DISCUSSION PAPER NO. 333

THE DEADLY FUNGUS: AN ECONOMETRIC INVESTIGATION INTO THE SHORT-TERM DEMOGRAPHIC IMPACT OF THE IRISH FAMINE, 1846-1851*

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July 1978

For private circulation only - preliminary version.

*This paper is indebted to the loyal and competent research assistance of Michael Waks. The research was supported by Northwestern University Research Committee Grant No. 6055.

"Make answer, Year, for all thy dead,
Who found not rest in hallowed earth;
The widowed wife, the father fled,
The babe age-stricken from his birth.

Make answer, Year, for virtue lost;
For courage proof 'gainst fraud and force
Now waning like a noontide ghost;
Affections poisoned at their source.

The labourer spurned his lying spade;
The yeoman spurned his useless plough;
The pauper spurned the unwholesome aid
Obtruded once, exhausted now."

Aubrey De Vere

"The Year of Sorrow - Ireland 1849"

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I - Introduction

It is not too often that the economic historian can add the adverb "fortunately" to his habitual sigh that his research is hampered by the absence of good data. As far as natural (as contrasted with man-made) demographic catastrophes are concerned, however, the modern economic historian of Europe has fortunately little to work with.[1] With a few exceptions, there is little information of an aggregative character that will allow us to measure the size and the immediate effects of large famines or plagues: their disappearance generally precedes the systematic collection of demographic data on the level of the country as a whole. While we can therefore make guesses as to the demographic impact of the Black Death or the epidemics of the seventeenth century, in most cases there is no way to establish with any certainty the number of people who actually succumbed to these catastrophes.

The one exception to this rule is the Irish famine of 1845-51. A lot is known about those fatal years in Irish history.[2] But the actual numbers involved in the Famine are still a matter of speculation. The reason for this, one suspects, is that until now the "normal" death and birth rates for Ireland were unknown. In this paper, new estimates for the prefamine demographic structure of Ireland will be utilized to estimate the actual number of those who died in Ireland during the "hungry forties." The total number of casualties as a measure of the sheer size of the disaster is by itself an interesting historical fact. However, the techniques employed in this paper allow us to go further. They make it possible to calculate the distribution of the number of casualties over Ireland's four

provinces (Ulster, Leinster, Munster, and Connaught) as well as over the 32 counties which were the basic administrative unit of Ireland. The county-by-county estimates allow us to test various hypotheses which relate the impact of the famine to economic conditions prior to the famine. One would like to know, for instance, to what extent the impact of the famine was related to prefamine poverty, to the degree of dependence on potatoes, to occupational structure, and so on.

For historical demographers the interest in the last great European natural disaster is self-evident. As far as the economic historians are concerned, the role of the famine as a major watershed in Irish history has been recently called into question. One author [(5).p.132] has gone so far as to suggest that "the Famine was less a national disaster than a social and regional one...even if famine had not intervened, a decline in population was inevitable."[3] It is, of course, not easy to test the hypothesis whether the great famine was a major watershed in Irish economic history without defining properly what is meant exactly by such a watershed. It is quite clear, however, that the vastness with which the potato failure looms over Irish history has not significantly been diminished by such revisionism. The present paper is not intended to shed light on the question to what extent did the famine cause a discontinuous break in long-term trends in the nineteenth century Irish economy. Rather, the purpose here is to measure the "abnormal" loss of population during the years 1846-1850, and to link the regional variation in these excess death rates to economic variables.[4] Once the quantitative dimensions of the famine are well-established, an assessment of the true importance of the famine and its place in Irish history will be facilitated.

Most of the variables generated will be reported in this paper by province only, though the regression analysis is based on 32 observations (counties). The province-wide figures are thus sums or weighted averages of county data. For convenience, the notation and symbols used in the text and the tables is presented in table 1.

One assumption which is made throughout this paper is that up to the great famine the Irish population was "stable," that is, the birth and death rates computed for 1841 hold generally for the entire period 1821-45. Needless to say, this assumption is an oversimplification. While it is still not clear that the existing evidence warrants acceptance of the hypothesis that birth rates were already falling before the famine due to rising marriage ages,[5] emigration becomes a major factor from the mid 1830s on. The direct effect of emigration is taken into account by the procedures used, but it is far more difficult to assess from the existing data what the secondary effects of emigration on other demographic variables were. While the assumption of a "prefamine steady state" is thus obviously an oversimplification, the sudden and catastrophic impact of the famine was of such an order of magnitude that not much violence is done to the facts by measuring the impact of the famine as a deviation from this steady state. The value of the variables for the steady state is based in part on the 1841 Census, in part on comparing the 1821 and 1841 Censuses and in part on other information, and are all computed on the basis of the assumption of a stable population between the 1821 Census and the eruption of the famine.

Table 1: List of Symbols and Notation Used

i - superscript or subscript pertaining to county i (i=1,...32).

Q_j - size of a given cohort in year j.

T - total outward migration from a given cohort.

H - total number of deaths among members of a given cohort.

p - average annual death probability of a member of a given cohort.

β - unadjusted share of a county in total overseas migration.

α - adjusted " " " " " " " "

I_i - net internal outmigration (total) from county i.

J - net internal outmigration of members of a given cohort.

N - subscript pertaining to prefamine values of variables.

F - " " " famine period " " " ".

b - average annual birth rate.

d - " " death " .

P_j - total population in year j.

E_1 - total overseas migration, 1841-46.

E_2 - " " " 1846-51.

G_j - persons born in a county but not living there in year j.

F_j - " living " " " " " born " " " ".

L - total population decline between 1841 and 1851.

U - fertility rate, defined as number of children alive aged less than five divided by women aged 17-45.

Ed_F - average excess death rate during the years 1846-51.

D_F - total number of excess deaths caused by the famine 1846-51.

L,U - (as superscripts only) - lower and upper bounds of estimated variables.

