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MODERN POPULATION TRENDS AND PROBLEMS

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INTRODUCTION

In March 1944, while the second world war was still raging, the Royal Commission on Population was appointed 'to examine the facts relating to the present population trends in Great Britain; to investigate the causes of these trends and to consider their probable consequences; to consider what measures, if any, should be taken in the national interest to influence the future trend of population; and to make recommendations'. This step was of twofold significance. First, it marked the recognition by the Government of the possible need to take policy decisions in the field of population—to translate the subject from the academic to the political plane. Secondly, it marked official recognition of the fact that despite a flood, during the immediate pre-war years, of reports of grave foreboding by the demographers of the day (whose anxieties have since proved to have been exaggerated) the Government had insufficient information to decide whether or not there was a 'population problem' in Great Britain. That the problem does not now appear to be so pressing as was once thought does not abate in any way the necessity for observing the facts. The Royal Commission, indeed, emphasized the necessity for continuous study of the population problem which, they said, will always be changing.

2. Since the Royal Commission reported in 1949(1), preoccupation with the need to improve the extremely low standards of living in the large under developed areas of the world, and so to avert political consequences of poverty (especially in the Far East), has turned attention to the world at large, where the problems are far greater and the knowledge much scantier. It is known that the population of the world is of the order of 2,600 millions, and, since the average annual rate of natural increase exceeds 1%, that every day there are more than 80,000 new mouths to feed. World resources are being used up at an increasing pace. How long can the resources last? Can production of food and raw materials not merely keep pace with the growth in population but be accelerated so as to enable existing standards to be raised, where necessary, to more acceptable levels? Even if the race be won for the world as a whole, what can be done to solve the paradox of the existence side by side of accumulating food surpluses in some countries with high standards of living and of near-starvation in undeveloped areas of low productivity?

3. The pressure of these urgent questions led the Population Commission of the United Nations to propose the holding of the World Population Conference at Rome in 1954, where some four hundred experts from all parts of the world were gathered together. Among them were actuaries from several countries who have taken a particular interest in population problems, in some cases by virtue of the official positions they occupy. Do these problems, however, concern actuaries as a whole? We think they do. Just as in a social

security scheme it is necessary to balance emerging expenditure and income, so, both in the national economy as a whole and on the international plane, there is the central problem of matching production to rising consumption demand. The problem is more complex, however, than social accounting, for population growth and economic development react upon each other in intimate fashion. Mouths and hands go together, and machines may multiply the power of hands; in turn, changes in the economy may alter family structure and affect the pace of population growth. The problem is thus multifactorial as well as dynamic. For its solution something more than 'political arithmetic' of a simple character is required. The demographer, the actuary, the economist, the sociologist, the geophysicist, and the biologist, all have their contributions to make in creating that informed public opinion which is necessary if Governments are to move in the right direction.

4. Lack of any general interest on the part of actuaries to-day has given rise to an impression that they have little to offer, and even their past contributions to demographic measurement tend to be forgotten. The basic processes of population projections, however, had been used in life office valuations, and cohort analysis was implicit in the investigation of the office experiences, many years before their appearance in demographic literature. The general employment of fertility rates specific for age and duration—to use the terminology now accepted outside the actuarial profession—was preceded by the development of select issue rates, originated by G. F. Hardy for National Health Insurance purposes, in 1911 (2). The analysis of mortality by age, duration and other factors, the construction of life tables of all kinds and the forecasting of mortality are subjects in which the actuary has contributed a large part of the formal development of existing methods. Though perhaps regarded by some as lying on the border of demography, scientifically-computed sickness rates come to mind as another significant actuarial contribution to population statistics. Actuaries have at times been keenly interested in census taking and have played their part in raising standards of accuracy and analysis, as is evidenced, for example, by the memorial addressed by the Institute to the Government prior to the 1901 Census (3). Mention must also be made of the mathematical contributions of King, Hardy and others to the graduation of data and to interpolation. These methods are invaluable aids to modern demographers.

5. As has been indicated, demography is to-day an interdisciplinary science; indeed, most modern demographers are experts in other fields who have discovered the need for population statistics and actuarial methods to assist their understanding of the factors involved in population and economic growth. The co-operative nature of modern population studies is especially characterized by a growing emphasis upon economic factors. The Population Division of the United Nations Organization has recently circulated privately a report (4) of a committee of experts on 'Gaps in existing knowledge of the relationships between population trends and economic and social conditions'. The committee urge that attention should be given (*inter alia*) to deepening the level of economic analysis associated with demographic studies and to the development of generalizations concerning the relationship of social, economic and population change; to an examination of interrelationships of population growth and capital formation and use; to studies of social and economic factors affecting differences in mortality; to continuing research on the

problems of dependency; to the investigation of the effects of a declining rate of population increase upon the economy of the densely-populated underdeveloped countries; and to studies of migration and associated problems of capital requirements. Altogether some fifty major 'gaps' are listed. Many of the problems, unquestionably real and important, are couched in terms which are to say the least vague, evidence itself of a need to infuse into demography clear thinking and above all an essentially practical approach. Dr William Farr, whose contributions to demography were of the highest order, was once referred to as 'the "beau-ideal" of an actuary' because 'he combined the highest mathematical theory with an admirable talent in its practical application'*(5). Farr, who had to fight hard to argue—against Malthus—that decreasing mortality was a desirable aim and did not lead to disastrous increases in numbers, was able to say that 'there is a limit to the increase of both people and produce: but the tendency now is, as men endowed with skill, weapons, tools and marvellous machines are diffused over the world, to create subsistence faster than population'(6). Is this still true?

6. We consider that there is ample justification for suggesting that these problems invite the attention of actuaries to-day. We propose in the present paper broadly to review them, dealing first with events in Britain since the publication of the Report of the Royal Commission and then with the larger world problem as seen, in the main, by the experts who attended the World Population Conference in 1954. Although British demographic trends are of much interest, and, indeed, about half the length of this paper is devoted to them, it is to the wider, global, questions that we wish particularly to draw attention.

DEMOGRAPHIC DEVELOPMENTS IN GREAT BRITAIN SINCE THE ISSUE OF THE *REPORT OF THE ROYAL COMMISSION ON POPULATION*

7. The period 1949–55 has been eventful not only in regard to the population movements recorded but also on account of the new facts that have become available about earlier periods and the changes of opinion that have occurred on certain aspects of demography. The numbers of births provide the main test of the Royal Commission's estimates of the future size of the population of Great Britain and a check on its conclusion about the extent to which we are replacing ourselves. Recent marriage experience is of interest because of the changing balance of the sexes, which has altered their respective marriage prospects. The rapid proportionate reduction in mortality at the younger ages since the last war in contrast to its slow rate of improvement at older ages, and the steadily increasing proportion of old people in the population, are features also worthy of special attention(7). It will be helpful when discussing the events of the last six years to take the Royal Commission's projections as an indication of informed opinion at the time of their Report, and to compare their expectations with actual events.

* It is a matter for deep satisfaction that, in the earliest years of the Institute, Farr's outstanding quality should have been recognized by his election as Honorary Member (in 1852)—a power, incidentally, which though it remains in the present Charter and Bye-laws of the Institute, has not been exercised since 1870.

Actual population and projected populations

8. The population projections of the Royal Commission, prepared under the supervision of its advisory Statistics Committee, were published in full in 1950(8); they were sixteen in number and embraced fairly wide ranges of assumptions concerning future trends in mortality and fertility. In the Commission's Report(1), reference had already been made to three of these projections, a group somewhat narrower in range. In comparing the expectations of six years ago with subsequent events, it seems reasonable to have regard not only to the Commission's short selection but also to the Committee's complete series.

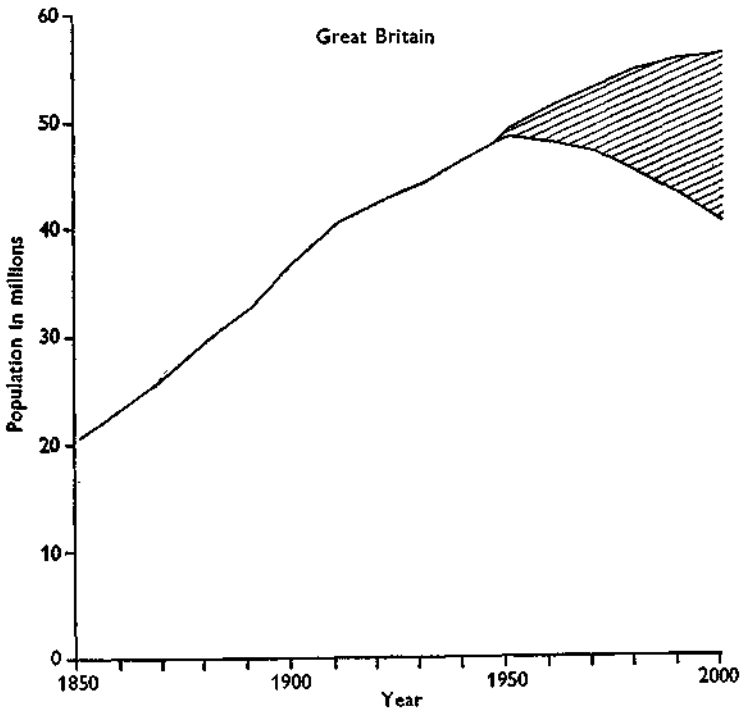

Chart 1

9. Chart 1 shows the size of the population of Great Britain during the 100 years from 1850 onwards and the Committee's range of possibilities for the next 50 years; these include everything from growth only a little less rapid than in recent years to a steady decline commencing immediately. Chart 2 gives on an enlarged scale the same kind of information as in the upper right-hand part of Chart 1. The extremes are indicated by the dotted lines, and the results flowing from the five different fertility assumptions are indicated by the continuous lines, which occupy nearly all the space between the extremes. Variations outside the continuous lines are the result of different assumptions about ages at marriage or about emigration. The three

projections selected by the Royal Commission for the purposes of their *Report* are represented by the thicker lines. These three projections all assume that future marriage rates will be intermediate between the marriage rates of men and women in 1942–47, that mortality rates will decline from 1947 to 1977 as over the previous 50 years, and that net migration will be nil. They differ in assuming (*a*) a full replacement level of fertility (Projection no. 9), (*b*) the same average family sizes as for couples married in 1927–38 (Projection no. 8) and (*c*) average family size falling to below 80% of replacement level (Projection no. 10). Two observations may be made: first, that the future size of the population depends very largely upon the fertility assumption adopted, and secondly, that the range of the Commission's selected projections was rather more restricted than that of the Statistics Committee's projections.

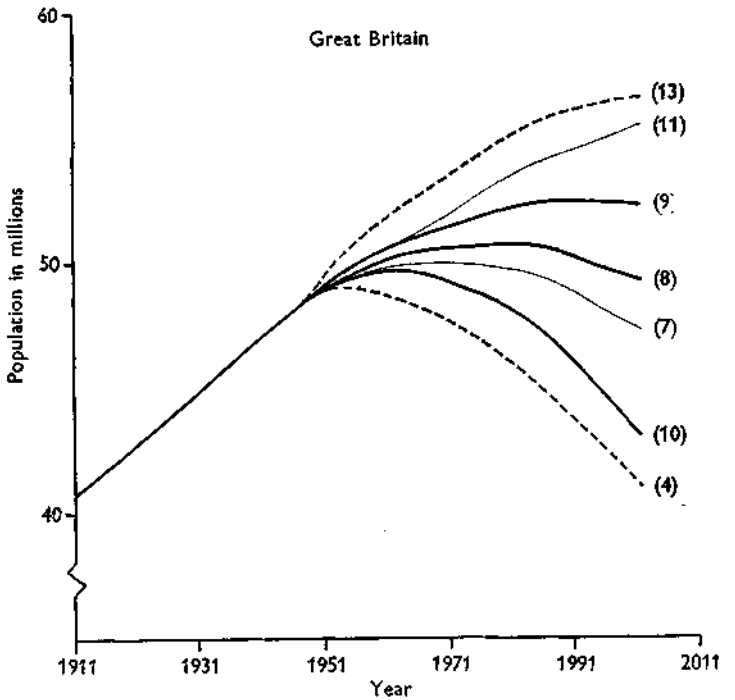

Chart 2

10. Owing to the fact that any range of reasonable assumptions makes little difference to expected population changes over a short term, comparisons with more recent projections need to be made on an even larger scale, as in Chart 3. The shaded area shows the range of the populations that would result from the Committee's five fertility assumptions, and the thicker lines show the results of two independent projections of the British population made in 1953–54. The upper one is based on a projection made by the Government Actuary and shown in the Registrar General's quarterly returns and in other official reports (9) (32), the lower is based on a projection made for England and

Wales by the French demographer, M. Bourgeois-Pichat (10), as part of a series of international comparisons. The official view here seems to be that a period of relative stability in fertility in the neighbourhood of present levels may be expected over the years immediately ahead. It is difficult to be precise because the full details are not available and because the Commission used an estimate of population which was framed on a slightly different basis from that currently employed, and which incorporated some inflation which has been corrected as a result of the 1951 Census. It would appear, however, that the actual numbers of people at mid-1955 on a basis comparable with that available to the Royal Commission were about 49·89 million, a marginal 10,000 or so more* than the highest number estimated in any of the Statistics Committee's projections.

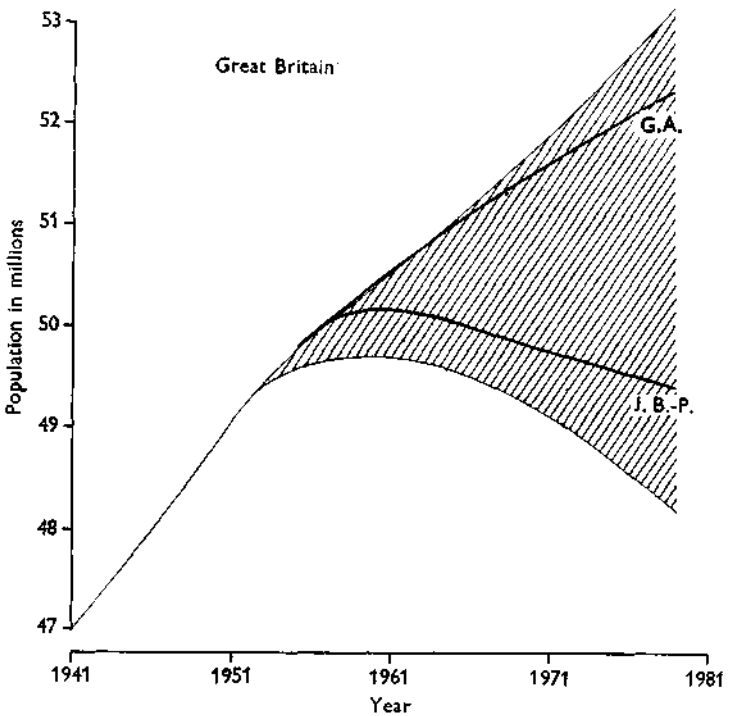

Chart 3

* *R.C.P. Projection no. 9*

	(millions)
Population mid-1947	48·19
Births mid-1947–mid-55	6·40
Deaths mid-1947–mid-55	−4·70
Migration mid-1947–mid-55	Nil
Projected population mid-1955	49·88

Official figures of Registrars General

	(millions)
Population mid-1947	48·19
Births mid-1947–mid-55	6·41
Deaths mid-1947–mid-55	−4·55
Migration mid-1947–mid-55	−·16
Current estimate 49·75 millions plus net adjustment to mid-1947 basis, viz. +·14	49·89

Births

11. As already pointed out, in the foreseeable future the numbers of births are likely to have a much more powerful influence than the numbers of deaths or of migrants in determining the general direction and pace of population changes (although there is potential scope for a large increase in the numbers of old people if ways are found of considerably reducing mortality at ages over 50). To analyse the estimated prospects further, reference need be made initially, therefore, only to fertility. The actual and projected numbers of annual births in Great Britain are given in Table 1. All the five Statistics Committee birth projections for 5-year periods start at a point well below the million mark, thus assuming that there would be a sharp fall immediately after 1947; thereafter they fan out at different levels, some higher than that obtaining before the Second World War and some lower.

