FERTILITY TRENDS, EXCESS MORTALITY AND THE GREAT IRISH FAMINE

Phelim P. Boyle *
and
Cormac Ó Gráda

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*University of Waterloo

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I. INTRODUCTION

The Great Irish Famine of 1845-9 set in train a population decline lasting over a century, and having a profound effect on subsequent economic and social trends. The crisis, possibly Europe's greatest in the nineteenth century, has prompted useful research on the nature of the prefamine economy, and on the appropriate definitions of poverty and backwardness (Crotty, 1966; Walsh, 1970; Mokyr, 1980b; Connell, 1968), and economic historians have also examined its short term demographic consequences. Edwards and Williams (1956) and Woodham-Smith (1962) provide readable accounts of the period ; Cousens (1963) and Mokyr (1980a; 1983) represent the vanguard of economic-demographic research in this area.

Cousens and Mokyr have attempted to delineate the contours of population growth during the immediate prefamine period, and then use this information to estimate more precisely the number that perished. Calculating excess mortality is not easy. In the first place, it requires an estimate of how many deaths there would have been in the absence of the Famine, but the nature of the mortality data available make this an extremely awkward task. Cousens (1960; 1963) produced estimates of excess mortality on a county-by-county basis and obtained a figure of 800,000 for famine-related deaths, but some flaws in his approach were pointed out by Mokyr (1980a), who suggests that casualties were much higher and obtains estimates ranging from one

illion to 1.5 million.

The second major determinant of population growth, the birth rate, presents its own problems of estimation. Mokyr (1983, ch. 3) has also produced estimates of the birth rate and marital fertility on the eve of the Famine. Though his results are plausible, the trend in fertility rates before the Famine remains a puzzle. Drake (1963), Lee (1968), Tucker (1970), and Mokyr (1980a) have discussed the main issues involved. The balance of opinion seems to indicate a decline in the birth rate during the 1820s and 1830s, though this has not been conclusively demonstrated (Ó Gráda, 1979, p. 289).

The third major demographic variable is the rate of emigration. Here, Adams' (1932 (1967)) work provides useful information on Irish emigration to North America. Using ship passenger lists Ó Gráda (1983) has shown how a demographic profile of these emigrants can be established. However, the period was also one of substantial exodus to England and Scotland, and very little reliable information exists on the demographic characteristics of these emigrants.

While establishing the numerical toll of the Famine is an important task, some insight into its impact by region and by age and sex is also useful. Cousens (1960) and Mokyr (1980a) have examined the regional aspect, but which age-groups were most affected by the crisis is still not known. To assume equal incidence across the life cycle is not persuasive, since work elsewhere has shown that

mortality crises typically affect some groups more than others. The Black Death, for instance, is commonly thought to have claimed more males and more young people (Hollingsworth and Hollingsworth, 1971). Smallpox epidemics also affect the young particularly hard, while cholera outbreaks hit the old. Goubert's work on the Beauvaisis suggests that the elderly were disproportionately affected by subsistence crises there in the seventeenth century (Das Gupta, 1981 ; Dechene and Robert, 1981; Goubert, 1968). Perhaps it was likewise with the Famine, for at the height of the crisis in west Cork it was reported that it was "the aged, who with the young - neglected, perhaps, amidst the widespread destitution - are almost without exception swollen and ripening for the grave" (MacArthur, 1956, p. 289). In the present paper an attempt is made to estimate age-specific death rates during the Irish Famine. The basic approach will be to use the 1821 and 1841 Irish census data, appropriately corrected, in conjunction with emigration statistics to obtain mortality and fertility estimates for the prefamine period. These estimates provide the basis for projecting the 1841 population forward to 1851,making allowance for emigration. Conceptually the method is straightforward, but several problems arise in its application. The paper describes the methods used to overcome these problems, and indicates some problems still remaining.

One contribution of this paper is to show how excess deaths during the Great Famine - about one million in all -

were distributed by age and sex. The results indicate that excess mortality was proportionately higher among the young and the very old and roughly equal for men and women. The other main contribution of our study concerns trends in the birth rate before the Famine. Evidence is presented which indicates that birth rates were declining during the 1821-41 period, and the birth rate estimates are corroborated using a technique proposed by Coale, Hill, and Trussell (1975). Our analysis indicates that the normal rates of mortality in prefamine Ireland were similar to, but somewhat higher than, those prevailing in England during the same period.

The layout of the paper is as follows. In Section II we discuss some of the problems with the 1841 census figures. In particular the population figures suffer from extreme age-heaping at the decennial ages. The method used to correct for this is described in some detail. Section III presents an analysis of Irish emigration for the 30-year period between 1821 and 1851. A summary demographic profile of the North American emigrants during these years is presented. Three separate assumptions have been used in connection with emigration from Ireland to Great Britain, and the details of these assumptions are explained. In Sections IV and V we discuss the difficulties of estimating prefamine birth- and death-rates, and our main results as regards famine mortality and prefamine demographic trends are presented in Section VI. Our approach and findings are summarized in Section VII.

I. AGE HEAPING AND OTHER PROBLEMS

Censuses were taken in Ireland at ten-yearly intervals beginning in 1821. Convenient summaries of the relevant information are contained in Vaughan and Fitzpatrick (1978). The 1821 census provides details of the total population in five-year age groups until twenty years and in ten-year age groups thereafter. The 1831 census provides no information on age-structure and, in addition, is generally believed to overestimate the actual population (but see Lee (1981) and below). The 1841 census reports the numbers alive at each age and sex. However, even a casual examination of the data reveals that the numbers returned at ages ending in zero are much too high (Lee, 1968; Mokyr and Ó Gráda). In particular there is massive age-heaping at ages 40 and 60. The 1851 census figures suffer from the same problem.