II - Ireland Before the Famine

The Irish famine, until recently, has been viewed by Irish historians as an event of singular importance. It is, therefore, rather astonishing how imprecise and cavalier Irish historians have been estimating the actual number of people who died during the famine as a result of the blight. The Commissioners of the 1851 Census [(1),pp. 509-510] carried out a simple calculation, extrapolating the 1841 population to a hypothetical level it would have reached in 1851 in the absence of the disaster. Rather than pursuing that computation in full, they then simply reported a total mortality (instead of excess mortality) of 985,366 which is the total number of persons reported to have died in 1846-1850 on the forms of the 1851 Census, a number which is essentially useless. In 1875, O'Rourke estimated the number at 1.24 million. Among present-day historians, the width of the spread in the various estimates is rather surprising. Green [(2),p.126] implies that only slightly more than half a million died,[6] but in the same volume O'Neill [(3),p. 255] cites one million as the number of famine deaths, while a third author [(4), p.312] thinks that excess mortality was "well over 500,000 (and) nearly a million ... may not be far from the truth." Other historians's estimates vary equally. In what appears to be the only careful computation of excess mortality during the famine, Cousens (5) arrives at a figure of 800,645. This estimate seems to have been taken over uncritically by some of the best work done on nineteenth century Ireland e.g. (6), p.44, and (7), p.1. For a detailed critique of Cousens's estimates, see below. Cullen [(7a), p.132] estimates the famine-related deaths at "roughly one million."[7]

These widely varying estimates seem to bear out Edwards's and Williams's statement [(9), p.vii] that "it is difficult to know how many men and women died in Ireland in the famine years between 1845 and 1852." Yet,

many economic historians will find themselves in disagreement with their subsequent statement that "perhaps all that matters is the certainty that many, many died." If possible, knowing with some precision how many people died is preferable to the vague notion that "many" died. Science, after all, is measurement. Below, a set of new estimates of the number of persons who actually perished due to the blight will be presented. As will be shown, existing data allowing a more or less accurate estimate of the number of famine-related deaths in Ireland. As is usually the case, the reconstruction of historical data from defective and incomplete information requires assumptions. These assumptions, wherever they are resorted to, will be stated explicitly so that the reader has an opportunity to to judge for himself the accuracy and reliability of the ensuing estimations.

To start with, the 1841 census estimated Irish population on June 5, 1841, at 8,175,124 persons.[8] The census also reports death and birth rates, but these data, and especially the death figures - as the Census takers readily admit - suffer from heavy underreporting (11).
It is easily shown that the crude birth rate reported by the census (33 per thousand annually for the country as a whole) cannot be correct unless an incredibly rapid decline of the birth rate occurred between 1821 and 1841. Some easy calculations show that a birth rate of 33 per thousand, given the populations of 1821 and 1841 and the fact that about 1,045 million Irishmen emigrated to North America or Great Britain between these two dates, implies a death rate of 16.9 per thousand annually. Such a death rate is implausibly low. It thus becomes necessary to re-estimate the birth rates for 1841, and then, using the annual emigra-

tion figures, to calculate the death rates that would lead to the 1841 population figure.

The birth rates could be estimated by taking the number of children aged one month or less at the time of the 1841 Census and correcting conservatively for infant mortality before multiplying by 12 to obtain the annual birth rate.[9] The birth rates calculated in that fashion reported in table (2), consitute a major improvement on the birth rates reported by the Ceesus. They confirm the impression of many contemporaries - seemingly contradicted by the census - that birth rates in Ireland were high. More important for the present purposes, they are available for each county and thus provide an indispensable foundation for the reconstruction of the prefamine demographic parameters.[10] Given the birth rates, it becomes possible to compute estimates for the normal (prefamine) death rates and the county-by-county outward emigration rates. The calculation of the "normal" death rate is, of course, indispensable for the "excess" death rate.

There are two ways to produce death and migration estimates broken down by county. Version I of the "normal" death rate was calculated as follows. Since total annual outmigration for Ireland is available,[11] it becomes possible to estimate a new set of death rates for Ireland as a whole, by calculating the aggregate average annual crude death rate as a residual. Comparing this death rate with the aggregate death rate reported in the 1841 Census, an underreporting factor can be computed. Applying this coefficient to the reported death rates for 1840 (since the 1841 figures are for five months only), one obtains a county-by-county

annual death rate. The accuracy of this estimate depends on the assumption that the variations in death underreporting in the 1841 Census were relatively small and random. This is less of a stringent assumption than may appear at first sight. The original death figures do not come from a civil registration administration but from questionnaires filled out by the Census takers. The underreporting stems largely from deaths occurring in families which had no survivors in 1841. There is no particular reason to suppose that the proportion of such "forgotten deaths" would vary from county to county.

Version II of the "normal" death rate was obtained by estimating the county-by-county breakdown of emigration for the period 1821-41, and then computing the death rates as a residual. The county-by-county breakdown of emigration is obtained by using a technique first suggested by Cousens (16) but which cannot be used directly due to some unacceptable inaccuracies in Cousens's original procedure.[12] The computation is carried out as follows: consider the cohort who were in the age bracket 11-20 in 1821. It seems reasonable to assume that in the ensuing 20 years mortality among persons in this cohort was comparatively low, while their propensity to emigrate was high. Total net outmigration of members of this cohort is by definition equal to:

$$(1) \qquad T^i = Q^i_{21} - Q^i_{41} - H^i \qquad i = 1, \ldots 32$$

where Q^i_j (j = 1821, 1841) are the number of persons in this cohort at times j, and H is the total number of cohort members who died in this period. To compute H^i we have to assume that the age specific death rates reported for the year 1840 in the 1841 census are representative of the mean death rate

for the period 1821-41 as a whole. Multiplying the reported death rates by the correction factor for underreporting,[13] we can compute H simply from:

$$(2) \qquad H^i = Q_{21}^i[1 - (1-p^i)^{20}] \qquad i = 1, \ldots 32$$

where p is the average probability of an average member of the cohort to die in any year in the period 1821-41, and is a weighted average of the annual age-specific death rates in 1840.[14] We then calculate the share of each county in total annual outmigration as:

$$(3) \qquad \beta_i = T_i/\Sigma T_i \ .$$

The interpretation of the β's is <u>total</u> net outmigration shares of each county. As such, they are not accurate estimators of a county's share in total <u>overseas</u> migration, since they include both overseas migration (which was always positive) and internal migration (which was negative if a county - such as Dublin or Antrim - was a net recipient of internal immigrants). For the present purposes it seems unwarranted to ignore internal migration. The 1841 Census (11) provides a way of dealing with this problem, since it lists all persons who were not living in the counties in which they were born. Assume that all such persons aged 31-40 in 1841 did , in fact, migrate in the period 1821-41. If I_i is <u>net</u> outmigration to other counties, i.e. the number of persons born in county i but living in another county minus those born in other counties and living in county i, let J_i be $\lambda_i I_i$ where λ_i is the ratio of those aged 31-40 to all adults over 16 in 1841 in county i. Since $\Sigma J_i = 0$, define:

$$(4) \qquad \alpha_i = (T_i - J_i)/\Sigma T_i$$

which is the true share of county i in net overseas migration.[15]