12. In the event, the numbers of births actually occurring fell immediately after 1947 much as predicted, and in 1951 Sir Hubert Henderson, who had been Chairman of the Royal Commission, was able to say that the number during 1950 (then thought to be 785,000) was very close to the Commission's expectation (11). The actual number in 1950 finally proved to be 790,000, and since then births have fallen but little during 1951–55 (although the number of potential mothers has declined). The actual number of births in the period mid-1947 to mid-1955 amounted to 6,412,000 compared with 6,401,000 expected on the most favourable fertility assumption (no. 9) of the Statistics Committee, an excess of less than 0·2%. Up to now, therefore, developments have been generally in accordance with this assumption, and the latest official population projection, taking account of this experience, follows broadly along the lines of Projection no. 9 of the Statistics Committee. Bourgeois-Pichat, however, by making a projection more similar to no. 10, appears to have adopted a less hopeful long-term view, and to have regarded the natural decline from the immediate post-war peak produced by 'postponed' births too much as a continuing factor.

Marriages

13. It is now desirable to examine the numbers and ages of married couples and the composition of their families, and so to analyse the birth data into their component parts. Perks (12) has emphasized that marriage is a selective force that tends to divide young adults into two classes with different potentialities of fertility. A variation in marriage rates will cause the passage of a marginal group from one class to the other and may well bring about an alteration in average fertility within marriage without any change in individual abilities or desires with regard to procreation. Owing to concurrent fluctuations in fertility arising from other causes, such as wars and variations in national prosperity, the effect of such an alteration is difficult to measure.* It is at least evident that it would be unwise to consider the level of marital fertility apart from the marriage rates to which it relates.

14. In the population projections of the Statistics Committee the expected annual average numbers of marriages of spinsters under age 45 during the period mid-1947 to mid-1952 in Great Britain varied between 277,000 and

* Clear evidence has, however, been found of a similar effect on mortality—the effect of a change in the proportions married upon the relative mortality rates of married and unmarried women.

Table 1. Annual live births (thousands), Great Britain

Projection	1947	1948	1949	1950	1951	1952	1953	Annual average 1954–58	1959–63	1964–68	1969–73
Royal Commission on Population:* No. 7	803							668	637	635	652
No. 8	804							701	669	667	686
No. 9	819							745	711	710	733
No. 10	804							660	599	566	561
No. 11	804							741	738	768	811
Bourgeois-Pichat†(10)				790				718 (1955)	666 (1960)		
Government Actuary's Quinquennial Review of National Insurance(9)								735	705	705	725
Actual numbers‡	994	876	826	790	768	764	775	(1954) 766 (1955) 757			

* The Royal Commission's figures are for mid-year to mid-year; those for 1954–58 and onwards have been interpolated.
† Bourgeois-Pichat's figures are for England and Wales; these have been increased by 13·3 % to allow for Scotland.
‡ England and Wales, occurrences; Scotland, registrations.

337,000 a year, but we now know that, in fact, they did not fall below 340,000 during these years and indeed averaged as many as 355,000, or 5% above the Committee's highest expectation. The Committee's projections for the following period mid-1952 to mid-1957 ranged from 273,000 to 301,000 marriages per year of spinsters under 45, but in 1953 the number recorded was about 330,000 and in 1954 there were 328,000 such marriages.

15. Since 1947, however, the numbers of marriages, although greater than the Committee expected, have fallen. Such a development was almost inevitable, not because of a decline in the proportions of spinsters marrying but because of a reduction in the actual numbers of young women available for marriage. Not only are the young spinsters of to-day the survivors of declining generations of births but also, as Hocking(13,14) has shown, the numbers of marriages in recent years have been materially higher than the annual supply of girls reaching marriageable age. Thus the number of women left unmarried has diminished. As a result, the age at marriage tends to fall, for, as relatively fewer unmarried women are left available year by year at what had been the normal ages of marriage, men marry younger brides.

Table 2. First-marriage rates per thousand Spinsters by age, England and Wales, 1947 and 1954

	15–19	20–24	25–29	30–34	35–39	40–44
1947	36·7	205·5	157·7	85·1	42·5	22·8
1954	44·6	237·8	154·5	72·0	37·8	21·1

Table 3. Number of Males per thousand Females at ages 15–44, England and Wales, 1871 to 1951

Proportions at ages 15–44	1871	1901	1911	1921	1931	1951
Total population (15–44)	927	923	926	876	915	969
Non-married population (15–44)	967	950	959	875	945	1,120

16. In England and Wales, first-marriage rates per thousand spinsters in 1947 and 1954 are as shown in Table 2. The rates were lower in 1954 than in 1947 at ages above 25, but, as a reflection of the problem of supply of women available for marriage indicated above, they were higher at younger ages; and as a result the average age of spinsters marrying bachelors fell from 23·9 in 1947 to 23·2 in 1954. But over the period the actual number of first marriages fell by 12% for all spinsters and by 10% for spinsters marrying bachelors.

17. The rise in marriage rates at most ages is partly due to an increase in the relative supply of men available for marriage. While the ratio of males to females at ages 15–44 in the total population has been rising continuously since 1921, it has risen still more in the non-married section of the population at these ages. Table 3, based on census populations, shows the changes in the sex ratio since 1871. The abnormally low ratio in 1921, and the sharp rise since that year, are the striking features of this table. It will be noted that, among the non-married aged 15–44, males exceeded females for the first time at the 1951 Census, even though the sex ratio is based on census populations which exclude the predominantly male defence forces stationed abroad.

18. The main factors influencing these changes in the sex ratio are well understood. The proportion of males to females at birth has increased (1911–15, 1038 per thousand; 1931–35, 1051 per thousand; 1946–50, 1061 per thousand) and improvements in infant and child mortality (heavier in males than in females) have raised the ratio of male to female survivors. In the early years of the century there was heavy emigration with a preponderance of males, and the losses in the first world war fell particularly heavily on young men. On the other hand, such male losses as there were in the second world war were in part offset by the heavy post-war emigration of the wives of Commonwealth and Allied servicemen. Apart from migration and special factors associated with war, it seems likely that the factors operating to produce the current high sex ratio will persist and that a further increase in the ratio may be expected.

19. The numerical superiority of males over females among non-married persons aged 15–44 is not spread evenly over all ages, but is particularly concentrated at the younger ages where marriage rates are highest. Since, on the average, bachelors marry spinsters 3 or 4 years younger than themselves, a better index of the relative supply of bridegrooms is the ratio of single men aged 20–29 to single women aged 15–24 in the population. In 1911 this ratio was 0·68, in 1931, 0·74, and in 1951, 0·79. This is of course only an approximate index, since many marriages occur outside these ranges of ages, but it does indicate the trend toward improved marriage prospects for younger women and explain the high ratio of men to women among the unmarried in 1951; it suggests that the proportions married at younger ages in the female population will be maintained at their present high level.

Total married women of reproductive age

20. Illegitimacy is comparatively low in this country, representing about 5% of all births. The fertility of the community is therefore determined principally by the total number of married women of reproductive age in the population, that is, by the survivors of women who married at any time during the preceding 35 years and who have not yet passed out of the child-bearing ages. New marriages will continually replenish this number. The annual addition of new marriages in relation to the total married population of reproductive ages has never been more than a small fraction, of the order of 5%, so that short-term changes in the marriage rates will have a correspondingly reduced effect upon the total proportions of married women in the population at those ages.

21. The proportions married in the total female population have increased in each age group and the increases have been outstandingly large at ages under 25. The proportion at ages 15–19 in 1954 (46 per thousand) exceeded that in 1938 (23 per thousand) by no less than 100%, and that at ages 20–24 (515 per thousand) had grown (from 328 per thousand) by 57%. An increase of 23% at ages 25–29 (from 643 per thousand in 1938 to 791 per thousand in 1954) is less striking but hardly less significant, applying as it does to larger proportions married. At the younger ages the major part of the increase occurred between 1938 and 1946, and, though an upward trend continues, the pace of increase is very much diminished.

22. The remarkable rise in the proportions at the younger ages and the much more modest increases at the older ages bring into relief two important

changes—more people are marrying, and they are marrying at younger ages. Table 4 shows the proportion of married women in the reproductive age-group 15–49 as a whole and in the more critical age-group 20–39, in which 90% of births occur. The proportions for the age-group 15–49 represent in fact the fractions of the reproductive years of all women which fall within married life. From 1911 to 1931 this proportion rose slightly from 502 to 529 per thousand; it rose more rapidly between 1932 and 1938 to 566. It had reached 626 by 1946, and 683 by 1954. For the age-group 20–39, the proportion had risen from 552 in 1911 to 757 in 1954.

Table 4. Proportion of Females married, England and Wales, 1911–54

Year	Married women per thousand total female population aged	
	15–49	20–39
1911	502	552
1931	529	572
1938	566	623
1946	626	686
1947	635	697
1948	643	707
1949	651	716
1950	657	724
1951	666	731
1952	673	741
1953	678	749
1954	683	757

23. The fact that such a high degree of marriage has been attained is important. There is no sign yet of any recession in the proportions. On the contrary, it would not be necessary for rates of new marriages to be as high as in the years immediately preceding 1951 to achieve further increases in the proportion of married women in the population aged 15–49. Marriage rates as low as those experienced before the war would not of course suffice for this purpose.

24. The marriage rates in some age-groups were lower in 1954 than in 1953. For instance, at ages 25–34 the rate for bachelors fell from 149·5 per thousand to 146·0. The reductions are not, however, important, and in the light of the foregoing remarks may be seen in perspective.

Marriages and fertility

25. In a paper published a few years ago(15) the proportions of first, second and third children born by 1946 to women who had attained the age of 16 in each year from 1935 to 1942 were compared. In general, the later the year in which a woman had attained this age of 16 the greater the number of her children at any specified subsequent age; the average rate of improvement in family size from year to year was something like 4%. The analysis in this paper showed that improving prospects of marriage during the period probably accounted for about 2½% of this 4%, and thus 1½% was the annual rate of

increase in fertility within marriage. A corresponding analysis of the fertility of married women grouped according to year of marriage over the period 1935–45 revealed an average annual rate of increase in family size of roughly 1%; thus both analyses brought out rates of growth in fertility within marriage of a similar order of magnitude.

26. More recently, the Registrar General for England and Wales has given, in his review for 1946–50(16), a comprehensive survey of fertility or, as he calls it, 'reproductive capacity replacement' over the last hundred years according to year of birth of woman; it was illustrated by a most interesting and highly significant diagram. For generations of women who have reached the age of 45 it showed a steady decline in successive generations in the total number of children born, but for all generations who have not reached the age of 45, it showed a recovery in the most recent period. It should, however, be emphasized that much of the recovery is due to the increase in marriage rates and in the proportions married. In another analysis(17) the Registrar General has shown that the effective reproduction rate (for women) grew from 0·829 in 1938 to 1·017 in 1950. Of this increase of 0·188 he attributed no less than 0·147 to higher marriage rates; another 0·056 arose from improvements in mortality and stillbirth rates. Over the whole of this particular period the contribution of fertility within marriage was actually negative—it fell by about 0·04; as there was a large increase in marriage rates over the period, such a fall might have been expected in accordance with Perks's theory (see paragraph 13). In view of the impossibility of exact analysis these figures must not be taken too precisely, but they do illustrate the importance of the enhanced prospects of marriage in connexion with recent increases in births.

27. More recently still, the Registrar General(18) has examined fertility rates specific for age and duration of marriage in England and Wales and has shown them to have changed very little since 1950; average family sizes (live-born children per married woman) carried forward to December 1953 were consistent with this appearance of stability. Carrier(19) has projected generation replacement rates having regard to changes in marriage experience and the tendency to concentrate family building in the early years of married life, and suggests that the ultimate shortfall from replacement may be about 5% for the generation of women born in 1931.

Reproductivity

28. As the word 'reproduction' has been mentioned, something should perhaps be added about the latest developments in connexion with its measurement. Before the Royal Commission was appointed, the 'net reproduction rate' had come into general use in statistically more developed countries because it was considered to be the best available single indicator of the long-term trend of population where the data were plentiful enough to enable it to be calculated. It did not, however, survive investigation by the Statistics Committee and the staff of the Commission, or the critical analysis of Whelpton(20) in the U.S.A. It was shown to be misleading because, although age-standardized, it summarized merely the current experience of many generations of women of different marriage durations and provided no more indication of future trend than was contained in the birth rate. As a result

one hardly heard the 'reproduction rate' mentioned at the Rome Conference in 1954; certainly it was given no prominence. In fact, the proportion of time devoted by the Conference to the theory and mathematics of population growth was relatively small; much greater emphasis was placed on the analytical study of actual experience in contrast to the exploration of theoretical models.

29. Without an index of the nature of the net reproduction rate there is undeniably something of a vacuum in demography, because the trend of population is not concisely measured. Efforts to fill the gap by making population projections are not very satisfactory. Realizing this, the Commission's staff developed a substitute in what has been called a 'replacement index' which is based on the average size of family born to a particular marriage cohort and is much more complex in construction than the net reproduction rate. The Commission used this in their *Report* and went so far as to assert categorically that there was a deficiency in current family size in comparison with the requirement for replacement purposes and that the extent of the shortfall was 6%. In fact, however, Hajnal(21) had obtained replacement indices from 1·00 to 0·81 on various assumptions and had said that 'the variety of reproduction rates is only a reflection of the limits of knowledge about the demographic prospects'.

30. In an effort to break the deadlock some alternative statistical models of self-reproducing populations have recently been constructed(22) so as to represent the current demographic situation in Great Britain as closely as possible in all respects other than family size. The aim was to compare the numbers of children actually born to married couples at the end of specified periods of married life with the number they should have had if there was to be exact replacement. The results obtained broadly supported the Commission's statement and, in addition, analysed recent variations in replacement in this country from year to year according to date of marriage.

Family size

31. If the measurement of reproduction was not mentioned in Rome, that of fertility certainly was, and many alternative ways of measuring it were mentioned; one author(23) referred to no less than fourteen methods. There is no agreement at the moment as to which of the many possible approaches is the best. An aspect that deserves particular attention here is the question of family size—not merely *average* family size but rather the respective proportions of married couples who have had no children, one child, two children, three children and so on. The Royal Commission found that the average family size in this country had remained fairly constant for some years, and demographers naturally attach great value to anything having the appearance of stability in the notoriously unstable field of population. It has been pointed out, however, that uniformity of average family size has really been the result of two important changes which have roughly counterbalanced one another. On the one hand there has been a continuation of the long-term decline in the proportion of very large families (of six children or more), and on the other hand there has been a decrease in the number of couples with very small families.

32. These changes are illustrated in Chart 4, which has been derived from the statistics of the Family Census of 1946 undertaken for the Royal Commission (24). The percentages in the various categories of completed family size (no children, one child or two children; three or four children; five to nine children; ten or more children) are shown by the thickness of the bands between the dividing lines. The dotted lines give not unreasonable forecasts for families that will be completed in the near future. The year of marriage of the parents is shown along the bottom of the chart. The tendency toward more uniform family size is clearly seen in a widening of the band representing one or two children and in the narrowing of the bands for five children and over. In comparison with the big alterations of the past half-century the change expected in the next two decades is small.

