(1)}$	$K^{\varepsilon(15)\delta(2)}$	...	$K^{\varepsilon(15)\delta(15)}$	$K^{\varepsilon(15)*(*)}$
Birth 1968, 1969	1. RSFSR	$K^{\beta(1)\sigma(1)}$	$K^{\beta(1)\sigma(2)}$	...	$K^{\beta(1)\sigma(15)}$	$K^{\beta(1)\delta(1)}$	$K^{\beta(1)\delta(2)}$	...	$K^{\beta(1)\delta(15)}$	$K^{\beta(1)*(*)}$
	2. Belorussian SSR	$K^{\beta(2)\sigma(1)}$	$K^{\beta(2)\sigma(2)}$	...	$K^{\beta(2)\sigma(15)}$	$K^{\beta(2)\sigma(1)}$	$K^{\beta(2)\sigma(2)}$	...	$K^{\beta(2)\sigma(15)}$	$K^{\beta(2)*(*)}$
	⋮	⋮	⋮		⋮	⋮	⋮		⋮	⋮
	15. Turkmen SSR	$K^{\beta(15)\sigma(1)}$	$K^{\beta(15)\sigma(2)}$	...	$K^{\beta(15)\sigma(15)}$	$K^{\beta(15)\delta(1)}$	$K^{\beta(15)\delta(2)}$	...	$K^{\beta(15)\delta(15)}$	$K^{\beta(15)*(*)}$
Totals		$K^{*(*)\sigma(1)}$	$K^{*(*)\sigma(2)}$	...	$K^{*(*)\sigma(15)}$	$K^{*(*)\delta(1)}$	$K^{*(*)\delta(2)}$	...	$K^{*(*)\delta(15)}$	$K^{*(*)*(*)}$

(TsSU, 1968, 69, 70, 71, 72, 73, 74, 75), surviving inter-republic migrants from census migration tables (TsSU, 1972), births and deaths totals for republics from vital statistics tables (TsSU, 1968, 69, 70, 71, 72, 73, 74, 75). Infant migrants are estimated by applying half the non-infant migration rate to the republican birth totals.

3.2.4 An accounts based model

A model, known as the accounts based model, uses the known data described above to estimate the missing items in the accounts matrix (left unshaded in Figure 11). This is described in full in Rees and Wilson (1977, Part 2). It will be sufficient for present purposes to regard it as a black box which produces a first estimate, $\hat{\underline{K}}_{(1)}$, of the multi-republic accounts matrix.

3.2.5 Adjustment of the accounts matrix

There is some information in Figure 11 which the accounts based model ignores, namely, the final populations of the republics. This additional information can be employed to adjust the initially estimated accounts matrix. A simple two balancing factor is used.

The adjusted estimates are derived as follows:

$$\hat{K}^{\alpha(i)\omega(j)}_{(2)} = A^{\alpha(i)} B^{\omega(j)} \hat{K}^{\alpha(i)\omega(i)}_{(1)} \qquad (5)$$

where $A^{\alpha(i)}$ and $B^{\omega(j)}$ are factors that ensure that the estimates add up to the $\alpha(i)$ row totals and $\omega(j)$ column totals respectively:

$$\sum_{\omega,j} \hat{K}^{\alpha(i)\omega(j)}_{(2)} = R^{\alpha(i)} \qquad (6)$$

$$\sum_{\alpha,i} \hat{K}^{\alpha(i)\omega(j)}_{(2)} = C^{\omega(j)} \qquad (7)$$

where $R^{\alpha(i)}$ is the constraint total adopted for the $\alpha(i)$ row and $\omega(j)$ is the constraint total adopted for the $\omega(j)$ row. Substituting the right-hand side of equation (5) in the left-hand sides of equations (6) and (7), and rearranging we obtain

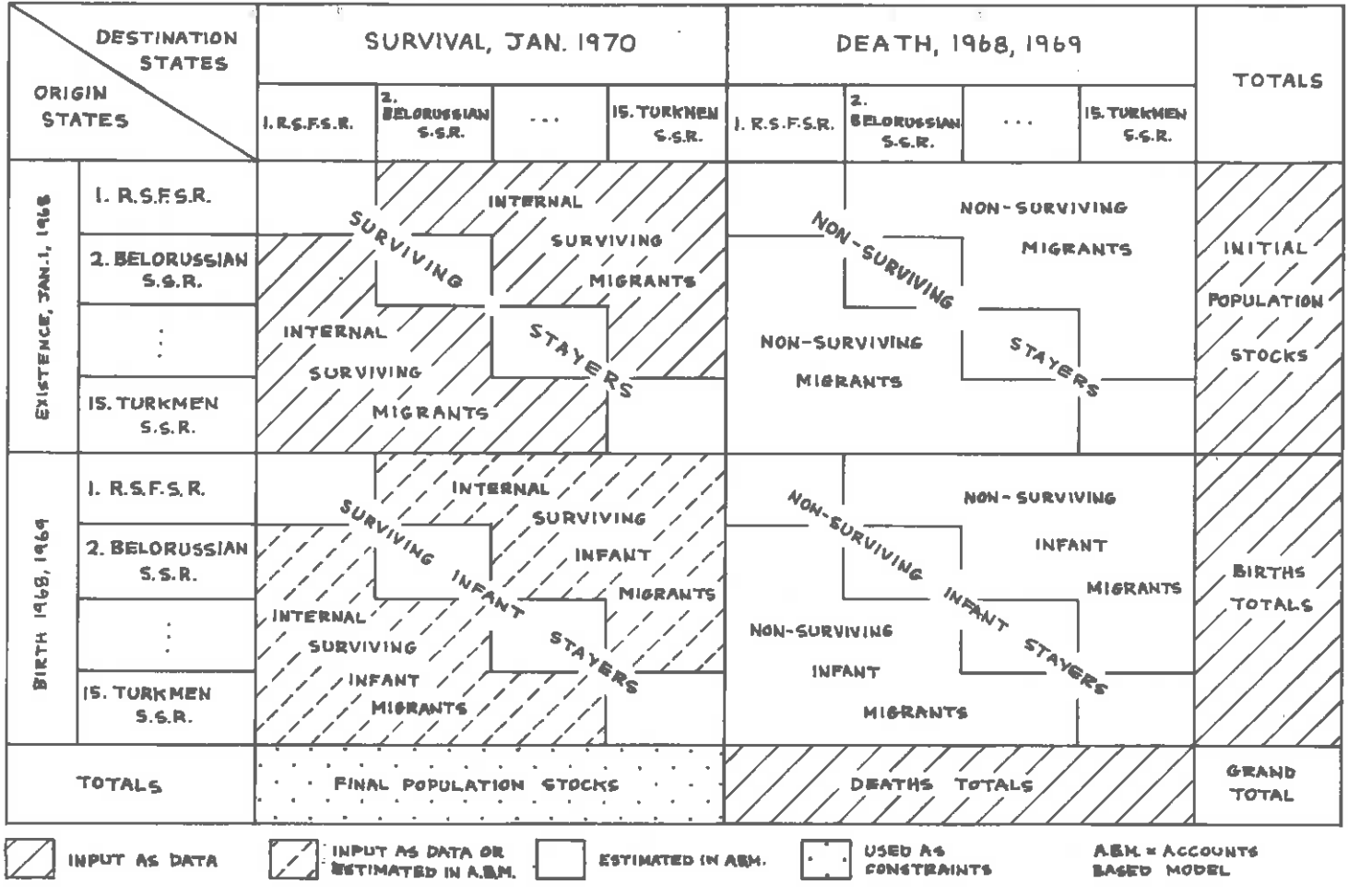


Figure 11. A classification of the elements of an accounts table for the Soviet republics

$$A^{\alpha(i)} = R^{\alpha(i)} / \sum_{\omega,j} B^{\omega(j)} \hat{K}^{\alpha(i)\omega(j)}_{(1)} \qquad (8)$$

$$B^{\omega(j)} = C^{\omega(j)} / \sum_{\alpha,i} A^{\alpha(i)} \hat{K}^{\alpha(i)\omega(j)}_{(1)} \qquad (9)$$

These equations are solved iteratively (see Wilson, 1974; Willekens, 1977), and ensure that the accounts matrix is adjusted to all the known population stocks, birth and death totals.

In order to solve equations set out above one condition must be met:

$$\sum_{\alpha,i} R^{\alpha(i)} = \sum_{\omega,j} C^{\omega(j)} \qquad (10)$$

that is, the sum of the row totals must equal the sum of the column totals. Frequently, this is not the case and

$$\sum_{\alpha,i} R^{\alpha(i)} = \sum_{\omega,j} C^{\omega(j)} + E \qquad (11)$$

where E is the error. Assignment of the error to the row and column totals is a matter of judgment based on knowledge of the reliability of the various statistical sources. In the USSR republics' case most suspicion falls on the January 1st 1968 population estimates. Errors in these estimates will have cumulated over the nine years from the 1959 Census and are likely to be high.

3.2.6 "Backcast" accounts

The accounting procedures so far described begin with accounts that use the initial population stocks as data. We could equally well begin, instead, by using the final population stocks as known information because of our suspicions about the January 1st 1968 estimates. After generating the initial accounts using the normal accounts based model, the difference between the model derived final populations and the observed, census based populations is subtracted from or added to the initial populations. These new January 1st 1968 population estimates are then used as input to the normal model. The backcast accounts can be constrained in the same fashion as the normal accounts.

Many of the concepts outlined above may be unfamiliar to many readers, but we hope they will become clearer as we describe their implementation for the 15 USSR republics.

3.2.7 Projection using the accounts

The accounts based model can be used in either historical mode as described above or in projection mode in which projected birth rates, death rates and migration rates take the place of the births, deaths and migrants figures.

3.2.8 An operational computer program

All these accounting techniques have been operationalized in a computer program (Jenkins and Rees, 1977) which we employ extensively in constructing the Soviet republic accounts.

3.3 Data from the 1970 All Union Census and other sources

3.3.1 Accounting periods

Accounts were constructed for the four, two-year periods:

(i) 1968–69 stretching from January 1st 1968 to January 1st 1970 (the two years prior to the 1970 Census);
(ii) 1970–71 stretching from January 1st 1970 to January 1st 1972;
(iii) 1972–73 stretching from January 1st 1972 to January 1st 1974;
(iv) 1974–75 stretching from January 1st 1974 to January 1st 1976.

The data input to our calculations are as follows.

3.3.2 Population data

Population estimates for the republics were extracted from the Narodnoe Khozyaistvo series for the dates listed above to be used as initial or final populations as appropriate with the exception of the January 1st 1970 populations which came from the 1970 All Union Census. The reliability of the population estimates decline steadily with the elapse of time from the date of the previous census. Thus, the 1970 stocks are the most reliable followed by the 1972, 1974, 1976 and 1968 stocks in that order.

3.3.3 Births and deaths data

Births and deaths data (Tables 8 and 9) were derived by multiplying the birth and death rates for the republics for each calendar year 1968 through 1975 in the Narodnoe Khozyaistvo series (TsSU, annual) by the

Table 8. Births data, 1968-76, for the Soviet republics (1000s)

Republic	Two year period			
	1968-69	1970-71	1972-73	1974-75
RSFSR	3,657	3,888	4,023	4,161
Belorussian SSR	288	296	293	293
Ukrainian SSR	1,384	1,456	1,468	1,468
Moldavian SSR	138	143	153	157
Estonian SSR	40	44	43	43
Latvian SSR	65	70	69	69
Lithuanian SSR	109	112	107	103
Georgian SSR	177	181	175	179
Armenian SSR	114	115	120	124
Azerbaydzhan SSR	310	299	278	281
Kazakh SSR	601	626	643	674
Uzbek SSR	786	834	870	939
Kirgiz SSR	177	188	193	200
Tadzhik SSR	203	216	228	248
Turkmen SSR	147	156	162	172
USSR	8,195	8,626	8,826	9,112

Notes:

1. Computed from annual birth rates given in TsSU (annual) and official population estimates
2. Births are given to nearest 1000 in the table. Estimated births to the nearest unit were used in the analyses.
3. The column totals will differ slightly from the USSR figure given because of rounding error.

Table 9. Deaths data, 1968-76, for the Soviet republics (1000s)

Republics	Two year period			
	1968-69	1970-71	1972-73	1974-75
RSFSR	2,137	2,278	2,409	2,582
Belorussian SSR	129	137	146	156
Ukrainian SSR	776	847	893	956
Moldavian SSR	50	55	59	69
Estonian SSR	25	30	31	33
Latvian SSR	51	53	56	59
Lithuanian SSR	53	55	59	61
Georgian SSR	68	70	73	77
Armenian SSR	25	26	28	30
Azerbaydzhan SSR	69	69	71	77
Kazakh SSR	154	160	176	196
Uzbek SSR	137	134	163	192
Kirgiz SSR	42	44	47	52
Tadzhik SSR	35	37	43	53
Turkmen SSR	29	30	34	38
USSR	3,786	4,024	4,287	4,632

Notes:

1. Computed from annual birth rates given in TsSU (annual) and official population estimates.
2. Deaths figures are given to the nearest 1000s in the table. Estimated deaths to the nearest unit were used in the analyses.
3. The column totals will differ slightly from the USSR figure given because of rounding error.

average of the year start and year end population estimates. The figures were aggregated to the two year periods noted above, and, for some purposes, reconverted to two year rates by dividing by the average on initial and final populations.

3.3.4 Migration data

Inter-republic migration data are available only for the 1968-69 period from the 1970 All Union Census (TsSU, 1972). Table 10, which gives these data, is similar to the table given in the Census, except that the diagonal element in the census table is omitted as it refers to persons relocating their residence but only within their origin republic, and the order of the republics has been altered.

The migration data derives from a 25% sample of the enumeration forms but has been inflated to constitute an estimate of the flows in the whole population when it appears in the census table. The introduction to the 1970 All Union Census, Vol. VII (TsSU, 1972), states

> "Data about migration and families was obtained on the basis of the materials of a 25% sample and extended to the whole population."

It is puzzling, however, that the figures in the table are not, therefore, multiples of four. The alternative interpretation - that the Table 10 figures refer to the sample numbers only and need to be multiplied by four - yields unreasonably high migration figures, higher than those for the U.K., for example, after correction from a two year to a one year period basis. Shabad (1977) appears to concur with this interpretation of the data.

These data relate to changes of residence in the two years preceding the 1970 Census, and control the length of the accounts period, since they are the only up-to-date data available at the present time. Table 10 represents the "exist-survive migration matrix" for the republics of the Soviet Union, that is to say the off-diagonal elements of the top left and quadrant of the accounts matrix, $\underline{K}_{SS}$.

3.4 The accounts building strategy

These then are the inputs of the accounts based model. At this point it is useful to slightly redefine the objects of the accounts-building process in terms of the available data. Given that we have data for initial and final populations, births and deaths, for all the

Table 10. Inter-republic migration flows, 1968-69

LOCATION JANUARY 1ST, 1968 \ DESTINATION — LOCATION JANUARY 1ST, 1970															
ORIGIN	Rs	Be	Uk	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu
RSFSR	—	79491	419660	23127	21141	22387	14177	11461	5108	13335	262200	64218	36264	18331	14221
Belorussian SSR	85005	—	22260	996	1404	6638	3914	703	151	553	9539	1170	316	381	465
Ukrainian SSR	427730	23699	—	18253	4408	6267	3609	3468	1227	2357	47700	7036	2049	1866	3234
Moldavian SSR	30036	861	18090	—	212	808	380	463	141	179	7623	284	175	101	635
Estonian SSR	13404	707	2766	128	—	1052	458	57	100	81	646	160	72	100	12
Latvian SSR	19179	2527	3474	216	1138	—	2567	132	56	155	1049	329	100	55	70
Lithuanian SSR	15392	1846	2261	124	345	3237	—	71	16	73	1321	275	71	60	40
Georgian SSR	33773	669	8356	313	260	358	165	—	5900	2944	3444	972	250	136	226
Armenian SSR	10323	264	2022	96	64	92	36	1074	—	4066	1434	712	180	158	231
Azerbaydzhan SSR	31697	1018	6656	331	224	368	124	1549	6494	—	4490	1287	100	205	1002
Kazakh SSR	298336	18700	65711	4637	2521	2455	1581	1097	598	1397	—	19925	21263	3511	2712
Uzbek SSR	108337	2678	18419	680	1170	613	292	555	540	723	44334	—	8999	9884	6213
Kirgiz SSR	43607	619	5194	172	845	282	80	92	44	344	24208	9399	—	1497	786
Tadzhik SSR	29600	545	4706	490	1395	181	88	80	92	113	6012	9355	1776	—	1040
Turkmen SSR	21717	855	3632	307	32	145	76	228	215	358	7907	5108	650	574	—

Source: TsSU (1972), 1970 All Union Census, Volume 7, Table 1.

two-year periods up to 1976, we need to make estimates of the appropriate migrant flows. The only data we have is for the 1968-69 period. For the subsequent periods we use these migration rates as the best approximation to those for the 1970-71, 1972-73 and 1974-75 periods. So our first task is to determine a set of migration rates which will give us a set of accounts in the projection mode of the model which are consistent with the observed final populations for each of the periods in question. To do this we have made four sets of runs using the 1968-69 data and vital rates up to 1976 (see Figure 12). We then tested the results of the model runs for each of the following two-years periods against the observed populations of the republics in a variety of ways. This testing methodology is described in section 3.9.

The set of accounts which generates the best results in the projection mode is taken as being the "best-fit" run, and the migration rates derived from it are used in developing a set of accounts for the period 1970-71, 1972-73 and 1974-75. The migration flows thus derived will show the pattern which is most consistent with the published Soviet population stock statistics. We will then use the accounts of the last period (1974-75) to generate our population projection.

Throughout this process we assume that the most accurate data are those from the 1970 Census. If any adjustment to data is necessary to make an accounts series consistent with the population stock series this adjustment will take place on estimate data and not on the Census data. We further take the view that any serious discrepancy in the inputs is more likely to be in the stock data than in the rate data. In assuming the rate data to be more likely to be accurate we follow the reasoning of Grandstaff (1974), but differ in the fact that we will accept the migration data from the Census as being substantially correct. Thus, our adjustments to the constraints for the accounts for the 1968-69 period will involve exclusively the initial populations for the republics in 1968. These adjustments occur in the constrained runs of the model and are described in more detail in the appropriate sections.

