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THE PROBABILITY OF A CESSATION OF THE GROWTH OF POPULATION IN ENGLAND AND WALES DURING THE NEXT CENTURY¹

It is a good deal easier to utter warnings against prophecy than to abstain from it. The most hardened scoffer at the weather forecasts has to decide every day whether he will take out an umbrella or not. Not a single investment can be made without an estimate of the relative probability of future events which can be foretold with so little certainty that even the old lady of Threadneedle Street has been known, and that within the last few years, to err most egregiously as to the immediate future of the price of consols.

Many things about which we are habitually obliged to form estimates are of a much more speculative character than the growth of population, and the estimates which we do form about them in many cases actually depend on our estimate of the probable growth of population. There is not a builder nor a town council in the country that is not obliged to prophesy every month what the growth of population in a particular district is likely to be, and it was the speculations of the Metropolitan Water Commission as to the population of London in 1931 that inspired me to make this contribution to the literature of the subject. The real question is not whether we shall abstain altogether from estimating the future growth of population, but whether we shall be content with estimates which have been formed without adequate consideration of all the data available, and can be shown to be founded on a wrong principle.

The generally accepted principle is that of 'as the increase

¹ This article contains the substance of a paper read before Section F of the British Association at Ipswich.

has been in the past so it will be in the future.' This is susceptible of more than one interpretation. All we really know of the increase in the past is contained in the totals obtained by the censuses. A schoolboy whose arithmetic is described as 'v. g.' would probably boldly disregard all the intermediate censuses and divide the total increase of 20,109,989 between 1801 and 1891 by ninety years. The quotient of 223,444 he would call 'the average annual increase,' and say that in order to get the probable increase of population in a certain number of years after 1891 you must simply multiply 223,444 by that number of years. If you ask him 'why?' he will be rather puzzled, and will probably take refuge in analogy. He may tell you, possibly, that if he sees a cyclist going by at twelve miles an hour he rather expects him to do about twelve miles in the next hour. But when you ask him whether he would expect a man whom he saw going at thirty miles an hour to arrive at the thirtieth milestone in an hour he would answer in the negative, because 'it isn't all down-hill,' or because 'no one has ever done thirty in the hour,' or something of that kind; and it turns out that he only expects the same amount of progress to be made in the future as in the present if the present pace is what he looks upon as a pace likely to be maintained.

A person with a slight smattering of statistics will probably say that the schoolboy's method is quite wrong, and that in arguing from the past to the future, you ought to consider not the number which has been added to the population, but the factor by which the population has been multiplied. You ought to consider not the absolute amount, but the rate of the increase. But which rate? For there is a different rate in every one of the nine decades. Are we to take the rate from 1801 to 1891, disregarding the intermediate censuses, or are we to somehow deduce something which may be called an average rate from the nine different rates? The Metropolitan Water Commission groped for an answer to this question and found none. A very able mathematician to whom I gave the figures of the ten censuses tells me that they are so irregular that no law of increase of the smallest value can be deduced from them. The Registrar-General's method in forming what are called the 'official estimates' cuts the knot by disregarding all the decades except the last. The only conceivable argument in favour of this course is the allegation that the immediate past being nearer the future than the long past, affords a better basis for estimating future probability. By itself this would justify the *reductio ad absurdum*, 'if the last ten

years are better than the last ninety, the last year must be better than the last ten,' but 'temporary fluctuations' have of course to be considered, and it may perhaps be asserted that ten years is sufficient, while twenty years is more than sufficient, to give an average unaffected by such fluctuations.

Which rate of multiplication be taken, however, does not very much matter, since any rate that can possibly be deduced from the census figures gives ridiculous results. Carried back into the past the assumption of a uniform rate of increase equal to that which prevailed in the decade 1881 to 1891 necessitates the supposition that in A.D. 525 there were scarcely two persons in England, and carried forward into the future it gives a population of a thousand millions in less than 300 years. After 350 years more there would be only just room for the people to lie down on the ground. Yet the rate of increase in the decade 1881—90 is the lowest of the nine.