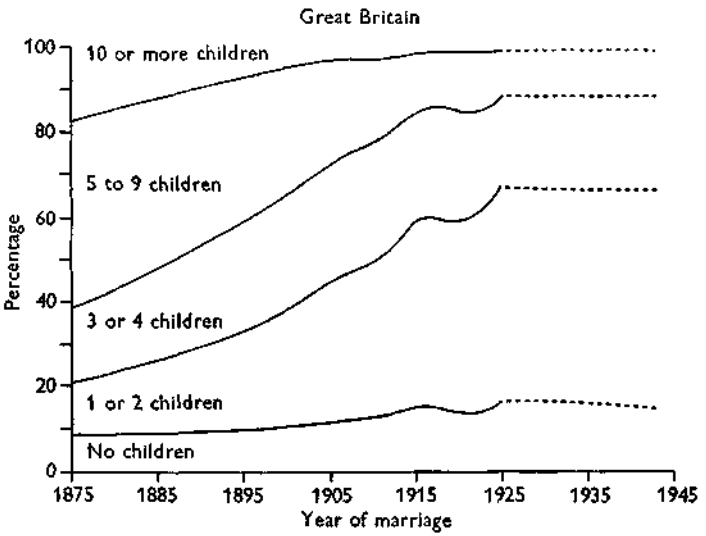

Chart 4

Mortality

33. The last decade has seen sharp proportionate falls in mortality at all ages up to middle life, to which a very high proportion of all children born can now be expected to survive, but there are far fewer signs of improvement at older ages.

Ten-year survival rates for males according to the mortality in England and Wales in specimen calendar years have been:

Age	1947	1954
15	·9818	·9903
35	·9660	·9742
65	·5787	·5752

Advances in medical knowledge and hygiene have been dramatically effective against infections, injuries and other causes of premature death, but have had little success in retarding the degenerative processes. It is not surprising therefore that techniques for forecasting mortality have tended to become more discriminating in relation to the prospects of progress against specific groups of diseases(25,26,27). This development has been part of a general tendency to apply analytical methods to elucidate the causes of changes in mortality rates in order to decide whether and in what manner these causes would operate in the future, i.e. to use knowledge of causes, such as medical advances or social changes, as a basis for more scientific estimation of future trends.

34. In the field of population statistics, no less than in other fields, such an approach clearly places the actuary in a stronger position to form a judgment. It is pertinent, however, to remember, first, that the more death rates are subdivided the greater the need to bear in mind the correlation between the subdivisions; and secondly, that despite the ever-present hope of dramatic reductions in death rates from specific causes (and the greater knowledge of their behaviour acquired from more refined analysis) the increase in precision likely to be attained by extrapolating the rates for the causes separately instead of in combination is not proportionate to the labour involved. The substitution of a combination of judgments for a single judgment may in some circumstances increase rather than reduce the resultant margin of error. There is still a wide field for research and experiment.

Social class differences in fertility

35. An important aspect of recent tendencies is the continuance of differences in fertility between the various occupational groups in the population. Social prestige is closely related in the public mind to occupation, and there is a fair amount of tacit agreement about the occupations which are deserving of high social esteem and those which are accorded a lower status. A recent work, edited by Glass(28), has dealt with the differences between the occupational statuses of sons and those of their fathers in the first half of the twentieth century in Great Britain, and has thus measured what may be described as 'social mobility'. Special inquiries showed that, if occupations were assembled in seven broad 'social classes', there was a two-thirds chance that the son would achieve a class different from that of his father and, apart from the top group, a two-fifths chance of the son improving on his father's performance. These figures indicate that there has been considerable movement between the classes in the last few decades. Further, the sizes and compositions of the classes have also varied materially.

36. Having regard to all this movement and variation, it is interesting and perhaps rather surprising that the proportionate differences in fertility between the social classes have changed relatively little since 1911 (although since fertility has declined, absolute differences have naturally diminished). Information on this subject has become available, during the last year or two, from three separate sources and they all give the same general picture. According, for instance, to the results of the Family Census of 1946 the average family size of couples married in the period 1920–24, expressed as a ratio of the average family size of couples married in 1900–9, was 75% for professional men and 75% for labourers. For both manual and non-manual

wage-earners it was 68%, and it was 70% for both employers and salaried employees. Thus there has been a smaller reduction for the 'highest' and 'lowest' social groups than for the intervening strata, but the differences are narrow.

37. The two other sources of information referred to are the results of the Censuses of 1931 and 1951. Taken in conjunction with the two preceding Censuses these provide no less than three different ways of comparing the trend of social class effects in fertility during a period of forty years. All confirm that the proportionate differences between the social classes have remained broadly the same over the period 1911–51, with the one possible exception that Social Class I (professional and managerial) appears to have moved back a little nearer to the general average.

Social class differences in mortality

38. The maintenance of the relative positions of the social classes as regards fertility is matched by a similar persistence of differential mortality, again with the possible exception that Social Class I, now a much enlarged group, differs less than it used to do from the general average, for both men and their wives. For infantile mortality, the relative levels of the classes have remained the same in spite of big reductions in the risk of death and an improvement in the monetary rewards of some occupations—miners for instance—relatively to those of others such as clerks.

39. A recent intensive study jointly carried out by the General Register Office and the Medical Research Council Social Medicine Unit(29) has remarked on the persistence of the social class differentials in infant mortality, and has suggested that there is a time lag in the expression of social improvements in improved health.

Ageing of the population

40. Despite the absence of mortality improvement at advanced ages, the proportion of older persons in the population continues to grow steadily. There are two main reasons why the proportion of persons aged over 65 in the population is increasing: (1) the annual numbers of births 50–70 years ago were both high and increasing yearly, whereas later they declined; and (2) mortality has diminished in early and middle life.

41. It should be emphasized that improving longevity will influence the proportion of old people, although it has not yet had as much effect as falling fertility. For England and Wales, Benjamin(30) indicated that a stationary population of both sexes supported by a constant annual flow of births and subject to the mortality of the decade 1901–10 would show 9·7% of age 65 and over; in a similar population subject to 1953 mortality there would be 14·0% aged 65 and over. It was not suggested that the increase in the proportion of old people in this comparison was entirely due to mortality improvement; the fertility of the second stationary population is in fact lower than that of the first by about 20%. In any case the major part of the effect of increased longevity has yet to make itself felt; up to the present, falling fertility has been the paramount influence. This can be seen by comparing the present-day population with that which would have resulted from a continuation of fertility at the level of 1870, if mortality and migration had

behaved as they have done during the last 80 years. If fertility had not fallen we should have had about 100 million persons in England and Wales in 1953 of whom about 5 million, or 5%, would have been over age 65. In fact we actually had 44 million of whom 5 million, or 11%, were aged 65 or over.* Thus, the bulk of the movement in the proportion aged 65 and over from 4·7% in 1901 to 11% in 1953 has been due to the decline in fertility. If present trends continue increased longevity will be reflected in an ultimate rise in the proportion to about 16% before the end of the present century, and only then will the effects of mortality and fertility changes have roughly balanced.

42. The numbers and proportions of persons aged over 60 or 65 have generally been estimated with comparative accuracy in population projections. Thus, pre-war forecasts of the proportion of persons aged over 65 in England and Wales in 1951, made while it was only about 8%, had ranged from 10·6 to 11·6%. Starting from 10·4% in 1947, the Royal Commission arrived at 11·1% for the proportion in 1952, in almost all its alternative projections for Great Britain.

43. Recognition of the economic problems of an ageing population led to the appointment of the National Advisory Committee on the Employment of Older Men and Women, and of the Committee on the Economic and Financial Problems of Provision for Old Age. Since the demographic aspects of the problems have been fully analysed in the reports of those committees(31,32), it is not proposed to discuss them further here.

Other elements

44. This review would not be complete without mention of two other elements in population growth.

45. The rise in the annual number of divorces in recent years (in Great Britain from 6,904 in 1938 to 29,671 in 1954) might give rise to suggestions of serious fertility losses as a result of broken marriages. It has, indeed, been estimated that in England and Wales(33) 7% of all marriages are now being terminated by divorce. It should also be borne in mind, however, (i) that about 70% of divorced persons remarry, and (ii) that about 40% of women divorced already have two or more children and only 30% are childless. Divorce therefore cannot be regarded as having a significant influence on fertility in this country.

46. It is also necessary to take note of the resumption of a net outward balance of migration from Great Britain. It seems likely that there is now a net loss of about 30,000 persons a year, representing the excess of emigration, mainly to the Commonwealth (especially to Australia and Canada), over immigration from Western Europe and the colonies (especially the West Indies). Numerically the net loss is not important, but its selective character may be significant; it is possible that Great Britain may be exporting higher degrees of skilled labour than it is importing, and the Overseas Migration Board, in their *First Annual Report*(34), have deplored the fact that no statistics

* Since those aged 65 and over in 1953 were born before 1890, only the denominator of the proportion is appreciably changed.

exist to give an 'accurate picture of the losses of [these] key men whose departure may affect the economic position out of all proportion to their numbers'.

The general situation in Great Britain

47. The population of Great Britain to-day still exhibits the same general features as were so well delineated by the Royal Commission, that is to say, a moderately satisfactory level of births, declining mortality, a prospect of steady total numbers for some time to come, particularly at working ages, and an almost certain increase in the proportion of the aged. If this survey of the last six years has not revealed any startling developments, it has at least drawn attention to some unsolved problems, such as the most effective measurement of replacement; some interesting statistical points, such as the effects of the change in the balance of the sexes; some odd features, such as the persistence of social class differences when a trend towards greater uniformity might perhaps have been expected; and, generally, the need for constant scrutiny of tendencies and for the extension of the range of research.

WORLD POPULATION AND RESOURCES

48. Current demographic changes and future prospects in Great Britain are of particular interest to us in this country, but they form only a small part of the world picture. The pace at which the British population is growing is slow compared with that of population in most parts of the globe, and many of the features described in the foregoing section are not typical of other countries at present, although some of them, such as the relative stability of the total numbers, may well be economically desirable. To appreciate the world situation fully it is necessary to know something of the demography of each of the major areas for, although to-day's problem is often spoken of as being one of 'world population and resources', the simple combination of regions into one amorphous whole is not particularly illuminating and may be misleading. National boundaries, economic barriers and ideological curtains tend to screen off one region from another, as regards both population and resources, and even within regions there are essential differences of development and culture; to minimize these in an attempt at generalization is to risk serious misunderstanding. For a proper appreciation of the world problem a series of outlines of the main elements in the population growth of the separate areas needs to be borne in mind. Even from the point of view of our own national welfare, this country should not be studied in isolation, for its resources are not independent of conditions overseas, whence an important part of its food and raw materials is and must continue to be derived. To take a single example, a change in the balance between population and resources in Argentina might well have an appreciable effect on the standard of living here at home.

Contrasts between different countries

49. A comprehensive survey of the demography of the main regions of the world would be beyond the scope of this paper. In order to give some idea, however, of the variety of situations that exist to-day, to place the comparatively minor contemporary population problems of Great Britain in their proper

perspective, and to prepare the way for a more general discussion of world population and resources, a brief outline is given in the Appendix of the demographic history, present position and future outlook of a few important countries. First, attention is focussed on a neighbour, namely, France, which although geographically close has exhibited important population differences from ourselves. Next, the twin giants of the present time, Russia and the United States of America, are discussed. Finally, in order to illustrate the position in countries experiencing more serious problems, but yet providing sufficient statistics for a fairly accurate demographic assessment, short accounts are given of India and Japan. The total population of the six countries, including Great Britain, amounts at present to nearly 1,000 million, or more than one-third of the numbers of the human race, and the range of their characteristics comprehends most of the various types of demographic conditions encountered in the world to-day. Some more extreme examples are mentioned later in the main text (paragraphs 69–70).

50. For convenience of reference, Table 5 gives a few salient facts for the countries that are discussed in the Appendix; the essential features to note are the wide variations in experience from one country to another and the steady pace of growth in the larger areas.

Table 5. Population development in Selected Countries, 1900–75

Year	Great Britain	France	U.S.S.R.	U.S.A.	India	Japan
	Total estimated population (millions)					
1900	37	39	111	76	245	45
1925	44	40	145	115	270	60
1950	49	42	207	152	360	84
1975 (forecast)	52	45	260	210	480	110
	Crude birth rate per thousand					
1925	18	25	44	22	45	35
1950	16	20	24	24	35–40	28
	Crude death rate per thousand					
1925	12	17	20	12	35	20
1950	12	13	10	10	25	11
	Crude rate of natural increase per thousand					
1925	6	8	24	10	10	15
1950	4	7	14	14	10–15	17

Note. The crude rates for India are estimates based on data collected in the 'registration areas'.

51. It may be added that the United Nations Organization's estimates(35) indicate a growth in world population from 2,400 millions in 1950 to a total of the order of 3,500 millions in 1975. These are arresting figures and lend urgency to the task of formulating population policies. To keep a sense of balance, however, it needs also to be said that such forecasts are based upon present levels of industrialization and urbanization and upon what Mrs Taeuber at Rome referred to as the projection of the 'lethargy of peasant societies'.

Population growth is bound to bring in its train social, economic and cultural changes which tend to modify that growth. Yet the immediate outlook is of a world increase exceeding 1% per annum, and there is very little prospect of any sudden modification.

Resources generally

52. It would be very helpful if a similar table could be given for the resources required in each country for the subsistence of the population, but the necessary information is not available. If it were, our knowledge of the relationships between population and resources would be greatly improved.

53. In any discussion of relationships between populations and resources it is essential to inquire how closely the concept of 'resources' can be defined, and to investigate what information is available about such relationships in the past. Neither of these tasks is easy, and many writers on the subject do not attempt them; nevertheless, precision in definition and investigation of all available information are cardinal principles of scientific method, and therefore call for the attention of actuaries.

54. The type of resource most directly affecting human survival is food. As its production depends on factors such as bacteria in the soil and the maintenance of stocks of various forms of animal life, it is now generally grouped within the comprehensive term 'biological resources'. The number of calories required daily from food to support a human life is known, and so is the calorific value of each form of foodstuff; the supply of this type of resource and its relation to demand can thus be measured with some degree of precision. In a report published by P.E.P.(36) the developments in world population and in world food supplies over the last 40 years were charted, each being expressed as a proportion of the amount in 1912. Both were shown to have increased by about 40% since before the First World War, and their movements apparently kept broadly in step throughout the period.* The data do not show, however, whether one of the two elements was dominant in influencing the other, or if so which was the dominant element, or why it was that no greater divergence between them occurred. Before any attempts are made to derive further information from the comparison of populations and food supplies, the following important considerations should be borne in mind:

(1) The use of any single index of food production or of any unit such as the calorie is an over-simplication, because man needs a varied and balanced diet and because the type of food and the effectiveness of its preparation differ from one area to another.

(2) World-wide comparisons are less instructive than analyses in which each self-supporting region is considered separately, while making due allowance for the influence of international trade.

(3) In every region there is inequality in the distribution of food; even when supplies are generally adequate there will normally be some localized undernourishment.

* According to Stern(59), world food production per head, expressed in terms of 1934 prices, trebled between 1850 and 1950. It thus seems probable that production rose faster than population in the second half of the nineteenth century.

(4) Although undernourishment is itself defined in terms of well-recognized deleterious effects upon health, no precise measurement has been made of the statistical relationship between undernourishment and mortality in a population.

(5) The importance and effect of each of these considerations are likely to have changed materially during the last 40 years.

55. It may be said that, while it is possible broadly to define food resources, insufficient information is at present available about the relationships between population and economic development. In consequence, neither the Malthusian view that slowly developing resources tend to hold in check a population capable of rapid increase, nor the opposing belief that given the right social system enough can be produced to support any likely population, has been fully substantiated or discredited. There is enough latitude in the data to permit either tenet to be held. We may project population on demographic bases and independently project resources on economic bases, but if the two trends are inconsistent we have no statistical evidence upon which to attempt to reconcile them. There is here much scope for research.