A convenient measure of the nature and extent of age-heaping is provided by the Myers Blended Index (Myers, 1940). This index shows the preference for certain years of age. If there were no age preference the index value for each digit would be 10 percent. A summary index of the extent of age-preference in a population is obtained by finding one half the sum of the absolute deviations from 10 percent. Table I demonstrates the extreme age-heaping in the Irish male population for 1841 and 1851. Some appreciation of the extent of age-heaping reflected in these figures may be gained from noting that

(Table I here)

the 1960 population of the Philipines, considered to exhibit severe age-heaping, produces a summary preference index only about half that of these Irish populations.

It would be interesting to discover if this practice of age-heaping was associated with consistent under- or overstatement of ages for particular age ranges by one or both sexes. William Farr (1885), for example, refers to the tendency of women to understate their age. Spiegelman states that "there is evidence to suggest that older people tend to exaggerate their ages" (1968, p.). The Census Commissioners (Great Britain, 1843, p. xlv) were well aware of problems of this kind since they allude to " ... the common anxiety of individuals to deceive others as well themselves into the belief that they are younger than they really are". The authors spent some time investigating the data to detect age-shifting of this nature, but it proved difficult to reach definite conclusions mainly because the age-shifting and age-heaping effects could not be unravelled without a knowledge of the "true" underlying age distributions. However, we were able to detect evidence of certain biases and these will be mentioned later in the paper.

The 1841 Census Commissioners were aware of the extensive age-heaping in the recorded figures (Lee, 1968, p. 289) and produced their own smoothed age distribution (Great

ain, 1843, pp. 488-9). No indication of how these thed or "real" numbers were obtained was given, though seems that a graphical procedure was used. For the poses of the present paper it was decided to seek a more ctive technique. After some experimentation, it was ded to use a smoothing technique based on a formula ch is relatively unknown outside the actuarial rature. The formula in question is known as Hardy's cutting formula (Benjamin and Haycocks, 1970, p. 248). is a 23-term moving average formula which has been loyed in actuarial work to produce smooth values when the de data contain pronounced waves.

Hardy's wave-cutting formula involves the calculation a moving average of the crude values. Suppose U_i, $0 < i$ 00 represents the crude figures. Smooth values V_j, $11 <$ 89 are obtained as follows :

$$V_j = \frac{1}{65} \sum_{K=-11}^{K=11} \lambda_K U_{K+j}$$

where

$\lambda_K = \lambda_{-K}$

$\lambda_0 = \lambda_1 = 5$

$\lambda_2 = \lambda_5 = 6$

$\lambda_3 = \lambda_4 = 7$

$\lambda_6 = 4$

$\lambda_7 = 1$

$\lambda_8 = \lambda_{11} = -1$

$\lambda_9 = \lambda_{10} = -2$

When Hardy's wave-cutting formula was applied to the 1841 Census data the resulting figures were quite smooth and close to the "real" age distribution produced by the Census Commissioners. However, very minor dips were sometimes noted at ages ending in 1 or 2. In order to obtain a population where the numbers at each age formed a decreasing sequence these figures were smoothed again using the well-known Karup-King procedure (Shryock and Siegel, 1973, p.) For ages zero to 10 the Census Commissioners' "real figures were used. Table 2 indicates how the (adjusted) Hardy age-distribution compared with the Commissioners' "real" age-distribution and the age-distribution given in the Census for selected ages. Notice that the figures obtained after adjustment by the Karup-King formula are very close indeed to those obtained by the Census Commissioners.

(Table 2 about here)

Several authors, notably Tucker (1970), have commented on the serious undercounting of children in the 0-2 age-group. The "real" figures prepared by the Census Commissioners correct for this. For the moment these figures will be used. Our birth rate calculations in Section V will indicate how a possible cross-check may be obtained.

Although the details are not given here, a similar

sis was performed for the female population. eaping was found to be even more acute both in 1841 and

Most serious of all is the heaping of ages at death, ported in the 1841 census. Moreover, because of the in which this information was collected, the totals usly underestimate the actual numbers who died during period. However, it is instructive to note that the eaping is even more acute in this case. Once again the t is more pronounced among female deaths. Table 3 ins details of the summary preference indices for these ex distributions.

(Table 3 about here)

III. EMIGRATION FROM IRELAND 1821-1851

Emigration from Ireland rose to very high levels during Famine period and remained a dominant feature of Irish graphic history for the next century. However, it is aps insufficiently realized that there was also a ificant volume of emigration during the first half of nineteenth century. Indeed, Ireland produced relatively long-distance emigrants than any other European nation . While the majority went to North America, emigration ritain was also important.[1] It is convenient to deal these two groups separately.

(i) EMIGRATION TO NORTH AMERICA FROM IRELAND

Statistics for the annual number of emigrants from Ireland to British North America and the United States between 1825 and 1845 are given by Adams (1932 (1967), pp. 413-5). For purposes of the present paper it is assumed that emigration for the 1821-4 period averaged 13,000 annually. Emigration statistics for the period 1846-51 were obtained from the 1851 Census returns. Details of the numbers emigrating in each year are given in Table A1 of the Appendix.

Estimates of the age-sex composition of the emigrants were obtained by examining ships' passenger lists (Ó Gráda, 1983). It was assumed that the ships sampled contained representative samples of the emigrating population. During the 1820s the ratio of males to females was about 60 to 40 whereas later in the period the ratio was 55 to 45. Most of the emigrants were in the 20-35 age-group.

Age-heaping is again a serious problem in the recorded age-distribution and is of the same order of magnitude as in the 1841 Census (Mokyr and Ó Gráda). To surmount this problem Hardy's wave-cutting formula was again used to obtain a smooth progression. Emigrants under age 11 were assumed to be uniformly distributed. These smoothed figures were converted to percentages and the resulting percentages applied to the total annual numbers of emigrants , treating each sex separately in order to obtain the age-sex composition of emigrants for a given year.