3.5 The unconstrained accounts for 1968-69

The accounts derived in this way are the basic run of the model, using none of the possible adjustment or constraint procedures. Essentially, if unconstrained accounts are accepted, this means accepting

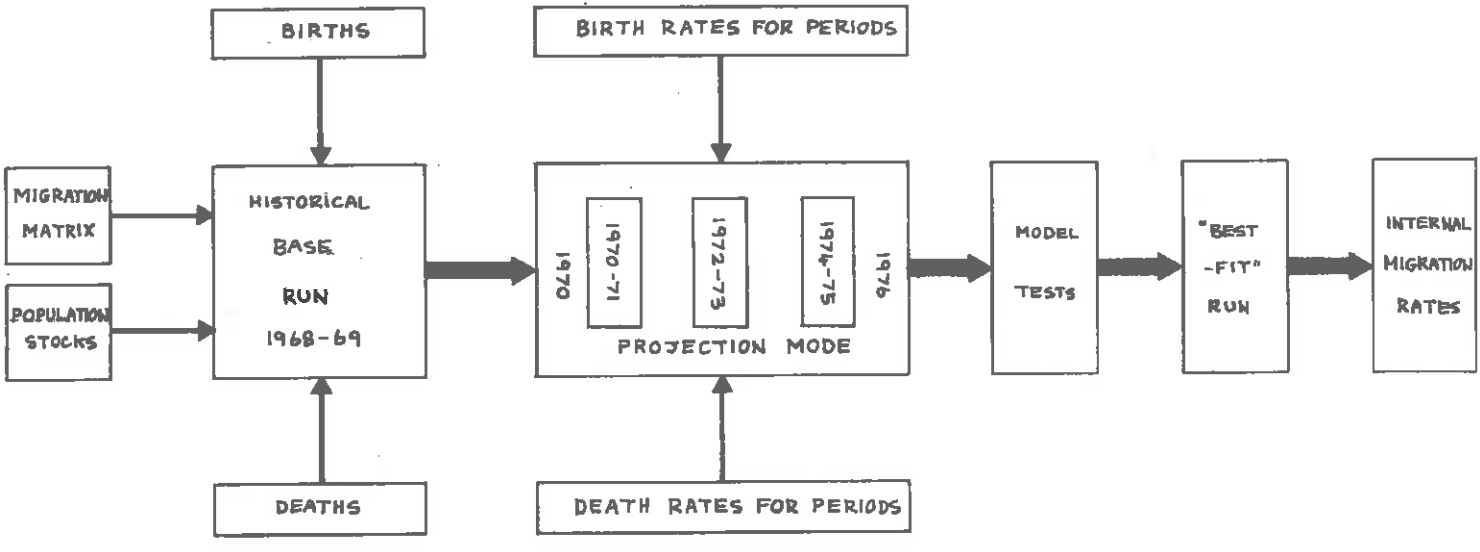


Figure 12. The accounts building process

the initial population, births, deaths and migrant figures just as they are reported. The model was then run in its simplest form, and there was no attempt to constrain the end of the period populations, in 1970, to the populations for each of the republics given in the Census. For the purposes of recognition throughout this paper this run will be called "unconstrained". The accounts table is set out in Table 11.

The results of the base run for the period 1968-69 demonstrate the inconsistencies inherent in the published series. Table 12 shows the differences between the estimates which this assumption generates via the model and the 1970 population stocks given in the Census for each republic. These figures generate a total percentage difference, estimated as described in the previous section of some 14% across the whole system. The actual accounts for this period which result from this run are shown on Table 11. One point of interest is that all the underestimations in this model run occur in non-European republics, whereas all the others are over-estimates, which indicates that within the constraint imposed by the total population of the USSR, the various flows must be redistributed across the multi-republic system.

Since the aim of this paper is to present a set of accounts which are consistent with the observed populations in the Census, in accordance with our basic assumption that this is the most accurate data source available, these results are not as satisfactory as it is possible to make them, since in effect they are inconsistent with the census results. Therefore, the next stage is to produce a set of accounts which match the census results for the republics for 1970. These accounts are described in the next section.

3.6 The constraints procedure

The theory behind the constraints procedure has already been described in section 3.1, but in this section we will show how this methodology has been applied to the Soviet republics. As has already been stated, the constraints are used to obtain a set of accounts which are consistent with an observed final population by setting this final population, in this case the 1970 Census results, as the desired final result of the accounts matrix and then using an iterative procedure to adjust the matrix until these constraints are satisfied. The resulting accounts are consistent with the births, deaths, initial populations and final populations

Table 11. The unconstrained accounts for 1968-69 for the Soviet republics

Initial state	Final state	SURVIVAL, JANUARY 1ST, 1970														DEATH in 1968-69												TOTALS
		Rs	Be	Uk	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	Rs	Be	Uk	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	
EXISTENCE JANUARY 1ST, 1968	Rs	24,000,946	79,491	418,660	23,127	21,181	22,387	14,177	11,461	5,108	13,335	262,200	64,118	36,264	18,731	14,221	2,077,420	579	2,501	166	237	249	122	83	27	92	1,573	382	267	114	101	127,911,000
	Be	85,005	8,559,324	22,260	936	1,404	4,688	3,914	702	151	553	9,535	1,170	316	331	465	708	126,819	186	7	16	74	34	5	1	4	57	7	2	2	3	8,213,999
	Uk	427,730	23,699	45,463,180	13,253	4,908	6,267	3,609	2,468	1,277	2,357	47,700	7,634	2,049	1,366	3,234	3,565	172	759,722	131	49	70	31	25	7	16	286	42	15	12	23	46,380,999
	Mo	20,886	861	18,030	3,374,425	212	806	330	463	141	179	7,643	284	175	101	635	250	6	151	49,106	2	5	3	3	1	1	41	2	1	1	5	3,429,000
	Es	13,804	707	2,166	128	1,285,611	1,082	458	57	44	81	646	160	72	180	12	112	5	23	1	28,533	12	4	0	0	1	4	1	1	1	0	1,304,001
	La	19,179	2,617	2,419	216	1,138	2,216,700	2,857	122	56	185	1,689	329	100	95	70	160	18	29	2	13	69,988	22	1	0	1	6	2	1	0	0	2,298,000
	Li	67,392	1,846	2,261	124	345	2,237	2,416,821	71	16	73	1,321	275	71	60	40	123	13	19	1	4	36	54,834	1	0	1	8	2	1	0	0	3,064,001
	Ge	13,773	663	3,351	313	260	353	165	4,524,659	5,900	2,549	3,444	972	250	136	224	281	5	70	2	3	4	1	66,126	31	20	21	6	2	1	2	4,659,000
	Ar	10,223	264	2,482	96	64	92	36	1,979	2,210,868	4,006	1,934	712	180	158	231	86	2	17	1	1	1	0	8	28,230	28	9	4	1	1	2	2,306,001
	Az	31,697	1,918	6,456	331	234	368	124	1,549	6,494	4,794,468	4,430	1,287	100	205	1,002	264	7	56	2	3	4	1	11	35	66,620	27	8	1	1	7	4,917,000
	Ka	238,366	18,700	65,721	4,657	2,621	2,955	1,581	1,097	598	1,397	12,681,821	19,925	2,243	3,571	2,712	2,487	136	548	33	28	27	9	8	3	10	148,095	119	156	22	19	12,673,000
	Uz	148,337	6,612	18,419	680	1,170	613	292	535	680	722	44,224	23,922,289	3,999	3,834	4,213	303	19	154	5	13	7	3	4	3	6	266	131,651	66	62	44	11,266,001
	Ki	43,657	619	5,194	172	845	282	80	92	49	344	24,208	9,399	2,702,588	1,497	786	363	5	43	1	9	3	1	1	0	2	145	56	40,598	9	6	2,835,959
	Ta	23,600	946	4,706	480	1,296	181	28	80	92	113	6,012	3,355	1,776	2,646,643	1,040	247	4	39	4	16	2	1	1	0	1	36	56	13	33,483	7	2,736,002
	Tu	21,717	855	3,432	307	32	145	76	223	215	358	7,967	5,108	650	574	1,953,680	131	6	30	2	0	2	1	2	1	2	47	30	5	4	22,192	2,022,999
BIRTH in 1968-69	Rs	3,611,918	1,126	5,998	321	302	320	203	164	73	191	3,748	918	518	262	203	20,164	4	25	1	2	2	1	1	0	1	11	3	2	1	1	3,656,504
	Be	1,200	224,114	364	16	23	109	64	11	2	9	136	19	5	6	8	6	2,476	2	0	0	1	0	0	0	0	0	0	0	0	0	228,381
	Uk	6,380	305	1,323,842	272	66	93	59	52	19	35	731	105	31	28	48	27		11,413		0	1	0		0	0	2	0	0	0	0	1,383,534
	Mo	595	17	357	125,383	4	16	7	9	3	4	150	6	3	2	13	2	0	1	977	0	0	0	0	0	0	0	0	0	0	0	137,517
	Es	287	11	43	2	39,644	16	7	1	1	1	10	2	1	2	0	1	0	0	0	446	0	0	0	0	0	0	0	0	0	0	40,365
	La	293	36	49	3	16	66,254	37	2	1	2	15	5	1	1	1	1	0	0	0	0	719	0	0	0	0	0	0	0	0	0	65,415
	Li	273	33	40	2	6	57	107,398	1	0	1	23	5	1	1	1	1	0	0	0	0	0	926	0	0	0	0	0	0	0	0	108,769
	Ge	643	13	159	6	5	7	3	174,922	112	56	66	18	5	3	4	3	0	1	0	0	0	0	1,267	0	0	0	0	0	0	0	177,293
	Ar	254	7	50	2	2	2	1	26	112,512	99	35	18	4	4	6	1	0	0	0	0	0	0	0	602	0	0	0	0	0	0	113,625
	Az	998	32	210	10	7	12	4	49	204	305,785	141	41	3	6	32	4	0	2	2	0	0	0	0	1	2,111	0	0	0	0	0	309,651
	Ka	7,675	443	1,558	110	60	58	37	26	14	83	537,093	472	504	83	64	29	2	6	0	0	0	0	0	0	0	3,554	1	2	0	0	601,224
	Uz	2,778	93	642	24	41	21	10	19	19	25	1,846	773,972	314	345	217	16	0	3	0	0	0	0	0	0	0	5	4,626	1	1	1	785,719
	Ki	1,360	19	162	5	26	9	2	3	1	11	785	293	172,855	47	25	6	0	1	0	0	0	0	0	0	0	2	1	1,231	0	0	176,864
	Ta	1,093	20	176	18	52	7	3	3	3	4	223	387	66	139,699	39	5	0	1	0	0	0	0	0	0	0	1	1	0	1,253	0	282,018
	Tu	788	21	132	11	1	5	3	8	8	13	287	185	24	21	144,656	3	0	1	0	0	0	0	0	0	0	1	1	0	0	1,032	147,211
TOTALS		23,165,170	8,310,141	47,180,148	3,560,160	1,374,985	2,335,649	3,123,201	4,730,985	2,334,586	5,107,195	13,098,867	4,825,595	1,994,118	2,183,782	2,154,184	2,137,494	129,084	776,043	59,443	29,380	51,220	68,399	67,547	28,992	69,716	158,382	137,001	42,416	34,974	23,445	244,824,162

Table 12. January 1st 1970 populations: unconstrained accounts estimate, census counts and differences

Republic	Unconstrained accounts estimate (1)	Census (2)	Difference (3)=(2)-(1)	Percentage difference 100x[(3)/(2)]
RSFSR	129,606,109	130,079,210	473,101	0.4
Belorussian SSR	8,980,161	9,002,338	22,177	0.2
Ukrainian SSR	47,020,868	47,126,517	105,649	0.2
Moldavian SSR	3,560,462	3,568,873	8,411	0.3
Estonian SSR	1,330,995	1,356,079	25,084	1.8
Latvian SSR	2,326,621	2,364,127	37,506	1.6
Lithuanian SSR	3,122,201	3,128,236	6,035	0.2
Georgian SSR	4,730,986	4,686,358	-44,628	-1.0
Armenian SSR	2,394,588	2,491,873	97,285	3.9
Azerbaydzhan SSR	5,127,296	5,117,081	-10,215	-0.2
Kazakh SSR	13,098,688	13,008,726	-89,962	-0.7
Uzbek SSR	11,825,995	11,799,429	-26,564	-0.2
Kirgiz SSR	2,954,189	2,932,805	-21,384	-0.7
Tadzhik SSR	2,883,981	2,899,602	15,621	0.5
Turkmen SSR	2,134,893	2,158,880	23,987	0.1
USSR, total	241,098,031	241,720,134	622,103	0.3

Notes:

1. Positive differences mean that the populations are underestimated in the unconstrained accounts, while negative differences mean overestimation with respect to the Census numbers.

which are the row and column sums of the accounts matrix. However, for this procedure to work the row sum must equal the column sum, if this is not the case it becomes necessary to adjust one of these totals to meet this condition.

For 1968-69 this condition is not met for the Soviet republics. If one adds the births to the initial populations for the Soviet Union as a whole, and then subtracts them from the total deaths, added to the final population as shown in the 1970 Census, a difference of some 622,103 persons results. It is, therefore, necessary to adjust one or more of the elements of the row or column constraints to remedy the situation. Following the assumptions outlined in the previous section we have adjusted the initial population estimate for 1968, and have followed this procedure throughout the paper.

The problem is then how best to allocate this difference. One method might be to simple allocate the difference equally to each republic, but this was felt to be unrealistic. The method finally used was to allocate the difference proportionally to each republic according to the share of the total population which that republic had in 1970. Thus, to take a single example, in 1970 the RSFSR had 0.540 of the total population of the Soviet Union, therefore, in this case it would have 0.540 of 622,103 allocated to it. Providing that these proportions sum to 1.000 over the entire USSR, the whole of the difference can be allocated in this way. Once this is done the constraints procedure will then become operative, since the row constraints are equal to the column constraints.

The way in which this procedure is applied to the whole of the Soviet Union is shown in Table 13. The direction (up or down) in which the adjustment takes place depends on whether the row constraints are larger or smaller than the column constraints. Since we are mainly interested in the initial populations (which with births forms the row constraints), if the difference between the row and column sums is negative, that is, the row sum is less than the column sum, we raise the initial populations proportionally, whereas if the difference is positive it means that the row sum is greater than the column sum and we decrease the initial populations proportionally.

If we examine the figures shown in Table 13, we see that the adjustments to the initial populations seem quite significant, but, in

Table 13. The constraint calculations for the 1968-69 period

Republic	Initial constraints Row totals	Initial constraints Column totals	Adjusted constraints Row totals	Adjusted constraints Column totals	Proportions used in allocating error
	Init. popn	Deaths	Init. popn	Deaths	
RSFSR	127911000	2137474	128247262	2137474	0.538140
Belorussian SSR	8820000	129087	8843167	129087	0.037243
Ukrainian SSR	46381000	776042	46502857	776042	0.194963
Moldavian SSR	3484000	50444	3493140	50444	0.014764
Estonian SSR	1304000	29382	1307431	29382	0.005610
Latvian SSR	2298000	51220	2304053	51220	0.009780
Lithuanian SSR	3064000	52999	3072052	52999	0.012942
Georgian SSR	4659000	67546	4671241	67546	0.019388
Armenian SSR	2306000	24993	2312061	24993	0.010309
Azerbaydzhan SSR	4917000	68916	4929927	68916	0.021169
Kazakh SSR	12678000	154204	12711202	154204	0.053817
Uzbek SSR	11266000	136999	11295723	136999	0.048814
Kirgiz SSR	2836000	42415	2843455	42415	0.012133
Tadzhik SSR	2736000	34974	2743202	34974	0.011996
Turkmen SSR	2029000	29445	2034330	29445	0.008931
Sub-totals	236689000	3786140	237211103	3786140	1.000000
	Births	Final popn	Births	Final popn	
RSFSR	3656501	130079210	3656501	130079210	
Belorussian SSR	288382	9002338	288382	9002338	
Ukrainian SSR	1383535	47126517	1383535	47126517	
Moldavian SSR	137519	3568873	137519	3568873	
Estonian SSR	40366	1356079	40366	1356079	
Latvian SSR	65416	2364127	65416	2364127	
Lithuanian SSR	108772	3128236	108772	3128236	
Georgian SSR	177292	4686358	177292	4686358	
Armenian SSR	113696	2491873	113696	2491873	
Azerbaydzhan SSR	309652	5117081	309652	5117081	
Kazakh SSR	601229	13008726	601229	13008726	
Uzbek SSR	785719	11799429	785719	11799429	
Kirgiz SSR	176864	2932805	176864	2932805	
Tadzhik SSR	203018	2899602	203018	2899602	
Turkmen SSR	147210	2158880	147210	2158880	
Sub-totals	8195171	241720134	8195171	241720134	
Totals	244884171	245506274	245506274	245506274	622103[a]

Notes:

a. The difference between initial row and column constraints which is proportionately distributed among the initial populations of the republics to yield row and column constraints that add up to the same grand total.

fact, the proportional allocation by republic is in all cases less than 0.3% of the original Soviet estimate. So in a total population of the size with which we are dealing it is felt that such adjustments, particularly on a proportional basis, are allowable, and indeed necessary, in order to obtain a consistent set of accounts. This then, is the method for simply constraining a conventional set of population accounts for the Soviet Union. The constraints procedure in the model can only be used in the historical base run of the model. Our strategy is to use four different sets of possible accounts for the base run, based on different sets of assumptions, to put these into the projection mode of the model with constant rates for births and deaths in the projection periods. We then test the populations obtained at the end of each period against the observed population estimates for the same dates. The projection with the closest fit will be deemed to have the best internal migration rates. These internal migration rates will then be used in constrained sets of historical accounts for the periods 1970-71, 1972-73 and 1974-75.

3.7 The constrained accounts for 1968-69

3.7.1 The procedure

The previous section demonstrated that the unconstrained accounts for 1968-69 did not provide a set of accounts which were consistent with the census populations of January 1st 1970. However, we can set the end of period populations to the census levels and then adjust the entire accounts matrix until it is consistent with these totals. The resulting accounts table is laid out in Table 14.