These periods, it may be urged, are long. But applied to short periods the assumption of a uniform rate of increase equal to that shown by the last decade leads to just as absurd results as when it is applied to long periods. As is well known, the Registrar-General, whose annual reports reveal no acquaintance with the very accurate statistics of immigration and emigration now collected by the Board of Trade, ignores his own figures of births and deaths, on the ground that in estimating a population immigration and emigration cannot be disregarded. The official estimates of the population in the middle of each of the following ten years which he forms after each census on the assumption that the rate of increase shown by it will continue, are allowed to stand in each of his annual reports till the next census, and would, we must suppose, be allowed to stand if a plague swept away half the people. When the next census is taken they are, of course, found to be wrong. [At the last census the error amounted to 701,843 at the end of the decade, while Dr. Longstaff had in the pages of this Journal estimated the population within 10,251.¹] They are then corrected on the assumption that throughout the decade population annually increased at the rate observed during the whole decade. Now whenever the rate of increase in a decade is less than in the preceding decade, these 'corrected' figures, on which the 'corrected' birth, marriage, and death-rates are calculated, present a very odd and most unnatural series of increases. Thus they represent the increase for 1871-2 to have been 307,901, and make the annual increase

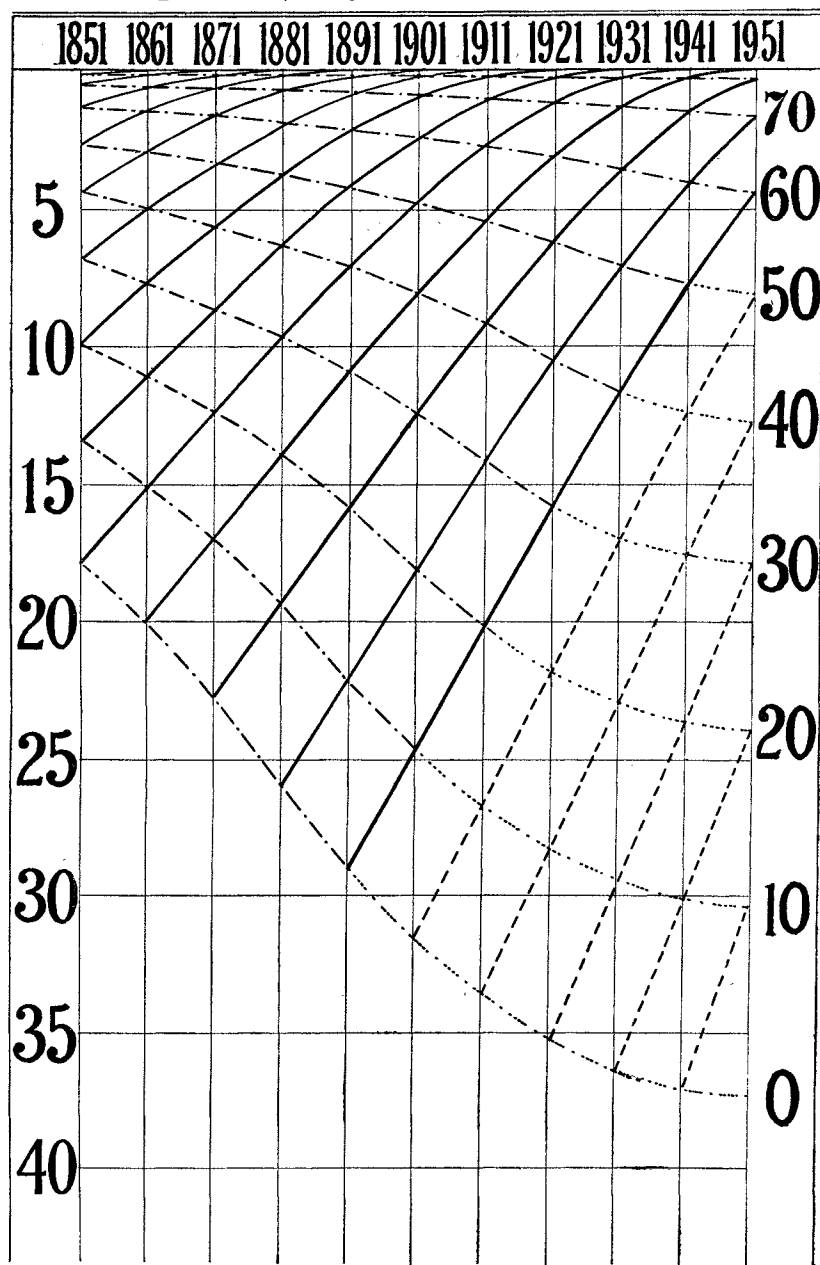
¹ ECONOMIC JOURNAL, vol. i., p. 382.