EMIGRATION TO BRITAIN FROM IRELAND 1821-51

According to the 1841 British Census there were 419,256
-born people living in Britain at that date, of whom
ere male. Ten years later the corresponding number was
66, of whom 195,538 were under twenty. These figures
de the British-born children of Irish parents.
ing these figures are correct, some important
rences between the emigrants to Britain and those who
ed the Atlantic already begin to emerge.[2] The high
ntage of females in the 1841 figures indicates that
ants to Britain contained relatively more women than
to North America. The proportion under twenty years
51 indicates that the proportion of children emigrating
itain during the 1841-51 decade was significantly
r than in the corresponding emigration statistics for
America.

Precise statistics on the annual numbers of emigrants
Britain are unavailable. The best one can do is piece
ther the evidence to hand. Rough estimates of the
ers of emigrants in different subperiods are produced by
s (1932 (1967), pp. 123, 141-2, 175-6) and Redford
4, pp. 156-8), and Flinn et al. (1977, especially pp.
3, 455-7). Guided by these estimates and assuming that
of the Irish in Britain in 1841 emigrated during the
ious twenty years, figures were obtained for the annual
ers during this period. Estimates of the year-by-year
ls are given in Table A1 of the Appendix. Three
inct assumptions were used to measure the sensitivity of

our final results to this variable. Under Basis A the volume of emigration peaked three times during the period and the total number of emigrants was 1,045,000. A much more regular pattern is given by Basis B. The annual number of emigrants for the first twenty years is 15,000 and the annual number for the last ten years is 36,000. The British Census returns indicate that the volume of Irish emigration was higher than this, and it is well known that the pattern of emigration was was somewhat more uneven. Basis C accordingly presents an emigration pattern somewhat intermediate between the first two but closer to Basis A. Our analysis in Section IV indicates that the emigration schedule given by Basis C is the most plausible of the three.

To establish the sex-distribution of the emigrants the available information concerning the 1841 Irish residents of Britain was used. For Bases A and C the pre-1841 emigrants were assumed to be 52% male. After 1841 a 50-50 split was assumed for basis A and a slightly higher percentage of males for basis C. In view of the age-distribution of the Irish residents of Britain in 1851 it was assumed that the emigrants to Britain (under Bases A and C) had the same age-distribution as the remaining Irish population. Such an assumption gives an age-distribution for the 1851 Irish-born British residents which tallies with the information given in the Census. For pre-1841 emigration the same assumption concerning the age-distribution of emigrants was used. Finally, for Basis B it was assumed that the age-sex

osition of emigrants to Great Britain was identical to of North American emigrants for each year of the od.

ESTIMATION OF PRE-FAMINE MORTALITY

The population figures given in the 1841 and 1821 Irish uses, taken in conjunction with the assumed emigration erns described in the last section may be used to obtain mates of the mortality rates prevailing in Ireland ng these two decades. Mortality rates were assumed to approximately constant [3] during this period and it was med that these rates represent the "normal" level of ality for the ensuing ten years.

The basic procedure used was to project the 1841 Census wards on an assumed mortality basis, making due wance for the year-by-year incidence and composition of rants. The projected 1821 population is then compared the actual 1821 population and the parameters of the ality law are adjusted until "good" agreement is ined. At the same time constraints had to be imposed on mortality law to obtain rates that were "reasonable".

The method eventually adopted was obtained after siderable experimentation. As a starting point in resenting age-specific mortality rates up to age 35, the lish Life Table III Journal of the Institute of uaries, 1892) was used. This Table was computed on the is of English mortality experience during the period

1838-54. By making some adjustments to the mortality rates a reasonable fit was obtained. For the age-range 35-80 it was assumed that a Gompertz law would apply. There is evidence (Redington, 1969; Daw, 1961) to suggest that the Gompertz law provides a good approximation over these age ranges. Under this law the numbers surviving to age x: l_x are given by

$$l_x = k\, g^{cx}$$

where x fixes the radix of the table. The constants g and c were obtained by minimizing the sums of squares of the differences between the actual 1821 and the projected 1821 population figures. For ages beyond 80 the life table was approximated by a fifth degree spline of the form

$$l_x = (ax + b)(x - 100)^4$$

where a and b were selected to fit smoothly with the Gompertz curve.

In order to combine these three separate components into a global optimization procedure a method devised by Brass (Carrier, 1971) was used. Firstly the mortality rates were adjusted to ensure a smooth progression at age 35. From this a "standard" life table was obtained, which was used as a basis for the Brass logit model. The two constants were selected by minimizing the sums of squares of the differences between the actual and projected 1821 populations. Broad age-groupings proved most effective in handling this optimization procedure. Thus for Basis C

ration) the following results were obtained when the
ization was carried out.[4]

(Table 4 here)

The age-sex distribution was not available from the Census returns. However, the total number of males was n - 3.34 million - as well as the total number of les, 3.46 million. In the optimization procedure used male and female populations were projected separately each age and combined to obtain the aggregate figures in e 4. The requirement that the total of the projected population was equal to the recorded male population in was included as a constraint and similarly for the l female population.

Using this approach estimates of the male and female -specific mortality rates were obtained. The esponding life tables for Bases A and B are given in endix Table A2. Note that the rates are quite close

under all three assumptions. Table A4 summarizes the age-specific mortality rates under our three emigration assumptions, while Table A3 gives the expectation of life at various ages. Under all three assumptions we find that the male mortality levels for the age-range 10-40 are lighter than the female rates.

The nature of the data preclude a precise measure of the infant mortality level. The infant mortality rates obtained are in the expected range, but of course depend strongly on our initial selection of the corresponding English Life Tables. However, the birth rates will be based on the same assumption concerning infant mortality, with the result that any errors in the latter will be absorbed in the former. For example, if the infant mortality rates obtained are too low (compare Mokyr, 1983, ch. 2), there will be an appropriate reduction in the calculated birth rate so that the"correct" number of survivors is still obtained.