Given the values of α and β, then, we can apply them to the nation-wide emigration figures and thus estimate the number of people leaving each county every year in the period 1821-41 for Great Britain and North America. Since we assume that the birth rates calculated for 1840 obtained throughout the period 1821-41, an alternative set of death rates can be obtained by solving:

$$(5) \qquad P_{ij} = P_{ij-1}e^{(b_{N_i} - d_{N_i})} - \beta_i E_j \qquad \begin{matrix} i = 1,2,\ldots 32 \\ j = 1822,\ 1823,\ \ldots 1841. \end{matrix}$$

for the unknown values of d_{Ni}. The initial values of P_{21i} and the final values of P_{41i} are known, so that the death rates could be computed by an iteration procedure. This provides us with an alternative estimate of the death rates before the famine. The estimated birth and death rates are all reported in table 2. The closeness of the two versions as reported in the table is misleading. In fact, the differences between the death rates estimated by the two different procedures are far from negligible. The raw correlation coefficient between the two sets is only about .64, which is rather low. Since it is not possible to judge between the two sets of estimates on an a priori basis it becomes necessary to employ both in all computations and check whether the results are sensitive to the particular version used.

Table 2: Average Annual Birth, Death and Emigration Rates, 1821-1841. (per 1000).

	Birth Rate	Death Rate, Version 1	Implied Emigration Rate[a]	Death Rate, Version 2[a]	Emigration Rate
Ulster	39.1	20.8	9.4	21.8	8.4
Leinster	37.4	25.4	6.2	25.1	6.5
Munster	41.2	24.7	5.8	25.0	5.5
Connaught	41.2	23.6	5.3	22.4	6.5
Ireland	39.7	23.6	6.9	23.5	7.0

a- estimated as a residual.

III - Computation of Famine Death Rates.

The demographic information available for the decade following the 1841 census is of an uneven quality. Until 1846 it may be assumed that, except for total emigration figures, the basic variables such as death and birth rates, marriage age, etc., were not changed radically. However, the five years between 1846 and the 1851 Census are extremely disturbed from every point of view, and there is no justification to use the steady state values for the prefamine period to these years. The decade can be hence conveniently divided into two subperiods of equal length, 1841-45 and 1846-50.

The death rates for the critical years 1846-50 can be estimated in two alternative ways. One procedure is to obtain the recorded death rates for the famine years from the 1851 Census. The other procedure is to estimate the death rates as a residual from comparing the 1846 and 1851 total populations after accounting for births, overseas migration, and internal migration. The latter procedure described in detail below, will be adopted here. The former procedure, constitutes the basis of the estimates of S. H. Cousens (1), (2), and its rejection in this paper warrants some explanation. Cousens utilized the information provided in Vol. V of the 1851 Census (3). This information contains the number of persons who were reported to have died in the decade 1841-51. Two separate sources of famine deaths were reported in the Census, namely those reported on Census forms (i.e., reported to have died in the famine years by surviving family members in 1851) and those

who were reported to have died in public institutions (workhouses, prisons, hospitals, etc.). Cousens simply added the two to obtain county-by-county death rates after correcting for the supposedly incorrect time pattern of the deaths reported to have occurred during the decade. He then subtracted off an annual normal death rate set somewhat arbitrarily equal to 22 per thousand for every county, and estimated excess death rates. The basic objection to Cousens's procedure is that they double-count those who died in institutions and were reported by their relatives anyway, while they undercount those who were neither. The latter objection is probably by far the more important, since entire families had been eliminated from Ireland, by death and/or emigration, so that deaths occurring in these families would never surface in the Census In addition, memories concerning deceased relatives - always a weak reed - were likely to have been blurred especially in these turbulent times. Not only are Cousens's figures therefore biased downward, but the biases are not uniform over Ireland as will be demonstrated below. The conclusion is that the 1851 Census data cannot be used for the purpose of estimating the excess death rates during the Irish famine.

The only alternative to Cousens's procedure is to estimate the death rate as a residual. Suppressing subscripts for counties, the following identity has to hold for each county:

$$(6) \qquad P_{51} - P_{41} = P_{41}[e^{5(b_N - d_N)} - 1] - E_1 + P_{46}[e^{5(b_F - d_F)} - 1] - E_2 - I$$

which is, or course, negative since population declined. E_1 is total overseas outmigration from any county for the years 1841-45, and E_2 is total

outmigration for the famine years. Dealing first with the internal migration terms, let us define G^i_{41} and G^i_{51} as the number of persons born in a county i but not living there in 1841 and 1851 respectively, and F^i_{41}, F^i_{51} as persons living in a county but born elsewhere in Ireland.[16] Using this notation (suppressing the subscript i), net internal outmigration may be written approximately as:[17]

$$(7) \qquad I = (G_{51} - F_{51}) - (G_{41} - F_{41})e^{-(5d_N + 5d_F)}$$

Let us now define P_{46} as:

$$(8) \qquad P_{46} = P_{41}e^{(b_N - d_N)5} - E,$$

which is equal to the population of 1846 net of changes in G and F due to internal migration or death of people who had migrated before 1841.[18] Population decline L between 1841 and 1851 is just the negative of equation (6). Using (7) and (8) we obtain:

$$(9) \qquad L = P_{41} - P_{46}e^{5(b_F - d_F)} + E_2 + (G_{51} - F_{41}) - (G_{41} - F_{41})e^{-5(d_N + d_F)}$$

which can be solved for the value of d_F:

$$(10) \qquad d_F = \frac{1}{5} \log \left[\frac{P_{51} + E_2 + (G_{51} - F_{51})}{P_{46}e^{5b_F} + (G_{41} - F_{41})e^{-5d_N}} \right].$$

The values of d_F can be calculated if we have information on two variables neither of which is readily available, E_2 and b_F. It is necessary to discuss briefly how these figures were calculated.