grow gradually till in 1879-80 it amounted to 342,799. Then comes the census year, which stands by itself, as three-quarters of it lie in one decade and the other quarter in another; it is allotted an increase of 331,854. After this the new period begins in earnest with an increase of only 288,800 in 1881-2; and the rising process starts again and continues till the increase of 1890-1 amounts to 318,912. In short, the increase grows steadily till it reaches the census of 1881, then it comes down with a crash only to begin immediately to rise again.¹ It must always happen under this system that the addition to the population in the last half of a decade is greater than the addition in the first half, even when the addition in each decade is less than the addition in the preceding decade. The truth is that every estimate of population, past, present, and to come, ought to be founded on a consideration of the factors on which the growth or decline of population is dependent—births, deaths, immigration, and emigration. The number of births and deaths, and of immigrants and emigrants, is now so well known, that if two government departments, the Board of Trade and the General Registry Office, would only recognise each other's existence, the population at the present time, or at any point in recent years, could be given within ten thousand of the actual number.²

In estimating future population the most important data we have to rely upon are the ages of the people as taken at recent censuses. These are shown measured down from the top on the first five perpendicular lines of the diagram opposite. The lines sloping downwards from left to right divide the total population according to each ten years of age from eighty downwards, so that the top layer of persons includes all over eighty years of age, the next all between seventy and eighty,

¹ See the last column in Table I. at the end of this article, where the official increase is compared with the excess of births over deaths. The official increase is calculated from the middle of one year to the middle of the next, and is therefore printed halfway between each pair of calendar years. It will be observed that in each year from 1863 to 1866, and also in 1870, 1875, and 1890 the official increase is actually greater than the excess of births over deaths—so that, if we accepted it, we should be obliged to assume that in those years immigrants exceeded emigrants.

² The Board of Trade statistics of migration relate to the United Kingdom as a whole, so that the distribution of migration between England, Scotland, and Ireland would have to be allowed for. But the Irish Registrar-General already gives real estimates of the population of Ireland, so that the adjustment has only to be made between England and Scotland. The fact that the Irish Registrar-General gives real estimates, and the English and Scotch Registrar-Generals only 'official' estimates (*i.e.* estimates based on a hypothesis absolutely known to be wrong), has a singular effect on the published estimates of the population of the United Kingdom, as these are made up by adding the 'official' estimate for Great Britain to the true estimate for Ireland.

Population of England and Wales, 1851-1951.

The population in each census year is measured down from the top, the figures on the left indicating the number of millions. The lines sloping downwards from left to right divide the population at each census into persons over 80; persons between 70 and 80; between 60 and 70; and so on down to between 0 and 10. The ages are shown by the figures on the right. The lines sloping upwards from left to right divide the persons born in each decade from those born before and after it. They thus show graphically how each generation becomes smaller as it passes from under ten years of age at one census to over ten but under twenty at the next, and then to over twenty but under thirty, and so on.

the next all between sixty and seventy, and so on down to the children under ten. Now as the number of immigrants at any particular decade of age is probably always exceeded by the number of emigrants of that age, the people who are between ten and twenty at one census are (with the exception that some immigrants are substituted for some emigrants) the survivors in England of those who were under ten at the preceding census, and similarly with each ten years of age. So if we call the persons born between one census and the next a generation, the lines sloping upwards from left to right divide each generation from the next, and show how each generation becomes smaller and smaller, till it finally becomes extinct on the death of some centenarian.