V. ESTIMATION OF PRE-FAMINE BIRTH RATES IN IRELAND

The mortality estimates derived in the last Section may be used to estimate the number of births in each year from 1821 to 1841. Assuming that mortality rates were approximately constant over this period[5] the numbers alive at each age from 1 to 20 years in 1841 can be projected backwards to their year of birth. This procedure is carried out separately for each sex, making allowance for the relevant emigrants. The emigrants are "added back" in each

r. In this way an estimate of the number of male and ale infants born in each year can be obtained.

The birth rates thus derived provide some interesting parisons with the existing literature on this topic. yr (1980a) calculated a crude birth rate of 39 per 1000 r the period, and the present paper suggests that his imate is consistent with ours. In addition, though, we d that the birth rate declined over the period. This line is clearly present irrespective of whether Basis A, or C is used for emigration to Britain. Several authors e indicated that birth rates were dropping during this iod (see Ó Gráda, 1979) but as far as we know, this paper sents the first firm numerical estimates of the nomenon. Perhaps a decreasing marriage rate may offer a tial explanation (Ó Gráda, 1982), but this interesting stion remains open.

Two independent procedures are used to provide a ss-check on our results. First the Coale-Hill-Trussell 75) technique is used to provide an estimate of the th-rate in 1841 which is in good agreement with our ults. Second, the male/female ratio at birth can be puted each year, and we have strong prior beliefs ncerning the size of this ratio on general demographic ounds.

(Table 5 here)

The results obtained when the 1841 population from ages 1 to 20 are projected backwards to their year of birth are summarized in Table 5. The crude birth rates decline from around 42 per thousand to about 36.5 per thousand. It is worth mentioning that the technique employed here enables us to estimate the entire age-sex composition of the Irish population for each year from 1821 to 1841. By relating the total number of births each year to the female population aged 15 to 44, we can obtain estimates of the general fertility rates over the period. Although the results are not presented in this paper, general fertility rates declined over the period as well.

Note from Table 5 that the same pattern of declining birth rates is obtained under all three emigration assumptions. The sex ratio at birth has also been calculated under all three bases. The ratio of male to female births is quite plausible (around 1.05) from 1826 onwards. However, for the first four years the number of female births exceeds the number of male births. We suspect that this anomalous result is due to certain biases in the 1841 Census which remain even after we have smoothed the age-groups.[6]

As mentioned earlier, it is possible to obtain alternative estimates of the Irish birth-rate in 1841 by using the approach developed by Coale, Hill, and Trussell. The Census figures give the numbers of children ever-born by year of marriage (Great Britain, 1843, p. 486). Restricting the analysis to first marriages the following

figures may be extracted :

(Table 6 here)

From these figures the average parities for marriages less than five years old and for marriages of between 5 and 10 years may be computed. Using the notation of Coale, Hill, and Trussell, we obtain for the observed parities and the calculated parities, P_i and $\hat{P}_i$:

DURATION OF MARRIAGE		P_i	$\hat{P}_i$	R_i
LESS THAN 5 YEARS	i=1	1.098	1.122	.979
BETWEEN 5 AND 10 YEARS	i=2	2.854	3.26	.875

These estimates assume a singulate mean age at marriage of 23 and that the age at which first marriages begin to occur is 15. The ratio R_i should be approximately constant for both groups but we note that R_1 exceeds R_2. This could be due to faulty recall among the marriages of long duration. It has been assumed that the value for the range 0-5 is more reliable and so a value of 0.98 has been used in

our calculations.

The final step in the birth rate estimation is to multiply the standard age-specific marital fertility rates by 0.98 and apply the resulting rates to the numbers of married females in the 1841 Irish population. This yields a figure of 308,000 births for 1841, resulting in a birth rate of 37.2 per thousand which compares well with the figures given in Table 5.

There are features of the mid-nineteenth century Irish demographic context which favour the use of this procedure. Researchers agree that illegitimacy was uncommon and birth control of no importance. On the other hand, there are undoubtedly errors in the Census data but such errors plague any attempts at estimating birth rates from this material. The Coale-Hill-Trussell method is more robust than most in handling such errors.

VI. THE INCIDENCE OF EXCESS DEATHS DURING THE FAMINE

In order to estimate the excess deaths arising from the Famine, the Irish population as given by the 1841 Census is projected forward to 1851, allowing for emigration [7] following the approach used by Mokyr (1980a) and for normal mortality. Our projection is carried out separately for each sex on an age-specific basis. The projected population is compared with the actual population as given by the 1851 Census and the difference represents the excess deaths. Age-heaping is very prevalent both in the 1851 Census

figures and the samples obtained from ships' passenger lists, and has been handled as in Section II. The normal mortality during the decade was assumed to correspond to that obtained in Section IV.

The projected population aged 10 and over in 1851 can be obtained for the 1841 population without any reference to the births during the decade. However, the population below age 10 in 1851 depends on the births during the decade. Hence for this age group the estimates of the excess death rates during the Famine will be very dependent on the birth rates assumed. The procedure adopted here permits a separation of the excess deaths on an age-specific basis, so that the significance of the birth rate assumption can be isolated.

For the first five years it was assumed that the general fertility rate was the average of the general fertility rates for the period 1837-40. To obtain the number of births each year, this rate was applied to the number of women in the 15-44 age cohort. It was assumed that male births exceeded female by 5.2 percent.

During the Famine period conditions were anything but normal, and the assumption of a constant birth rate is untenable. There seems to be no obvious method of obtaining reliable estimates of the birth rate during the Famine. Hence a rather simple indirect approach has been devised to cope with the problem. It must be emphasized that this approach is particularly subject to error, and rests on rather questionable assumptions.