As far as emigration figures are concerned, the Census provides us with total overseas migration for each year in the decade 1841-51. While the figures are not perfect they appear to be based on reasonable assump-

tions and cannot be readily improved upon save one aspect: the Census takers as well as subsequent scholars failed to take into account Irish migration to Great Britain.[19] While the annual pattern of the latter is unknown, an idea of the size of total Irish migration to Britain can be attained by comparing the number of persons born in Ireland and living in Britain in 1841 and 1851. Assuming that one quarter of the Irishmen living in Britain died during those ten years, the total number of migrants can be readily calculated. For the purposes of this paper it has been assumed that half of these migrants migrated before the famine and half during it, which amounts to 41,942 annually, from a total of 419,420 for the entire decade. The question is, how were all emigrants (to North America as well as to Britain) distributed over the various counties? As will be recalled, in order to calculate the county-by-county distribution for the years 1841-45 the prefamine shares were used to multiply total outward migration figures. This procedure cannot be used for the famine, since the assumption of relatively constant geographical pattern of outmigration - not a very attractive assumption to start with - becomes totally unreasonable once disaster strikes.

Direct information on the distribution of emigrants going overseas becomes available for the years 1851-55 in (4). It is not clear, however, if the α's computed from postfamine data reflect accurately what happened during the critical years 1846-51. Various possibilities were experimented with. In addition to taking simply the α's for 1851 and for the total period 1851-55, the series for each county were regressed over time and extrapolated backward to the center of the famine if the time trend was significant at the 1% level. A separate set of α's was computed under

the assumption that the true values of α for the famine years were between those of 1841 and those computed from postfamine data, and a simple average of the two variables was used. For each set of α's, and for the two versions of d_N, a different vector d_F was obtained.

Secondly, it is necessary to calculate b_F, the crude birth rate during the famine years, in order to calculate d_F from eq. (10). It is quite clear that the famine had a serious impact on the birth rate. The catastrophic conditions in Ireland led, beyond doubt, to a serious amount of marriage postponement, directly affecting the birth rates. The famine relief system often separated married couples (in workhouses for instances). Furthermore, fecundity must have been affected by the drastic reduction in caloric intake, with a steep increase in spontaneous abortions and stillborn. It would thus appear necessary to adjust the birth rate in order to avoid counting "averted deaths" as famine casualties. This, however, is a rather difficult philosophical issue that cannot easily be resolved: is it truly warranted to ignore averted births as a measure of demographic impact of the famine? Taking one extreme position, one might wish to argue that an unborn child is as much a casualty as an ordinary death, while on the other extreme one might wish to count only the "dead proper". Rather than decide this thorny issue, the position taken here is to establish figures consistent with the two extreme positions, thus establishing a lower and an upper bound for the estimated excess death rates.

The one extreme position counting each averted birth as a death simply implies $b_F = b_N$ and can be readily calculated. The alternative pos-

ition is more difficult to estimate, since it appears that the decline in birth rates was particularly severe in 1846, 1847, and 1849 but rebounded somewhat in 1848 and 1850 as the worst effects of the famine were slowly wearing off. Unfortunately, the 1851 Census does not provide as fine a breakdown by age and county as the 1841 Census, but even if it had contained this information, how would one interpret it? If for example it was found that in 1851 the number of those aged 4-5 (born in 1846) was far lower than expected, could one conclude from that that birth rates had declined in proportion? This would only be the case if the death rates of infants and toddlers had risen equiproportionately to the rise in the general death rate. The validity of this assumption will be discussed below. The lower bound value of b_F will thus be calculated as:

$$(11) \qquad b_F = \frac{U_F}{U_N} b_N \ .$$

Given d_F and thus the excess deaths rates $Ed_F = d_F - d_N$, the total number of people who should be considered famine casualties can be computed immediately as $D_F = P_{46}(e^{5Ed_F} - 1)$.[20] The results provide not only an aggregate estimate of excess deaths during the famine, but are broken down by county. The results are summarized in tables (3) and (4).

As Tables 3 and 4 indicate, the total mortality due to the famine was far higher than most modern historians suppose. The upper bound estimates, which count averted births as deaths are close to a million and a half, the lower bounds are still well in excess of one million. These are, to repeat, <u>excess</u> death figures, persons who died in the disaster years who would not have died otherwise. The 1851 Census Commissioners were thus close to the mark when they perceived a gap of 2.5 million people

Table 3: Average Annual Death and Excess Death Rates and Total Excess Deaths in Ireland, 1846-51: Version 1 of Prefamine Death Rates.

(all rates in per 1000)

I - α's derived from a mean of the shares in 1851 and the prefamine shares.

	Ulster	Leinster	Munster	Connaught	Ireland
d_F^U	47.1	39.3	61.1	83.7	56.5
Ed_F^U	26.3	13.9	36.4	60.1	32.9
D_F^U	339,588	141,072	492,229	512,183	1,485,072
d_F^L	40.2	34.1	49.7	72.8	47.8
Ed_F^L	19.4	8.7	25.0	49.2	24.2
D_F^L	246,129	87,146	328,331	407,515	1,069,121

II - α's derived from a mean of the shares of 1851-55 and the prefamine shares.

	Ulster	Leinster	Munster	Connaught	Ireland
d_F^U	45.1	41.1	61.6	84.0	56.5
Ed_F^U	24.3	15.7	36.9	60.4	32.9
D_F^U	312,166	160,068	499,633	515,146	1,487,013
d_F^L	38.2	35.8	50.2	73.1	47.8
Ed_F^L	17.4	10.4	25.5	49.5	24.2
D_F^L	219,637	104,622	335,325	410,320	1,069,904

Table 3 cont'd

III - α's derived from the shares in 1851 extrapolated backward on the basis of trends 1851-55.