Non-biological and capital resources

56. The other types of man's resources are sometimes grouped under the two headings 'non-biological' and 'capital', that is to say, the supply of minerals and energy on the one hand and the accumulated stock of buildings, machinery and wealth and the labour force on the other hand. The difficulty of appreciating their past interrelationships with population is greatly enhanced by problems of definition owing to the continual process of scientific discovery and consequent changes in needs.

57. Even though forecasting presents many difficulties, the outlook for the years to come demands serious consideration, because economic burdens can be mitigated wherever man can plan ahead instead of having to adjust himself suddenly to unforeseen changes. There are two aspects of the future that call for different methods of approach. Either the prospects for the next 20 or 30 years can be looked at on the basis of a continuance of current tendencies, or a much longer period ahead can be considered by studying the estimated reserves of coal, oil, uranium and other useful materials and sources of energy, and estimating how long they may be expected to last if present techniques, and new methods that can be foreseen, are employed and if an assumed rate of consumption is realized. In so far as the problems of the near future are the more pressing they should receive the greater attention, but the longer-term prospects are also important since they provide the general framework within which any developments must take place.

58. At present, the opinions of those who write on the 'ultimate' state of man's resources are mostly cheerful, and since it is often assumed that every conceivable beneficial device will have been fully developed for his welfare it is difficult to see how the conclusions drawn could be otherwise. The rapid progress in the peaceful uses of atomic energy that was demonstrated at the Geneva Conference of 1955 gives just cause for hope. Looking so far ahead, however, carries one beyond applications of atomic energy in the present conventional forms to the days when thermo-nuclear forces are controlled, solar energy is harnessed to add its quota, and areas that are no more than

deserts to-day are made to blossom; or even to the time when mankind has achieved 'freedom from the mine' and 'freedom from the plant'(37), all necessary sources of energy and food being readily extracted by chemical processes from the surface rocks and the sea. Speculations such as these will not be referred to further in the present paper except to support the contention that a great intensification of scientific research is urgently needed in order that material progress may be accelerated. Attention will rather be paid here to the difficult transitional period in which we now find ourselves and in particular to the problems of the third quarter of the twentieth century.

59. Some indication of the problem of man's needs may be obtained from a study of the use he has made of the world's natural resources of energy. In order to illustrate this, a special very large unit has been devised—the Q, which is defined as 10^{18} British thermal units. It is the energy contained in about 38,000 million tons of coal. Putnam(38) estimates that the number of such units employed by mankind in the Christian era up to A.D. 1850 was roughly $6Q$. Since 1850, another $4Q$ have been used, and consumption has now risen to a rate of $1Q$ every 10 years. There seems little doubt that to-day's relatively very rapid rate of use does not represent man's maximum demands, for not only are the leading nations raising their standards of consumption, but also the less developed countries are beginning to advance in their use of power. Nevertheless, taking into account coal, oil and other fossil fuels, Putnam estimates the total reserves still available in the earth as no more than $27Q$. Additional energy that might become available from wind-power and water-power can provide only one-half Q per century, and the burning of timber and peat will add little to this. These are the estimates of one man, in a field where there are wide differences of opinion among the experts. Nevertheless, they do not seem to be seriously challenged by the views advanced on papers on resources that were submitted to the World Population Conference in 1954, although some writers referred to future improvements in estimates of available reserves. On Putnam's figures, however, it looks as though global non-biological resources are certainly adequate for man's needs over the next 30 years, whatever may happen afterwards.

60. To what extent will new sources of energy help in the problem of the future? There seems little doubt that solar radiation is a valuable and at present untapped supply. It is estimated that, at least in theory, the sunlight falling on the deserts of southern North America could supply all the present energy needs of the United States of America. For the time being, however, this source is uneconomic because of the high installation costs of the necessary apparatus, and in any event much research is needed before use on a commercial scale can begin. Atomic energy, although extremely promising in the long run, is also expensive to develop and, further, presents many practical problems. One has only to think of trying to use it to run an automobile if there were no petrol or oil. Nevertheless, the rapid advances made with breeder reactors and the beginning of experiments with the harnessing of thermo-nuclear forces promise well, and the final note should be one of optimism.

61. Although the world does not face problems of securing adequate energy in the immediate future, there are a number of present-day difficulties connected with non-biological resources. One is that current techniques of ore extraction need to be changed as the types of deposits of important metals and

chemicals now being worked become exhausted. Another is that the supply of metals such as copper, lead and zinc is dwindling and that there is a need to find adequate substitutes for use in industry. Easier methods of nitrogen fixation are also needed. Generally, the high initial capital cost of the new sources of power is an obstacle to rapid installation.

62. A different group of problems arises from the present maldistribution of resources throughout the world and the difficulty of mitigating it by means of trade. There is little or no coal in the under-developed lands of the East, and there may be few natural reservoirs of oil and gas, although until fuller geological surveys are made it is not possible to be sure what potentialities the earth holds. Atomic energy is said to be better and more readily adapted to the needs of industrially developed than of under-developed countries. It was argued at Rome that trade does not always help to level matters out, and in some circumstances may even operate to accentuate disparities in natural wealth. What appeared from the discussions to be needed most of all is a generous measure of investment of capital equipment in the East at the expense of some sacrifices by the advanced countries of the West, whatever political difficulties such a gesture may present.

Biological resources

63. Capital investment is needed also to increase the productivity of the land, but questions of 'biological resources' are generally more complex than those of minerals and energy; they depend to a greater extent on intricate social, cultural and economic factors. Nevertheless, whereas the need for energy is growing much faster than population, nutritional requirements can amount to no more per head than a man can eat. The problems of the immediate future are caused mainly by the facts not only that large sections of the world's population are at present underfed but also that it is difficult to increase production as fast as populations are growing and thus to maintain even the present meagre standards in less developed areas.

64. It is not easy to speculate about the potentialities for increased food production, because extensive soil surveys are needed for an accurate assessment, and these have yet to be made. Pessimists argue that the land is being overworked and the forests destroyed, with the result that 'dust-bowl' conditions are on the increase. Optimists point to the fertility of highly developed countries such as Denmark, and argue that by substituting improved agricultural techniques for primitive methods it should be possible to raise yields per acre substantially in India and elsewhere. More painstaking estimates, such as those quoted by the Registrar General for India in his Census Report (56), must command greater credibility than the airier forms of speculation. Even more relevant are the published figures for recent actual advances in productivity. In a Report of the United Nations Food and Agricultural Organization (39) it has been stated that the last 10 years have seen more rapid and widespread advances in the technical methods of agriculture and fisheries than in any previous decade. The figures of percentage increase in production are most encouraging, but it must be remembered that their base-line was an abnormally bad year just after the Second World War. According to the P.E.P. Report referred to in paragraph 54, the United Nations Food and Agriculture Organization has estimated that world output has increased by about 1% per annum since 1934–38. This is the average of figures for

different regions that vary from over 2% for North America to no more than 0·1% for less fruitful areas such as South-east Asia. It is in the less fruitful areas generally, however, that population is growing by more than 1% every year, that nutrition is already insufficient in quantity and quality, and that extreme poverty limits the effective demand for food.

65. Additional capital equipment is needed every time a population increases, for example, for medical care, food, education and even employment; the addition has been estimated at from £100 to £1,500 per head according to the type of country concerned. If the capital cannot be made available, each new generation will be impoverished in comparison with the last. Although some writers stress that capital formation also influences the rate of population growth, and that much research is needed into the interrelationships between national capital and income, it seems clear that expanding human numbers must require both extra income and extra capital. Unfortunately, countries where population is increasing the most rapidly are often those where it is least possible to create the necessary capital, for the lower the living standards the less the ordinary people can save. Nevertheless, a paper to the Rome Conference(40) criticized the view that upward population trends may be an obstacle to economic progress. The author argued that the need for increased resources is a potent stimulus to development, and that in particular an improved survival rate from birth to adult life should, by changing the age distribution, reduce the dependency ratio and increase productivity.

Outlook for the near future

66. The outlook for population and resources in the next quarter of a century varies a great deal from country to country. In France, a modest rise in population is hoped for by demographers—perhaps by about 7% as forecast in the most recent projections(41). The country should be able to sustain this increase and yet advance its standard of living, for its present population density is relatively low and the national economy is largely self-supporting. In America and Russia, however, a steady rise in population is expected, perhaps of 38% in the U.S.A. and of 26% in the U.S.S.R., during the third quarter of the century. In both these countries there is considerable confidence that resources can be expanded by far more than this increase in numbers, and in view of the short past history of modern development and the sources of natural wealth that are still untapped this view seems justified.

67. Relatively little change in the total British population, particularly at working ages, is expected in the near future, and this is perhaps fortunate, because a substantial proportion of the food and raw materials necessary for the support of the nation has to be purchased from overseas. In order to pay for imports the British have to trade the products of their skill and capital resources, and the economic position of the country is dependent on terms of trade which are unlikely to be more than barely favourable. As other nations improve their industrial efficiency, Great Britain is likely to face increasing competition in its efforts to export, and perhaps a decreasing demand for its products. If technical superiority can be maintained by developing valuable new equipment and products such as nuclear reactors and fissile material, much can be done to overcome these handicaps. Economic dangers of the same kind are present in Japan, but with a population likely to rise by some

30% between 1950 and 1975, Japan is confronted by a more acute problem than Great Britain. The proportion of food requirements grown at home is small, and since the war there has been a loss of overseas markets. The opportunities for emigration are very restricted, and continued American aid appears to be necessary for the economic well-being of the nation.

68. In India, although plans have been made to increase industrialization, very rapid development can hardly be expected, because of the difficulty of raising the necessary capital. In attempting to cater for a 33% rise in population between 1950 and 1975, the question of maximum food production therefore assumes great importance; but, from a careful survey, experts see a definite limit to the expansion that can be achieved. Relatively little help can be expected from international trade, and it has been argued that the only hope of averting famine lies in the increasing use of some form of birth control. Experiments have shown that it is difficult for the peasant masses to use current Western contraceptive techniques effectively (42), in spite of a desire for family limitation, and much will probably depend on the rapid discovery of simpler methods.

Extreme cases

69. This brief account of selected countries gives an idea of the range of prospects for the nations of the world to-day. Some areas, however, exhibit distinctive features in their population growth that have not so far been referred to in this paper, including certain islands in which the race between population and resources may be seen in an even more simple and direct form than in India. Among these Puerto Rico is perhaps a classic example. Its area is only 3,400 square miles, but its population grew steadily from 45,000 in 1765 to 732,000 in 1877, and reached no less than 2,211,000 by 1950. The density is now 646 per square mile. As a result of the use in the island of the most recent medical discoveries and techniques the death rate had been reduced to 7·5 per thousand by 1954, but the birth rate was then still as high as 34·7 per thousand. Although fertility is beginning to decline—the birth rate had been no less than 42·2 per thousand in 1947—a further rapid increase in population seems inevitable before the fall can become really effective. Two distinguishing features in the circumstances of Puerto Rico are, first, that there are good opportunities for emigration—70,000 persons left the island in 1953, bound mostly for the United States of America—and secondly, that, for reasons connected with religious beliefs and social customs, sterilization has achieved a growing popularity as a means of birth control.

70. An island with a population density even of double that of Puerto Rico is Barbados, where 220,000 people are crowded on to a space of 166 square miles. This region can hardly be said to be 'under-developed', since its only appreciable asset, the soil, is fully given over to its best use, which is the production of sugar cane. In the absence of mineral and other resources, the prospects for industrialization are inevitably poor. When civil registration commenced, 30 years ago, the population numbered 155,000, and the birth rate and death rate were more or less evenly balanced at about 35 per thousand; but by the middle of the century the advance of medicine and sanitation had already brought the death rate down to about 15, while the birth rate remained almost unchanged. In the last 5 years sugar production has been

at a very high level—three times as great as in 1922—but the weather is said to have been exceptionally favourable, and it is doubtful if the present output can be maintained, let alone improved. Barbadians are apparently well aware that the island is over-populated; nevertheless, birth control is not at present extensively practised, and their numbers continue to increase. Some outlet is being sought in emigration, but it would appear that the next few years will bring a further increase in population density, and there is a grave danger of widespread misery if the sugar crop should fail to maintain its present yield and value(43). Recent hurricane damage has accentuated the danger.

The core of the problem

71. It may be instructive to turn for one moment from human populations to those of animals. Data that have been collected from various species show that animal numbers fluctuate irregularly, but remain much below the levels which their fertility rates would permit (and do permit in special circumstances such as the colonization of a new and favourable territory). The limiting factors, in order of importance, are considered(44) to be food shortage, predation and disease. Man in his primitive state may well have been subject to similar natural influences, but from the stone age onwards his inventiveness has added many factors promoting population growth; his power to devise means of increasing the food supply, to protect himself, to build shelter, and more recently to prolong life, has combated all the influences restricting numbers. He should now be in a position to exercise control in the long term over not only the rate of growth but also the quality of his species, and should be more than ever before the master of his fate. If mineral resources and supplies of energy necessary for modern industrial life are being used up, as they undoubtedly are, it should be at least possible for him to adapt himself to their limitations and to maintain the highest possible degree of economic development and the highest level of human happiness.

72. Where, then, does the problem of population and resources lie? It may be argued that it is found in man's reluctance to accept the responsibility for curbing population growth. This non-acceptance has been defended from deeply held religious convictions the sincerity of which must be recognized —as we must also recognize the sincerity of those who argue that unbalance between resources and population is merely one of redistribution of resources. Sincerity does not, however, overcome the challenge of plain arithmetic. In present circumstances it seems inescapable that the international inequalities that are a source of danger to peace will for a time remain very difficult to mitigate. Aid given to under-developed countries in order to avert famine may well be defeated in its purpose by stimulating a further increase in numbers to press upon resources unless restraint in the production of children is exercised by the recipients of that aid.

Redistribution of population

73. There are many facets of the problem of world population upon which it is not possible to touch in this paper, even in the lightest possible manner. One aspect, however, demands special attention. It has been strongly urged(45) that a better balance between population growth and resources might be secured by redistributing population. It is true that about one-half of the

world's population is concentrated in one-twentieth of its land area and that there are parts of the globe, for instance, Australia and Brazil, where there are room and potential resources for many more people than are at present occupying the territory. There is, however, a large discrepancy between theory and practical politics. In a paper to the Rome Conference, the Population Division of the United Nations reviewed the dimensions of intercontinental migration in the period 1945–52(46). The total movement amounted to only 6·3 million, of which 4·5 million was attributable to emigration from Europe, and a further 1·1 million to immigration into Europe. A net migration from Europe of an average of 400,000 persons a year is, however, less than one-tenth of the annual natural increase. Emigration from Asia, other than Russia, amounted to less than a quarter of a million—an insignificantly small amount for a total population of more than 1,320 million. It would require very large numbers indeed to have any significant effect. As pointed out at a Royal Statistical Society discussion(47), 'the emigration of two million Chinese, which would amount to a quarter of the population of Australia, would be only 0·4 per cent of the population of China'.

74. The main restraints upon migration are: (1) inimical climates in those countries where there is room to spare; (2) economic obstacles to the acquisition of land by the immigrants; (3) lack of domestic capital for the development of the transport and industrial facilities to support their settlement; (4) the reluctance of many immigrants to accept peasant status or unskilled jobs rather than remunerative employment in industry which they would prefer to seek but which is in short supply; and (5) the cultural difficulties of assimilating populations of different ethnic origin. It seems unlikely that these obstacles can be overcome in the near future to an extent sufficient to raise migration to the level of a major palliative to population pressure.