The essence of the approach is to obtain estimates of the total deaths of children born during the Famine from the recorded deaths given in the 1851 Census. An undercounting factor is obtained from relating recorded to actual deaths where the information is more reliable, and extrapolating the results. For the 1841-6 period we have estimates of the population alive at each age for both sexes and, in particular, of the numbers alive from ages 0 to 10. In addition we can produce counterfactual estimates of the numbers aive at each age from 5 to 10 for each year between 1846 and 1851, assuming that the Famine did not occur. It is assumed that normal mortality prevailed between 1841 and 1846. On this basis the expected number of deaths among the 0-10 age group can be computed for each year and sex. Furthermore, the actual deaths in each Famine year among children aged 5 to 9 may also be estimated. Those deaths arise from two sources : normal deaths, which may be estimated by calculating the number of children in that age-group exposed to risk, and Famine deaths, which may be computed by comparing the 1851 outcome with the projected 1851 population figures. An adjustment must be made to allow for the fact that this comparison is made at the end of the period. Adding these two sets of figures together, an estimate of the total expected annual deaths among children aged 5-9 during the Famine period is obtained.

Let us denote the ratio of expected to recorded deaths as the undercounting factor. For the period and age groups in question the following results were obtained. To iron

but local irregularities the average figures for the two five-year periods were computed.

(Table 7 here)

On the basis of Table 7 the following under counting factors have been used for the Famine period for both males and females :

(Table 8 here)

By using these factors an estimate of total deaths during the Famine of children aged 0-4 is obtained for both sexes. The normal deaths may be obtained by assuming that the population at each age declined linearly during the period 1846-51. By subtracting normal from total deaths, estimates are obtained of the excess deaths for each year of age and sex. From this information, age-specific excess death rates for ages 0-4 may be generated. In addition the projected 1851 population for ages 0-4 can be projected. The difference between the projected and actual 1851 populations gives the excess mortality due to the Famine. The results are summarized in Table 9.

(Table 9 here)

Our results indicate that the total excess deaths during the Famine amounted to one million. Under all three assumptions about emigration more males died than females. The difference is most pronounced under Basis C, which we believe reflects the most plausible assumption.

By comparing the excess deaths with the average population for the period 1846-51, we see that the very young and very old were especially vulnerable. Table 10 gives the excess deaths for four relevant age-groups, expressed as percentage of the average population in the age-group during the Famine years. Note that 29 percent of the excess deaths took place in the lowest age-group and that this age-group represented only 13.5 percent of the average population during the Famine era. The percentage of excess deaths for the over-60 age-group was also considerably higher than the percentage of the population over 60 at the time. In relative terms, therefore, the lowest number of excess deaths took place among the age-group 10-59. This group accounted for 68.5 percent of the mean population, and about 40 percent of the excess deaths.

(Table 10 about here)

In terms of absolute numbers, there were more excess ths among males than females. The differential is atively small, however, and sensitive to the sex position of the emigrants.

Comparing total excess deaths (per annum) during the ine with the average annual population during the period, see that the impact of the Famine was to double the gross th rate per thousand. This result is already evident m Mokyr's pioneering work (Mokyr, 1980a).

It is of interest to compute the age-specific death es prevailing during the Famine, and to isolate the -specific excess death rates. Different approaches were empted, of which the following seemed the most isfactory. The 1846 population was projected forward til 1851, allowing for emigration and non-crisis rtality. An optimization procedure was used to find the rtality table giving a projected 1851 population closest the acual 1851 population recorded in the census uitably smoothed). It turns out that the mortality perience during the Famine can be represented in terms of e-Famine mortality by means of a simple linear ansformation of the age-specific death rates. For male ves the transformation is

$$Q_x = 0.0065 + 1.95\ q_x$$

ere is normal mortality (Table 11, Basis C). For female ves the transformation is even simpler :

$$Q_x = 1.98\ q_x$$

These last two equations show clearly that the impact of the Famine was to double the pre-Famine death rate. In the case of male lives, there was an additional constant increase in mortality which operated at each age.

(Table 11 about here)

Mortality no doubt fluctuated from year to year during the Famine (Cousens, 1960). To facilitate computation, we have assumed that it remained constant during the period; it is on this basis that the life table and age-specific mortality factors for the Famine are given in Table 11. It may be noted there that a new-born male had only a 49 percent chance of reaching age 5 and a 29 percent chance of reaching 30 if these conditions were to persist. In the same way, a newly born female stood a 54 percent chance of reaching age 5 and a 36 percent chance of reaching age 30. The age-specific death rates during the Famine were higher for males at each age, whereas this was not true in the pre-Famine period. This again indicates that the Famine had a greater impact on male mortality. It would be of interest to relate these findings to the medical and other pertinent literature.

It should be noted that our calculations make no allowance for deaths among emigrants during the Famine period. The contemporary evidence indicates that the number

such deaths was also substantial (Mokyr, 1980a).

(Table 12 about here)

. SUMMARY AND CONCLUDING REMARKS

This paper has developed estimates of the age-specific ess mortality rates during the Great Irish Famine and lyzed fertility trends for the pre-Famine period. oring deaths among emigrants, our calculations confirm t one million Irish people perished as a result of this aster.[8] The effects of the Famine were particularly ere among the very young and very old, and relatively e severe among males than females. For both sexes the e-specific mortality rates were approximately doubled ring the Famine period.

Our procedure enables us to reconstruct the population age and sex throughout the period 1821-41. In addition, produces year-by-year estimates of the birth rate, which dicate a fall of about one-eight between 1822 and 1841. e result was robust with respect to our assumptions garding emigration. There has been considerable debate ong economic historians on this point, and we hope our ntribution will be of assistance in resolving the issue.