Now, provided that the rate of mortality and loss by migration remain the same at each age period, it is possible to calculate with absolute accuracy from the observed decrease of a generation between any two censuses, how much the next generation will decrease when it arrives at the same age. For example, if it be known that everyone over 100 in 1881 died before 1891, it may be confidently assumed that everyone over 100 in 1891 will die before 1901. If it be known that the people between fifty and sixty in 1881 lost about 27 per cent. of their numbers before 1891, it may be taken for granted that the people between fifty and sixty in 1891 will lose the same proportion between 1891 and 1901. Nothing is requisite to get the total population over ten at the next census except to work out by proportion sums the population in each ten years of age and add up the results.

Before, however, we can apply this method, it is necessary to inquire whether we are justified in assuming that the rate of mortality and loss by migration will not change. As to the future of mortality and loss by migration every man has a right to his own opinion, but no one can expect to prove anything. We may therefore fairly treat it as an even chance whether the rate of loss is likely to increase or diminish. In the past a decrease of the rate of loss by mortality has been counteracted by an increase in the rate of loss by migration, so that estimates in which this method has been used have been surprisingly accurate. The compilers of the census returns of 1861 published one of these estimates in 1863, according to which the population over twenty in 1881 should have been 14,167,745. When the census of 1881 was taken eighteen years afterwards, the recorded number was 13,958,616, the error being only fifteen per thousand. In 1871, the method was again applied to predict the 1881 population, and the number over ten in 1881 was estimated at 19,365,188. The

recorded number was 19,306,179, so that the error was only just over three per thousand. The last two censuses have been, in many respects, far inferior to their predecessors, and no similar calculations appear in them. If, however, one had been inserted, the population over ten in 1891 would have been predicted at 22,129,736, and it was actually 22,053,857. The difference here is slightly greater than in 1881, but it is less than $3\frac{1}{2}$ per thousand, and would not amount to the thickness of a line in the diagram. I have worked this estimate out by quinquenniums of age instead of by vicenniads and decades like those of 1861 and 1871, and its accuracy all the way down is astonishing. Only in two quinquenniums does the error amount to 4 per cent., and both of these are among the ages over eighty-five, where the numbers are too small to give a very sound statistical basis.¹

In the diagram I have extended the lines dividing the population by ages so as to show how many people in each decade of life over ten there will be in 1901, how many in each decade over twenty there will be in 1911, and so on to 1951, on the assumption that the rate of mortality and loss by migration at each age will remain the same as in the decade 1881-91. What will be the length of the line indicating the total population in 1901 and the following years now depends solely on the length added below for the new generations born after 1891, and, given the same assumption of no change in mortality and loss by migration, the size of each of these generations at each date depends on the number of births. If we decide how many will be born in each future decade we can add one generation after another with ease and certainty.

The question is, therefore, what is the probable number of births? Here we border on considerations of a more speculative character, but we have still something statistical to rely upon. The fact that it is the custom to calculate birth-rates as a rate per thousand on the whole population makes it natural to say that the number of births depends in the first place upon the population, so that if the population increases rapidly the births will increase rapidly. The continuous lines of the diagram show that the population over certain ages will increase rapidly for many decades, so that we might consequently expect a considerable increase in the number of births. But of course, as a matter

¹ See Table II. at the end of this article, first five columns. The sixth column gives an estimate constructed by the same method for 1901. The last column is a similar estimate for 1991, with the additional assumption that the number of births in each decade remains the same.

of fact the increase of population over and under certain ages has obviously no tendency to increase the number of births. The number of old women and children may be doubled without making it the least more likely that the births will increase until the children have grown to marriageable age. The number of births is more likely indeed to be somewhat repressed, since the old people and children form a burden upon the shoulders of those in the prime of life. It is consequently much more true to say that the number of births depends in the first place upon the number of men and women between certain ages. For practical purposes the ages of twenty and forty are sufficiently near the mark, and they are much more convenient than the ages for each sex which would have to be taken if perfect accuracy were required. Now from 1853 to 1876 the number of births, after allowing for some deficiency in registration, increased rapidly and was almost uniformly just about 12 per cent. on the number of persons between twenty and forty. From 1876 onwards the number of births has been almost stationary, and the rate per cent. on the persons between twenty and forty has consequently been rapidly declining. In ten years it had fallen to 11 per cent. ; by 1890 it had further fallen to 10 per cent. ; in 1891 it went up to about 10·4 per cent. ; in the next two years it was 10 per cent. ; in 1894 it descended to 9·8 per cent.¹