	Ulster	Leinster	Munster	Connaught	Ireland
d_F^U	50.3	37.2	60.1	84.7	56.9
Ed_F^U	29.5	11.8	35.4	61.1	33.3
D_F^U	384,037	119,125	477,475	522,075	1,502,712
d_F^L	43.4	32.0	48.7	73.9	48.2
Ed_F^L	22.6	6.6	24.0	50.3	24.6
D_F^L	289,072	65,762	314,394	417,821	1,087,049

Table 4: Average Annual Death and Excess Death Rates and Total Excess Deaths 1846-51: Version 2 of Prefamine Death Rates. (All rates in per 1000).

I - α's derived from a mean of the shares in 1851 and the prefamine shares.

	Ulster	Leinster	Munster	Connaught	Ireland
d_F^U	46.1	39.7	61.6	84.8	56.6
Ed_F^U	24.3	14.6	36.6	62.4	33.1
D_F^U	310,594	148,679	495,491	538,262	1,493,026
d_F^L	39.2	34.5	50.2	74.0	47.9
Ed_F^L	17.4	9.4	25.2	51.6	24.4
D_F^L	218,531	94,476	331,329	432,690	1,077,026

II - α's derived from a mean of the shares of 1851-55 and the prefamine shares.

	Ulster	Leinster	Munster	Connaught	Ireland
d_F^U	44.0	41.5	62.1	85.1	56.6
Ed_F^U	22.2	16.4	37.1	62.7	33.1
D_F^U	282,238	167,772	502,908	541,277	1,494,195
d_F^L	37.6	36.2	50.7	74.3	47.9
Ed_F^L	15.8	11.1	25.7	51.9	24.4
D_F^L	192,435	112,041	338,335	435,546	1,078,357

Table 4 cont'd

III - α's derived from the shares in 1851 extrapolated backward on the basis of trends, 1851-55.

	Ulster	Leinster	Munster	Connaught	Ireland
d_F^U	49.2	37.5	60.5	85.8	56.8
Ed_F^U	27.4	12.4	35.5	63.4	33.3
D_F^U	353,000	125.575	479,240	548,329	1,506,144
d_F^L	42.4	32.3	49.1	75.0	48.2
Ed_F^L	20.6	7.2	24.1	52.6	24.7
D_F^L	260,832	71,965	315,978	442,228	1,091,003

approximately for which overseas emigration could account only for about one million. The "gap" thus calculated is in fact somewhat too small, since the Census Commissioners applied a "natural rate of growth (i.e., b_N-d_N) of 1.0036% [(5a), p. 509, also (4), p. xvi], which understates the true rate by about .6% and therefore understates the gap by a quarter of a million people or so. On the other hand, one has to add to out-migration those who went to Great Britain. The only correct procedure is to subtract total emigration from each year's hypothetical population and compute deaths rates and excess death rates by comparing the actual 1851 population with the "counterfactual" one that would have obtained with normal birth and death rates. Eq. (10) follows precisely this procedure.

Furthermore, there are two reasons to believe that the estimates presented are, in fact, biased downward, though the magnitudes of the biases are probably small. The first source of bias is technical in nature. Eq. (10) treats E_2 as one sudden event occurring in 1851 (as E_2 is added to the 1851 population) rather than as a constant flow occurring continuously over the five years. This assumption tends to bias the estimates of d_F (and thus Ed_F) downward, though by a small amount.[21] The second source of downward bias is quantitatively more important. Until now it has been assumed that mortality and emigration were mutually exclusively, so that excess mortality rates were computed by subtracting off all emigrants. Thus the procedure employed completely ignores all

those who died at sea or shortly after arrival due to famine-related causes. The number which theoretically should have been in our estimate consists of two components. First, since emigration was always somewhat risky as a result of conditions on board, the spurt in emigration figures due to the famine by itself led to more mortality. Secondly, there is much evidence to support the contention that mortality rates en route to America rose dramatically during and because of the famine. Overcrowding, poor nutrition, and the already emaciated condition of many emigrants, compounded by the contagious diseases which raged in Ireland, led to many deaths of emigrants. Moreover, the season of travel was extended to cover the entire year, which meant that many emigrants arrived in the U. S. and Canada in the late fall, hence reducing the probability of surviving the harsh winter. Furthermore, the sudden surge in demand for passage to America made many unseaworthy vessels participate in the emigrant trade, some of which sank.

How many deaths should be added to our excess mortality figures on account of deaths amonth emigrants? Beyond doubt, the death rates on some "coffin ships" were staggering: on the Ceylon almost 45 per cent of the steerage passengers died on the way; on the Loosthank 33 percent [(6),pp.131-32]. Many who arrived alive died shortly after. The Agnes arrived in 1847 with 427 passengers, of whom only 150 were alive after 15 days [(7), p. 231]. Yet, these horror stories are not necessarily representative of the emigration movement during the entire period. The mortality on board emigration ships was unusually high in 1847, far higher than in any other year.[22] It is quite obvious, moreover, that there

was large variability among emigrant ships, and that even in the fatal year 1847 the majority of ships arriving in Quebec contained passengers in good health among whom death rates were minimal [(12), pp. 398ff]. For the year 1847, we have the Government Emigration Office In Quebec's report (13). The officials in Quebec reported that 98,125 persons embarked on ships or were born on board, the vast majority of which were Irish. Of these, 5,282 (5.39%) died at sea, 3,389 (3.46%) died in quarantine on Grosse Isle, and 8,154 (8.3%) died in hospitals. Total mortality in 1847 to Canada was thus about 17%. However, the next year only 1.11% died on board or in quarantine. The voyage to the U. S. -- which imposed tighter regulation on passenger ships -- was generally less lethal than to Canada.[23]

All in all, maybe 5 percent of total overseas migration at the very most should be included in the total death rates. This would add at most about 46,000 to the overall death figures during the period 1846-51, and of course even less to the excess deaths. Thus, the bias tends to make our estimates somewhat too small, but not by an amount that could change any of the conclusions.