Year-by-year totals of the Irish population are readily ailable from our work. Two years in particular may be of terest. Virtually all recent writers on the topic have

indicated that the 1831 Census returns overestimate the actual Irish population.[9] Our reconstruction gives 3,845,000 males and 4,002,000 females, producing a total of 7,847,000, which is in good agreement with the Census figure of 7,767,401. The most interesting population total of all is that for 1845, the highest-ever population figure reached in Ireland. Our calculation indicates that the 1845 population was 8,528,000.

Throughout the paper we have indicated those areas where statistical information is unreliable or scanty, and where necessary, have tried to devise cross-checks for consistency and develop a range of assumptions. A case in point concerns the age/sex profile and volume of emigration to England, Scotland, and Wales. Additional work at the micro level would be extremely valuable here. More solid information on Famine births would also be helpful. The parish registers which we have sampled certainly provide a clue to trends, but we have only made a start in that respect.[10] A much more comprehensive survey is needed to convey the national picture. We hope that the methodology developed in this paper will prove useful as and when more and better information becomes available. It may also help in tackling population history at a regional level.

1. Emigration elsewhere was of minor significance in the pre-Famine period.

2. Admittedly these can suggest only broad outlines, but the available information is scanty. No age information is available on the 1841 Irish-born residents of Great Britain. For 1851 Irish-born residents, the sex composition is not recorded in the published census, but a sample of 1352 Irish-born residents of Britain in 1851, which we owe to Professor Michael Anderson of the University of Edinburgh, provides useful evidence on this point. Of the 1352, 689 or 51% were male. Over 31% of the sample were aged under 20, a higher proportion than the share of the Irish-born under-20s in the total population (195,538 out of 733,866, or 26.5%). This sample provides further evidence that the emigrants to Britain during the 1840s contained a relatively higher number of children and women than did the emigrants to North America.

3. This approach was inspired by Mokyr (1980a), who projected the total population backwards, and used the crude birth, death, and emigration rates.

4. Certain adjustments were made to the actual recorded and projected population figures to obtain the numbers in Table 4. By analogy with the 1841 census we expect the number of infants to be under-counted. To correct for this, the age-group 0-14 given in the 1821 census has been increased

by 100,000. There is also evidence of overstatement of age, which is not corrected for by our smoothing technique. To correct for this, 50,000 have been transferred from the projected population total for the age-group 40-59 to the projected age-group 15-39. This last adjustment is in line with the findings of Wrigley and Schofield (1981, pp. 104-8). While the direction of these adjustments is consistent with other research in this area we have no direct method of estimating their size. But indirect support is provided by the numbers in Table 4 which show a very good fit between the actual 1821 population and the projected 1821 population.

5. In particular, we have assumed that infant mortality was approximately constant over the 1821-41 period. A significant rise in infant mortality could mean that there was no decline in the actual birth rate, but the admittedly scant evidence to hand (see e.g. Ó Gráda, 1982) does not point in that direction.

6. The "incorrect" sex ratio at birth for 1821-5 may be accounted for as follows. Suppose that females in their 20s tend to record their age as exactly 20, so that age-heaping at age 20 is not symmetrical. Our smoothing technique will not correct for this bias. An example may illustrate this point . Suppose we consider five ages :

6. For most of this section the discussion will assume that Basis C estimates are used. The procedure is general, however.

7. Thus our calculations support Mokyr against revisionist accounts (e.g. Daly, 1981, pp. 20-2), which de-emphasize the demographic effect of the Famine.

8. Lee (1981) has recently challenged the conventional approach to the 1831 census. Interestingly enough he comes up with an estimate of 7.9 million for the actual 1831 population - a figure remarkably close to our own.

9. Our analysis indicates that birth-rates during the Famine years averaged (approximately) 28 per thousand, which corresponds to a 25% reduction from their pre-crisis level. A recent paper by Menken et al. (1981) discusses some of the links between nutrition and fertility. To provide some independent evidence on our figure, we examined several parish registers. The average number of baptisms during the Famine period seems to have been justover two-thirds of the average number of the early 1840s. Even if the birth rate had remained as before, the number of baptisms would have declined in line with the population. However, the average annual population of Ireland of 7.5 million was some 90% of its 1841-5 average. On the heroic assumption that our sampled parishes experienced a similar population decline, the Famine birth rate would have been about 80% of its previous norm. This result is not inconsistent with the argument in the text.

Age	Actual Number in Population	Recorded Number in Census
14	220	220
17	210	190
20	200	260
23	190	150
26	170	170

The 260 aged 20 in the census include 40 aged 23 and 20 aged 17. If we smooth these figures using a three-year moving average the smoothed age-distribution becomes

Age	"Smoothed" Age Distribution
17	223.3
20	200
23	193.3

Comparing the "smoothed" age distribution with the true distribution, we see that the combined effect of the smoothing technique and the "untruthful" ladies leads to over-representation in the 15-20 age cohort. If this group is projected backwards these females will be over-represented at birth. The same effect on the sex ratio at birth would result if males in their late teens tended to record their age as 20 to a greater extent than would be expected by symmetric age-heaping.

TABLE 1: Myers Blended Index
Irish Census

Terminal Digit of Age	1841 Males	1851 Males	1960 Philippines
0	25.73	27.77	16.06
1	5.43	5.07	7.22
2	8.92	8.73	10.00
3	6.73	6.18	8.47
4	8.76	8.34	8.35
5	11.94	12.45	12.72
6	10.37	10.15	8.58
7	6.92	6.50	8.86
8	9.86	9.70	11.26
9	5.34	5.11	8.49
Summary Preference Index	18.04	20.37	10.04