Now if the future births were estimated at this rate on the number of persons between twenty and forty we should have no grounds for expecting a cessation of the growth of population, though the growth would be at a much less rate than heretofore. But the statistics make it probable that the birth-rate on persons between twenty and forty will continue to fall. It must be remembered that the effect of the births having been nearly stationary for twenty years will be to change considerably the age distribution of the group of people between twenty and forty. A larger proportion of them will be at the higher ages. It seems at first sight paradoxical to say that the persons between twenty and forty can be older at one time than another, but it is really quite simple. The persons between 0 and 100 years old obviously do not average fifty years, and in just the same way the persons between twenty and forty do not average thirty. What the exact average age will be depends chiefly on the variation in the number of

¹ For the number of registered births in the two periods 1853-75, and 1876-94, see Table I. The number of persons between 20 and 40 was 5,501,767 in 1851, 6,009,977 in 1861, 6,686,685 in 1871, 7,663,086 in 1881, and 8,805,930 in 1891. The numbers for the intermediate years can be estimated with sufficient accuracy for the present purpose.

births between twenty and forty years before. As the number of persons born rose rapidly year by year before 1876, the number of persons becoming twenty years of age in each year has been rising rapidly and will continue to rise rapidly till 1896. After that it will still continue to rise because there has been a reduction of juvenile mortality, but the rise will be far less rapid. The consequence will be that while in 1891 30 per cent. of the twenty to forty group were under twenty-five, in 1911 not more than 27 $\frac{1}{3}$ per cent. will be so.

This increase in the average age of persons in the prime of life, or, to put the same thing in other words, this diminution in the increase of the number of persons reaching marriageable age in each year, must tend somewhat to reduce the birth-rate. How much effect should be attributed to it would not be very difficult to calculate if the necessary statistics of the ages of parents were forthcoming, but unfortunately none such exist.

If, however, we take into account not only the diminution to be expected from this cause, but also the diminution to be expected from the working of the enormously strong economic and social forces which have brought about the diminution of the last twenty years, it seems a very moderate hypothesis to suppose that the rate of births on the number of persons between twenty and forty may fall to a little below 9 per cent. by 1901 and to the neighbourhood of 8 per cent. by 1911. This, with a further slight diminution to a little below 8 per cent. by 1921 is all that is necessary in order to keep the number of births stationary at the level of 1881-90. Adopting then this hypothesis, I have continued the lines of the diagram so as to show what the future of the population will be if the rate of mortality and loss by migration at each age, and also the absolute number of births, remain the same as in 1881-90. It will be seen that the increase of population, large at first, becomes less and less, till it is trifling in 1941-51. It would continue, but always growing less and less, till about 1995, when the last survivor of the period before 1891 would disappear, and the population would then stand at its maximum of 37,376,000.¹

I have no desire to stake my reputation as a prophet on the growth of population following exactly the line shown in the diagram, and ceasing to increase in 1991.² I am only prepared

¹ See Table II. last column.

² Since the sentence above was in type, the Registrar-General's returns for the first three quarters of 1895 have been completed, and make it practically certain that the number of births in the present year will considerably exceed the highest

to assert confidently that the line shown is a much more probable one than that which might be laid down by the 'official' method, and which would shoot through the bottom of the diagram between 1921-31 and encircle the globe before the diagram was widened very many yards. Whether the cessation of the growth of population is reached, as I personally should expect, before 1991, or afterwards, it must be reached at last, and if it is reached without any violent changes in mortality, migration, or natality, it will necessarily be reached by a curve of increase closely approximating to that laid down in the diagram. The value of the diagram lies not in its prediction of a maximum population of thirty-seven millions, but in the fact that it shows how a cessation of growth may be reached within no very long period without any violent or unnatural changes. Its lines are the curves of a wind-blown sandhill, not the jagged slopes of a rock or the equal slope of a railway embankment. During the last twenty years most of us have not succeeded in detecting any considerable change in the manners and customs and practices which affect natality, and yet it only requires a continuance of the change which has undoubtedly been going on to bring about a state of things which would cause the possibility of a decline of population, instead of the possibility of over-population, to be the bugbear of alarmists. This consideration need not lead us to the indiscriminate encouragement of natality which prevailed in the time of Pitt, but it may well serve to diminish hostility to measures which somewhat lighten the burden of parentage on the shoulders of those persons who are likely to bring up children such as will really be, in the old phrase, the true riches of the state.