75. Nevertheless, in emphasizing that the contribution of migration to the reduction of numbers in the overcrowded regions is unlikely to be dramatic, it must also be made clear that there should be no relaxation of efforts to foster migration where it is mutually beneficial to the sending and receiving countries. Apart from the mere effect upon numbers, migration can confer more specific benefits out of all proportion to the numbers involved. It may raise the level of efficiency of the economy of a developed country by remedying maladjustment of the balance of skills in the labour force; Canada, for example, has been very selective in the types of labour that she has encouraged to immigrate in the post-war years. In undeveloped countries with high fertility, high mortality and average income at subsistence level—what Liebenstein(48) calls the Malthusian equilibrium—emigration may under suitable conditions disturb equilibrium in the direction of raising average incomes and rendering possible the accumulation of domestic capital. This, together with other economic developments arising from the importation of capital and innovations, may react upon population growth. The econometricians have done much to study the dynamics of this process in theory. Such migration as takes place, however, is still largely on an empirical or political basis without previous assessment of capital requirements, economic consequences, or social and cultural needs. The problem seems to be one to which actuaries might make a valuable contribution by studying the demographic and potential economic effects of specified amounts and types of migration.

CONCLUSION

76. The purpose of this paper is to direct the attention of actuaries to the problems of population with which the world is faced. There is now an awareness the world over that in wide areas the growth of populations and increases in available economic resources are, to say the least, not commensurate. In a number of countries governmental action has been taken—not always perhaps on lines that would commend themselves in this country—in an attempt to mitigate the adverse social effects which arise when the population increases more rapidly than the economic resources requisite to sustain it, even at a level of bare subsistence. At home, a decade of full or overfull employment has caused the apprehensions of the 1930's (when, incidentally, the net reproduction rate was round about 0·80) to be forgotten. To-day it is not declining population but the problem of meeting the needs of 50 million people in a relatively small area, by the importation of a large part of their food and much of the raw material essential to their industrial life, which must always be in the background of our thoughts about the long-term prospects of Great Britain. The Report of 'The Presidential Materials Policy Commission' (the 'Paley' Report)(57) in the United States indicates that, even in that country of vast and seemingly ever-growing productive capacity, there are grounds for apprehension concerning the adequacy of certain of that country's natural resources on a long-term view. Thus, although the degree of emphasis and urgency varies from country to country, it has come to be accepted that an ever-growing world population gives rise to problems of matching economic resources.

77. The policies of Governments, both nationally and internationally, if they are to be realistic, must be based on the scientific measurement and interpretation of both demographic and economic phenomena. Actuaries, who have done so much in the past to help in developing the techniques of demographic measurement, have their part to play in collaboration with economists, biologists and others in helping to define the problems to be solved and to measure the results of any governmental action. In the first part of this paper attention has been directed to some of the demographic tendencies in Great Britain since the Royal Commission on Population reported in 1949. There has been in recent years a retreat from single generalized measures of population changes, such as the net reproduction rate, to more analytical and even homely methods of a 'descriptive' character.

78. The primary function of the actuary, however hidden by his basic approach through the conception of a present value, is in reality the estimation of emerging costs over the years. His training in taking the long view for such purposes should prove of inestimable help in measuring the trends and tendencies not only of the population but also of the correlative economic factors which, as the Rome Conference demonstrated, equally call for long-term appraisal before the problems of population can be understood and their solution attempted. The Population Commission of the United Nations at its 8th Session has stressed that 'the object of the United Nations effort toward development of the less developed countries will be imperilled if the population factor is neglected', and has referred to the need for 'essential information upon which to decide the direction of action designed to raise levels of living' and to 'indicate both the nature of population stresses and the

spheres within which action is possible'. The United Nations Organization has drawn up a long list of gaps in existing knowledge on the relationship between population and economic and social factors. Here, surely, is a vast field of study in which the younger generation of actuaries, with their basic training in statistical methods, can make a major contribution.

POSTSCRIPT

79. By a happy coincidence, just as this paper was completed, powerful support for one of its main theses has been provided by the publication of a report on *World Population and Resources* (58). This authoritative study is the result of several years' work by a group of persons who are 'either professionally concerned with some aspects of the problem or have given a great deal of time to studying it...'. The Report points out that much has been written on the subject in recent years; but official contributions tend to be factual and statistical and to steer clear of the more awkward and fundamental policy issues, while unofficial contributions have been written largely from a restricted standpoint and sometimes in a controversial vein. The aim of this independent Report is to do something to stimulate more responsible and practical discussion.

80. It would not be appropriate here even to summarize the group's conclusions and recommendations, but, as an example of the measures advocated, mention may be made of the group's recommendation that Governments applying for technical assistance from the United Nations Organization should be 'requested to indicate the anticipated increases in and resources in comparison with the anticipated related increases in local population'. The necessity is urged for regular investigations into population and resources and for research into the economic implications of very rapid rates of population increase, especially regarding capital formation, the capital requirements of different categories and the trend of income per head. Actuaries who, as it is hoped, may feel drawn to this field of research could suitably begin by studying this able Report.

APPENDIX

Notes on the Populations of Selected Countries of the World

(1) *France*

When, at the beginning of the nineteenth century, the first censuses were taken on both sides of the Channel, there were 29 million persons in France but only 11 million in Great Britain. These numbers were in much the same proportion as the areas of the two countries, and thus each had about the same population density. To-day their relative positions are greatly altered; the French population is about 15% smaller than the British, namely, 43 million as against 51 million. The populations have developed quite differently and their rates of growth have been widely disparate, especially during the past hundred years. Since 1850 there has been an increase of some 30 million people in Great Britain, although a net total of about 4 million emigrated. France gained only about 4 million people in the same period, of whom about one-half were accounted for by a balance of immigration over emigration (49).

A generally similar contrast would be found if France were compared with one or other of the remaining Western nations. Elsewhere, rapid growth, leading to outward migration and other signs of population pressure, has been the common experience, and in not sharing this France stands alone. Whereas in Great Britain fertility did not start to fall until around 1880, it is estimated that knowledge of effective contraceptive practices had commenced to spread in France a hundred years earlier. Probably encouraged by the Revolution, the diffusion of such knowledge continued until by 1850 some form of birth control may well have been practised by the majority of French families. There are signs that small families were officially encouraged, at a time when birth control—along with other French institutions—was frowned upon elsewhere in Europe. Since the nineteen-thirties, however, and especially since the Second World War, successive French Governments have sought to attract immigrants of suitable race and age, and have offered inducements to increase family size. The sale of contraceptives has been prohibited since 1920, and from 1940 there has been a severe penal code directed against abortion. Family allowances on a voluntary basis in industry began to appear in 1916, and by 1930 almost half the working population were covered (50). Government intervention began in 1931 to remedy complaints of uneven operation of the system of allowances and their extension to agricultural workers was effected after 1939. By 1945 the practice of granting allowances had developed into a large, integrated and costly social security system—without impairing industrial financial autonomy—and the allowance represented a substantial proportion of the standard wage. Despite the illicit contraception and abortion which a repressive law has tended to encourage, the birth rate in France has recovered from 15·1 per thousand in 1935–39, when it was actually below the death rate of 15·7 per thousand, to a level of 18·7 per thousand in 1953, when the death rate was 12·9 per thousand. Although the birth rate is now slowly declining, it can be said that France has been more successful than most Western countries in maintaining post-war fertility increases. Fertility is higher, and population growth more rapid, in France than in Great Britain at the present time.

(2) *Russia*

The Union of Soviet Socialist Republics is more than 8 million square miles in extent, a space into which Great Britain and France together could be fitted no less than twenty-eight times over; and one approximately equal to the combined area of Central and North America. As there have been only three complete modern censuses, in 1897, 1926 and 1939, and as registration of births and deaths has been somewhat incomplete and the publication of statistics intermittent, the demographic history and present situation of the Union are less clear than for some other countries. It is believed, however, that in the earlier part of the eighteenth century there were about 20 million people in Russia, mainly in the European part, and that by the middle of the nineteenth century the number of persons had increased to 60 million. In 1939, 171 million were enumerated, and within the enlarged boundaries of to-day the population is probably now appreciably in excess of 200 million. (The U.N. Economic Commission for Europe has published an estimate of 207 million at December 1951.) This tenfold increase in 200 years is similar to the rate of growth of the British population in the same period, but the

circumstances of the two increases are different. The number of persons per square mile is by far the lower in Russia, and much of the development there has taken the form of opening up new territories. It is estimated that there was a net movement of 3½ million people from the western to the Asiatic part of the country in the nineteenth century, and of another 3½ million in the years 1900–14(51). In more recent times internal migration, much of it compulsory, has been on a massive scale(52).

The rate of population growth in the Soviet Union remains high to-day. In 1926, the reported birth rate of 44 per thousand for the European part exceeded the reported death rate by 25 per thousand and, although the birth rate for the whole territory may by now have fallen to about 24 per thousand, mortality has fallen also and the rate of natural increase may still be as large as 15 per thousand. The fall in fertility may have been associated with a movement towards the towns, in which 37–40% of Russians now live compared with 15% in 1926(53), and with social and economic changes under the Communist régime. But recently the Soviet Government has called upon parents for an increase in the numbers of their children, and has proclaimed a three-child, rather than a two-child, family to be the national ideal. The doctrine of Malthus is regarded as heretical, and the official view is that matching resources will derive from the added productivity arising from any likely increase in population in the future. A revision of the original League of Nations projections(52) gives 241 millions for the U.S.S.R. in 1970.

(3) *The United States of America*

The rate of population increase during the past 150 years has been considerably more rapid in the United States even than in Great Britain or Russia. Although to-day there are about 160 million persons in the United States, in 1820 the population was only 10 million and was lower than that of England; but it was already growing at the rate of 35% every 10 years, and the exceptionally favourable opportunities for its development attracted the attention of Malthus himself as an example of the power of the human species to reproduce. The development of his argument was hampered, however, by lack of knowledge of the extent to which immigration was helping to advance the rate of growth. The absence of reliable statistics in this respect continued until the end of the nineteenth century; nevertheless, it has been estimated that during that century 18 million persons entered the country and remained there, while the natural increase was 53 million. Since 1900, another 10 million have been added by immigration(54), but further admission is now on a controlled scale and has not accounted for the greater rate of population increase in the United States than in Great Britain in recent years. The birth rate is higher in America (24·7 per thousand in 1953) and the death rate lower (9·6 per thousand in 1953) than in Great Britain. Differences in age distribution account for part of the disparity, but not all of it. An increase of from 20 to 30% in the next 15 years in the United States population (i.e. to between 190 and 204 million) has been forecast on various assumptions—a greater relative increase than in any projection for Great Britain(55). This difference in outlook depends to a material extent on the prospects for fertility, and is influenced by the fact that, since the post-war peak, births in the United States have remained at a relatively high level, as in France, and have not fallen as had been predicted. There has not, however, been any official policy

of encouragement or inducement to parents to have larger families, and the increase in fertility (which is partly due to higher rates of marriage and lower marriage ages) is doubtless mainly attributable to high prosperity and an optimistic economic outlook. It has to be borne in mind that before the Second World War the United States had experienced a period of acute economic depression which may have brought about abnormally low levels of fertility and that the present level may be 'normal' in relation to present economic circumstances.

(4) *India*

On the strength of very limited information, it is believed that the population of India increased, probably in rather an irregular fashion, during the seventeenth, eighteenth and nineteenth centuries. In more recent times, the rate of growth has been rapid, and from rather more than 250 million in 1921 the population had risen by 1951 to 360 million. Incompleteness of registration of births and deaths renders it difficult to give an accurate picture of mortality or fertility, but it appears that, except in years of famine, the rate of natural increase has remained positive and has averaged over 10 per thousand. Although some Indians have moved overseas, emigration has necessarily been insignificant in relation to so large a population. The application of modern medicine has reduced the death rate, although even to-day it is of the order of 25 per thousand. Fertility may have declined slightly, but at present there seems little likelihood of a significant further decrease in the near future; indeed, the birth rate, after allowing for the effects of infantile mortality, may even rise as a result of improving health measures. Urban-rural differences in family size are probably unimportant, and in any event the proportion of industrial to agricultural workers is low and can hardly increase rapidly. It seems, therefore, probable that the population will continue to increase, to reach 450 million by 1969 and, if unchecked by famine, as many as 520 million by 1981 (56).

Tests and surveys show that there is undoubtedly a desire to limit families among the people, but it is not matched by sufficient knowledge or perseverance to learn or apply birth control techniques at present available. If the search that is now being made for a simple orally-administered contraceptive is successful, the chance of a rapid diminution in fertility will be greatly improved. The Indian Government is conscious of the fact that lack of balance between population and resources inhibits the economic development of the country, and religious scruples seem unlikely wholly to prevent the application of measures designed to reduce the gravity of the situation. In the meantime significant progress is being made to mobilize the country's huge labour force and to introduce more intensive land cultivation such as Japanese methods of rice-growing.

(5) *Japan*

In the exceptionally stable national conditions of 1725–1850, the Japanese population, which was partially enumerated every 6 years, is known to have remained nearly constant at about 30 million. The advent of the modern era was accompanied by an increase in numbers, as in other countries, and by 1920 the population had grown to 56 million. The recorded birth rates and death rates both rose during this period. This change may have been due in

part to an improvement in the proportion of events registered, but there was also a real upward movement in fertility that precipitated the increase in population, and this was attributable, at least in part, to measures designed to suppress abortion and infanticide. The population has continued to increase since 1920, despite a fall in fertility due to urbanization and other effects of industrialization such as a rise in the age of marriage. It is now almost 90 million, and according to current projections may reach 100–113 million by 1970.

Emigration has never supplied an adequate outlet to Japanese population pressure and, even when prospects were favourable because of national expansion of territory, only about 3½ million Japanese lived in Korea, Manchuria and elsewhere overseas. Since 1945 many of the pre-war opportunities for outward movement have been lost.

The Japanese Government is conscious of an acute population problem in an area that is only one-quarter of a million square miles in extent and of which only one-fifth is suitable for food production. In 1948 abortion was to all intents and purposes legalized, and the desire of people for family limitation has expressed itself in a remarkable decline in the birth rate—from 34 to 19 per thousand in 6 years. It is estimated that in 1952 there were about one and a half million abortions (reported and secret), while the number of live births was 2·1 million. It seems likely that more effective and less drastic methods of limitation will become more widespread in future. As a result of advances in medical treatment, the death rate has fallen from 18 to 8 per thousand since the beginning of the war, and thus even to-day there is a net rate of natural increase of 11 per thousand.

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ABSTRACT OF THE DISCUSSION

Mr F. A. A. Menzler, in introducing the paper, said that the idea of preparing it had taken root at the World Population Conference held in Rome in September 1954, under the auspices of the United Nations. The three authors had attended that Conference in various capacities and, like actuaries from other countries, had taken part in the proceedings.* Nearly a hundred years previously it had been the custom of Samuel Brown, the Institute's third President, to attend all international conferences on statistics and population and to give some account of them in the *Journal*. In that respect the paper maintained, or rather restored, a tradition.

But the conclusive argument for submitting the paper had arisen out of a discussion on the training of demographers. The authors had been under the impression that they were demographers, or at least demographic statisticians, but apparently nearly all the writers of the dozen or more papers on the education and training of demographers had never heard of actuaries, nor were aware of the fact that demography was one of the subjects in the Institute's rather exacting system of examinations. It had fallen to one of the three authors, not without a certain satisfaction, to remind the meeting that actuaries had made material contributions to the methods of demographic measurement—to which allusion was made in paragraph 4 of the paper—and that the Institute even had its own text-book on the subject, which it was comforting to know sold as well outside the Institute as in it. Incidentally, the Society of Actuaries had recently also published an official text-book on Demography.† Nobody had challenged those claims; indeed, full acknowledgments had been made by a number of speakers. Nevertheless, it was a fact that, as an Institute, they had not devoted much time of late to the consideration of such problems of population as had brought together some 450 experts from all the principal countries of the world, excluding only the Chinese People's Republic and Korea. Among them had been actuaries occupying official positions in the United States of America, India, Finland, Great Britain and Italy, and in the International Labour Office.