TABLE 2: Comparison of Age Distributions
Irish Census 1841 Males

Age	Numbers Recorded in Census	Smoothed Hardy	Smoothed Hardy & Karup-King	Commissioners "Real" Ages
29	30942	55840	58022	57550
30	128215	53797	56392	55820
31	23502	51469	53839	54400
32	48695	50760	51518	52650
33	30004	49989	49428	51050
34	39539	50057	47570	49450
35	61629	48697	45943	47670
36	49297	47029	44548	46300
37	23721	43916	43385	45010
38	35176	41543	42453	43540
39	15300	38501	41753	42100
40	128841	37139	40744	40450
41	18374	36241	39324	39230
42	32504	37211	37982	37940
43	26624	37865	36715	36750
44	25599	39152	35526	35290
45	46023	38653	34413	33870
47	17983	33350	32418	31840
48	28359	30131	31536	30950
49	11976	26697	30731	29990
50	100200	25372	29913	28930
51	10020	25435	29008	27950

Table 3: Summary Preference Indices of Age Heading

Age Distribution		Summary Preference Index
1841	Males (population)	18.04
1841	Females (population)	20.00
1851	Males (population	20.37
1851	Females (population	22.43
1830-41	Male Deaths	24.05
1830-41	Female Deaths	28.12

Table 4:

Age Range	1821 Total Population	1821 Projected Total Population
0-14	2,898,274	2,898,813
15-39	2,804,527	2,800,344
40-59	932,802	932,210
TOTAL	6,634,603	6,631,367

Table 5: Crude Birth Rate Estimates

1822-1841

Year	Basis A	Basis B	Basis C
	Birth Rate	Birth Rate	Birth Rate
1822	43.1	41.1	42.3
1823	42.6	40.7	42.1
1824	42.3	40.3	41.7
1825	42.1	40.1	41.3
1826	41.9	40.1	41.0
1827	41.9	40.1	41.0
1828	4.18	40.1	40.9
1829	41.7	40.1	40.9
1830	41.9	40.1	40.8
1831	41.5	40.0	40.6
1832	41.3	39.8	40.4
1833	40.9	39.5	40.0
1834	40.3	38.9	39.5
1835	39.5	38.3	38.8
1836	38.5	37.5	37.9
1837	37.8	36.7	37.1
1838	36.9	36.0	36.3
1839	37.1	36.1	36.5
1840	38.2	37.4	37.7
1841	36.7	36.3	36.4

Table 6: Number of Marriages and Numbers of Children
Irish Census 1841

Year	Number of marriages in year	Number of children ever born until 1841 to these marriages
1830	38358	148340
1831	37522	136152
1832	38009	126173
1833	38598	117003
1834	41112	110880
1835	41588	97620
1836	39002	77637
1837	37289	60773
1838	41866	52240
1839	40135	35207
1840	34603	15421
1841*	14400	1000

*Figures for 1841 are estimates only.

Table 7: Undercounting Factors

Males Age	Observed period 1841-46	1846-51
0	5.0	?
1	3.3	?
2	2.2	?
3	2.3	?
4	2.3	?
5-9	2.0	2.35

Females Age	Observed	
0	5.1	?
1	3.7	?
2	2.2	?
3	2.2	?
4	2.2	?
5-9	1.9	2.54

Table 8: Undercounting Factors Used For Famine Period

Age	
0	4.5
1	3.5
2	2.5
3	2.5
4	2.5

Table 9: Difference Between 1851 Projected Population and Recorded 1851 Population

Emigration Assumption	Males	Females	Total
Basis A	505,000	476,000	981,000
Basis B	544,000	528,000	1,072,000
Basis C	511,000	474,000	985,000

Table 10: Excess Deaths During Famine Years by Age and Sex

	Males		Females	
Age Group Age Group	Number of Excess Deaths (total)	Average Number in Population (annual)	Number of Excess Deaths (total)	Average Number in Population (annual)
0-4	146,000 (29)	508,000 (14)	139,000 (29)	491,000 (13)
5-9	95,000 (18)	471,000 (12)	92,000 (20)	455,000 (12)
10-59	204,000 (40)	2,526,000 (68)	191,000 (40)	
60+	66,000 (13)	211,000 (6)	52,000 (11)	234,000 (6)
Total	511,000(100)	3,716,000(100)	474,000(100)	3,839,000(100)

*Figures in brackets denote percentages.

Table 11: Summary of Famine Mortality (Normal and Excess)

(Basis C - Emigration)

	l_x		$100\ Q_x$		e_n (years)	
Age	Males	Females	Males	Females	Males	Females
0	100,000	100,000	344	268	18	21
5	48,786	54,073	31	27	31	33
10	43,315	48,999	16	12	29	32
15	40,121	46,418	16	11	27	28
20	36,726	43,360	21	18	24	25
25	32,892	39,480	23	20	21	22
30	29,221	35,557	24	22	19	20
35	25,592	31,502	32	31	16	17
40	21,261	26,325	42	40	14	15
45	16,888	21,121	51	47	12	13
50	12,734	16,301	62	55	10	11
55	8,963	12,064	74	67	9	10
60	5,931	8,266	88	82	8	8
65	3,617	5,187	105	100	7	7
70	1,989	2,935	126	120	5	6
75	962	1,463	151	145	4	4
80	397	623	196	192	3	3
85	82	133	377	373	1	1

APPENDIX

TABLE A1 EMIGRANTS FROM IRELAND DURING PERIOD 1821 - 1851

YEAR	EMIGRANTS TO NORTH AMERICA	EMIGRANTS TO BRITAIN BASIS A	BASIS B	BASIS C
1821	13000	25000	15000	15000
1822	13000	25000	15000	15000
1823	13000	25000	15000	15000
1824	13000	25000	15000	15000
1825	13719	25000	15000	15000
1826	18450	25000	15000	15000
1827	21741	6000	15000	15000
1828	16685	6000	15000	15000
1829	20143	6000	15000	15000
1830	38444	55000	15000	45000
1831	68112	55000	15000	45000
1832	65397	55000	15000	45000
1833	37316	55000	15000	45000
1834	49243	55000	15000	45000
1835	24071	55000	15000	45000
1836	26500	6000	15000	15000
1837	48191	6000	15000	15000
1838	11057	6000	15000	15000
1839	31733	6000	15000	15000
1840	54713	6000	15000	15000
1841	67351	9000	36200	15000
1842	92804	9000	36200	15000
1843	38265	9000	36200	15000
1844	55294	9000	36200	15000
1845	77286	9000	36200	15000
1846	105955	135000	36200	100000
1847	215444	112000	36200	100000
1848	178159	90000	36200	70000
1849	214425	70000	36200	50000
1850	209054	50000	36200	40000
1851*	44871	15000	9050	10000