However, while this set of accounts is consistent with the 1970 Census population stocks the adjustment procedure leads to the alteration of the migration flows in the K_{ES} matrix. By using a balancing factor routine on the entire table we are in fact adjusting the migration flows as well as the initial populations. The births and deaths totals remain unadjusted when used as constraints.

It is interesting to examine the extent to which these flows have been altered. This can be done by subtracting the exist survive sub-matrix of the constrained accounts with the principal diagonal set to zero in each case:

Table 11. The constrained accounts for 1968-69 for the Soviet republics

BIRTH IN 1968-69 / EXISTENCE, JANUARY 1ST, 1969	Rs	Be	Uk	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	DEATH IN 1968-69 Rs	Be	Uk	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	TOTALS
Rs	125,177,868	78,515	467,214	23,489	29,982	32,419	14,092	7,938	20,287	12,320	133,442	52,738	28,577	18,981	17,340	2,046,805	570	3,350	161	331	258	121	58	105	90	434?	315	211	118	122	123,247,258
Be	35,593	3,519,408	21,345	979	2,009	3,183	3,224	492	607	542	9,184	973	252	359	575	715	126,930	182	7	23	108	34	4	4	4	49	6	2	2	4	8,843,167
Uk	440,761	24,152	45,710,128	18,285	6,965	9,266	3,695	3,474	5,230	2,352	41,587	5,959	1,663	1,990	4,062	3,662	175	759,761	131	71	109	32	18	28	16	251	34	12	13	29	46,502,855
Mo	30,981	375	12,048	3,312,806	302	1,205	388	330	576	178	6,449	240	142	108	796	257	6	151	49,110	3	13	3	2	4	1	40	2	[illegible]	1	5	3,493,139
Es	3,519	496	1,906	88	1,464,985	1,084	213	28	154	56	389	93	40	74	118	79	4	16	1	28,577	12	3	0	0	[illegible]	4	1	1	0	0	1,707,433
La	13,281	1,723	3,334	145	1,115	2,432,491	1,766	63	159	104	616	187	55	59	59	110	12	19	1	13	49,773	15	0	0	[illegible]	4	1	1	0	0	2,304,051
Li	15,492	1,815	2,206	121	491	4,123	2,883,918	48	64	71	1,127	227	62	62	49	129	13	19	1	6	52	37,140	1	0	[illegible]	7	2	1	0	0	3,072,052
Ge	48,250	944	11,581	435	85	742	234	4,697,836	33,933	4,074	4,173	1,141	281	201	394	461	7	97	3	6	8	1	66,170	172	28	26	7	2	[illegible]	3	4,671,241
Ar	2,646	66	497	29	23	54	9	188	2,183,861	983	308	148	36	41	71	22	[illegible]	4	0	0	0	0	[illegible]	23,916	7	2	[illegible]	0	0	1	2,312,060
Az	22,588	1,034	6,429	331	334	549	127	1,102	24,534	4,497,832	3,915	1,088	81	218	1,256	270	7	55	2	4	6	1	8	140	66,134	24	7	1	[illegible]	9	4,929,223
Ka	349,767	21,662	76,728	5,284	4,180	4,178	1,892	850	2,726	1,836	12,699,715	19,138	19,616	4,261	3,875	2,905	158	622	38	46	65	16	7	14	11	148,382	119	145	27	27	12,711,201
Uz	131,365	3,309	21,666	892	2,027	1,078	352	446	2,692	849	45,532	8,921,552	8,596	12,406	9,183	1,092	23	180	6	22	12	4	3	14	6	275	131,755	64	78	65	11,295,724
Ki	52,087	772	6,356	211	1,508	516	180	80	281	420	15,438	3,745	2,488,697	1,983?	1,269	456	5	53	1	16	5	1	1	0	2	156	58	44,674	12	9	2,843,459
Ta	18,536	824	4,417	461	1,309	289	15	54	389	106	4,983	2,438	1,353	2,687,588	1,226	218	4	37	4	22	3	[illegible]	1	-0	1	30	45	10	27,447	8	2,743,205
Tu	17,857	696	2,904	286	37	173	62	130	704	286	5,526	3,460	422	430	1,972,982	149	5	24	2	0	2	1	[illegible]	3	2	33	20	3	3	28,726	2,034,329
Rs	2,611,608	1,120	5,805	321	426	463	201	115	290	189	1,771	752	407	230	247	39,670	8	24	1	3	3	1	1	0	1	9	2	2	[illegible]	1	3,652,501
Be	1,462	289,016	356	16	33	160	64	2	3	9	134	16	4	6	18	6	2,070	2	0	0	1	0	0	0	0	0	0	0	0	0	288,381
Uk	6,552	360	1,363,663	273	56	139	65	37	78	35	621	89	24	30	60	27	[illegible]	11,335	1	0	[illegible]	0	0	0	0	2	0	0	0	0	1,283,525
Mo	608	17	355	155,396	6	24	7	6	12	4	131	5	2	2	15	2	0	[illegible]	774	0	0	0	0	0	0	[illegible]	0	0	0	0	137,517
Es	147	8	30	1	28,204	16	6	0	3	1	6	[illegible]	[illegible]	1	0	1	0	0	0	441	0	0	0	0	0	[illegible]	0	0	0	0	40,366
La	188	25	33	2	16	64,288	35	1	3	1	9	3	[illegible]	1	1	1	0	0	0	0	0	711	0	0	0	-0	[illegible]	0	0	0	65,419
Li	274	33	39	2	9	85	107,379	1	0	1	20	4	1	1	[illegible]	1	0	0	0	0	0	914	0	0	0	0	0	0	0	0	108,773
Ge	921	18	222	8	10	15	4	173,383	639	78	79	21	6	4	7	4	0	1	0	0	[illegible]	0	1,871	0	0	0	0	0	0	0	177,291
Ar	64	1	12	0	1	1	0	5	112,983	24	7	4	1	1	2	0	0	0	0	[illegible]	[illegible]	0	0	589	0	0	0	0	0	0	113,695
Az	1,025	33	209	10	10	18	4	35	835	265,948	123	34	2	6	29	4	0	[illegible]	0	0	0	0	0	4	2,111	0	0	0	0	0	269,451
Ka	8,266	514	1,772	126	100	99	43	21	65	38	515,434	455	466	101	92	34	2	7	0	0	0	0	0	0	0	3,562	.1	2	0	0	661,230
Uz	4577	112	755	28	70	37	12	16	92	29	1,588	772,693	209	[illegible]	320	19	0	4	0	0	0	0	0	0	[illegible]	5	4,625	[illegible]	1	1	785,717
Ki	1,716	24	199	6	47	17	5	3	5	12	802	204	172,527	62	87	8	0	[illegible]	0	0	0	0	0	0	0	2	[illegible]	1,283	0	0	176,866
Ta	1,859	19	163	17	71	10	3	2	12	4	182	275	50	189,882	45	5	0	1	0	0	0	0	0	0	0	[illegible]	[illegible]	0	1,248	0	203,020
Tu	646	25	104	9	1	6	2	5	26	10	199	125	16	18	104,882	2	0	1	0	0	0	0	0	0	0	1	1	0	0	1,085	147,210
TOTALS	139,103,211	3,902,339	81,116,676	3,958,832	1,556,280	2,564,125	3,122,136	4,686,367	2,401,375	5,117,081	13,208,716	11,799,188	2,703,894	2,899,101	2,182,379	2,457,494	129,087	776,043	50,444	29,284	51,217	62,398	67,547	24,993	68,917	159,204	137,001	42,416	34,934	23,445	245,506,234

$$\underline{D}^{m}_{ES} = \underline{K}^{m}_{ES}(\text{constrained}) - \underline{K}^{m}_{ES}(\text{unconstrained}) \qquad (12)$$

where $\underline{D}^{m}_{ES}$ refers to a matrix of differences for the migrant terms of the exist-survive portions of the accounts specified on the right hand side of the equation. The $\underline{K}^{m}_{ES}$(unconstrained) submatrix is equivalent to the migration matrix in Volume VII of the All Union Census, 1970.

We can examine the resulting differences, shown in Table 15, in two ways: the direction of difference (positive/upward or negative/downward) and the magnitude of the difference (large/small). These two aspects are discussed in turn.

3.7.2 The direction of adjustment

Of the 210 flows in the inter-republic migration matrix 102 are adjusted downwards and 108 upwards as a result of applying the constraints procedure to estimation of the accounts. Overall the migrant numbers are 120.6 thousand higher in the constrained accounts than in the unconstrained. Before this could be regarded as a measure of the overall sampling error involved in the census migration tables a more detailed investigation of all the issues raised in this paper would have to be conducted.

The flows are considered in four pairs of blocks, grouped in terms of origin and destination republics into the four regions used in earlier discussions in section 2 of the paper. The directional patterns are displayed in simplified form in Table 15 by the shading of negative differences (where the adjusted accounts flows exceeds the census flow).

(i) The Western republics

The same number of out-migration flows from these republics were increased in the process of adjustment (28 negative values) as were decreased (28 positive values). Most migration flows to the Baltic republics were adjusted upwards. Flows to Georgia and Azerbaydzhan were adjusted downwards; flows to Armenia heavily upwards. All movements from the Western republics to Kazakhstan, Uzbekistan and Kirgizia were adjusted downwards, whereas flows to Tadzhikstan and Turkmenistan were adjusted upwards.

Table 15. Differences between inter-republic migration flows derived from the All Union 1970 Census and those flows adjusted in the 1968-69 constrained accounts

	Rs	Be	Uk	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	Totals
RSFSR	—	916	12416	638	-8771	-10092	85	3523	-15199	415	39758	11420	7687	-650	-3119	39027
Belorussian SSR	-988	—	415	17	-605	-3125	-20	211	-456	11	1355	197	64	-18	-108	-3050
Ukrainian SSR	-13033	-488	—	-32	-2017	-3099	-86	994	-3953	5	6013	1077	386	-124	-828	-15185
Moldavian SSR	-945	-14	42	—	-96	-397	-8	133	-435	1	974	44	33	-7	-161	-836
Estonian SSR	3885	211	860	40	—	-32	135	29	-80	25	257	67	28	26	2	5453
Latvian SSR	5898	798	1140	71	23	—	801	69	-98	51	433	142	45	15	11	9399
Lithuanian SSR	-90	11	55	3	-146	-1485	—	22	-48	2	194	48	15	-2	-9	-1430
Georgian SSR	-14477	-275	-3225	-122	-265	-384	-69	—	-27598	-1130	-729	-169	-31	-65	-168	-48707
Armenian SSR	7707	198	1525	72	41	58	27	886	—	3023	1126	564	144	117	160	15648
Azerbaydzhani SSR	-891	-16	17	0	-102	-181	-3	446	-20040	—	575	199	19	-13	-253	-20243
Kazakh SSR	-51401	-2962	-9017	-647	-1659	-1719	-261	207	-2188	-189	—	727	1627	-750	-1163	-69395
Uzbek SSR	-23208	-531	-3247	-122	-837	-465	-60	89	-2062	-126	-1258	—	403	-2522	-2970	-36916
Kirgiz SSR	-11400	-153	-1162	-39	-663	-234	-20	12	-177	-76	-1690	-346	—	-459	-423	-16829
Tadzhik SSR	965	24	289	31	-514	-73	3	26	-262	7	1079	1917	423	—	-186	3729
Turkmen SSR	3820	159	728	61	-5	-28	14	98	-469	72	2381	1648	228	84	—	8771
Totals	-94158	-2122	836	-29	-15616	-21256	538	6745	-73085	2091	50468	17535	11071	-4367	-9215	-130564

(ii) The Baltic republics

Out of 42 possible out-flows, 33 were adjusted down and only 5 were adjusted upwards. Thus, constraints procedure tended to reduce outmigration from the Baltic republics.

(iii) The Transcaucasian republics

Of the 42 outflows in this block of Table 15, 20 were adjusted downwards and 22 upwards. All the migrants flows from Georgia and a majority of those from Azerbaydzhan are adjusted upwards, whereas all those from the Armenian SSR are altered downwards. The reverse situation holds in the case of in-migration with flows to Armenia being raised in the constrained accounts and those to the Georgian and Azerbaydzhan SSR being reduced. These adjustments stem from the differences in January 1st populations of the republics derived from the unconstrained accounts and the census (Table 12).

(iv) The Central Asian republics

Of the 70 outflows associated with this group of republics, some 27 are adjusted downwards and 43 upwards. There is a clear distinction between the Kazakh, Uzbek and Kirgiz republics on the one hand, and the Tadzhik and Turkmen SSRs. The constraints procedure increases outflows from the former three republics and reduces inflows to them, with the reverse occurring for the other two republics in the Central Asian region.

Although we have described the adjustments in terms of broad regional grouping, the adjustments do not accord with this grouping. No grouping shows consistency in the direction of adjustment of all of its constituent republics.

3.7.3 The size of the adjustments

If we express the adjustment as a percentage of the original unadjusted flow, most of the adjustments fall between 10% and 45% of the original. However, the flows to and from Armenia are subject to much larger adjustment in all cases, and this has the effect of substantially increasing the net migration rate to Armenia. Apart from this anomaly very few of the possible 210 flows are adjusted by more than 50%. Therefore, taken in aggregate these adjustments would seem to be

acceptable in order to produce a set of population accounts which are consistent with the observed population stocks, although in doing this we are treating population total figures from the census as having much greater reliability than the migration figures.

3.8 The arithmetic "backcast" accounts for 1968-69: unconstrained and constrained

In section 3.7 it was demonstrated that it was possible to derive a set of accounts which were consistent with the observed population stocks for 1970. This involved adjusting not only the initial, January 1st 1968 populations but also the migration flows, and therefore assuming that the migrant figures derived from the Census were in error to a greater or lesser degree. This section will show that it is possible to derive a set of accounts which are consistent with the 1970 stocks, but which preserve the flows which are shown in the Census inter-republic migration table (Table 10).

This process once more involves adjusting the initial populations, but by means of an "internal" adjustment, rather than by an "external" adjustment. The principle involved is to load the adjustment into the diagonal term of the "exist-survive" quadrant of the accounts table rather than to spread it throughout the accounts matrix. To do this it is necessary to return to the simple unconstrained version of the model. The process involved is as follows.

(i) From the unconstrained accounts constructed in section 3.5 we can extract the surviving stayer terms for the 15 republics. This we will call $K^{\varepsilon(i)\sigma(i)}{}_{(u)}$ and this was computed in the accounts based model from the row accounting equation as a residual.

$$K^{\varepsilon(i)\sigma(i)}{}_{(u)} = K^{\varepsilon(i)*(*)}{}_{(u)} - \sum_{j\neq i} K^{\varepsilon(i)\sigma(j)}{}_{(u)} - K^{\varepsilon(i)\delta(i)}{}_{(u)} - \sum_{j\neq i} K^{\varepsilon(i)\delta(j)}{}_{(u)} \qquad (13)$$

where u refers to terms from the unconstrained accounts.

(ii) Surviving stayer terms can also be computed directly from knowledge of the Census 1970 population and the number of immigrants. In effect, we use a column accounting equation to a second, alternative estimate of $K^{\varepsilon(i)\sigma(i)}$

$$K^{\varepsilon(i)\sigma(i)}_{(b)} = K^{\varepsilon(*)\sigma(i)}_{(c)} - \sum_{j \neq i} K^{\varepsilon(j)\sigma(i)}_{(m)} \qquad (14)$$

where b refers to backcast estimates, c to census constraint and m to census migration tables. Note that the population stock as of January 1st 1970 is that of persons alive two years earlier. In other words, it is the population aged two and over.

(iii) These two estimates of the surviving stayer terms will differ by an amount $D^{\varepsilon(i)\sigma(i)}$

$$D^{\varepsilon(i)\sigma(i)}_{(b-u)} = K^{\varepsilon(i)\sigma(i)}_{(b)} - K^{\varepsilon(i)\sigma(i)}_{(u)} \qquad (15)$$

(iv) If we then add this difference (positive or negative) to the initial population estimates used in the unconstrained accounts we obtain a new estimate of the January 1st 1968 population stock in each republic:

$$K^{\varepsilon(i)*(*)}_{(b)} = K^{\varepsilon(i)*(*)}_{(u)} + D^{\varepsilon(i)\sigma(i)}_{(b-u)} \qquad (16)$$

This procedure is equivalent to adding the difference between the final population stocks computed in the unconstrained accounts and the census populations

$$K^{\varepsilon(i)*(*)}_{(b)} = K^{\varepsilon(i)*(*)}_{(u)} + (K^{*(*)\sigma(i)}_{(c)} - K^{*(*)\sigma(i)}_{(u)}) \qquad (17)$$

since the $K^{\beta(i)\sigma(i)}$ and $K^{\beta(i)\sigma(j)}$ terms are assumed to be the same in the two sets of accounts.

Accounts are then constructed in the same fashion and with the same data already described for the unconstrained accounts, substituting the new estimates of the initial population, $K^{\varepsilon(i)*(*)}_{(b)}$, for the ones employed previously, $K^{\varepsilon(i)*(*)}_{(u)}$. We term this procedure an arithmetic "backcast", arithmetic because it is simply an arithmetic cal lation through the accounts table (whereas it should be possible to reverse the model to actually calculate this term), and "backcast" because it is

the opposite of a traditional forecast. The procedure calculates an initial population from a final population instead of vice versa. The advantage of this procedure is that it produces a set of accounts which are consistent with the observed 1970 population constraints without adjusting the migration flows. We run an unconstrained version of the accounts based model with the internally adjusted initial populations and all other data constant. These populations, the populations they generate for 1970 and the amount that they differ from the census stocks are shown in Table 16.

As this table shows the differences between the final populations of the accounts and the census figures are very small. Most of the errors can be attributed to the cumulative rounding error in the calculation of the various model variables. However, it is possible to entirely remove them by balancing of the column and row totals and constraining the accounts matrix in the same way as for the previous constrained run. Because the differences between the column and row totals of the initial accounts matrix and the constraints are very small in this case, the constrained backcast accounts are little different from the unconstrained backcast. These two runs are called "unconstrained backcast" and "constrained backcast". The accounts tables are reproduced in full in the Appendix to this paper.