The purpose of the paper was quite simply to re-awaken the interest of the profession in Britain in the vital questions of population and resources which would increasingly engage attention in the years ahead. References were made in the paper to various problems that awaited research. Some of these were of direct domestic interest to actuaries. For example, the forecasting of mortality might almost be described as actuarial bread and butter. It seemed to be fashionable to eschew the word 'forecast' and to substitute the pallid word 'projection', as if it were in some way disreputable to attempt to form a judgment on the likelihood of future happenings upon the possibilities of which people had in any event to take decisions. Yet the very justification of actuaries' existence as a profession was precisely in the duty to make forecasts of emerging costs involving *inter alia* mortality, however wrapped up in the concise summaries which they termed present values.

Could their present conventional methods of forecasting mortality be justified when the relative incidence of the different causes of death was changing before their very eyes? If time permitted, it would be tempting to refer to the rise and fall in statistical esteem of the net reproduction rate. The esoteric cult associated with that statistical measure had scarcely found expression in Rome. The Royal

* *J.I.A.* **81**, 186. † Reviewed *J.I.A.* **82**, 162.

Commission on Population had introduced, with the guidance of its Statistical Advisory Committee, a substitute based on the average size of family born to a particular cohort of marriages; but, as pointed out in the paper, the relative constancy of the average size of family in recent years itself concealed counterbalancing changes. Clearly there was room for further research in which, he suggested, Cox's statistical models should be kept in mind. In the meantime, it had to be conceded that the net reproduction rate retained some degree of respectability in that a better standardized measure for the purpose in view had still to be devised.

The discussions at Rome had placed great emphasis upon economic factors. In that connexion the Population Division of the United Nations Organization had listed some fifty major gaps in existing knowledge of the relationship between population trends and economic and social conditions. That gave ample scope for the active-minded and, if encouragement were needed, he would mention that ample prize funds were at the disposal of the Council.

What was the practical significance of it all? The reply was perhaps most succinctly expressed by the figures quoted in paragraph 64 of the paper. World output of food was estimated by the United Nations Food and Agricultural Organization to have increased by about 1 % per annum since 1934–38, but that overall average concealed variations from over 2 % for North America to 0·1 % for less fruitful areas, such as South-Eastern Asia. But in the less fruitful areas population was growing by substantially more than 1 % per annum. In short, there was a worldwide problem of the uneven distribution of resources with inherent dangers to peace, in which Britain and indeed all nations had a paramount interest. Realistic national and international policies could be based only on the scientific measurement and interpretation of both demographic and economic phenomena. To that actuaries had both the competence and the duty to make their contribution.

Mr C. M. Stewart, in opening the discussion, observed that, judging from his opening remarks, Mr Menzler would be very pleased to know that the Actuarial Tuition Service, in the course of training in demography, asked students to submit answers to the following question: 'What is the general demographic outlook for the population of Great Britain? Would you regard it as similar to that for the world as a whole at the present time?' Clearly that question was set in order to focus the student's attention on the great contrast between the relatively stable position in Great Britain as regards numbers in the population and economic prospects, and the position in the world as a whole, where the population was increasing rapidly and apparently outstripping food production in large areas.

That contrast was brought out very clearly by the authors in their paper. Indeed, the contrast was so marked that it might be wondered whether the two sections of the paper could really be allied at all. But, of course, they could, and by placing them alongside one another in that manner the authors had effectively demonstrated the gulf that existed.

The first half of the paper dealt with developments in Britain in the period 1949–55. The authors studied the position in some detail, they discussed some interesting statistical points, and concluded that there had been no startling developments.

As regards mortality, it was to be noticed that no improvement had been experienced at the upper ages. It was perhaps natural to look for improvements

at all ages, but that need not be the case. It might be that improvement over one range of ages, by the conquest of mortality from some disease, would result in an increase in the death rate at the ages following. It was possible to make a fairly reasonable hypothesis about persons who formerly succumbed to the disease being in any case of less than average vitality, and reconstructing the life table to correspond could result in higher mortality rates at higher ages. It was speculation, of course, but so, for that matter, were most hypotheses on the future course of mortality rates.

On migration, the net movement was negligible. Future prospects might well depend to some extent on conditions outside the country, e.g., in the West Indies. It was also possible that the expected future shortage of young marriageable women might result in increased emigration of young single men, perhaps not directly in search of wives but rather indirectly because there would be a greater number without the home ties that went with marriage.

On fertility, as the authors pointed out, the recent experience had matched the most optimistic of the Royal Commission's assumptions. If the Royal Commission were meeting again, in 1956, he wondered what their most optimistic assumption would be. What weight would they give, for example, to the current maintained high level of fertility in England and Wales, or to the even higher level in Scotland where the net reproduction rate exceeded 1·10? How would they evaluate the probability that, with an improving standard of living and close cultural links with the U.S.A., Britain might go some way towards the level of fertility currently being experienced there, with a net reproduction rate exceeding 1·5? He suggested that a range of projections might reasonably include an illustration where fertility exceeded replacement level to some extent.

On the subject of fertility, he believed much was to be gained from examining the fertility achievement of successive generations of women, perhaps in the manner outlined by the authors in paragraph 30, but it was probably overzealous to go on and make hypotheses about the probable future achievement of young women not yet 20 years of age—as the authors said in paragraph 27 that Carrier had done. There was, however, a great deal of value in Carrier's paper, and the authors would agree that it was not to be judged by that single reference quoted out of context.

Before leaving that section of the paper, he wished to draw attention to Table 4. There the proportions married among women in the fertile age range were set out. It had to be remembered that the proportion married at ages under 25 was low compared with the proportion married above that age, and should the number in the younger group suddenly become a much larger proportion of the whole, then it was possible to have an increase in the proportion married at each age and yet the proportion married for all ages combined might fall. Such an apparent paradox was likely to occur in about ten or fifteen years' time when the post-war bumper crops of births entered the age range 15–25. He mentioned that as a warning for future reference, not as a criticism of the authors for using such proportions in the paper, where they served their purpose adequately.

In the second half of their paper, the authors dealt with the world problem. They said quite frankly that that was the purpose of their paper and that the discussion of the position in Great Britain was a curtain-raiser, and they took pains to persuade their readers that it was a problem which concerned actuaries. He was convinced, as were the authors, that it was a problem of extreme importance and urgency, and one which the actuary, by virtue of his training and

outlook, was well able to understand, and, it was to be hoped, to play a useful part in solving.

The authors had been necessarily brief in presenting data on the world problem. They mentioned five countries, but those interested could find much more in the P.E.P. publication mentioned in the list of references. Like the authors, he had been most impressed with that 'authoritative study', as the authors called it, not least with the section dealing with birth-control. It was a model of tact and circumspection and should certainly be read by everyone whose religious beliefs prohibited the use of mechanical means of contraception.

There was one other source of data which he would like to mention, namely, Sir John Russell's book *World Population and World Food Supplies*. That volume dealt at some length with current production and consumption of food in the several major areas of the world, with future possibilities for production by way of improved efficiency and extending the area under cultivation, and, more remotely, with finding possible new sources of supply.

The main problem was defined in the last sentence of paragraph 63—that large sections of the world's population were underfed and were growing in numbers so fast that it would be difficult to maintain even the current inadequate standards of nutrition, let alone improve them.

Looking at the world as a whole, it was possible to see large areas, e.g., in South America and Australia, which offered scope for large increases in food production, but the difficulties involved in transferring produce from there to the needy areas, or in arranging for the emigration of persons from the needy areas to those lands, were enormous. Examples of those difficulties were the volume of trade necessary, the capital investment required to enable the needy areas to become industrialized and so able to afford to import food, and the political difficulties of obtaining agreement in the receiving countries to their being flooded with settlers alien to them in many ways, such as language, culture, outlook, and so on.

But any such steps, even if they were practicable, could be no more than a temporary solution. The population increase would be likely to continue unabated until the physical limitations of the world prohibited any further growth. That position had not yet been reached for the world as a whole, but it had been over-reached in certain small areas, e.g. England, which was unable to produce enough food within its own shores and was dependent upon a large volume of food being imported from abroad, and yet English towns continued to encroach on the already inadequate area of cultivated land.

The main answer to the problem could only be to tackle it locally, and in that connexion the example being set in India was notable. There, it had been recognized that no rapid improvement in the standard of living could take place without a simultaneous reduction in the rate of population increase. Not only were active steps being taken towards rapid economic development, but there was an awareness of the need for family limitation and a preparedness to do something to promote it. The Indian Government, under the Second Five-Year Plan, had earmarked £3 m. for setting up birth-control clinics. It was to be hoped that all the difficulties—and they were many—would be overcome and that the example being set would encourage others to take similar steps.

Sooner or later the tap of population increase had to be turned off. For a certain time they might be able to run and fetch buckets, but eventually they would run out of buckets. They had to ensure that the tap was turned off before that situation arose. Birth-control was the only answer; he was referring to

birth-control as an end—not to the various means to that end, which were the subject of much controversy. They might be optimistic and assume that the tap would be turned off in the East, quite spontaneously, as it had been in the Western world. They might be pessimistic and point out that time was short, that there were fewer buckets left, and that the flow was much faster than it had been. But let them be realistic, and be aware of the fact that it was within man's power to turn off the tap, and by default the problem was of his creating.

Mr R. D. Clarke said that the study of population had economic, sociological and political implications of the utmost importance, although naturally those in the Institute thought of it primarily as a branch of statistics. That had already been made abundantly clear by what had been said so far. Those wider implications had clearly been much in the minds of the authors of the paper, in which the major problems then facing the world as a consequence of current population trends had been set forth cogently and dispassionately.

A good example of the way in which a few figures could epitomize a major social change might be found in Table 3. In 1921 there were 875 unmarried men in the age group 15–44 for every 1,000 unmarried women in the same age group. In 1951 the situation had entirely changed and there were 1,120 unmarried males to 1,000 unmarried females. That decline in spinsterhood, to use Hocking's vivid phrase, had substantial consequences in the country's labour situation at all levels. At one end of the scale it was no doubt a contributory cause in the extreme shortage of domestic servants. A shortage of female labour, however, was felt at all levels and in most branches of employment. At the same time, the substantial increase in the numbers of married women in employment compared with the pre-war period reflected another major change in social custom and family life. A change of a more intangible kind which might be expected to occur was some decline in the influence of women in public life. During the past thirty years a considerable impression had been made in many departments of public life by unmarried women who had taken up careers in professional and administrative fields or in journalism, politics, social welfare, etc. It was possible that, with the decline in the numbers of unmarried women, there might be some decline of feminine influence in the quarters where public opinion was formulated or where power was effectively exercised to determine policy. As he had indicated, developments of that kind were intangible and they were difficult to appraise, but culturally and socially their consequences could be far-reaching.

The increase in marriages meant, of course, an increase in the number of family units requiring homes, and so it intensified the housing problem, already rendered acute by the natural increase in the total number of the population and by a general improvement compared with pre-war days in the standard of accommodation required by the mass of the community. No doubt demographers were already making a contribution to long-term planning for the country's future housing policy.

In paragraph 26 the authors rightly pointed out that much of the recovery in fertility in recent years had been due to the increase in marriage rates and in the proportions married. The fertility rates of married women had changed little during the past few years. Obviously there was a limit to the possible increase in proportions married, and it was not therefore likely—although he thought that the opener seemed to feel differently—that further increases would continue for much longer to contribute to rising reproductivity. It would accordingly be

necessary for fertility within marriage to remain at least at its current level if the population was to replace itself in each successive generation.

It was at that point that the demographer had to give up any pretence of estimating or forecasting. He would, however, refer to two factors both of which might have a depressing effect on fertility rates. The first was the increase of married women who were in employment. The second stemmed from the social class differentials in fertility, to which the authors had drawn attention in paragraphs 35–37. At the time of speaking there was a tendency for the numbers engaged in non-manual occupations to increase relatively to those engaged in manual occupations. Moreover, middle-class standards of life and attitudes were being accepted by an increasing proportion of the total population. Both those movements could have the effect of diminishing the more fertile section of the community and increasing the less fertile section. On the other hand, a change of fashion in what had come to be called family-building habits could easily nullify any prediction based on such speculative premises.

Nearly half the paper was concerned with the population problems of the world as a whole. It was indeed desirable that they should turn their attention to the international sphere. Their own national problems dwindled to triviality beside the pressure exerted by rapid expansion of population in Asian countries. It was not necessary to be a neo-Malthusian to be concerned at the tremendous strain on world resources caused by ever-growing numbers of human beings. From Table 5 in the paper it seemed likely that at the current rate of increase the population of the world would at least double itself within the space of a century. Quite clearly that could not continue indefinitely, otherwise a period of a thousand years would bring a thousandfold increase in population. One day a check to that rate of increase had to come, as the opener had said, or else there would not be standing room on the earth's surface for everybody living.

In paragraph 51 the authors stated that population growth was bound to bring in its train social, economic and cultural changes which tended to modify that growth; but the validity of that as a general statement was somewhat undermined by the examples of Puerto Rico and Barbados, quoted in paragraphs 69–70. It was perhaps conceivable that by irrigating deserts and developing other areas then underpopulated, the earth could support twice or even three times the current size of the human race. But sooner or later the checks were bound to begin to operate, and the choice would lie between famine and war on the one hand and conscious limitation on the other. It was to be hoped that wisdom might prevail while there was time.

Mr J. Hamilton-Jones thought that the theme of the paper was summed up in paragraph 53, in which—to paraphrase—actuaries were urged to look beyond the field of demography into the field of human ecology. What happened when that was done was illustrated by the structure of the paper. In dealing with Great Britain, the authors were purely demographers. Much of what they said was to some extent already familiar. But in dealing with world population and resources the authors were on new ground. In fact, in his view, the ground was comparatively so unmapped that it was no place for the inexperienced or the amateur. It challenged actuaries to use their best research talents.

Many times in the paper the phrase 'population problem' occurred, and in paragraph 51 the authors referred to the task of formulating population policies. He thought that actuaries had to concentrate their efforts there. The main problem, he thought, was the problem of data collection and presentation, with

which they were so familiar and on which they could speak so authoritatively. As regards population policies, he felt that even the great Plato had blundered when he had come up against that subject; in Book V of his *Republic* he wrote that in his ideal city marriages should be placed under the control of the magistrates in order that they might, as far as they could, keep the population at the same point, taking into consideration the effects of war and disease. In the light of subsequent human history, there was no ground for supposing that man's highest development would be in any way furthered by the maintenance of a stationary population.

If, then, they were to avoid the unscientific and purely speculative aspects of ecology, wherein lay the most promising field for actuaries to study? In the time scale they were looking into the future, but he felt that research concentrated on the detailed pattern relating to the next 25 or 30 years was far more valuable and authoritative than less concentrated research spread over half a century or more of the unknown future. Chart 1 was only spread over a little more than two human life-spans, a thought which was likely to deter anyone who wished to establish a reputation for long-term prediction. As to the subjects for research, they should heed the warning which was contained in the last sentence of paragraph 28 and deal first with the thorough analysis of actual experience.

His remarks had been suggested by a mistrust of much of the speculation into which they would be led by paragraphs 56–62 of the paper, particularly the imprecise ideas about world resources of energy. Before the second world war he had heard a lecture by a newspaperman from *The Times*, who had told his audience of schoolboys that, if newsprint continued to be used at the rate then current, world resources of pulp would disappear in 50 years. As schoolboys they had been delighted with the idea that that might curtail the production of textbooks. Nearly half the period to which the lecturer had referred had elapsed, but nobody was suggesting that newsprint would run out in the next quarter of a century. He thought that illustrated the powerful effect of suitable warnings when applied to some definite problem connected with world resources.