Table (5) provides a comparison with the estimates provided in tables (3) and (4) with the set of excess famine estimates provided by Cousens (1). Part a of table should be compared with the two last rows in tables (3) and (4),(since Cousens's estimates are formally equivalent to Ed_F^L). For the province of Munster, Cousens's figures appear to be approximately correct. For Leinster they are somewhat on the high side, but since Ed_F^L is a lower bound, and the true figure is likely to be somewhere between Ed_F^L and Ed_F^U, the bias does not appear to be major. For

Table 5: Comparison of Excess Death Rates Based on eq.(10) with those Estimated By Cousens. (rates in per 1000).

a: Cousens's implied annual average excess death rates, by province.

	Ulster	Leinster	Munster	Connaught	Ireland
Ed_F^L	11.88	15.23	23.42	24.52	18.41
D_F^L	147,417	154,842	306,608	191,778	800,645

b: Correlation matrix between Cousens's implied annual average excess death rates with selected excess death rates based on eq. (10). n = 32.

	EdC	EdM1	EdM2	EdM3	EdM4	EdM5	EdM6
EdC	1	.3296	.4963	.5615	.4316	.5887	.6451
EdM1		1	.8938	.8482	.9559	.7534	.6932
EdM2			1	.9894	.9003	.9316	.9043
EdM3				1	.8645	.9371	.9311
EdM4					1	.8664	.8154
EdM5						1	.9891
EdM6							1

Legend: EdC: Excess Death Rate implied by Cousens's figures.
EdM1...EdM6: Excess Death Rates presented in tables (3) and (4) (in that order).

Ulster, and especially for the counties in Connaught, the Cousens estimates are much too low. One reason for this bias is the fact that Cousens subtracted a uniform d_N (= 22 per thousand) from his d_F's. For Leinster (with county Dublin in which prefamine death rates were around 35 per 1000), this is patently mistaken. This uneven bias in Cousens's figures is reflected in part b of table 5, which shows the low correlation between Cousens's and the present estimates. For some of the other variants of Ed_F^L, the correlations are in fact far weaker than those reported in table 5. The average value of the raw correlation coefficients between Cousens's implied values of the excess mortality rates and the ones estimated here is .4625 for version 1 of the prefamine death rates and .5551 for version 2 of the prefamine death rates. It is thus useless to base any further analysis on Cousens's county-by-county estimates.

IV - An Analysis of Famine Death Rates

As tables (3) and (4) demonstrate, the famine was anything but uniform in its impact on Ireland. Some areas apparently suffered far more than others. The breakdown of the death rates by province does not fully reflect these differences, since there was also considerable intra-provincial variation. The excess death rates are, as shown above, somewhat sensitive to our assumptions concerning famine emigration rates and prefamine mortality rates. Nonetheless, four groups of counties - somewhat roughly - can be distinguished according to the severity of the famine. First, low excess death rates are observed for East Leinster including Dublin, as well as in the Northeastern counties of Ulster. Medium excess death rates occurred in Central Ireland (West Leinster and Tipperary), as well as in Central Ulster (Tyrone and Armagh). High excess mortality rates characterize most of Munster and the Southern counties of Ulster, while finally extremely high excess mortality occurred in most of Connaught, particularly Sligo, Galway, and, worst of all, Mayo.

What accounts for this pattern? Before we embark on this issue, it is necessary to explain one rather fundamental point. It is as meaningless to talk about the "cause" of the Irish famine as it is to talk about the "cause" of the great Chicago fire. Like Mrs. O'Leary's infamous cow, the Phytophtora Infestans, the fungus which was responsible for the destruction of the potato crop, was wholly exogenous to the Irish economy. Thus, by analyzing the pattern of the excess mortality rates, we are not asking ourselves what caused the famine, as much as what factors made some regions more vulnerable than others. While in 1845 the blight was only partial, the destruction of the crop in 1846 and 1848 was general and nationwide, so that the exogenous shock administered to the Irish

economy was, broadly speaking, uniform. The variance of the effect, therefore, has to be explained in terms of the initial (i.e. prefamine) conditions.

A detailed analysis of factors that could be responsible for the extent of the excess mortality cannot be attempted at this stage. But a brief list of possible candidates may prove useful. First, since the blight was first and foremost a reduction of the potato crop, the degree of dependency on potatoes would at first sight appear an obvious determinant of famine mortality.[24] A second strong candidate is prefamine income. Presumably with a higher income, a peasant facing the loss of his crop could feed his family by dissaving or borrowing with greater ease, and the obstacles to emigration were less formidable.[25]

A third factor which is likely to be a major factor in explaining excess mortality rates is urbanization. Urban areas were more commercialized so that the absence of potatoes did not completely cut off the food supply, though it did raise the prices of necessities to dangerous and, at times, lethal levels. The absence of a food retail system in the more remote provinces in the West and South is often cited as a major cause of mortality. This degree of self-sufficiency in food supply (on the household level) cannot be readily measured, but it is likely to be negatively correlated with the level of urbanization. Finally, urbanized areas were likely to have had lower excess death rates simply because their prefamine death rates were already considerably higher.

Some of the characteristics of the population are also possible factors in the impact of the famine. Literacy rates are one such factor. Literacy may have been correlated with other skills which were important

for survival (e.g., personal hygiene, ability to adjust rapidly to unknown foods such as Indian corn, knowledge about emigration opportunities, and so on). The occupational structure of the population may also have mattered. Arguably the larger the proportion persons dependent on agriculture, all other things equal, the more vulnerable is a society to harvest failure. This, of course, is false as a general rule, but does not seem too objectionable for a society dependent on a subsistence crop. As I have argued elsewhere, this is what happened in Belgium [(3),Ch.VII].