We now have four sets of possible accounts. The next step is to determine which of these generates the best internal migration rates, in order to determine the migration flows to put into the accounts for each of the three subsequent two year periods up to 1976. These accounts are constrained to fit the observed population estimates for each of the terminating years.

3.9 Choosing the best set of accounts

3.9.1 Measures of goodness of fit

In order to determine which of the sets of accounts to use we must have a standard methodology to test the results against the observed estimates. The standardisation is necessary because some of the results may be very close to each other. To this end four measures of comparison were utilized:

Table 16. A comparison of initial and final populations for the backcast accounts

Republic	Initial population in unconstrained accounts (1)	Adjusted initial population in backcast accounts. (2)	Initial population differences (3)=(2)-(1)	Final population in unconstrained backcast accounts (4)	Census 1970 populations (5)	Final population differences (6)=(5)-(4)
RSFSR	127911000	128143366	232366	130079154	130079210	56
Belorussian SSR	8820000	8842148	22148	9002307	9002338	31
Ukrainian SSR	46381000	46486653	105653	47126509	47126517	8
Moldavian SSR	3484000	3492411	8411	3568873	3568873	0
Estonian SSR	1304000	1329086	25086	1356078	1356079	1
Latvian SSR	2298000	2335507	37507	2364125	2364127	2
Lithuanian SSR	3064000	3070037	6037	3128238	3128236	-2
Georgian SSR	4659000	4614371	-44629	4686347	4686358	11
Armenian SSR	2306000	2403286	97286	2491891	2491873	-18
Azerbaydzhan SSR	4917000	4906782	-10218	5117072	5117081	9
Kazakh SSR	12678000	12828822	150822	13008861	13008726	-135
Uzbek SSR	11266000	11239397	-26603	11799371	11799429	58
Kirgiz SSR	2836000	2813573	-22427	2932777	2932805	28
Tadzhik SSR	2736000	2752654	16654	2899608	2899602	-6
Turkmen SSR	2029000	2052987	23987	2158894	2158880	-14
USSR	236689000	237311080	622080	241720105	241720134	29

(i) a total difference measure, TD;

(ii) an absolute difference measure, AD;

(iii) a percentage difference measure, PD;

(iv) a measure in dissimilarity units, on a scale 0 to 100, which is equivalent to the index of dissimilarity formula, which is a relative difference measure, RD.

These measures were then tabulated and the best of the runs picked out from the tables. Each indicator measures a slightly different aspect of goodness of fit.

In more detail the measures used were as follows. We let $K_o^i(t)$ refer to the observed population estimate at time t in region i, and $K_m^i(t)$ refer to the model estimate at time t in region i.

(i) The total difference measure, TD

$$TD = \sum_i K_m^i(t) - \sum_i K_o^i(t) \qquad (18)$$

In the case of this measure a negative value means overprediction, and a positive value means underprediction.

(ii) The sum of the absolute differences, AD

$$AD = \sum_i |K_m^i(t) - K_o^i(t)| \qquad (19)$$

In this case the absolute values of the differences areused instead of the real difference.

(iii) The sum of the absolute percentage differences, PD

$$PD = \sum_i (100) \left| \frac{K_m^i(t) - K_o^i(t)}{K_o^i(t)} \right| \qquad (20)$$

(iv) The relative difference measure, RD

The formula used to calculate it is as follows:

$$RD = \tfrac{1}{2} 100 \sum_i \left| \frac{K_m^i(t)}{K_m^*(t)} - \frac{K_o^i(t)}{K_o^*(t)} \right| \qquad (21)$$

where the two terms within the brackets have the sum of the model and the observed estimates as divisors respectively. This is a version of the much used index of dissimilarity.

These statistics indicate the fit of the model estimates to the observed population sums for each republic.

3.9.2 Testing the accounts series

The methodology for testing the accounts series has already been described in section 3.4. However, we are now in a position to use it. We now have for each of the four runs of the model a projection series consisting of end-of-period population stocks for each of the periods 1970-71, 1972-73 and 1974-75. For each of these periods we have used two-year birth and death rates calculated from the data provided and released by the Central Statistical Bureau for the USSR in the Narodnoe Khozyaistvo series. In this sort of projection mode the computer program (Jenkins and Rees, 1977) automatically uses the internal migration rates for each republic calculated as a transition rate. That is, each element of the accounts matrix is divided by the appropriate row total.

To determine the best set of internal migration rates for the subsequent periods after the historical base run we will compare these end-of-period projected stocks with the official estimates for each period using the test statistics described in section 3.9.1. An important point to note is that each test run begins with the 1970 base population. The end-of-period populations of each test run are gathered together in Table 17.

3.9.3 The goodness of fit of the four test runs

The four test statistics for each of the four runs are gathered together in Table 18. The differences between model runs and official estimates are reported in the table for January 1st 1972 (the end of the first "projection" period), January 1st 1974 (the end of the second "projection" period), and January 1st 1976 (the end of the third "projection" period).

The first and most striking feature is the narrowing of the gap between the total USSR estimated and model figures between 1972 and 1974, with some widening to 1976. The gap of 1.15 millions in 1972 is larger than it should be in this kind of projection and it casts grave doubt on the accuracy of the January 1st 1972 estimates. This point will be treated in more detail in the next section.

Table 17. The "forecast" populations in each of the four test runs (populations are in millions)

Republics	"Observed" population (Jan 1st estimate)	Type of 1968-69 accounts			
		Unconstrained	Constrained	Backcast unconstrained	Backcast constrained
JANUARY 1ST 1972					
RSFSR	131,771	131,880	132,020	131,877	132,153
Belorussian SSR	9,171	9,162	9,161	9,162	9,164
Ukrainian SSR	48,048	47,770	47,753	47,769	47,780
Moldavian SSR	3,695	3,646	3,645	3,646	3,647
Estonian SSR	1,395	1,385	1,408	1,386	1,386
Latvian SSR	2,419	2,395	2,427	2,396	2,396
Lithuanian SSR	3,219	3,187	3,185	3,187	3,188
Georgian SSR	4,813	4,760	4,702	4,759	4,760
Armenian SSR	2,635	2,579	2,674	2,580	2,580
Azerbaydzhan SSR	5,375	5,313	5,288	5,313	5,314
Kazakh SSR	13,592	13,445	13,317	13,450	13,203
Uzbek SSR	12,731	12,395	12,335	12,393	12,340
Kirgiz SSR	3,110	3,058	3,028	3,057	3,059
Tadzhik SSR	3,149	3,054	3,063	3,054	3,054
Turkmen SSR	2,328	2,270	2,290	2,271	2,271
USSR	247,451	246,299	246,296	246,299	246,295
JANUARY 1ST 1974					
RSFSR	132,913	133,708	133,987	133,701	134,254
Belorussian SSR	9,268	9,311	9,309	9,311	9,315
Ukrainian SSR	48,521	48,381	48,348	48,380	48,401
Moldavian SSR	3,764	3,727	3,726	3,727	3,729
Estonian SSR	1,418	1,414	1,459	1,414	1,415
Latvian SSR	2,454	2,424	2,488	2,424	2,425
Lithuanian SSR	3,262	3,237	3,233	3,237	3,239
Georgian SSR	4,878	4,823	4,707	4,822	4,824
Armenian SSR	2,728	2,667	2,862	2,669	2,670
Azerbaydzhan SSR	5,514	5,485	5,434	5,484	5,487
Kazakh SSR	13,928	13,873	13,614	13,884	13,387
Uzbek SSR	13,289	12,981	12,857	12,979	12,868
Kirgiz SSR	3,219	3,182	3,120	3,180	3,183
Tadzhik SSR	3,283	3,209	3,228	3,210	3,209
Turkmen SSR	2,430	2,380	2,422	2,381	2,382
USSR	250,869	250,803	250,794	250,803	250,788
JANUARY 1ST 1976					
RSFSR	134,650	135,522	135,939	135,511	136,341
Belorussian SSR	9,371	9,450	9,447	9,450	9,455
Ukrainian SSR	49,075	48,936	48,885	48,935	48,966
Moldavian SSR	3,850	3,803	3,800	3,803	3,805
Estonian SSR	1,438	1,440	1,508	1,441	1,442
Latvian SSR	2,497	2,449	2,546	2,450	2,451
Lithuanian SSR	3,315	3,281	3,275	3,281	3,283
Georgian SSR	4,954	4,885	4,710	4,883	4,887
Armenian SSR	2,834	2,756	3,057	2,759	2,761
Azerbaydzhan SSR	5,689	5,653	5,575	5,652	5,656
Kazakh SSR	14,337	14,309	13,917	14,325	13,575
Uzbek SSR	14,079	13,595	13,402	13,592	13,419
Kirgiz SSR	3,368	3,307	3,212	3,303	3,307
Tadzhik SSR	3,486	3,372	3,401	3,373	3,371
Turkmen SSR	2,581	2,494	2,558	2,495	2,497
USSR	255,524	255,251	255,230	255,251	255,216

Source: computer runs by authors as described in the text.

Table 18. The goodness of fit statistics for the calibrations

Year (Jan 1) Goodness of fit statistic	Type of 1968-69 accounts Unconstrained	Constrained	Backcast unconstrained	Backcast constrained
1972				
TD	1,152	1,155	1,151	1,156
AD	1,370	1,776	1,363	1,920
PD	20.07	22.24	19.90	22.15
RD	0.60	0.79	0.62	0.74
1974				
TD	67	75	66	81
AD	1,743	2,723	1,728	2,857
PD	16,66	28.25	16.54	20.90
RB	0.70	1.02	0.71	1.15
1976				
TD	272	295	271	308
AD	2,178	3,709	2,157	3,866
PD	22.94	42.05	22.88	29.51
RB	0.86	1.49	0.88	1.53

Notes:

1. TD = total difference in 1000's
2. AD = sum of absolute value of differences in 1000's
3. PD = percentage difference in %
4. RD = relative difference (index of dissimilarity) scaled 0-100

The second feature of the table is that there is relatively little to choose between the different test runs: they all display the same order of magnitude of difference from the estimate series. However, the test statistic figures do suggest that the unconstrained models fit the estimate series better than do the constrained, although there is relatively little to choose between the simple unconstrained and the backcast unconstrained. Nevertheless since the test statistics are designed to make such discrimination possible, they clearly favour selection of the backcast unconstrained model by a short head. The rates generated by this model type for 1968-69 are therefore used in constructing the accounts for 1970-71, 1972-73 and 1974-75.

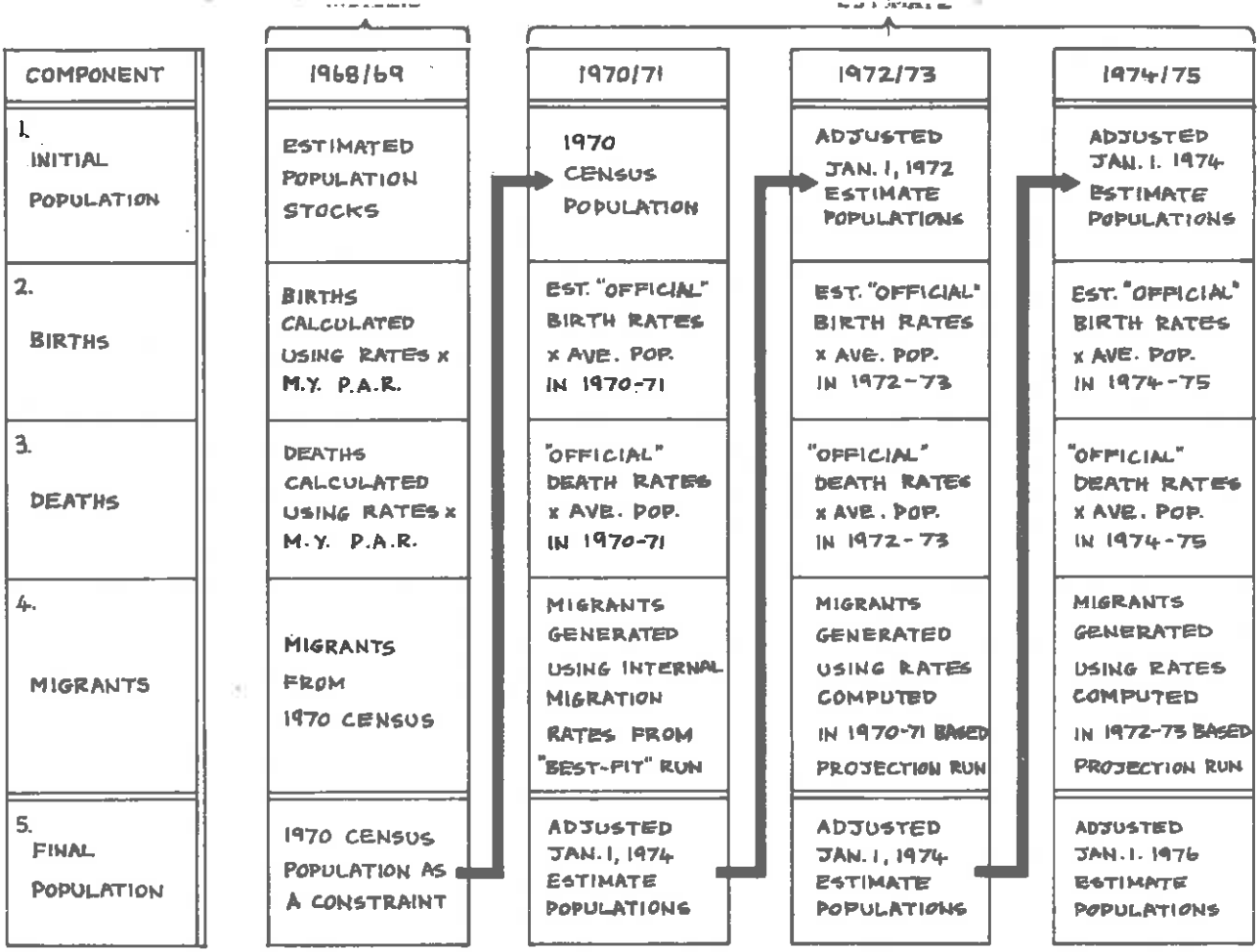
3.10 The construction of constrained accounts for the periods 1970-71, 1972-73 and 1974-75

The earlier part of section 3 of the paper has dealt with the problem of deriving a best fit set of accounts for the historical base period, 1968-69. For these accounts a set of internal migration rates were derived which give us the best possible fit to observed populations by region for 1972-76, which are published in the official Soviet statistical series. We now propose to use these internal rates to produce a series of accounts for 1970-71, 1972-73 and 1974-75. To do this we will use the model in the historical mode for each of the periods in question, constraining them to the observed population estimates. This process is shown diagrammatically in Figure 13.

(i) Births are calculated for each period and for each republic using the method described earlier in the paper.

(ii) Deaths are derived in the same way.

(iii) Migrants are taken for each period from the "best-fit" projections for the period in question, step by step. The 1970-71 migrant flows are generated by applying the migration rates of the 1968-69 backcast unconstrained accounts to the 1970 Census populations. The 1972-73 migrant flows are computed by applying the migration rates of the 1970-71 constrained accounts to the January 1st 1972 adjusted population estimate used as an initial population in the 1972-73 accounts. The 1974-75 migrant flows derive from an application of the 1972-73 accounts derived migration rates to the adjusted January 1st 1974 adjusted estimate population.



M.Y. = MID YEAR P.A.R. = POPULATION AT RISK AVE. POP. = AVERAGE POPULATION

Figure 13. Strategy for producing estimate accounts

(iv) Initial populations are derived from the official time-series published in Soviet statistical releases.

(v) The final populations are also taken from the Soviet statistical series.

This, however, is only the bare bones of the strategy. As is shown on Figure 13 some adjustment must take place in order to develop an accounts series which is as consistent as possible with the trends implied in the gross movements out-lined in section 2. This adjustment is to allow the constraints procedure to function to the best possible effect. At all times in this adjustment procedure we will maintain the initial assumption that the most accurate data for population stocks available is the 1970 Census, and thus will perform each adjustment on the stock furthest from the Census.

This process is shown by the arrows on Figure 13. It begins in the bottom cell of the 1968-69 column. The 1970 Census stocks are brought up to the top cell in the 1970-71 column to become the initial populations for this period. It is necessary to adjust one of the components of this run for the constraint procedure to function, and in keeping with our assumption, we therefore adjust the 1972, final, population, the element in the bottom cell of the 1970-71 column. This is done in the way outlined in section 3.6. The adjusted final populations then become the initial populations for the 1972-73 run, and the official estimate for 1974 is adjusted to make the row constraints. This then becomes the initial population for the final period, and finally we adjust the population for 1976 in order to achieve consistency. Thus, in effect, we are "rolling forward" the constraints procedure to cover the entire 1968 to 1976 period. In this way we will obtain an adjusted time-series which is based on the results of the 1970 All Union Census, which also may remove some of the errors inherent in the official series, and at the same time produce a series of "estimate" accounts which plot the probable course of the populations of the republics of the Soviet Union in the period 1968-76. We have termed these accounts "estimates" as opposed to the "historical" accounts derived for 1968-69, because they are approximations rather than direct counts.