The work of actuaries had to have a defined purpose to be effective, and he submitted that their purpose in that subject should be to advance slowly in the direction of more efficient measurement both in the population sphere and in the sphere of resources.

The Rt. Hon. L. J. Edwards, P.C., M.P. (a visitor) said that he had read the paper with great interest; he had been especially interested to see how in so many points it seemed to fit in with the work that had been done at P.E.P. in the past two or three years, culminating in the Report to which attention was called in the paper and to which reference had already been made in the discussion. He was very grateful to those who had said such kind things about that Report.

It was, of course, difficult to come to grips with a problem of that size and the P.E.P. Report in summing up had said:

> There are four great problems, and these are piled on top of one another. They are: (1) how to go on adding to existing output enough extra suitable foods for the 30 million or more children that are born each year over and above the replacements for those who die; (2) how to feed regularly with suitable foods the existing number of people, perhaps 1,750 million, who have had to go hungry for at least part of every year; (3) how to produce (otherwise than at the expense of food supply) enough raw materials, fuel and power, to enable the increased world population to earn its living and to add to wealth; and (4) how to ensure either that increasing populations can

secure access to distant areas where extra food and raw materials can be produced or that an increasing supply of food and raw materials from elsewhere can be transported and distributed to and paid for by countries deficient in home supplies.

The judgment on that fourfold aspect of the problem was:

> It is impossible to foresee a tolerable world situation until all four of these problems have been solved.

He thought it might be said that the mind faltered and the imagination was not adequate to the problems that were posed, and he believed it was desperately important that all of them, from their own different specialist knowledge, should work together on the various aspects.

In the P.E.P. Report there were set down 17 specific proposals for research and action. In many of those proposals there were jobs waiting to be done by actuaries, and he hoped that one result of the paper that had been presented would be a forward move on the part of actuaries into that important field.

Of course, one of the difficulties was that no global approach to the problem would do. Considering only, for example, the differing fertility rates between various areas of the world or between different countries, it was possible to see at once a complicated set of consequences, not only economic but some of them of the most profound political importance. Some 15 months earlier he had been in Japan, a country which had fascinated him from that point of view. In the Appendix there was a special section about Japan, and some figures were given in Table 5 of the population of Japan. The latest figure given was 84 million. He happened to have seen recently the figure of the 1955 census for Japan, giving a current figure of approximately 89¼ million, or an increase over the five-year period of over 5 million. That, let it be remembered, had taken place in spite of the fact that in each one of those years there were likely to have been not less than 1½ million induced abortions. That was the type of problem with which the Japanese medical men as well as the demographers were having to try to come to grips.

He had been interested in the reference that was made to what was the desirable population in any given country. There again, there was no straightforward or single answer; there again, the field needed much more examination.

In the P.E.P. Report the conclusion was reached that broadly there were four kinds of things that needed to be done. First, the more advanced countries had really to come to the help of the less advanced countries on a larger scale than they had done hitherto. Secondly, it was necessary for countries really to try to conserve their minerals and other resources carefully instead of exploiting them with the greatest waste and without any regard either for posterity or for the needs of other parts of the world. Thirdly, there was needed a much more free and easy system of international trade. But the conclusion had been reached without any hesitation that even if all those things happened there remained the fourth point, the tackling of the basic problem of the control of the population, which could not be avoided. That was the greatest difficulty of all, for there were many considerations to be borne in mind. Some nations wanted an expanding population for political purposes. Some nations objected to contracting the population on other grounds.

Whatever it might be and however it was done, he entirely agreed with the opener that control of population could not be avoided, and that, however it was done, it had to be done. He was encouraged in that view by the fact that

a rapidly expanding population was exceptional. The history of population in the world was a history of the population expanding, if at all, very slowly. All the evidence that he had been able to see from history, from pre-history, from primitive communities, pointed to the fact that the problem facing the world was a relatively recent one, and he believed that they would find ways of dealing with it if only they worked together. It might very well be that the historian writing in three or four hundred years' time would confirm that the current period of a great expanding population was an exception in the history of the world.

It was not possible to foresee so far ahead, but it was possible to foresee an enormous amount of work. He concluded by saying that if P.E.P. could be of any help to anyone who wished to work in that field, the help would be gladly given.

The President (Mr J. F. Bunford) remarked that he had found the information collected in Table 5 of particular interest. One of the most striking points about it to him was that the crude death rate in Japan was so low, and indeed was still, apparently, falling. It would have been most interesting also, in view of the enormous numbers involved, if it had been possible to give figures for China, but he imagined that at the time of speaking a great deal of the information about Chinese population was wrapped in mystery.

The authors had underlined the importance of the tremendous implications of population and resources and their relative distributions. It was said in paragraph 54 (4) that no precise re-assessment had been made of the statistical relationship between under-nourishment and mortality, but instinct, if nothing else, said that there was bound to be a degree of correlation there—for example, the very heavy mortality in India, where it was known that a great many of that enormous population were living at or below the starvation line.

The authors also referred to the possibilities of turning deserts into fertile land, and indeed something had been done in that direction in a small way—yet locally in a big way. Some of them knew of the 90-mile desert scheme on the borders of Victoria and South Australia. That was not, strictly speaking, desert country, because there was a rainfall, but it was completely useless land growing mostly scrub. There a great experiment had been undertaken by a life assurance office, and the introduction of certain mineral trace elements—for example, copper—into the soil had in fact turned what was useless land into country which produced great tracts of good grazing land and quite considerable quantities of crops. He thought that some comfort might be drawn from that, although it was, in relation to the whole problem, so very small.

The problems of maldistribution of population and resources were, as the authors said, a threat to peace. Those maldistributions had existed for a long time, and they were perhaps emphasized by the more extreme views which were being taken in the name of nationalism or political outlook. In fact, he would think that those new forms of disturbance were bound to act as a restraint upon the carrying out of the redistribution of resources. The generous instinct of a country with excess resources—and recent examples of generous practice could be cited—towards a country with little resources was apt to be curbed not only for the reason given in paragraph 72 of the paper, but also by the fear that the resources given might be applied to the disadvantage of the donor through some violent change in the political atmosphere in the donee country. He felt that that was not a thing that could be altogether overlooked.

Mr N. Benz feared that in the earlier paragraphs the authors were being rather gloomy, and he wondered what tune they had whistled to keep up their spirits.

His first reaction on seeing the section beginning with paragraph 7 was one of immense relief that somebody had done a job which he had had an uncomfortable feeling he should have been doing himself, namely, to see how the sixteen projections of the Royal Commission's Report actually tied up with what was happening. One thing that fascinated him was that the authors were not content with getting fairly near, but had got to within ·01 by bringing into paragraph 10 the adjustment of ·14.

In the section on mortality he was not clear whether in paragraph 34 the authors were disapproving of subdividing death rates by causes of death when looking to the future.

In paragraph 46 the authors mentioned what was to him a most important immediate problem that came out from the paper, the problem of migration. He had been interested, in looking at some figures which had appeared in one of the authors' recent publications, to see that most of the emigration from Great Britain was from that part which was not 'England and Wales'—but perhaps he had better not pursue that point.

The second half of the paper had very properly attracted a great deal of attention, since it raised the most fundamental problems that could face mankind. He hesitated to offer much comment on those matters, but there were one or two points which particularly interested him.

Paragraph 60 referred to atomic energy. He thought that on the whole they had been remarkably fortunate in that, so far as could be told, in the immediate post-war period there had been no stinting whatever of the resources necessary for the development of atomic energy in Britain. Furthermore, from the limited publicity that was being given about that industry, generally speaking it appeared that they had managed to go ahead without any major technical hitches.

He had also been interested in paragraph 62, in which the authors referred to the need for a generous measurement of investment of capital equipment in the East at the expense of some sacrifices by the advanced countries of the West, whatever political difficulties such a gesture might present. He imagined that the authors themselves were under no illusions about the dimensions of those political difficulties; but he was not sure that he would go all the way with the authors, for the reason which the President had given, in the sense that those problems had been in existence for a good many years, and he would be reluctant to take what might appear to be panic measures.

He thought that the conclusions of the paper really came in paragraph 74, where the authors outlined the five main restraints upon migration. That paragraph had set him thinking about various migrations in the past. They had only to think of places like Northern Ireland, Canada and Israel to see that some migrations had been outstandingly successful and some less so. What the distinguishing features of successful migrations were was something that had so far eluded him.

In conclusion, he said that he had very much enjoyed the paper. He had nearly taken the authors to task on what they said about France, because he did not think that they gave anything like sufficient prominence to the enormous differences that had occurred since the days of the French Revolution between the histories of Britain and of France, but that would have been ungracious in view of the excellence of the paper.

Mr M. C. Polman said that, after reading the paper, he had begun to wonder why it had been suggested that the actuary had a particular contribution to make to the subject, and he had then fallen to wondering whether possibly the actuary's technique had been brought to bear to the extent that it might be. He had always felt that that particular subject was especially amorphous. Little was known about the relative importance of the causes at work, although a great number of the causes could be recognized when seen. He had also often wondered whether enough research had yet been carried out to discover what the real facts were.

Some work had of course been done to demonstrate the kind of things that the actuary could do in order to apply his technique to the subject. Cox's paper on model populations, which were to be used to measure the deviations from the exact reproduction of a population over a period, was one particular case. It was founded on the conception of the model office and also on the accounting idea of a standard budget.

That also led him to wonder whether to some extent their technique tended to lead them astray on the subject. They were accustomed to think in terms of calendar years, or sometimes in terms of periods of five years such as the inter-valuation period. Such periods were, however, much too short for population problems. Possibly twenty-five years was a reasonable time over which to consider movements—perhaps a longer one was necessary. Some effort had been made in that direction in the tracing of the average family size, and there were such things as 'children ever born', which was one of the jargon phrases used and which referred to the average number of children born to a woman over her fertile period. That might lead to a minimum period of thirty years for the consideration of demographic developments. If they were only to consider the subject in cycles of thirty years, were they not being a little panicky in thinking that things were going astray in the next ten years or so? That was a political aspect and not, he thought, a technical aspect at all.

Mr H. A. R. Barnett suggested that the problem of control of births—whether it was possible or not—had to be considered on a global basis, because the first law of nature applied to nations as well as to individuals, and no one nation would control its population to the extent of keeping it stationary or even reducing it consciously if it knew that there were other nations that proposed to take no such action. In other words, a nation was not going to reduce its size simply to be overwhelmed by another nation. The opener had used the expression 'turn off the tap', but no doubt he had really meant stemming the flow—'turn down the tap'. But apart from each nation considering its own problems, it was no good for one nation to embark on limitation as part of a world problem unless all the other nations would do likewise. It was rather like disarmament all over again.

In paragraph 26 the authors pointed out that over the period in question fertility within marriage had fallen. That might possibly have been due to the decrease in infant mortality, the reason for that being that when couples planned the size of their families they did not necessarily simply plan the number of children they wanted to have born to themselves. If they planned a family of, say, two children and the first child was stillborn or died at a very tender age, it might well be that they would then still decide to have another two. If the infant mortality rate was decreasing, it would mean that those couples who would then have had three births including the deceased child would now only need to have

two if the first child had not died. It was a fairly obvious point, but it might be overlooked.

From a first reading of paragraph 34 it appeared that the authors were against any subdivision of death rates. He was not sure whether they really intended that. If they were simply trying to say that there was no point in subdividing into the hundreds of different possible causes of death, then he agreed with them; but if they were saying that the number of subdivisions should be one, then he disagreed with them, because he thought that it might well be that the ideal number of subdivisions was a small one, perhaps between four and ten—he would not try to hazard a precise guess about what might in fact prove to be the ideal number.

Mr W. A. B. Hopkin (a visitor) thanked the President for giving him the opportunity to speak. He was not, he said, prepared with a considered comment, and the reason he had not volunteered one was that he had felt that the paper was an important one being considered by an important and responsible body, and he had felt reluctant to address the meeting on the subject without having put more time into the study of the paper than he had in fact been able to do.

Perhaps he ought also to excuse himself on the ground that it was some years since he had been professionally concerned with demographic problems.

On reading the paper, which like others he had found very interesting, he had felt that he would have liked to have a little more detail in the treatment of the demographic evolution of the United Kingdom since the Report of the Royal Commission. Of course, he had rather a particular point of view on that, because he had had something to do with the work of the Royal Commission; but he thought it was interesting to look in some detail at those developments and try to reason back to the ideas that people had had at the time when the sixteen projections had been made, to see how far what had since happened could be said to depart from the expectations then held.

He thought that, on the whole, the paper, so far as it went, was moderately kind to the work of the people who had been forecasting, or projecting, for the Royal Commission. Perhaps they had been too kindly treated because, if he read the paper correctly, it appeared that it was only just possible to get the evolution of events into the Royal Commission's frame of reference, and then only within the very extreme range; the actual population just managed to squeeze into the topmost projection. On reading that, he had been reminded of what Mr V. P. A. Derrick had often said in discussion in the Royal Commission context, namely, that whenever an attempt was made to forecast a population it always came out higher than the maximum estimate.

On more detailed matters, he felt he would have liked to have a more thorough examination in the paper of the question of marriages. He thought he was right in saying that the thing that had happened which he did not think anybody had expected when the Royal Commission was doing its work on population projections was that marriages had not come down as it had been thought they would. The diagnosis had been that the age of marriage had been falling already before the war; it had gone sharply further down during the war, and that was a process that could not go on for ever; and that once it stopped happening there was bound to be a sharp drop in the number of first marriages, which in time would bring down the number of births. That did not seem to have happened up to the time of speaking; the number of marriages had kept up.

Obviously one of the interesting things that was going on was the change in the sex-ratio at the ages at which most marriages took place, and it seemed to him that that was clearly having some effect in keeping up the marriage rate among women. He hoped he was not doing the paper an injustice, but he thought that the figures it gave were principally in terms of what was happening to marriages and in the proportions of marriages of women, and it did not tell what had been happening to marriage rates and the age of marriage among the men. In other words, was what had been going on simply the result of the changing balance between the sexes, or was there a movement which had nothing at all to do with that but which represented a general trend towards younger marriage, and, if that was so, what were the prospects of its going on? Could he put the question in the following way? Had the Royal Commission been wrong, as it were, by misdating by five or ten years the time when the fall in age of marriage would come to an end, or was it something that could conceivably go on for some time longer? That was something which he thought was quite important if anyone were trying to consider again the future birth rate, and he did not think a great deal of help on that was to be got from the paper. It was a problem that had intrigued him as he had been looking at what had been happening to numbers of births in the past five years. That was all the demographic study that he had done in that time, and he had been puzzled at seeing the number hold up, with none of the expected fall taking place. If the authors could add a note on that, he would be most interested to know what they would say.

Mr F. W. Bacon, in closing the discussion, said that, as the opener had pointed out, the paper fell into two parts which dealt with what were really quite different problems. The first section dealt with the position in Great Britain, where the main concern was how to maintain a relatively stable population. The second part dealt with the position in the economically undeveloped countries where the problem was the opposite one of how to keep the population growth within reasonable limits—and, to forestall criticism, he would define 'reasonable' as the limits which would permit the current standard of living to be maintained and, if possible, increased.

In pre-war days they had become so accustomed to thinking in terms of falling birth rates and mounting surpluses of foodstuffs and raw materials that it was perhaps difficult to adjust their thinking to the opposite position which currently obtained in the world as a whole—that of rising populations pressing on limited resources. He thought that one of the great merits of the paper was that it both compelled them and helped them to make that adjustment.