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yet recorded. It will probably be nearly 10·2 per cent. on the number of persons between twenty and forty.

TABLE I.—*Number of Births, Excess of Births over Deaths, and Official Estimate of the Increase of Population.*

1853—1875.				1876—1895.			
Year.	Births.	Excess of Births over Deaths.	'Official' Increase.	Year.	Births.	Excess of Births over Deaths.	'Official' Increase.
1853	612,391	191,294		1876	887,968	377,653	329,272
1854	634,405	196,500		1877	888,200	387,704	333,720
1855	635,043	209,340		1878	891,906	352,034	338,230
1856	657,453	266,947		1879	880,389	354,134	342,799
1857	663,071	243,256		1880	881,643	353,019	331,854
1858	655,481	205,825		1881	883,642	391,707	288,800
1859	689,881	249,100		1882	889,014	372,360	292,007
1860	684,048	261,327		1883	890,722	367,725	295,243
1861	696,406	261,292		1884	906,750	375,922	298,514
1862	712,684	276,118	251,699	1885	894,270	371,520	301,826
1863	727,417	253,580	254,842	1886	903,760	366,484	305,174
1864	740,275	244,744	258,034	1887	886,331	355,573	308,552
1865	748,069	257,160	261,262	1888	879,868	363,897	311,981
1866	753,870	253,181	264,533	1889	885,944	367,591	315,434
1867	768,349	297,276	267,841	1890	869,937	307,689	318,912
1868	786,858	306,236	271,188	1891	914,157	326,232	322,469
1869	773,381	278,553	274,586	1892	897,957	338,273	326,046
1870	792,787	277,458	278,017	1893	914,542	344,584	329,663
1871	797,428	282,549	287,278	1894	889,242	390,727	333,315
1872	825,907	333,642	307,901	1895			
1873	829,778	337,258	312,061				
1874	854,956	328,324	316,278				
1875	850,607	304,154	320,551				
			324,882				

TABLE II.—*Population at the several Ages—Estimates and Recorded Numbers.*

Age.	1881 Estimate (1863).	1881 Estimate (1873).	1881 Census.	1891 Estimate.	1891 Census.	1901 Estimate.	1991 Estimate (births stationary).
Over 100	277	198	141	142	146	168	453
95—100			1,230	1,246	1,208	1,391	3,853
90—95		9,226	6,790	7,236	7,831	8,643	21,085
85—90	160,274		29,987	33,337	34,541	39,835	95,670
80—85		139,624	95,750	103,428	105,681	126,203	257,813
75—80			202,322	230,398	233,333	265,597	560,440
70—75		588,929	349,955	408,930	417,914	443,907	854,393
65—70	1,893,012		502,469	564,245	571,948	627,024	1,206,888
60—65		1,275,740	727,622	787,225	772,879	877,200	1,487,568
55—60			806,464	881,769	884,124	1,026,544	1,701,750
50—55		1,850,034	1,022,075	1,162,988	1,160,032	1,282,440	1,967,199
45—50	4,453,332		1,151,371	1,323,083	1,336,842	1,545,331	2,216,150
40—45		2,547,015	1,399,354	1,565,728	1,547,016	1,796,953	2,373,045
35—40			1,541,399	1,778,508	1,781,790	2,044,767	2,555,260
30—35		3,218,221	1,745,469	2,027,098	2,027,469	2,304,551	2,677,462
25—30	7,660,850		2,047,992	2,392,543	2,350,259	2,722,679	2,937,024
20—25		4,416,449	2,328,226	2,689,422	2,646,412	3,046,411	3,074,640
15—20			2,547,232	2,962,154	2,950,865	3,183,174	3,183,174
10—15		5,319,752	2,800,331	3,210,256	3,223,567	3,253,438	3,253,438
5—10			3,147,396		3,395,178		3,395,178
0—5			3,520,864		3,553,490		3,553,490