The constraints calculations are summarized in Table 19. The row and column totals represent summary figures for the USSR as a whole. In the first two-year period, 1970-71, the discrepancy of inputs to,

Table 19. The constraint calculations for 1970-71, 1972-73 and 1974-75: a summary table for the USSR

1970-71: initial constraints

	Row totals		Column totals
Initial population	241,720,130[a]	Final population	247,451,000[b]
Births	8,625,671[c]	Deaths	4,023,714[c]
Total	250,345,801	Total	251,474,714
Difference		-1,128,913	

1970-71: adjusted constraints

	Row totals		Column totals
Initial population	241,720,130[a]	Final population	246,322,087[d]
Births	8,625,671[c]	Deaths	4,023,714[c]
Total	250,345,801	Total	250,345,801
Difference		0	

1972-73: initial constraints

	Row totals		Column totals
Initial population	246,322,087[d]	Final population	250,869,000[e]
Births	8,825,555[c]	Deaths	4,287,015[c]
Total	255,147,642	Total	255,156,015
Difference		-8,373	

1972-73: adjusted constraints

	Row totals		Column totals
Initial population	246,322,087[d]	Final population	250,860,627[f]
Births	8,825,555[c]	Deaths	4,287,015[c]
Total	255,147,642	Total	255,147,642
Difference		0	

1974-75: initial constraints

	Row totals		Column totals
Initial population	250,860,627[f]	Final population	255,524,000[g]
Births	9,111,591[c]	Deaths	4,631,759[c]
Total	259,972,218	Total	260,155,759
Difference		-183,541	

Table 19. continued

1974-75: adjusted constraints

	Row totals		Column totals
Initial population	250,860,627[e]	Final population	255,340,459[h]
Births	9,111,591[c]	Deaths	4,631,759[c]
Total	259,972,218	Total	259,972,218
Difference		0	

Notes:

a. The 1970 Census population of the USSR.

b. The January 1st 1972 official estimate of the USSR population.

c. Births and deaths computed from published birth and death rates and official estimate populations.

d. The adjusted estimate for January 1st 1972 = the official estimate plus the difference between row and column initial constraints for 1970-71.

e. The January 1st 1974 official estimate of the USSR population.

f. The adjusted estimate for January 1st 1974 = the official estimate plus the difference between the row and column initial constraints for 1972-73.

g. The January 1st 1976 official estimate of the USSR population.

h. The adjusted estimate for January 1st 1976 = the official estimate plus the difference between the row and column initial constraints for 1974-75.

i. N.B. The constraint adjustment procedure assumes that there is no international migration between the USSR and the rest of the world.

and outputs from the USSR population is 1.129 millions. Clearly, the official Soviet demographers must have neglected in their estimation work to apply this accounting check to their work. Once this discrepancy is remedied the differences between initial row totals and column totals in the accounts for 1972-73 and 1974-75 are much smaller, and within the bounds of tolerable error, given our assumption about no international migration - or at least no net gain or loss from international migration.

We turn now to a brief discussion of the results of the accounts building exercise for 1970-76. The full accounts tables can be found in the Appendix to the paper.

4. Results of the accounts building process

4.1 Introduction

The population accounts for the 1970-71, 1972-73 and 1974-75 periods present a revised picture of population dynamics in the USSR in the six years after the 1970 Census. In this section of the paper the revised picture is described and compared with the official scenario presented in section 2.

4.2 Population change after adjustment

For the constraints procedure to function the sum of the row totals of the accounts matrix must equal the sum of the column totals. In order to meet this condition the final population stocks on January 1st 1972, 1974 and 1976 had to be adjusted. The adjusted republic populations are shown in Table 20. From these populations biennial rates of growth were computed using the formula

$$r^i(t,t+2) = \frac{1000(P^i(t+2) - P^i(t))}{(P^i(t+2) + P^i(t))/2} \qquad (22)$$

The resulting growth rates are given in Table 21. The comparable tables giving the official statistics are Table 1 (population stocks) and Table 5 (rates of change).

Comparison of these two pairs of tables reveals the effect of the adjustments. The adjustments have the effect of reducing the populations of most republics and of lowering the rates of growth. These changes are examined period by period, and then an assessment of trends is made.

In the 1970-71 period the rates have been lowered for all republics, but the relative position of each republic remains the same. The national average growth rate has dropped by 4.5 per thousand.

In the 1972-73 period the republic growth rates have all been raised so that for these two periods at least the adjustments appear to be "smoothing-out" the path of the growth-rates over time, since in the original table this period shows a considerable dip in the growth-rates. While this dip is still present in the adjusted table it is not so marked.

Table 20. Populations of the Soviet republics, 1970-76 (in millions) derived from the constrained accounts

Republic	Date: January 1st in Year			
	1970	1972	1974	1976
RSFSR	130.079	131.170	132.909	143.553
Belorussian SSR	9.002	9.129	9.268	9.364
Ukrainian SSR	47.127	47.829	48.519	49.040
Moldavian SSR	3.569	3.678	3.764	3.847
Estonian SSR	1.356	1.389	1.418	1.437
Latvian SSR	2.364	2.408	2.454	2.495
Lithuanian SSR	3.128	3.204	3.262	3.313
Georgian SSR	4.686	4.791	4.878	4.950
Armenian SSR	2.492	2.623	2.728	2.832
Azerbaydzhan SSR	5.117	5.350	5.514	5.685
Kazakh SSR	13.009	13.530	13.928	14.327
Uzbek SSR	11.799	12.673	13.289	14.069
Kirgiz SSR	2.933	3.096	3.219	3.366
Tadzhik SSR	2.900	3.135	3.283	3.483
Turkmen SSR	2.159	2.317	2.430	2.579
USSR	241.720	246.322	250.861	255.340

Table 21. Rates of change computed using the adjusted populations

Republic	Period		
	1970-71	1972-73	1974-75
RSFSR	8.3	13.2	12.3
Belorussian SSR	14.0	15.1	10.4
Ukrainian SSR	14.8	14.3	10.7
Moldavian SSR	30.2	23.0	21.9
Estonian SSR	23.7	20.9	13.3
Latvian SSR	18.4	18.9	16.7
Lithuanian SSR	24.0	17.8	15.4
Georgian SSR	22.1	18.0	14.8
Armenian SSR	51.3	39.2	37.4
Azerbaydzhan SSR	44.6	30.1	30.6
Kazakh SSR	39.3	29.0	28.3
Uzbek SSR	71.4	47.4	57.0
Kirgiz SSR	54.1	39.0	44.6
Tadzhik SSR	77.9	46.2	59.3
Turkmen SSR	70.8	47.4	59.6
USSR	18.9	18.3	17.7

Notes:

1. Rates are biennial rates per 1000 population.
2. Sources: from the constrained populations given in Table 20.
3. The underlined figures in the 1974-75 column are those which show a fall from the corresponding republic growth rates in the 1972-73 column.

In the original table the 1974-75 period is a time of recovery of growth rates for all republics. However, in the adjusted table this is not the case. The republics, the growth rates of which are underlined, continue to decline in terms of growth rate, whereas the unmarked republics show a recovery of between 0.5 and 13.1 per thousand. All the republics which continue to decline are the low fertility regions of the West, the Baltics, and Transcaucasia, the one exception being Armenia. It is the high-fertility republics of Central Asia which show some recovery, together with Azerbaydzhan. Once more, however, there is an exception, and this is Kazakhstan, which exhibits a continued decline. However, in terms of fertility this republic is low for Central Asia and we consider this to be a funotion of the proportion of ethnic Europeans in the republic, which exceeds 52%. Thus, in terms of population composition this may have more in common with the European republics than the other Central Asian republics, explaining the continued decline in growth rate.

The national average growth rate shows a decline in this period, but the adjustments have had the effect of holding this measure remarkably stable. The variation of growth rate amongst the republics is still, however, of interest, and this topic is discussed next for each period in turn.

4.3 The spatial pattern of growth

The new 1970-71 pattern is shown in Figure 14a. This once more shows the distinctive pattern of low growth at the centre of the system, increasing with distance to the south and to the south-west. An interesting facet of the adjustment is that Georgia now falls in the same group as the Baltic republics. However, generally speaking, the pattern remains the same as in the previous map in section 2 (Figure 6).

The 1972-73 pattern is shown in Figure 14b. The point of most note in this period is that while the general trend is for the rate of growth to decrease, as mentioned in the preceding part of this section, the most marked changes are in the Central Asian republics. These drop at least one class in every case. The only other change is the movement of the RSFSR up one class. The pattern with lower growth in the central and western republics and higher growth in the peripheral areas remains the same.

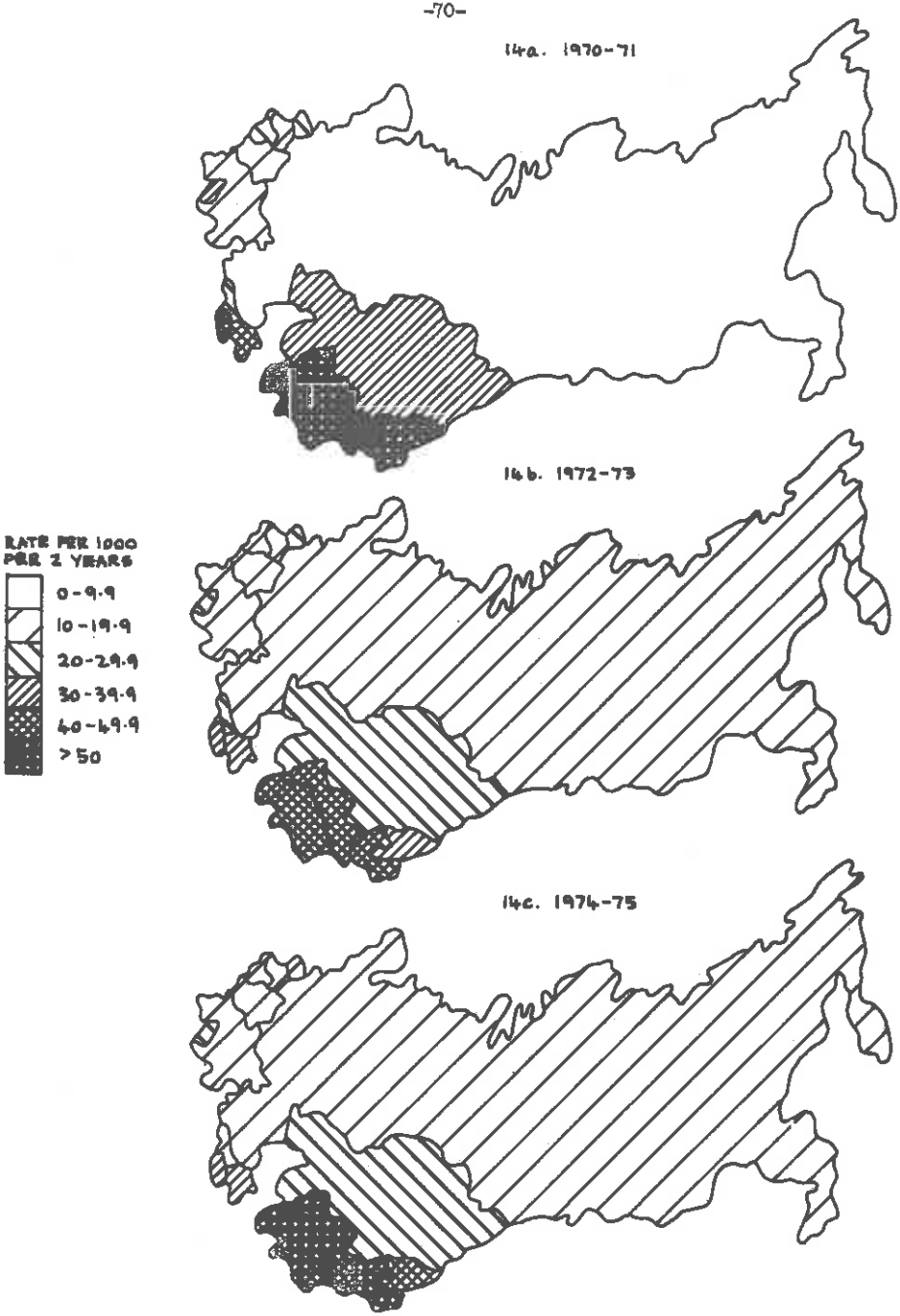


Figure 14. Population growth rates, 1970-71, 1972-73, 1974-75 for Soviet republics derived from the corresponding accounts

The pattern for 1974-75 is shown on Figure 14c. Once more the Western and the Baltic republics show little change, and in fact there seems to be a movement towards homogeneity in these areas. The RSFSR also shows no change. Kazakhstan remains a sort of transitional region, which separates the low-growth central republics from the high-growth peripheral republics of Central Asia. Transcaucasia also appears to become a transition area. The two southern republics have rates of growth much higher than Kazakhstan, but the Georgian growth rate is closer to those of the Central and Western republics. Thus, the general pattern is maintained, and this period even sees a strengthening of the dichotomy between the Central Asian republics and the Western and Central republics.

4.4 Components of growth from the accounts for 1970-71, 1972-73 and 1974-75

4.4.1 The tables

From the accounts tables for the 1970-71, 1972-73 and 1974-75 periods presented in section 3 we can extract the components of growth for the republics in the same periods. These are contained in Table 22, and the derived natural increase and net migration rates are given in Table 23.

4.4.2 Natural increase

There is a general trend for natural increase rates to fall for all republics over the 1970-76 period. They decrease at different rates but the republics maintain their rank order in terms of natural increase.

The maps of natural increase rates (Figure 15) display the distinctive pattern which has been evident throughout this work, a pattern in which the lowest rates are to be found in the Western Republics, the Baltics and the RSFSR. Kazakhstan and Moldavia exhibit rates which are between those of the Western and Central Asian republics, and the Central Asian Republics, especially Uzbekistan, Kirgizia and Turkmenistan, have very high relative rates. In terms of natural increase the republics of Transcaucasia are split between the two groups, Georgia being nearer to the transitional republics of Kazakhstan and Moldavia, and Armenia and Azerbaydzhan being in the high fertility group with the Central Asian republics. It should perhaps be emphasised that the fertility component of natural increase is the one that leads to this pattern since the regional differentials in mortality are minimal.

Table 22. Components of growth from the constrained accounts: 1970-71, 1972-73 and 1974-75 (1000's)

Period Republic	Births	Deaths	Natural increase	In-migrants	Out-migrants	Net migrants	Total change
1970-71							
RSFSR	3,888	2,278	1,610	916	1,435	-520	1,901
Belorussian SSR	296	137	159	125	157	-32	127
Ukrainian SSR	1,456	847	609	641	548	93	702
Moldavian SSR	144	55	89	69	49	20	109
Estonian SSR	44	30	13	38	19	19	33
Latvian SSR	70	53	17	55	28	27	44
Lithuanian SSR	112	55	56	39	19	20	76
Georgian SSR	181	70	112	37	43	-7	105
Armenian SSR	115	26	89	51	9	42	131
Azerbaydzhan SSR	299	69	229	45	41	4	233
Kazakh SSR	626	160	469	481	427	54	521
Uzbek SSR	834	134	700	279	106	173	873
Kirgiz SSR	188	44	144	98	79	19	163
Tadzhik SSR	216	37	180	85	30	55	235
Turkmen SSR	157	30	127	58	27	32	159
USSR	8,626	4,024	4,602	3,018	3,018	0	4,602
1972-73							
RSFSR	4,023	2,409	1,615	1,223	1,098	124	1,739
Belorussian SSR	293	146	148	138	147	-9	139
Ukrainian SSR	1,468	893	575	662	546	116	691
Moldavian SSR	153	59	94	55	63	-8	86
Estonian SSR	43	31	12	38	21	17	29
Latvian SSR	69	56	14	59	27	32	46
Lithuanian SSR	107	59	48	33	24	9	58
Georgian SSR	175	73	103	30	46	-16	87
Armenian SSR	120	28	92	30	17	13	105
Azerbaydzhan SSR	278	71	207	25	69	-44	163
Kazakh SSR	643	176	466	434	503	-69	398
Uzbek SSR	870	163	708	136	228	-92	616
Kirgiz SSR	193	47	146	78	100	-23	123
Tadzhik SSR	228	43	185	36	73	-36	148
Turkmen SSR	162	34	128	34	49	-15	113
USSR	8,826	4,287	4,539	3,013	3,013	0	4,539

Continued .....

Table 22. continued

Period Republic	Births	Deaths	Natural increase	In-migrants	Out-migrants	Net migrants	Total change
1974-75							
RSFSR	4,161	2,582	1,579	1,210	1,144	66	1,645
Belorussian SSR	293	156	137	126	166	-40	97
Ukrainian SSR	1,469	956	512	613	605	8	520
Moldavian SSR	157	69	88	57	62	-5	83
Estonian SSR	43	33	10	33	24	9	19
Latvian SSR	69	59	10	59	28	31	41
Lithuanian SSR	103	61	42	34	25	9	51
Georgian SSR	179	77	102	26	55	-29	73
Armenian SSR	124	30	94	29	19	10	104
Azerbaydzhani SSR	281	77	204	30	63	-33	171
Kazakh SSR	674	196	478	435	513	-79	399
Uzbek SSR	939	192	747	199	166	33	780
Kirgiz SSR	200	52	148	91	92	-1	147
Tadzhik SSR	248	53	195	56	51	5	201
Turkmen SSR	172	38	134	50	35	15	149
USSR	9,112	4,632	4,480	3,047	3,047	0	4,480

Source: computer runs described in the text.

Table 23. Natural increase and net migration rates, by republic 1970-76, derived from the constrained accounts

Republic	1970-71		1972-73		1974-75	
	Natural increase	Net migration	Natural increase	Net migration	Natural increase	Net migration
RSFSR	12.3	-4.0	12.2	0.9	11.8	0.5
Belorussian SSR	17.5	-3.6	16.0	-1.0	14.7	-4.3
Ukrainian SSR	12.8	2.0	11.9	2.4	10.5	0.2
Moldavian SSR	24.6	5.6	25.3	-2.2	23.2	-1.3
Estonian SSR	9.8	13.9	8.5	12.4	6.9	6.4
Latvian SSR	7.0	11.4	5.6	13.3	4.0	12.7
Lithuanian SSR	17.8	6.2	14.9	2.9	12.7	2.7
Georgian SSR	23.6	-1.5	21.2	-3.3	20.7	-5.9
Armenian SSR	34.8	16.5	34.3	4.9	33.8	3.6
Azerbaydzhani SSR	43.8	0.8	38.1	-8.0	36.5	-6.0
Kazakh SSR	35.2	4.1	34.0	-5.0	33.8	-5.6
Uzbek SSR	57.2	14.2	54.5	-7.1	54.6	2.4
Kirgiz SSR	47.8	6.3	46.2	-7.2	44.9	-0.4
Tadzhik SSR	59.5	18.4	57.5	-11.3	57.7	1.6
Turkmen SSR	56.7	14.1	53.9	-6.5	53.4	6.2
USSR	18.9	0.0	18.3	0.0	17.7	0.0

Notes:

1. Rates are per 1000 population per two years.
They are computed by dividing the natural increase and net migration figures for the relevant period from the constrained accounts by the average of the initial and final populations.