It has also been argued that the size of landholding was a major element in the Famine. The main victims of the famine were farm laborers, cottagers, and very small tenants. But was farm size <u>as such</u> that crucial? Many cottagers and smallholders worked part-time in rural industry or on other farms, others migrated to England on a seasonal basis. Thus, they may have had comparatively more resources that were not associated with potatoes than someone whose farm was large enough to guarantee a comfortable existence on potatoes in ordinary years. There is no way of determining this issue a priori, and only empirical tests can shed light on it. A quite different variable is the quality of housing in Ireland. The 1841 Census provides data on housing broken down by quality of the structures in four classes. The importance of a variable incorporating the average quality of housing in a county is as follows. Housing quality may be viewed as a proxy for income, so that if the income variable fails to explain excess famine death rates but the housing variable is more successful, this could indicate a severe errors in variable problem in the income figures. Furthermore, since income is an annual flow and housing is a stock, housing may be a better indicator for the reserves of past saving that the Irish could liquidate, now that a

very rainy day had arrived. Unfortunately the relation between housing and wealth is more complex than that. A relatively high quality of housing could mean three things, with vastly different implications. First, it could simply mean a higher income and to the extent that there are measurement errors in the income variable, it could be viewed as a substitute for income. Secondly, given income, better housing could mean a higher propensity to save and thus more wealth on the eve of the famine, which could then be used to survive the famine. Thirdly, it is possible that better housing was associated with the same income levels and the same savings behavior but with a stronger preference for housing quality (or possibly lower prices for houses). In that case the association between housing quality and mortality could become positive, since better housing meant less liquid assets. The conversion of houses into money and from there into food was, of course, next to impossible during the crisis. Finally, better housing may have provided some form of protection against certain diseases. With greatly reduced resistance, the Irish became more susceptible to such weather related disease as pneumonia, in addition to diseases of the digestive system (where housing probably did not matter much). A further index of availability of capital which could be used for emergency food is livestock. In contrast to housing, this form of capital can easily be converted from capital goods to consumers goods. While ownership of livestock was heavily concentrated among the wealthier farmers, their availability nearby might have made a difference for the poor farmers. Reports on livestock theft were, needless to say, common, and much livestock was sold off in anticipation thereof [(4),p.124]. But the actual figures are very difficult to interpret. The puzzling and sur-

prising fact is that during the 1840s the value of livestock increased in Ireland.[26] According to the 1841 Census, the value of livestock in Ireland was £20.7 million [(5), p.455],while in 1847 it was £22.5 million and in 1848 £23.1 million. [(6), p. 6]. In a country in which millions and millions were starving, livestock would be expected to be eaten or sold rather than maintained. Some of that, of course, did occur, as disaggregating the data will reveal. Pigs, a main consumer of potatoes, decline in numbers from 1,353,101 in 1841 to 517,446 in 1847. The proportion of their value to total livestock value fell from 8.1% to 2.8%. On the other hand, the proportion livestock owned by large farms (above 30 acres) increased from 34.8% to 56.4%.[27] Finally, it is not impossible - though highly unlikely - that livestock was increasing rapidly between 1841 and the famine, so that a decline in aggregate livestock numbers may have taken place after all.[28] One might conclude tentatively that there is not much prima facie evidence that the eating of livestock (except pigs) served as an important defense against starvation. There are, however, other grounds for a defense of including the livestock variable. For example, livestock per capita is a good proxy for the capital-labor ratio, which is strongly correlated with the technological development of agriculture and the diversification of crops. Moreover, cattle, sheep, and poultry produce dairy products which could have been an important complement to famine diets - as well as a good reason not to slaughter the animals.

Finally, one could argue that the amount of rent per capita should be used as an independent variable. One reason for this, as argued in a different context by Cousens (11) and by Almquist (12) is that rents per capita are a good measure of population pressure.[29] More important, perhaps,

is the fact that landlords paid poor rates, and poor rates maintained the poor. While the British government passed emergency relief measures under Peel and Russell, and opened soup kitchens all over Ireland in the spring of 1847, it was decided in June 1847 that the Irish Poor Law system should be put in charge of any further assistance. With some understatement Woodham-Smith [(13),p.310] notes that "from this point onwards the good intentions of the British Government become increasingly difficult to discern." Be that as it may, the notion that the property of Ireland was to support the poverty of Ireland means for our purpose that the more the landowners could pay in poor rates, the better the chance of inhabitants to receive the much needed emergency relief from the local Union. The financial condition of the vast majority of the Irish Unionswas desperate, so that ability of landlords to pay the poor rates could be a matter of life and death.[30]

The main results of the regressions of the excess death figures are presented in tables (6) and (7). A few notes on the interpretation of the tables are in order. First, since no less than 32 different versions of Ed_F were generated, it is of course not possible to report all of the many hundreds of regressions tried. The figures presented in tables (6) and (7) should be viewed as a sample, though on average the versions of Ed_F chosen are the ones that are the most plausible a priori, and they tend to lend themselves somewhat better to explanation by the independent variables mentioned. The differences between the omitted versions and the ones presented are, on the whole, small. All regression equations tried, as well as the raw data, are available from the author

Table 6: Regression Analysis of Excess Mortality Rates, part 1: Version 1 of Prefamine Mortality Rates. (t - values in parentheses).

Regression #	1	2	3	4	5
Dependent Variable[a]	$Ed_F^U(1)$	$Ed_F^U(1)$	$Ed_F^U(1)$	$Ed_F^U(2)$	$Ed_F^U(2)$
Form	linear	linear	linear	linear	linear
Constant	.0542 (2.89)	.0064 (.21)	.0652 (3.39)	.0793 (2.86)	.0478 (1.65)
Income p.c.				-.0023 (-1.89)	
Labor Income p.c.	-.0016 (-1.22)				
Housing Quality Index[b]		.0494 (1.74)	.0481 (1.76)		.0456 (1.82)
Livestock p.c.			-.0072 (-2.16)		-.0062 (-2.15)
Percentage Small Farms[c]	.0399 (2.16)	.0444 (2.48)		.0283 (1.53)	.0246 (1.32)
Average Farm Size[d]			-.0218 (-.46)		
Literacy Rate	-.1130 (-2.55)	-.1106 (-2.32)	-.1169 (-3.06)	-.1201 (-2.76)	-.0648 (-1.87)
Percentage Urban		.0120 (.56)		.0288 (1.30)	
Percentage Non-agricultural					-.0662 (-2.43)
Rural Industry	-.0043 (-.18)				
Potato Acreage p.c.		.0130 (.47)		-.0158 (-.56)	
Percentage of acreage in potatoes					
Rents p.c.	.000086 (.03)		.0038 (1.24)		
R^2	.6719	.6932	.7194	.6971	.7734
F (d.f.)	10.65 (5,26)	11.75 (5,26)	13.33 (5,26)	11.97 (5,26)	17.75 (5,26)