*(to March 31)

TABLE A2

ABRIDGED LIFE TABLE VALUES FOR 1821 - 41
IRISH MORTALITY

	BASIS A		BASIS B		BASIS C	
AGE	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
0	100,000	100,000	100,000	100,000	100,000	100,000
1	82,170	85,122	83,662	86,546	82,711	86,482
2	76,710	79,482	78,302	81,207	77,723	80,877
3	73,934	76,505	75,540	78,351	75,149	77,863
4	72,151	74,561	73,755	76,475	73,482	75,879
5	70,860	73,184	72,458	75,140	72,270	74,466
10	67,588	69,702	69,151	71,743	69,174	70,869
15	65,983	67,869	67,520	69,944	67,644	68,964
20	64,010	65,641	65,509	67,747	65,753	66,638
25	61,377	62,716	62,812	64,846	63,212	63,570
30	58,610	59,624	59,966	61,761	60,521	60,315
35	55,559	56,258	56,813	58,381	57,530	56,757
40	51,237	51,656	52,329	53,724	53,252	51,879
45	46,190	46,563	47,069	48,528	48,198	46,474
50	40,576	41,249	41,199	43,064	42,506	40,844
55	34,466	35,866	34,803	37,486	36,230	35,163
60	28,426	30,128	28,491	31,502	29,956	29,156
65	22,562	24,336	22,393	25,429	23,803	23,167
70	17,059	18,777	16,719	19,578	17,987	17,518
75	12,158	13,700	11,729	14,230	12,782	12,475
80	8,066	9,331	7,634	9,633	8,435	8,255
85	3,960	4,774	3,627	4,868	4,091	4,026

ABLE A3 EXPECTATION OF LIFE VALUES BASED ON 1821 - 1841 IRISH MORTALITY AND ENGLISH LIFE TABLE III

AGE	MALE LIVES			
	BASIS A	BASIS B	BASIS C	ELT III
0	37.6	38.2	38.4	39.9
1	44.6	43.9	45.4	46.7
5	47.6	47.2	47.8	49.7
10	44.8	44.4	44.9	47.0
15	40.5	40.4	40.8	43.2
20	37.0	36.5	36.9	39.5
25	33.4	33.0	33.3	36.1
30	29.9	29.5	29.7	32.8
35	26.4	30.0	26.2	29.4
40	23.4	23.0	23.1	26.1
45	20.7	20.2	20.3	22.8
50	18.2	17.8	17.8	19.5
55	16.0	15.6	15.5	16.4
60	13.8	13.5	13.3	13.5
65	11.8	11.5	11.2	10.8
70	9.8	9.5	9.2	8.4
75	7.8	7.5	7.2	6.5
80	5.5	5.3	4.4	4.9
85	3.6	3.4	3.0	3.7

AGE	FEMALE LIVES			
	BASIS A	BASIS B	BASIS C	ELT III
0	38.8	41.0	38.3	41.0
1	44.5	47.3	43.3	47.3
5	47.5	50.3	46.1	50.3
10	44.8	47.7	43.4	47.7
15	41.0	43.9	39.5	43.9
20	37.3	40.3	35.8	40.3
25	33.9	37.0	32.4	37.0
30	30.5	33.8	29.1	33.8
35	27.2	30.6	25.8	30.6
40	24.4	27.3	23.0	27.3
45	21.7	24.1	20.4	24.1
50	19.2	20.8	18.0	20.8
55	16.7	17.4	15.6	17.4
60	14.4	14.4	13.3	14.4
65	12.3	11.5	11.3	11.5
70	10.2	9.0	9.3	9.0
75	8.1	6.9	7.2	6.9
80	5.7	5.3	5.0	5.3
85	3.7	4.0	3.0	4.0

TABLE A4 AGE SPECIFIC MORTALITY RATES FOR IRELAND 1821 - 1841

RATES PER 1000

AGE	BASIS A		BASIS B		BASIS C	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
0	178.3	148.8	163.4	162.5	172.9	135.2
1	66.4	66.3	64.1	61.7	60.3	64.8
2	36.2	37.5	35.3	35.2	33.1	37.3
3	24.1	25.4	23.6	24.0	22.2	25.3
4	17.9	18.5	17.6	17.5	16.5	18.6
5	13.5	13.8	13.4	13.0	12.5	13.9
10	5.4	5.9	5.4	5.6	5.0	6.0
15	5.0	5.5	4.9	5.3	4.6	5.7
20	8.0	8.7	8.0	8.3	7.5	8.9
25	8.9	9.7	8.9	9.3	8.3	10.0
30	9.7	10.6	9.8	10.3	9.2	11.1
35	13.8	14.8	14.0	14.4	13.2	15.6
40	18.8	19.3	19.1	18.8	18.0	20.4
45	23.4	22.5	23.9	22.2	22.6	23.9
50	29.2	26.1	30.1	25.9	28.5	27.9
55	35.3	31.4	36.6	31.3	34.8	33.7
60	40.4	37.1	43.6	38.7	41.6	41.5
65	50.4	46.8	52.6	47.1	50.4	50.3
70	60.7	56.5	63.4	57.1	61.1	60.8
75	73.1	68.4	76.4	69.3	73.9	73.4
80	96.0	90.5	100.2	92.0	97.4	96.8
85	186.8	177.3	194.3	180.5	189.9	188.3

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