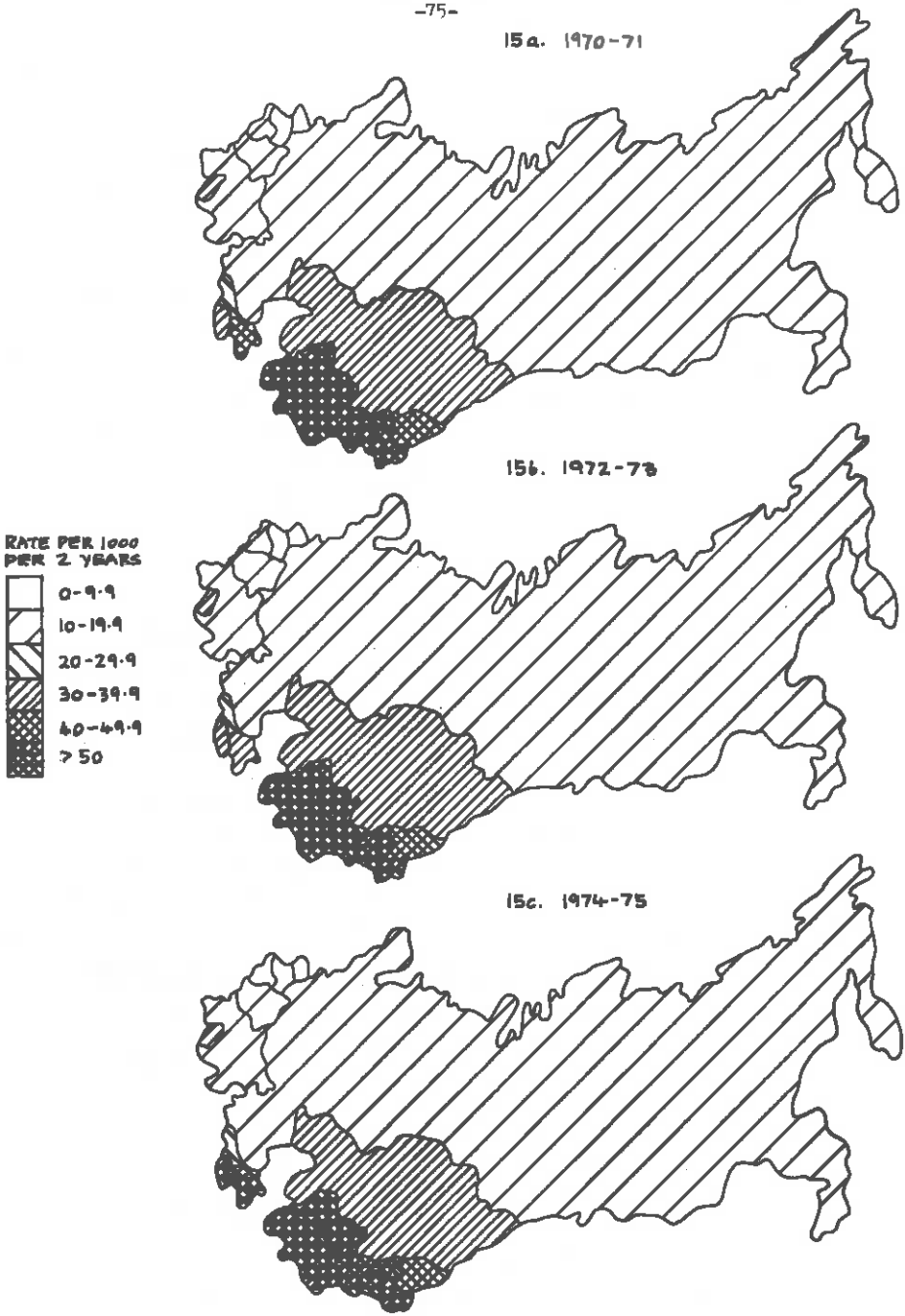


Figure 15. Spatial distribution of natural increase rates

4.4.3 Net migration

The net migration rates for each two year period from 1968-69 through to 1974-75 have been assembled for ready reference in Table 24, and they have been mapped for 1970-76 in Figure 16.

The most striking feature of the time series is the anomalous position of the 1970-71 period for the RSFSR, Moldavia, Azerbaydzhan , Kazakhstan, Uzbekistan, Kirgizia and Tadzhikstan. The sign of the net migration rate differs for those republics from those for all the other periods. We cannot, however, regard this as an aberation from trends with much confidence because of all the methodological difficulties and data inconsistencies involved in assembling the net migration statistics. The discrepancy between inputs and outputs in the 1970-71 period was inexplicably large. Our comments are therefore confined to fairly broad descriptions of the trends and avoid placing undue emphasis on period to period fluctuations.

The RSFSR shows a tendency to diminishing net in-migration over period. Belorussia on the other hand loses through net migration throughout the period. The Ukraine shows slight gains through net migration. Moldavia experiences net outflows. The Baltic republics all show consistent net in-migration, the only republic group to do so. Of the Transcaucasian republics Georgia and Azerbaydzhan exhibit net outflows, while Armenia shows consistent net gains, although these diminish over the period. Kazakhstan, Uzbekistan and Kirgizia all show net losses (except in the 1970-71 period). The Tadzhik SSR and Turkmen SSR show fluctuating patterns of net flows.

4.4.4 The interaction of net migration and natural increase

Webb (1964) has recognized eight divisions of the graph of net migration versus natural increase. However, as in our graph for the 1968-69 period (Figure 9), all the republics fall into three categories (Table 25):

(i) net in-migration exceeds natural increase
(ii) natural increase exceeds net in-migration
(iii) natural increase exceeds net out-migration.

Only two republics, Estonia and Latvia, fall in the first category - these two republics exhibit the lowest rates of natural increase of all the Soviet republics.

Table 24. Net migration rates, best estimates from constrained accounts, 1968-76

Republic	Net migration rates (per 1000 per 2 years)			
	1968-69 CA	1970-71 CA	1972-73 CA	1974-75 CA
RSFSR	2.4	-4.0	0.9	0.5
Belorussian SSR	-0.0	-3.6	-1.0	-4.3
Ukrainian SSR	0.4	2.0	2.4	0.2
Moldavian SSR	-3.2	5.6	-2.2	-1.3
Estonian SSR	28.8	13.9	12.4	6.4
Latvian SSR	20.0	11.4	13.3	12.7
Lithuanian SSR	0.2	6.2	2.9	2.7
Georgian SSR	-20.2	-1.5	-3.3	-5.9
Armenian SSR	39.4	16.5	4.9	3.6
Azerbaydzhan SSR	-10.8	0.8	-8.0	-6.0
Kazakh SSR	-11.8	4.1	-5.0	-5.6
Uzbek SSR	-12.8	14.2	-7.1	2.4
Kirgiz SSR	-15.8	6.3	-7.2	-0.4
Tadzhik SSR	-4.2	18.4	-11.3	1.6
Turkmen SSR	3.4	14.1	-6.5	6.2
USSR	0.0	0.0	0.0	0.0

Source: assembled from Tables 6 and 23.
CA : constrained accounts

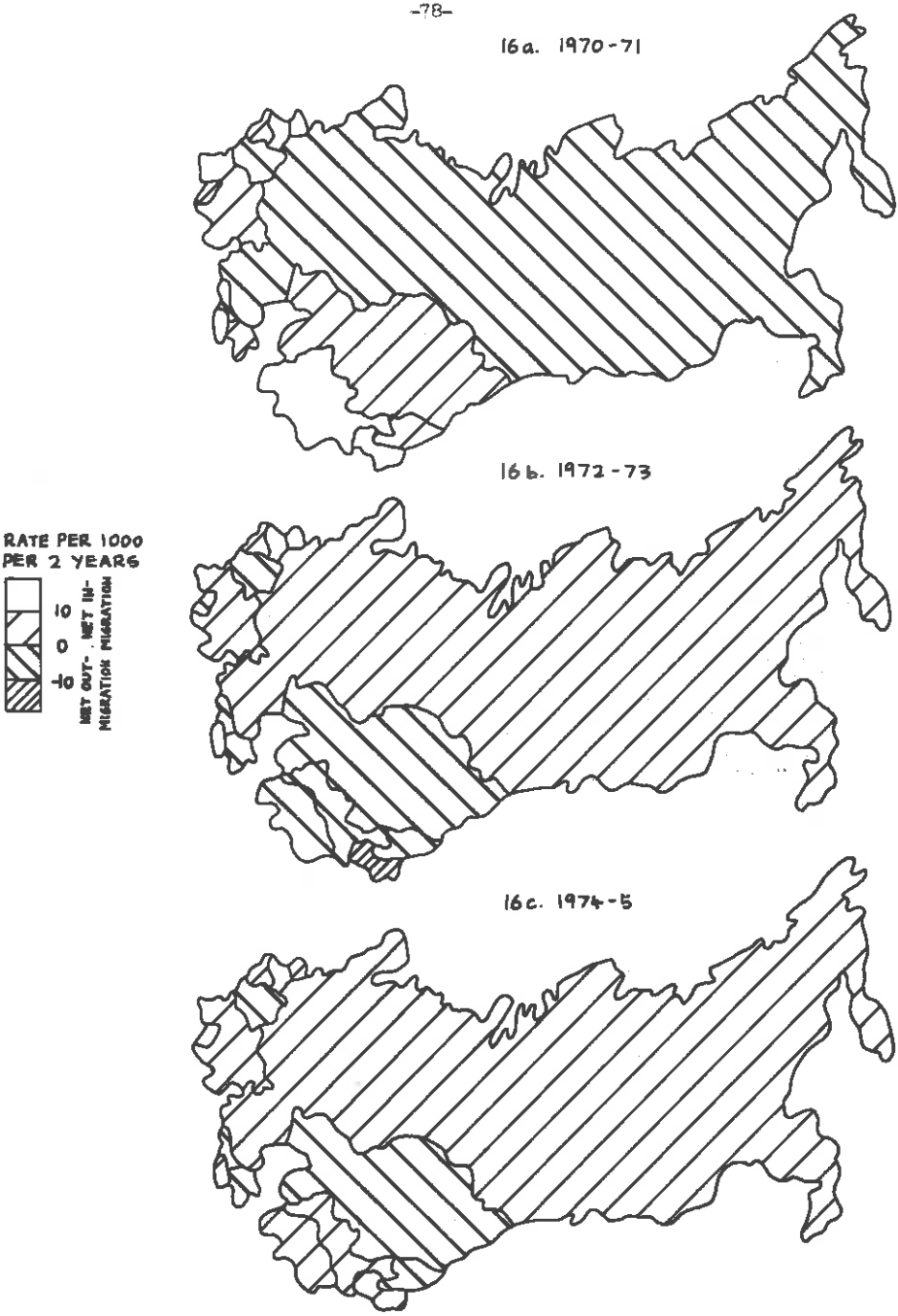


Figure 16. Net migration rates, 1970-76, derived from the constrained accounts for the three periods

Table 25. Net migration and natural change combinations for Soviet republics, 1970-76

	Classification	1970-71	1972-73	1974-75
(i)	Net in-migration exceeds natural increase	Latvian SSR Estonian SSR	Latvian SSR Estonian SSR	Latvian SSR
(ii)	Natural increase exceeds net in-migration	Ukrainian SSR Uzbek SSR Kazakh SSR Azerbaydzhan SSR Lithuanian SSR Moldavian SSR Kirgiz SSR Tadzhik SSR Armenian SSR Turkmen SSR	RSFSR Ukrainian SSR Lithuanian SSR Armenian SSR	RSFSR Ukrainian SSR Uzbek SSR Lithuanian SSR Tadzhik SSR Armenian SSR Turkmen SSR Estonian SSR
(iii)	Natural increase exceeds net out-migration	RSFSR Belorussian SSR Georgian SSR	Belorussian SSR Uzbek SSR Kazakh SSR Georgian SSR Azerbaydzhan SSR Moldavian SSR Kirgiz SSR Tadzhik SSR Turkmen SSR	Belorussian SSR Kazakh SSR Georgian SSR Azerbaydzhan SSR Moldavian SSR Kirgiz SSR

In all other republics natural increase is numerically more important than net migration. The Ukraine, Lithuania and Armenia remain in the second category of the classification - natural increase exceeds net in-migration - through the six years. Two republics, Belorussia and Georgia, remain in the third category - natural increase exceeds net out-migration for the three periods.

The other eight republics move between categories (ii) and (iii). The RSFSR moves from category (iii) in 1970-71 to category (ii) in the next two periods. Uzbekistan, Kazakhstan, Azerbaydzhan and Moldavia move from category (ii) in 1970-71 to category (iii) in 1972-73 and 1974-75, becoming net exporters of population through migration. The remaining three republics, Kirgizia, Tadzhikstan and Turkmenistan move from category (ii) in 1970-71 to category (iii) in 1972-73 and back again to category (ii) in 1974-75, reflecting a fluctuating pattern of net migration over time.

5. Conclusions

5.1 Methodology

When we embarked upon this paper we thought that it would represent the straightforward application of a well developed methodology to the population system of the USSR. Nothing could be simpler. How wrong we were.

The investigation has revealed:

(1) inconsistency in the published 1970 Census migration tables - no emigrant figures given - and misinterpretation of the net balances by some previous authors;

(2) inconsistency in the official population estimate series - the initial population accounts do not match the estimates, particularly in 1970-71;

(3) several possibilities for resolving the inconsistency in the 1968-69 period, and a method of testing the efficacy of each way of constructing population accounts for the period.

There must, therefore, remain some doubt about the exact levels of population in Soviet republics between the 1959, 1970 and 1979 censuses. A range of population values for the RSFSR, USSR and rest of USSR have been assembled in Table 26 to illustrate this point. The most probable values for the three populations are those in the constrained accounts row. By 1976 these are close again to the official estimates after their radical departure in 1970-71. The middle row of figures refer to our preferred test run "pseudo-projections" (those for the backcast unconstrained row) which overshoot the official estimates and adjusted estimates for the RSFSR and undershoot for the rest of the USSR. These "overshoots" and "undershoots" represent the error introduced through a lack of precise figures on inter-republic migration between the censuses. The official estimates and adjusted estimates embody information on the estimated migration pattern for 1970-76, but this was inaccessible to us directly. The constrained accounts tables contain our best estimate of what the inter-republic migration might have been, taking into account both the 1968-69 detailed migration information and the "migration information" locked away in the 1972-76 population estimates.

Table 26. A comparison of the populations of the RSFSR, USSR and rest of the USSR derived by alternative accounting methods

Republic Source	1968	1970	1972	1974	1976
RSFSR					
OE	127.911	130.079	131.771	132.913	134.650
BC & BCUT	128.143	130.079	131.877	133.701	135.511
CA	127.911	130.079	131.170	132.909	134.553
USSR					
OE	236.689	241.720	247.451	250.869	255.524
BC & BCUT	237.311	247.720	246.299	250.803	255.251
CA	236.689	241.720	246.322	250.861	255.340
Rest of USSR					
OE	108.778	111.641	115.680	117.956	120.874
BC & BCUT	109.168	111.641	114.422	117.102	119.740
CA	108.778	111.641	115.152	117.952	120.787

Notes:

OE = official estimates

BC & BCUT = backcast population for 1968 and backcast unconstrained test run for 1972-1976

CA = constrained accounts

Rest of USSR figures obtained as a residual (USSR population - RSFSR population)

One broad lesson we would draw from our analysis is that insufficient attention has been paid by Western commentators and by Soviet official statisticians to the methodology for population estimation. We hope this paper stimulates such attention if only so our mistakes can be pointed out.

5.2 A summary of migration patterns

Despite all the difficulties of methodology and data, what can be said about the likely way in which migration patterns evolved in the Soviet Union in 1968-76? Table 27 draws together net migration estimates for various periods between 1959 and 1976 from other parts of the paper, and juxtaposes them in comparable two year flow terms.

The figures suggest that the late 1960s saw a fundamental change in Soviet migration patterns from one of a transfer from the RSFSR to the Central Asian republics, to a reverse flow. Failure to recognize that this had occurred may have caused official Soviet statisticians to overestimate the populations of the Central Asian republics and underestimate the population of the RSFSR. This is what the anomalous figures for 1970-71 suggest. Perhaps, instead of distributing the initial accounts error of 1.129 millions evenly among all 15 republics we should simply have reduced the Central Asian republics only.

5.3 Criticisms and possible improvements

In many respects the analysis presented here has its drawbacks. It is useful to detail these as an aid to further research and improvement in methodology.

(1) The assumption of zero external migration is clearly in error, and it would be valuable to include such external migration figures in the analysis. Satisfactory data have not as yet come to hand. We would welcome such a supply.

(2) The Soviets do publish migration data for republics, and for rural-urban flows, for calendar years between censuses (Vestnik Statistiki, various years), but we have yet to resolve the inconsistencies in these tables. For example, the number of out-migrants from republic A to republic B does not appear to equal the number of in-migrants from republic A to republic B. We would welcome rebuttal on this point.

Table 27. Net migration estimates, 1959-76 (1000's)

Republic	Period					
	1959-69[a]	1959-67[b]	1968-69[c]	1970-71[d]	1972-73[d]	1974-75[d]
RSFSR	-310	-448	313	-520	124	66
Belorussian SSR	-52	-64	-0	-32	-9	-40
Ukrainian SSR	84	99	16	93	116	8
Moldavian SSR	12	17	-11	20	-8	-5
Estonian SSR	17	12	38	19	17	9
Latvian SSR	28	24	46	27	32	31
Lithuanian SSR	9	11	0	20	9	9
Georgian SSR	-17	1	-95	-7	-16	-29
Armenian SSR	27	12	91	42	13	10
Azerbaydzhani SSR	-11	-1	-54	4	-44	-33
Kazakh SSR	125	186	-150	54	-69	-79
Uzbek SSR	65	112	-145	173	-92	33
Kirgiz SSR	13	26	-45	19	-23	-1
Tadzhik SSR	13	18	-12	55	-36	5
Turkmen SSR	7	7	7	32	-15	15
USSR	10	12	-10	0	0	0

Sources:

a. From Table 7 in this paper. Originally from Shabad (1977), p.185. The figures have been multiplied by 2/11 to reduce them to two year equivalents.

b. The residual from subtracting 1968-69 figures from those for 1959-69. The figures have been multiplied by 2/9 to reduce them to two year equivalents.

c. From Table 6 in this paper.

d. From Table 22 in this paper.