The real problem arose from the fact that the world population was increasing at a rate of something over 1 % per annum—the P.E.P. Report suggested that the most reasonable estimate was about 1·3 % per annum. He agreed with Mr Clarke that that was a rate which could not be maintained indefinitely without reaching the physical limits of the habitable world—a point which had also been stressed by the opener.

What was more important, perhaps, was that the rate of increase was itself increasing, and it was interesting and important to ask whether that was likely to continue. At that current rate of increase the population was likely to double itself in something over fifty years, which was not much more than half the period which obtained in the second half of the 19th century. The increase in population was mainly due to a reduction in mortality, and from that point of view it was interesting to compare the position in the undeveloped countries

where reductions in mortality had been brought about in the past thirty years—it was mainly in the past thirty years that that had happened—with the way in which the population in Great Britain increased in the 18th and 19th centuries.

In Britain during the second half of the 18th century the crude death rate had been reduced from something like 30 per thousand to about 22 per thousand, and then there had been a period during the first three quarters of the 19th century when the death rate had been virtually stable. A second fall had taken place in the last quarter of the 19th century at about the same time as the reduction in the birth rate had occurred. He thought it would be interesting to investigate whether there was any parallel between what had happened in Great Britain and what was happening in countries like India. It might well be that a certain reduction in mortality could take place which would permit a large increase in population, but that there was a limit to such reduction until standards of living rose and birth rates themselves began to fall. It was therefore of importance to try to determine—perhaps he should say 'investigate' because he did not think it possible to determine at that stage—whether Western experience was likely to be repeated.

Was it true, as the authors suggested, that population growth was bound to lead to social, economic and cultural changes which would modify that growth? If it was true, then the second question arose: could production be increased sufficiently during the interim period—the period before birth rates started falling? On the second question—the increase in production—an increase in overall production of something like 1 % to 1½ % per annum as a global figure was needed to cope with the rising population and, judged by Western standards, that would appear to be fairly easy of achievement. It had in fact been achieved, as the authors pointed out, over the past forty years. But the real difficuty, as the authors also pointed out, was that the increase was not evenly distributed, and unfortunately it was just in those countries where population was increasing most rapidly that production was increasing least rapidly. But over and above the annual increase required to maintain current standards of living there was the further point that a substantial increase in food production, which he thought the P.E.P. Report estimated at about 25 %, was required to bring the one-half to two-thirds of the world population which was then existing at completely inadequate levels of nutrition up to the very low standard of 2,200 calories per day, and he thought that an increase in production of that order would be much more difficult to achieve.

One of the difficulties he found in considering the problem was that writers on questions of world resources appeared to fall into two schools, the optimists and the pessimists. The optimists tended to concentrate on the global view and to stress the potentialities of scientific discoveries in increasing agricultural and industrial production. The pessimists concentrated on the maldistribution aspect and also stressed the great capital costs involved in the commercial application of those scientific discoveries. As an example of the discrepancies between different writers he would instance the question of the fuel reserves of the world. In paragraph 59 the authors quoted some estimates by Putnam of the world fuel reserves. Another writer on that subject, E. H. Stern, in the *Westminster Bank Review*, quoted figures for world fuel reserves which were about six times those quoted by Putnam. It was difficult for the ordinary mortal to make up his mind between differing estimates when they varied as widely as that.

On the question of capital requirements the authors quoted the capital required in respect of each person added to the population as varying between £100 and £1,500 per head. He thought he was right in saying that the upper figure referred to requirements in the United States and the lower to the estimated requirements in India and Pakistan; in his opinion the latter was probably much more typical of what was likely to be required for the undeveloped countries. In that connexion it was perhaps worth pointing out that Philip Redfern, in a paper to the Royal Statistical Society, had estimated the net fixed capital assets in Great Britain at £24,000 m., which worked out at roughly £500 per head, of which half consisted of housing and public services.

In that connexion there was a point which was often made and which had been made by one of the authors at the Rome Congress. It was the question whether population growth itself stimulated economic expansion. He thought that the answer was 'it all depends'. It was true that an increase in population could be a great stimulus to the economy if it resulted in increased purchasing power and so stimulated increased production of goods. But the vital condition, of course, was that there should be an increase in purchasing power. That was likely to occur if the additional population was fully employed. But he thought the real difficulty was that in a predominantly agricultural country an increase in population only too often meant that there were more people trying to scrape a living out of the same piece of land. The result then was not an increase in purchasing power but what was in fact concealed unemployment resulting in a falling standard of living. He therefore felt that population growth could have very different results in countries like, say, the United States on the one hand and India on the other.

To go back to the first of the two questions which he had raised earlier, whether Western experience was likely to be repeated and whether after a time lag there was likely to be a fall in birth rates in the economically undeveloped countries, he wished to make one general point. A lot was said in that connexion about the spread of knowledge of birth-control, and while that, he would agree, was highly desirable, he would also stress that it was only a means, and that it would not be effective unless there was also the will and the desire for family limitation. What it was necessary to try to establish was what were the conditions which were likely to lead to that will and desire. The question was sometimes put in the simple form: Did a rise in the standard of living lead to a fall in the birth rate, or was it a fall in the birth rate which permitted a rise in the standard of living? There he thought that British experience might be helpful. It was common knowledge that the fall in the birth rate in Britain started at the beginning of the last quarter of the 19th century; it had happened in a period which was known to the economic historian as the 'Great Depression' which followed a period of rapid economic expansion which was often referred to as the 'Golden Age'. That would suggest that it was not necessarily rising standards of living which led to a reduction in the birth rate. It had to be admitted, however, that in the period when birth rates started to fall, although there was quite a lot of unemployment and trade depression, nevertheless the real wages of those who were employed had risen fairly rapidly, because prices also fell substantially; but he would suggest that the evidence, such as it was, rather suggested that there was no direct and simple connexion between changes in birth rates and changes in standards of living.

He thought that probably a much more potent reason for the fall in Britain had been the break-up of the family as an economic unit. The 19th century had

been a period in which children ceased to be an economic asset to their families and became an economic liability. That had arisen partly because of the virtual disappearance of cottage agriculture and peasant handicrafts, with the growth of industry, and also because, although during the earlier part of the century children were an economic asset because they could be employed in industry, yet with the passing of the various Factory Acts and finally with the Education Act of 1870, which made education compulsory up to the age of 10, children had to be supported up to that age. At the same time, the fall in mortality, as Mr Barnett had pointed out, had the result that more of the children born survived and had to be supported. Also, at the same time, there had been a substantial change in the economic climate. The individual could improve his economic position, and he thought it would be fair to say that the formation of trade unions for the unskilled workers had played quite a part in that. Finally there had been the changed status of women. All those developments had resulted in a growing contrast between the standards of living of parents who had small families and those who had large families. In the words of the Royal Commission on Population, it was a period in which, from the economic point of view, 'it paid to travel light'.

It was probably rather dangerous to try to apply elsewhere conclusions derived from British experience, but he felt that possibly there were some lessons there for public policy in India and other similar countries. The first was that, in spite of what some speakers had said in the discussion, more than birth control propaganda was required. Secondly, anything which had the effect of reducing the value of children as an economic asset was likely to tend to a reduction in family size. Industrialization, plus the prohibition of the employment of children, was likely to lead to that result. Then there had also to be opportunities for the individual to raise his standard of living. There again, he thought that industrialization was likely to help, provided it was coupled either with a minimum wages Act to prevent sweated labour or the formation of trade unions and producers' co-operatives. That sort of development was likely to break down the conservatism of the peasantry and the ex-peasants who went into industry, and to substitute hope for fatalism, which to his mind was the first requisite for that responsible attitude which made a man wish to limit his family to that which he could afford to bring up. Finally, he thought that education in general and an improving status for women were likely to help in that direction.

All those things were good in themselves provided that they were introduced with proper caution and not in a hasty and ill-considered way. They could therefore be introduced for their own value, which was helpful, because it meant that their introduction would not rouse the opposition that might be provoked if they were put forward specifically in order to curb population growth.

Finally, he thought that where economic aid was given to the undeveloped countries it should, as far as possible—as Mr Edwards had suggested—take forms which would help forward those objectives rather than be confined to economic charity which helped people to survive but did not help them to live.

In conclusion, he wished to support the authors' plea that actuaries should take more interest in those problems. He felt that, in speculating on some of the problems, he had probably been guilty of rushing in where the authors wisely feared to tread; but in spite of the remarks of one or two speakers who had deprecated speculation, he thought that it could be useful if it helped to stimulate research, and he hoped that some of their members would direct their attention to that field.

The President observed that, in his opening remarks, Mr Menzler had said that the object of the paper was to re-awaken the interest of the profession in Britain in vital questions of population and resources. If Mr Menzler had not said that, the President would have said that the paper served two purposes, the first being to lay before actuaries a concentrated and highly interesting account of the developments which had taken place in recent years and the various factors which influenced population and their needs of food and other things; the second was to state pointedly that many of the problems so arising were of the type which came within the realm of actuarial capacity and that actuaries should make a greater contribution to their solution.

The claim of actuaries, so the authors said, to be regarded as experts in the field could only be maintained if the claim was supported by practical work. The principles of the emerging cost technique had surely a close bearing on many of the items in the gap of existing knowledge to which the authors referred in their concluding paragraphs, and the emerging cost technique was one in which actuaries were particularly trained. They claimed, quite rightly, that their work touched the national economy and welfare at many points, and he imagined that the three authors might have felt at the time of the Population Conference in Rome that several of the papers there submitted might well have been submitted by actuaries. If he was correct in that, it underlined the authors' plea, to which Mr Bacon had referred, for a greater contribution from actuaries to the studies of the various problems which were involved in that large field. All that was said, of course, without prejudice to the contributions already made by actuaries, some of which occupied an honourable place in that long and interesting bibliography which came at the end of the paper.

He wished to say a word of thanks to Mr Stewart for his opening remarks. Some other speakers who had followed him had echoed in some sense the slight degree of pessimism to which Mr Stewart had given voice. The question of family control was one which called for earnest consideration in the light of resources available within the area concerned.

He hoped that the visitors, particularly Mr Edwards and Mr Hopkin, to whose contributions they had listened with the greatest interest, would forgive him for having concentrated on one particular theme in the paper.

He wished to acknowledge the indebtedness which the Institute felt towards the authors. All three of them had done much for the Institute already, and if he looked particularly towards one of them, he thought that the other two would not mind. That one had served on the Council for 27 years and had filled all the honorary offices, culminating in a most active and enthusiastic Presidency. He doubted whether the Institute had ever had such an enthusiastic son—and he had not finished yet! Neither had the other two. Mr Benjamin and Mr Cox had each done much, but each also had the great advantage of having many years ahead of him. In the name of the Institute, he thanked all three authors for a highly important paper and for having been instrumental in starting a most interesting evening's discussion.

Mr B. Benjamin, in reply, said that the time available was sufficient for him to say only one or two things relating to matters of principle.

He wished to take the opener to task for trying to draw conclusions about replacement from the net reproduction rate which very neatly and conveniently summarized current experience but which really had little to do with replacement. Since women who were then getting married were marrying at younger

ages and completing family building much earlier in married life, the age rates used in the reproduction rate should be much reduced at the older ages. It was quite easy to reduce the reproduction rate to ·95 if allowance was made for that change. But he would agree with the opener that there could be no economic improvement unless the population effects of that improvement were also encompassed in the planning. That was one of the main theses of the paper.

Mr Clarke had seemed to think that spinsters were really only useful in domestic service and at elections. He would remind Mr Clarke that they managed to combine both functions effectively as married women!

Mr Hamilton-Jones had come to an essential part of the paper in giving an objective picture of the exact role which the actuary could fill. It was quite true that they should eschew direct consideration of population policy, and that they should concentrate on their primary function of data presentation. Mr Hamilton-Jones had also pointed the way very shrewdly by saying that they should concentrate on producing more efficient methods of measurement. If they could do that, i.e. if they could analyse actual experience much more effectively than had been done in the past, then he thought they would be in a better position to advise those responsible for population policy.

Mr Edwards had given them a reminder of the urgency of 'the four great problems' that 'are piled on top of one another'. It was that urgency that had made the authors try to shock the Institute into giving more attention to consideration of demographic problems. Contrary to Mr Benz's belief, the authors were not at all gloomy about that, and he would agree with the President that there were many factors which encouraged optimism.

As to the question of forecasting mortality, the authors did not think that it was a bad thing to subdivide causes. They merely cautioned against over-subdivision.

Mr Barnett was quite right in saying that there was an important political problem in so far as no one country would be willing to take unilateral action in the population sphere if it felt that it would be to its economic harm.

As to Mr Hopkin's point about the question of the high marriage rates, a matter to which Mr Clarke had also referred, it was quite true that marriage rates had been sustained at a higher level than had been expected, but he thought it was also true that any further contribution to increased fertility from that source was likely to be very small indeed.

Mr Bacon, in closing the discussion, had taken the authors to task for referring to some estimates which were widely different. He thought that that really only emphasized the great gaps in information which existed and the important contribution which actuarial method might make to sharpening the definition in parts of the population and economic field which were extremely hazy. As to whether changes in population did bring about action which tended to modify those changes, it was certain that nothing would be done without a willingness to tax human intelligence and study.

Mr P. R. Cox, in reply, said that there was one point that he wanted to emphasize. He thought that everybody had in their minds the question of what actuaries should really be doing in the field of population and resources. He would not like it to be thought that all they could do was to concentrate on data collection and presentation. There was a great deal to explore in the relationships between population and economic trends, and several recent publications had suggested that there was still more that could be found out about the past. Prof. Brinley

Thomas's *Migration and Economic Growth** and J. A. Banks's *Prosperity and Parenthood*† were instances of such publications. There was indeed a lot more work for actuaries to do on the relationship between population and economic trends.

The authors have written:

In referring to the assessment of the trend of mortality we noted the laudable modern tendency to adopt a more intensively analytical approach but we added a word of caution on oversubdivision by medically certified cause. Mr Benz and Mr Barnett have rightly taken us to task for lack of clarity and we therefore take this opportunity of correcting the defect. The proper understanding of recent mortality changes and particularly of the concentration of improvement at younger ages must, as stated in paragraph 33, take account of the fact that modern therapeutic and environmental advances have affected in the main the risks of mortality associated with 'unnatural' causes, e.g. infections and injuries, leaving degenerative disease to take its unrelenting toll. Observation of disease differentials is inescapable if only because it is implicit in age differentials. Therefore the separate study of groups of diseases is highly desirable and indeed from an actuarial point of view much overdue. Our caution is against treating medical labels as being more distinct than they really are.

We would assure Mr Stewart that the reference to Mr Carrier's paper in paragraph 27 was designed to round off the report on fertility prospects by quoting an evaluation of those prospects for the latest cohort in respect of which it was possible to hazard a forecast. Those born in 1931 are now 25 years of age and the current modal marriage age is low. We do not think that Carrier's valuable paper was over-speculative.

Mr Clarke's contribution was more serious than was suggested by the light-hearted reference in the closing remarks of Mr Benjamin. An important part of demography (and one which emphasizes its multi-disciplinary character) is the examination of the interaction between marriage and fertility changes and the social and economic life of the nation.

Mr Hopkin was right to suggest that we were a little kind to the Royal Commission's forecasts, in the sense that comparison was made not with any projection which the Commission had declared to be more likely or with the middle of their range of projections but with that which had turned out to be close to actual experience.

We must pay tribute to Mr Bacon's very competent summing up of the thoughts which the paper had provoked (and was intended to provoke) and we are grateful for much illumination of the economic factors involved. It is doubtless true that fertility restrictions occur when economic conditions arise which make it advantageous to 'travel light', and that these conditions can be engineered. If this is possible it is certainly more desirable than, in Mr Clarke's words, having to face the real threat of famine and war as the final incentive to action.

* Cambridge, 1954. † Routledge and Kegan Paul, 1954.