(3) The level of spatial resolution adopted is somewhat unsatisfactory. The RSFSR and Ukraine, in particular, need to be broken down into their constituent economic regions so that a more detailed picture of the spatial dynamics of population in the USSR could be drawn. Having carried out an analysis at the 15 republic level we are now in a much better position to carry out a 26 zone analysis (10 economic regions in the USSR; 3 in the Ukraine; plus the other 13 republics). The data are available for an extension of this analysis.

(4) The level of population category resolution adopted (that is, the aggregate or whole population) is also unsatisfactory in many respects, particularly at the projection stage of our analysis, planned for Part 2 of this paper. However, the necessary age-sex disaggregated migrant data are not published, though unpublished data is, we believe, in principle available. It may prove possible to combine age-sex disaggregated projections on a republic by republic basis with multiregional projections on an aggregate basis following suggestions by Rogers (1976). The former analysis would capture the growth potential inherent in the youthful population pyramids that characterize many Soviet republics; the latter analysis would ensure the correct distribution of the natural increase generated population among republics.

(5) Finally, it will be necessary to revise the analysis to take account of the January 1979 Census, preliminary results of which are now becoming available. Firm net migrant numbers for 1970-79 can be computed (as in Shabad, 1979) using the 1970 Census and 1979 Census populations as constraints, but the development of population accounts for 1976-79 will require care.

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Appendix A.1 The backcast unconstrained accounts for 1968–69

Parent stock / Offspring stock	SURVIVAL JANUARY 1ST, 1970														DEATH IN 1968–69										TOTALS
	Rs	Be	Ua	No	Es	La	Li	Ge	Ar	Az	Ka	Uz	Kc	Ta	Tu	Rs	Be	Ua	No	Es	La	Li	Ge	Ar	Az	Ka	Uz	Kc	Ta	Tu	
EXISTENCE JANUARY 1ST, 1968 — Rs	188,931,986	79,491	419,660	23,127	21,141	22,287	14,277	11,461	5,085	13,235	262,200	64,218	76,244	15,351	14,121	1,691,591	977	3,493	166	233	245	122	84	26	92	1,699	383	269	119	100	128,148,348
Be	85,005	8,581,448	12,240	996	1,404	6,688	3,014	703	151	953	9,539	1,170	316	321	465	707	126,032	185	7	15	73	34	5	1	4	67	7	2	2	3	8,842,147
Ua	427,230	23,689	48,350,520	15,853	4,406	6,267	2,409	2,468	1,277	2,357	49,700	7,036	2,049	1,866	3,234	3,558	172	39,739	131	48	69	31	25	7	16	283	42	15	12	23	46,486,653
No	20,916	861	13,090	3,282,894	242	808	330	463	141	179	7,623	234	175	101	635	250	6	151	43,109	2	9	3	3	1	1	45	2	1	1	4	3,329,088
Es	18,904	787	2,766	123	4,289,882	1,032	458	57	49	81	696	160	72	100	12	112	5	23	1	23,554	12	4	0	0	1	4	1	1	1	0	2,335,507
La	19,179	2,827	3,974	216	1,138	3,290,187	2,967	132	86	185	1,049	229	100	58	70	160	18	29	2	13	50,017	22	1	0	1	6	2	1	0	0	3,079,037
Li	15,392	1,846	2,161	184	305	3,237	2,992,856	71	16	73	1,321	275	71	60	40	128	13	19	1	4	35	54,936	1	0	1	8	2	1	0	0	4,614,372
Ge	73,773	669	8,556	913	260	353	165	4,904,916	5,900	8,944	3,444	572	250	176	226	281	5	70	2	3	4	1	66,113	10	20	20	6	2	1	2	2,403,287
Ar	10,315	264	2,022	96	64	92	36	1,070	2,358,126	4,006	1,434	712	180	158	231	86	2	17	1	1	1	0	3	24,302	28	9	4	1	1	2	4,906,780
Az	31,697	1,018	6,656	331	224	368	124	1,549	6,494	4,396,827	4,496	1,287	100	205	4,002	264	7	55	2	2	4	1	11	33	65,615	27	8	1	1	7	12,229,823
Ka	208,366	18,700	65,711	4,617	2,524	2,495	1,581	1,097	588	4,397	17,328,578	13,915	21,263	3,511	2,712	2,482	136	547	33	28	27	14	8	3	10	148,165	119	158	22	19	11,239,382
Uz	108,537	2,678	13,419	680	1,170	613	292	895	580	723	44,334	10,004,779	3,999	9,824	6,813	901	19	153	5	13	7	3	4	3	5	263	131,635	67	61	44	2,813,573
Kc	49,607	619	6,194	172	345	282	80	92	44	344	24,208	3,395	2,685,178	1,497	786	365	4	43	1	9	3	1	1	0	2	144	56	40,534	9	6	2,752,654
Ta	23,600	545	4,706	490	1,395	181	85	80	92	113	6,012	2,355	1,776	2,623,889	1,040	246	4	39	4	15	2	1	1	0	1	86	56	13	33,497	7	2,052,987
Tu	21,717	355	3,622	287	32	145	76	228	238	338	7,807	5,108	650	594	1,687,486	181	6	30	2	0	2	1	2	1	2	47	30	5	4	28,206	2,054,893
BIRTH IN 1968–69 — Rs	5,811,998	1,134	5,987	330	302	319	202	164	73	190	3,741	916	517	242	203	24,10	4	25	1	2	2	1	1	0	1	11	3	2	1	1	288,382
Be	1,386	284,115	263	16	23	109	64	11	2	9	186	19	5	6	8	6	2,071	2	0	0	1	0	0	0	0	0	0	2	0	0	1,733,534
Ua	6,265	383	1,361,286	272	66	93	64	52	19	35	710	105	30	28	48	26	1	14,387	1	0	1	0	0	0	0	0	0	0	0	0	137,518
No	591	17	152	135,383	4	16	7	9	3	4	80	6	3	2	13	2	0	1	975	0	0	0	0	0	0	0	0	0	0	0	40,347
Es	204	11	42	2	79,622	16	7	1	1	1	10	2	1	2	0	1	0	0	0	439	0	0	0	0	0	0	0	0	0	0	65,417
La	269	35	49	3	16	60,573	36	2	1	2	15	5	1	1	1	1	0	0	0	0	0	767	0	0	0	0	0	0	0	0	108,770
Li	273	35	40	5	6	57	107,401	1	0	1	25	5	1	1	1	1	0	0	0	0	0	0	924	0	0	0	0	0	0	0	177,293
Ge	649	18	161	6	5	7	3	174,390	115	87	66	19	5	3	4	3	0	1	0	0	0	0	0	1,279	0	0	0	0	0	0	123,495
Ar	244	6	48	2	2	2	1	25	112,827	35	34	17	4	4		1	0	0	0	0	0	0	0	578	0	0	0	0	0	0	309,651
Az	1,000	32	210	10	7	12	4	49	205	205,777	142	41	3	6	22	4	0	2	0	0	0	0	0	1	2,115	0	0	0	0	0	601,228
Ka	6,992	438	1,540	109	59	58	37	26	14	33	577,252	467	498	82	64	89	2	6	0	0	0	0	0	0	0	3,513	1	2	0	0	785,719
Uz	3,787	94	644	24	41	21	10	19	19	25	1,550	772,945	315	345	237	15	0	3	0	0	0	0	0	0	0	5	4,636	1	1	1	176,864
Kc	1,771	19	163	5	27	9	3	3	1	11	761	295	172,829	47	25	6	0	1	0	0	0	0	0	0	0	2	1	1,250	0	0	208,017
Ta	1,092	20	174	18	81	7	3	3	3	4	211	245	65	148,918	32	5	0	1	0	0	0	0	0	0	0	1	1	0	0	1,080	147,211
Tu	719	31	130	11	1	5	3	8	8	13	232	183	23	21	149,486	3	0	1	0	0	0	0	0	0	0	1	1	0	0	1,080	245,526,253
TOTALS	1,888,112	9,200,298	67,116,209	9,582,103	4,332,893	3,304,125	3,183,138	4,686,548	2,401,231	4,617,092	13,849,166	4,789,236	3,201,738	2,981,187	2,153,186	2,177,475	139,094	776,042	50,444	25,280	51,231	57,999	61,597	24,092	68,915	159,284	137,400	42,416	24,973	29,495	

Appendix A.2 The backcast constrained accounts for 1968-69

Real Sector / Institutional Sector	SURVIVAL JANUARY 1ST, 1970														DEATH IN 1968-69												TOTALS
	Rs	Be	Un	Ho	Es	La	Li	Ge	Ar	Pe	Ko	Ur	Ki	Te	Tu	Rs	Be	Un	Ho	Es	La	Li	Ge	Ar	Pe	Ko	Ur	Ki	Te	Tu	
EXISTENCE JANUARY 1ST, 1968	Rs	115,11,884	76,675	466,752	24,222	20,567	01,286	13,932	11,269	4,997	13,842	194,503	51,536	32,724	16,777	13,193	2,206,256	557	3,386	159	226	239	120	83	25	50	1,171	306	243	104	52	128,114,406
	Be	38,193	3,578,445	22,365	992	1,412	6,718	3,987	717	153	561	7,335	970	256	361	445	732	124,013	186	7	15	74	35	5	1	4	44	6	2	2	3	8,240,139
	Un	441,673	23,584	45,453,341	18,895	4,414	6,721	3,459	3,518	1,289	2,372	26,506	5,805	1,903	1,762	3,084	3,670	171	760,644	130	49	70	31	25	7	16	220	25	14	11	22	46,476,272
	Ho	31,250	804	13,250	3,382,409	214	122	385	474	144	182	5,886	236	104	96	611	260	6	152	49,106	2	9	3	3	1	1	35	2	1	1	4	3,491,617
	Es	13,821	703	2,752	127	1,230,594	1,060	464	58	44	32	494	132	67	94	31	115	5	23	1	28,569	12	4	0	0	1	3	1	1	1	6	1,328,789
	La	19,634	2,495	3,444	212	1,130	2,153,401	2,080	133	56	185	796	260	92	51	66	164	18	28	2	13	59,010	22	1	0	1	5	2	1	1	0	2,334,883
	Li	15,677	1,812	2,230	121	341	3,620	2,155,339	71	16	73	997	224	65	56	38	120	13	19	1	4	35	37,132	1	0	1	6	2	1	0	0	3,069,340
	Ge	34,382	656	5,238	306	257	356	125	4,439,633	5,870	2,329	2,593	791	239	127	218	286	5	69	2	3	4	1	66,109	30	20	15	5	2	1	2	4,613,310
	Ar	10,514	260	2,004	94	64	92	36	1,080	2,357,892	4,006	1,082	582	166	148	218	88	2	17	1	1	1	0	1	24,303	28	7	3	1	1	2	2,402,762
	Pe	32,441	1,004	6,597	325	222	358	125	1,567	6,496	4,783,804	3,406	1,052	92	192	947	270	7	55	2	2	4	1	11	33	66,613	21	7	1	1	7	4,905,663
	Ko	398,046	26,093	84,895	5,939	3,261	3,199	2,071	1,433	780	1,821	12,092,600	21,239	25,576	4,123	3,341	3,308	175	797	42	76	35	18	10	4	13	148,618	126	190	27	23	12,826,123
	Ur	135,182	3,220	22,257	815	1,416	747	358	680	659	382	41,002	8,980,572	10,124	11,278	7,159	1,124	23	135	6	16	9	4	5	4	6	247	131,749	75	70	51	11,280,125
	Ki	48,366	66	5,879	183	909	306	87	100	48	373	19,901	3,330	2,484,535	1,518	905	402	4	46	1	10	3	1	1	0	2	720	50	40,570	9	6	2,812,927
	Te	32,389	524	4,382	214	1,478	193	84	86	98	121	4,871	2,172	1,750	2,661,183	1,080	249	4	41	4	16	2	1	1	0	1	30	49	12	33,494	7	2,752,028
	Tu	28,521	892	3,809	319	34	153	81	263	232	379	6,947	4,420	635	559	1,082,975	196	6	31	2	0	2	1	2	1	2	38	26	5	4	23,884	2,052,522
BIRTH IN 1968-69	Rs	3,613,231	1,093	8,802	387	293	312	159	161	71	186	2,775	732	467	240	198	30,085	4	24	1	2	2	1	1		1	8	2	2	1	1	3,656,501
	Be	1,439	284,187	365	16	23	110	65	11	2	9	120	16	5	6	8	6	2,671	2	0	0	1	0	0		0	0	0	0	0	0	298,382
	Un	6,574	351	1,363,868	270	66	94	55	53	19	35	543	87	28	26	46	27	1	11,385	1	0	1	0	0		0	2	0	0	0	0	1,383,536
	Ho	416	17	357	135,367	4	16	7	9	3	4	116	5	3	2	13	2	0	1	915	0	0	0	0		0	0	0	0	0	0	137,579
	Es	210	11	42	2	39,615	16	7	1	1	1	8	2	1	2	0	1	0	1	0	458	0	0	0		0	0	0	0	0	0	40,366
	La	278	35	49	3	16	64,221	36	2	1	2	11	4	1	1	1	1	0	0	0	0	767	0	0		0	0	1	0	0	0	65,416
	Li	278	32	39	2	6	87	101,406	1	0	1	17	4	1	1	1	1	0	0	0	0	0	924	0		0	0	0	0	0	0	103,771
	Ge	661	13	169	6	5	7	3	174,911	112	57	39	15	5	3	4	3	0	1	0	0	0	0	1,219		0	0	0	0	0	0	177,294
	Ar	250	6	48	2	2	2	1	25	112,635	95	26	14	4	4	5	1	0	0	0	0	0	0	0	578	0	0	0	0	0	0	113,698
	Pe	1,023	32	208	10	7	12	4	49	325	285,800	108	34	3	6	30	4	0	1	0	0	0	0	0		2,116	0	0	0	0	0	309,653
	Ko	9,392	566	2,001	140	77	76	49	34	18	43	583,960	501	602	101	79	39	3	8	0	0	0	0	0		0	3,946	1	2	0	0	601,223
	Ur	4,711	112	776	29	50	26	12	23	23	21	1,423	772,845	393	393	249	20	0	4	0	0	0	0	0		0	5	4,426	1	1	1	785,720
	Ki	1,621	20	175	5	29	18	3	3	1	12	626	251	172,823	48	26	7	0	1	0	0	0	0	0		0	2	1	1,291	0	0	176,265
	Te	1,194	31	184	19	64	7	3	3	3	4	180	301	65	199,685	38	5	0	1	0	0	0	0	0		0	1	1	0	1,246	0	203,015
	Tu	844	32	136	11	1	5	3	9	8	14	223	158	22	21	144,680	3	0	1	0	0	0	0	0		0	1	1	0	0	1,020	147,201
TOTALS		10,175,321	9,402,118	47,148,616	1,782,172	1,858,988	2,160,116	2,213,214	4,628,958	2,488,578	17,982	11,088,782	11,776,825	2,722,605	2,870,863	1,856,881	2,127,478	129,488	776,043	59,443	29,382	57,210	82,299	67,595		68,816	154,205	37,001	42,416	34,974	29,445	285,506,478

Appendix A.3 The "best-fit" accounts for 1970-71

Initial State	Rs	Be	Wa	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	TOTALS
EXISTENCE JANUARY 1ST, 1970																
Rs	726,488,816	79,452	469,833	24,592	25,092	29,116	21,210	22,655	18,573	28,477	238,175	172,559	57,763	53,069	33,256	130,079,212
Be	87,644	8,715,583	26,411	1,521	4,694	2,342	5,954	1,419	539	1,200	11,537	3,195	511	1,124	1,110	8,002,340
Wa	376,163	20,585	45,782,409	13,272	4,540	7,013	4,101	5,960	4,006	4,372	53,465	16,436	2,338	4,689	6,593	47,126,516
Mo	20,804	592	14,021	2,467,993	173	723	391	629	352	263	6,762	524	192	201	1,010	2,568,873
Es	11,674	608	2,778	165	1,387,977	1,177	590	97	128	149	717	369	53	249	24	1,356,079
La	15,114	1,970	3,162	232	1,052	2,484,368	2,935	209	160	252	1,065	689	124	125	128	2,364,130
Li	10,689	1,859	1,891	126	230	2,872	3,085,015	95	39	106	1,163	506	77	118	64	3,128,233
Ge	17,616	395	5,027	241	159	240	128	4,575,467	11,047	3,239	2,230	1,346	205	203	274	4,686,360
Ar	2,993	76	677	41	22	34	15	610	2,458,616	2,459	531	649	82	131	165	2,491,869
Az	15,727	499	3,857	248	181	223	91	1,502	1,586	5,008,852	2,140	1,696	78	291	1,152	5,117,032
Ka	238,116	19,733	60,485	5,457	2,359	2,519	1,366	1,710	1,172	2,253	12,439,031	41,224	12,711	8,013	5,015	13,008,725
Uz	43,257	1,056	8,483	400	598	314	173	453	773	609	24,261	1,588,682	5,656	11,286	5,749	1,799,428
Ki	29,028	447	3,865	169	660	241	78	120	185	484	20,528	15,616	2,814,229	2,951	1,212	2,932,204
Ta	11,021	200	2,021	289	608	87	49	58	183	89	2,983	9,349	1,041	2,836,682	897	2,889,604
Tu	9,944	227	1,818	207	17	85	52	284	253	346	4,645	6,212	469	782	2,108,911	2,153,879
BIRTH IN 1970-71																
Rs	3,933,682	1,189	7,332	517	376	436	317	340	280	425	5,062	2,582	864	794	500	3,388,473
Be	1,440	291,459	495	25	23	146	99	24	11	19	206	54	8	17	19	294,224
Wa	5,310	318	1,434,984	366	70	109	72	92	62	68	826	253	44	72	102	1,456,170
Mo	420	12	292	141,190	3	15	8	13	7	6	136	11	4	4	20	143,824
Es	189	10	45	3	42,957	19	10	2	3	2	12	7	1	5	0	43,744
La	234	29	47	3	16	68,660	44	3	3	3	16	10	1	2	2	69,234
Li	190	23	32	2	5	51	110,803	1	0	1	21	9	1	2	2	111,711
Ge	340	7	97	5	3	5	2	179,190	218	63	44	26	4	4	5	181,419
Ar	69	2	15	1	1	1	0	14	113,812	57	12	15	2	3	3	114,586
Az	458	15	111	7	4	7	3	44	339	295,375	83	49	2	8	13	296,502
Ka	5,725	354	1,454	131	57	61	45	41	42	56	642,750	1,014	642	193	120	651,445
Uz	1,521	37	258	14	19	11	6	16	27	22	793	815,935	199	377	203	814,034
Ki	926	13	127	6	21	7	3	4	2	15	655	529	183,344	91	38	187,629
Ta	409	7	75	10	23	3	2	2	5	3	106	343	39	213,894	33	216,237
Tu	359	14	69	8	1	3	2	8	12	13	167	226	17	67	156,850	156,815
TOTALS	1,319,839	9,129,161	41,827,326	3,908,195	1,788,658	2,467,944	3,304,814	4,791,643	2,682,870	5,388,879	13,580,891	12,572,917	3,095,811	3,116,434	2,347,378	250,345,201

Initial State	Rs	Be	Wa	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	TOTALS
DEATH IN 1970-71																
Rs	2,235,823	604	4,387	261	278	326	185	167	92	188	2,037	941	417	322	223	130,079,212
Be	767	134,048	236	12	19	98	52	10	4	8	76	18	3	6	7	8,002,340
Wa	3,209	156	923,517	179	51	79	41	44	22	29	323	91	20	29	44	47,126,516
Mo	193	5	130	53,250	2	8	3	5	2	1	41	4	1	2	6	2,568,873
Es	102	4	25	1	28,368	13	5	0	0	2	4	2	1	2	0	1,356,079
La	133	15	29	2	12	27,721	26	2	0	2	6	4	1	0	0	2,364,130
Li	93	9	16	1	3	32	53,918	1	0	0	7	4	1	0	0	3,128,233
Ge	155	3	45	2	2	3	1	68,223	55	22	19	7	2	1	2	4,686,360
Ar	26	1	6	0	0	0	0	4	24,817	16	3	3	0	1	1	2,491,869
Az	138	4	34	2	2	2	1	11	57	66,990	17	5	1	1	3	5,117,032
Ka	2,088	112	541	42	26	29	16	12	8	15	152,427	230	193	45	34	13,008,725
Uz	379	3	76	3	6	3	2	3	4	4	176	127,467	41	68	38	1,799,428
Ki	255	3	36	1	7	2	1	1	0	3	124	90	41,470	18	9	2,932,204
Ta	97	1	18	2	7	1	1	1	0	1	17	51	8	34,785	6	2,889,604
Tu	87	3	17	1	0	1	1	2	2	3	28	34	3	5	28,480	2,153,879
Rs	23,692	5	32	1	2	3	1	2	0	2	15	8	3	3	2	3,388,473
Be	6	2,115	2	0	0	1	0	0	0	0	0	0	0	0	0	294,224
Wa	25	1	12,892	1	0	1	0	0	0	2	0	0	0	0	0	1,456,170
Mo	2	0	2	1,079	0	0	0	0	0	0	0	0	0	0	0	143,824
Es	1	0	0	0	478	0	0	0	0	0	0	0	0	0	0	43,744
La	1	0	0	0	0	770	0	0	0	0	0	0	0	0	0	69,234
Li	1	0	0	0	0	0	967	0	0	0	0	0	0	0	0	111,711
Ge	2	0	1	0	0	0	0	1,328	0	0	0	0	0	0	0	181,419
Ar	0	0	0	0	0	0	0	0	571	0	0	0	0	0	0	114,586
Az	2	0	1	0	0	0	0	0	0	1,962	0	0	0	0	0	298,502
Ka	25	2	6	0	0	0	0	0	0	0	3,723	2	2	0	0	626,445
Uz	7	0	1	0	0	0	0	0	0	0	2	4,523	1	1	1	814,034
Ki	4	0	1	0	0	0	0	0	0	0	2	2	1,335	0	0	187,629
Ta	2	0	0	0	1	0	0	0	0	0	0	0	1	1,300	0	216,237
Tu	2	0	0	0	0	0	0	0	0	0	0	1	1	0	1,037	156,815
TOTALS	2,239,897	137,269	947,051	54,140	30,263	53,092	55,221	69,821	25,634	69,248	159,605	133,692	43,837	36,593	29,838	250,345,201

Appendix A.4 The "best-fit" accounts for 1972-73

FINAL STATE / INITIAL STATE		SURVIVAL JANUARY 1ST, 1974														DEATH IN 1972-73										TOTALS
		Rs	Be	UK	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	Rs	Be	UK	Mo	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	
EXISTENCE JANUARY 1ST, 1972	Rs	127,726,416	80,487	461,344	25,682	22,417	23,961	17,028	14,254	7,658	13,316	262,067	65,992	36,578	17,272	14,807	2,261,231	640	4,101	201	250	333	156	123	39	87	1,690	435	280	118	108	131, 169, 841
	Be	83,130	2,841,135	99,966	1,105	1,517	2,116	4,799	1,633	223	663	3,715	1,210	323	366	484	311	142,286	233	9	17	101	44	8	1	4	62	8	3	3	4	9,129, 162
	UK	409,125	22,448	6,418,257	8,594	4,767	7,539	4,954	4,617	1,766	2,201	44,601	7,074	1,955	1,643	3,150	3,796	175	373,706	148	48	97	37	36	5	14	228	45	15	11	23	47,828,799
	Mo	29,748	344	13,273	3,559,913	217	1,012	442	645	202	173	7,375	295	173	92	681	272	7	179	57,259	2	12	4	5	1	1	48	2	1	0	4	3,678, 142
	Es	12,617	706	3,000	133	1,287,205	1,340	542	81	64	80	636	169	72	93	12	124	6	28	1	30,195	16	4	1	0	1	4	1	1	1	0	1,388,636
	La	16,682	1,006	3,056	189	965	2,327,280	2,464	153	67	124	838	282	91	42	58	144	16	28	1	11	54,103	23	1	6	1	5	2	1	0	0	2,437,963
	Li	13,687	1,526	2,145	117	518	3,641	3,123,917	88	20	65	1,148	257	63	49	96	125	13	20	1	3	42	57,392	1	6	1	8	2	1	0	0	3,208,315
	Ge	24,972	490	6,666	246	260	234	144	4,634,273	6,308	2,123	2,488	754	184	93	179	228	4	62	2	2	4	1	71,196	33	14	16	6	2	0	1	4,791,039
	Ar	7,820	193	1,648	77	50	88	31	1,147	2,589,643	2,360	1,062	526	135	110	177	72	2	16	0	0	0	0	9	27,112	20	8	4	2	1	1	2,622,380
	Az	35,257	1,125	7,994	393	260	606	162	2,437	10,473	5,234,508	4,898	1,309	112	211	1,138	324	9	74	3	4	6	2	19	65	68,816	32	9	1	1	5	5,150,477
	Ka	221,618	19,340	76,206	5,320	2,816	3,348	2,092	1,666	931	1,470	12,820,154	22,515	32,844	3,484	2,974	2,393	158	710	42	31	38	15	12	5	10	169,294	142	173	24	21	13,529,990
	Uz	116,433	2,847	21,295	778	1,204	831	370	890	827	758	46,542	12,205,488	9,638	9,778	6,794	1,066	23	199	5	16	10	4	7	4	5	300	152,353	74	67	49	12,672,920
	Ki	48,157	877	6,468	202	968	393	102	144	70	271	26,103	10,894	2,252,887	1,582	882	440	5	57	1	11	5	1	1	0	2	168	69	45,452	10	6	3,095,813
	Ta	26,539	664	6,230	694	1,783	294	129	139	114	136	7,149	12,126	2,184	3,923,881	1,306	133	6	57	4	19	3	0	0	1	1	47	76	16	41,679	10	3,134,633
	Tu	24,098	939	4,335	362	26	202	100	356	384	287	2,672	5,963	713	586	2,253,488	120	7	40	3	0	2	2	3	2	2	56	37	6	4	32,857	2,317,378
BIRTH IN 1972-73	Rs	2,970,246	1,233	7,078	386	343	443	241	249	116	209	4,614	1,057	566	265	227	35,927	5	33	1	2	3	1	1	0	0	13	3	2	1	1	4,023,197
	Be	1,462	252,559	401	18	25	141	77	17	4	9	156	21	5	6	8	7	2,102	2	0	0	1	0	0	0	0	1	0	0	0	0	283,182
	UK	6,232	345	1,446,121	286	67	116	62	72	27	34	485	109	30	25	48	29	1	13,506	1	0	1	0	0	0	0	2	0	0	0	0	1,467,249
	Mo	620	18	401	150,432	5	30	9	13	4	4	154	6	4	2	13	3	0	1	1,202	0	0	0	0	0	0	0	0	0	0	0	152,911
	Es	209	11	46	2	42,148	21	8	2	1	1	10	3	1	1	0	1	0	0	0	432	0	0	0	0	0	0	0	0	0	0	43,037
	La	335	30	44	3	13	68,038	36	2	1	2	12	4	1	1	1	1	0	0	0	0	784	0	0	0	0	0	0	0	0	0	69,198
	Li	229	28	36	2	6	61	105,811	2	1	1	19	4	1	1	1	1	0	0	0	0	0	965	0	0	0	0	0	0	0	0	106,939
	Ge	468	8	122	8	4	5	2	173,267	116	39	46	14	4	2	3	3	0	0	0	0	0	0	1,310	1	0	0	0	0	0	0	175,409
	Ar	179	5	37	2	2	2	0	27	118,405	68	25	13	3	2	4	0	0	0	0	0	0	0	0	621	0	0	0	0	0	0	119,595
	Az	921	30	207	11	8	13	3	64	273	270,131	127	39	3	6	29	4	0	0	0	0	0	0	0	1	1,200	0	0	0	0	0	272,670
	Ka	3,656	475	1,814	127	67	79	48	39	22	35	626,871	637	549	85	71	35	4	8	0	0	0	0	0	0	0	4,076	2	2	0	0	642, 593
	Uz	4,016	98	735	27	44	30	12	29	29	26	1,605	357,162	333	237	234	18	0	2	0	0	0	0	0	0	0	6	5,422	2	1	1	870,369
	Ki	1,508	21	191	7	31	12	4	5	2	12	817	341	188,875	48	28	6	0	1	0	0	0	0	0	0	0	2	1	1,439	0	0	193,351
	Ta	1,327	15	227	25	65	9	5	4	6	4	265	444	80	233,839	47	6	0	0	0	0	0	0	0	0	0	8	0	1	0	1,533	228,012
	Tu	848	34	152	13	2	7	4	13	12	14	301	209	86	20	163,963	5	0	0	0	0	0	0	0	0	0	2	1	0	0	4,163	162,249
TOTALS		128,908,545	2,410,193	48,819,383	5,787,536	1,467,992	2,403,817	3,161,821	4,877,452	2,787,840	5,268,617	13,327,335	12,788,887	3,218,891	3,985,893	2,438,144	2,408,125	145,668	883,261	58,925	31,083	95,881	58,665	72,682	27,886	74,779	176,128	152,615	47,972	42,444	21,083	255, 147, 647

Appendix A.5 The "best-fit" accounts for 1975–75

INITIAL STATE \ FINAL STATE	SURVIVAL JANUARY 1ST, 1976														DEATH IN 1974–75											TOTALS
	Rs	Be	Uk	No	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	Rs	Be	Uk	No	Es	La	Li	Ge	Ar	Az	Ka	Uz	Ki	Ta	Tu	
EXISTENCE JANUARY 1ST, 1974	Rs	125,181,860	72,980	453,282	25,044	13,982	28,742	16,826	14,074	7,358	15,327	215,537	167,392	46,042	29,417	24,999	2,532,505	613	4,270	235	230	341	158	111	35	105	1,922	753	367	231	185	132,908,564
	Be	100,342	8,951,067	24,172	1,826	1,505	3,642	5,202	1,000	248	725	11,416	2,226	456	697	858	974	152,176	258	11	18	116	50	8	1	5	80	15	4	6	7	9,267,691
	Uk	448,086	21,989	46,287,578	29,751	4,185	9,019	4,328	4,315	1,860	2,737	20,464	11,995	2,629	3,024	5,528	4,397	185	936,224	183	43	96	41	34	10	8	354	84	21	23	43	48,519,380
	No	29,867	759	17,917	3,435,873	191	582	433	553	195	197	3,686	455	213	155	1,018	280	6	177	66,645	3	11	4	4	1	1	54	3	1	2	3	3,765,874
	Es	15,716	735	3,229	164	4,842,285	1,605	614	81	71	106	707	303	104	182	22	153	6	32	1	34,843	18	6	1	0	1	6	2	1	2	0	1,417,956
	La	16,629	1,921	2,864	204	192	2,358,982	3,935	138	68	148	917	456	106	75	98	160	16	30	2	10	57,650	24	1	0	1	6	3	1	0	0	2,453,917
	Li	10,393	1,519	2,092	124	292	3,670	2,777,281	79	30	75	1,244	413	261	187	345	138	13	21	1	4	46	69,227	1	0	0	9	3	1	0	0	3,261,893
	Ge	28,694	522	7,317	298	209	384	167	4,749,885	2,892	2,868	2,671	1,378	268	187	307	295	4	73	2	2	5	1	75,583	39	33	21	9	1	2	2	4,977,839
	Ar	8,459	193	1,651	85	47	92	32	1,061	2,480,444	3,627	1,192	941	179	199	397	82	2	16	1	1	1	0	8	29,617	25	9	6	1	2	2	4,727,709
	Az	32,144	914	6,724	364	287	444	144	1,892	3,145	5,577,859	4,648	2,106	125	322	1,661	312	8	66	4	2	5	2	15	49	74,629	32	15	1	3	13	5,513,818
	Ka	319,142	17,207	70,007	5,382	2,445	3,209	1,948	1,413	987	1,657	13,237,485	34,284	27,856	5,811	4,740	3,096	149	690	49	28	33	18	12	5	11	188,830	241	221	45	37	13,527,537
	Uz	78,899	1,748	13,531	945	784	551	248	493	552	591	33,150	12,944,483	8,129	11,281	7,490	775	15	134	5	3	6	3	4	3	4	231	183,683	65	88	57	13,238,557
	Kc	40,880	515	4,850	175	120	223	84	105	57	353	23,009	14,116	3,873,287	2,174	1,203	396	4	48	2	9	4	1	1	0	3	160	100	50,083	12	9	3,218,894
	Ta	22,841	373	3,634	412	981	172	79	75	99	97	4,724	11,699	1,685	3,183,867	1,218	222	3	36	4	11	2	1	1	1	1	33	32	13	50,775	10	3,282,891
	Tu	15,936	553	2,638	248	21	128	64	200	217	259	5,847	5,011	581	647	2,388,709	154	4	26	2	0	2	1	2	1	2	41	42	5	5	36,691	2,429,920
BIRTH IN 1974–75	Rs	4,105,166	1,192	6,783	407	312	443	263	220	115	240	4,313	1,681	720	461	378	99,887	4	31	2	2	3	1	1	0	1	15	6	2	2	2	4,160,605
	Be	1,586	287,645	413	20	23	152	84	16	4	11	181	36	7	11	14	8	2,424	2	0	0	1	0	0	0	0	0	0	0	0	0	292,629
	Uk	6,786	333	1,445,587	315	63	121	65	66	28	42	767	181	40	45	53	32	1	14,288	1	0	1	0	0	0	0	2	0	0	0	0	1,468,217
	No	622	16	373	158,180	4	21	9	12	4	4	160	9	5	3	20	3	0	2	1,400	0	0	0	0	0	0	0	0	0	0	0	156,948
	Es	236	11	49	2	41,717	23	9	1	1	2	12	5	1	2	0	1	0	0	0	492	0	0	0	0	0	0	0	0	0	0	42,553
	La	233	27	42	3	13	67,855	35	2	1	2	13	6	1	2	2	1	0	0	0	8	818	0	0	0	0	0	0	0	0	0	69,062
	Li	227	24	35	2	4	93	101,917	1	0	1	85	6	1	2	2	1	0	0	0	8	0	959	0	0	0	0	0	0	0	0	103,253
	Ge	245	9	134	6	4	7	3	176,884	183	53	56	25	4	4	6	2	0	1	0	0	0	0	1,196	0	0	0	0	0	0	0	178,942
	Ar	192	5	38	2	1	2	1	24	122,884	83	27	21	4	6	7	1	0	0	0	0	0	0	0	667	0	0	0	0	0	0	124,034
	Az	819	24	721	9	5	11	3	48	253	279,725	118	54	3	9	42	4	0	1	0	0	0	0	0	1	1,914	0	0	0	0	0	284,122
	Ka	7,722	429	1,694	131	69	77	47	35	21	41	657,422	832	674	141	115	38	2	8	1	0	0	0	0	0	0	4,622	3	2	0	0	938,721
	Uz	2,814	61	477	19	27	20	9	17	19	21	1,163	926,577	286	397	264	14	0	2	0	0	0	0	0	0	0	3	1	1,573	0	0	200,244
	Ki	1,265	16	150	6	22	10	2	3	2	11	714	441	195,208	67	38	7	0	1	0	0	0	0	0	0	0	1	2	0	4933	0	248,423
	Ta	865	14	137	16	37	6	3	3	4	3	178	441	64	209,661	50	4	0	1	0	0	0	0	0	0	0	1	1	0	0	1,306	172,123
	Tu	989	20	93	8	1	5	2	7	8	10	206	212	21	23	118,443	2	0	1	0	0	0	0	0	0	0	1	1	0	0	1,206	159,972,225
TOTALS		64,883,292	3,314,521	49,103,730	3,869,256	1,436,855	2,475,304	2,777,617	4,930,893	2,603,905	5,584,814	14,328,742	14,068,815	7,305,280	3,402,870	2,870,146	2,531,392	157,478	985,443	68,826	37,742	83,163	61,497	77,183	29,836	74,941	196,445	191,576	52,369	37,138	28,316	