Table 6
(continued)

Regression #	6	7	8	9	10
Dependent Variable[a]	Ed_F^U (2)	Ed_F^U(2)	Ed_F^U(2)	Ed_F^U(2)	Ed_F^U(3)
Form	linear	linear	linear	linear	linear
Constant	.0703 (3.15)	.0139 (.49)	.1094 (6.52)	.0070 (.28)	.1240 (2.90)
Income p.c.			-.0023 (-1.80)		
Labor Income p.c.	-.0028 (-2.08)	-.0025 (-2.43)			
Housing Quality Index[b]		.0705 (2.89)		.0513 (1.87)	-.0016 (-.04)
Livestock p.c.					-.0144 (-3.39)
Percentage Small Farms[c]	.0346 (2.08)	.0384 (2.15)		.0493 (3.09)	-.0071 (-.26)
Average Farm Size[d]		-.0382 (-.95)	-.0449 (-1.04)		
Literacy Rate	-.1145 (-2.62)		-.1299 (-2.90)	-.0724 (-1.87)	-.1165 (-2.29)
Percentage Urban	.0326 (1.38)		.035 1.59		
Percentage Non-agricultural				-.0444 (-1.55)	-.0534 (-1.33)
Rural Industry					
Potato Acreage p.c.			-.0146 (-.46)		
Percentage of acreage in potatoes	-.0042 (-.11)				
Rents p.c.		.0018 (.61)		-.00046 (-.17)	
R^2	.7051	.7204	.6830	.7334	.6517
F (d.f.)	12.44 (5,26)	13.40 (5,26)	11.20 (5,26)	14.31 (5,26)	9.73 (5,26)

Table 6

(continued)

Regression #	11	12	13	14	15
Dependent Variable[a]	$Ed_F^U(3)$	$Ed_F^L(2)$	$Ed_F^L(2)$	$Ed_F^L(2)$	$Ed_F^U(2)$
Form	linear	linear	linear	linear	logarithmic
Constant	.1027 (3.02)	.0414 (1.48)	.0521 (2.52)	.0084 (.31)	-.5467 (-.24)
Income p.c.	-.0029 (-1.80)				-1.6705 (-2.38)
Labor Income p.c.			-.0021 (-1.73)	-.0023 (-2.29)	
Housing Quality Index[b]	-.0063 (-.15)	.0259 (1.07)		.0525 (2.23)	
Livestock p.c.		-.0053 (-1.91)			
Percentage Small Farms[c]		.0266 (1.48)	.0367 (2.38)	.0388 (2.25)	.2905 (.55)
Average Farm Size[d]				-.0343 (-.89)	
Literacy Rate	-.1585 (-2.27)	-.0670 (-2.01)	-.1036 (-2.56)		-.9851 (-2.10)
Percentage Urban	.0813 (2.48)		.0264 (1.21)		-.0283 (-.26)
Percentage Non-agricultural		-.0589 (-2.25)			
Rural Industry	.0605 (1.94)				
Potato Acreage p.c.					-.0891 (-.32)
Percentage of Acreage in Potatoes			-.0166 (-.45)		
Rents p.c.				.0016 (.59)	
R^2	.5711	.7323	.6775	.6689	.6810
F (d.f.)	6.92 (5,26)	14.22 (5,26)	10.92 (5,26)	10.51 (5,26)	11.10 (5,26)

Table 7: Regression Analysis of Excess Mortality Rates, part 2: Version 2 of Prefamine Mortality Rates. (t - values in parentheses).

Regression #	1	2	3	4	5
Dependent Variable[a]	$Ed_F^U(1)$	$Ed_F^U(1)$	$Ed_F^U(2)$	$Ed_F^U(2)$	$Ed_F^U(2)$
Form	linear	linear	linear	linear	linear
Constant	.0590 (2.03)	.0392 (1.25)	.0818 (3.52)	.0650 (3.42)	.0132 (.51)
Income p.c.	-.0027 (-2.39)			-.0024 (-1.85)	
Labor Income p.c.			-.0030 (-2.20)		-.0016 (-1.38)
Housing Quality Index[b]	.0643 (2.33)	.0487 (1.80)			.0652 (2.44)
Livestock p.c.		-.0042 (-1.36)			
Percentage Small Farms[c]		.0253 (1.26)	.0309 (1.78)	.0388 (2.15)	.0436 (2.70)
Average Farm Size[d]	-.0151 (-.29)				
Literacy Rate		-.0699 (-1.88)	-.1057 (-2.33)	-.0900 (-2.09)	-.0389 (-.87)
Percentage Urban			.0265 (1.08)		
Percentage Non-agricultural		-.0538 (-1.84)			
Rural Industry	-.0090 (-.34)			-.0287 (-1.27)	-.0246 (-1.22)
Potato Acreage p.c.	-.0175 (-.52)				
Percentage of acreage in potatoes			-.0418 (-1.02)		
Rents p.c.				.0025 (.74)	
R^2	.6375	.7307	.6774	.6803	.7367
F (d.f.)	9.15 (5,26)	14.11 (5,26)	10.92 (5,26)	11.06 (5,26)	14.55 (5,26)

Table 7
(continued)

Regression#	6	7	8	9	10
Dependent Variable[a]	$Ed_F^U(2)$	$Ed_F^U(3)$	$Ed_F^U(4)$	$Ed_F^L(1)$	$Ed_F^L(2)$
Form	linear	linear	linear	linear	linear
Constant	.0850 (3.27)	.1036 (2.71)	.1085 (6.14)	.0117 (.48)	.0636 (2.99)
Income p.c.	-.0023 (-1.98)		-.0027 (-2.03)		
Labor Income p.c.					-.0024 (-1.90)
Housing Quality Index[b]		.0112 (.34)		.0314 (1.15)	
Livestock p.c.		-.0118 (-3.12)			
Percentage Small Farms[c]	.0321 (1.72)	.00015 (.01)		.0405 (2.56)	.0330 (2.08)
Average Farm Size[d]			-.0159 (-.35)		
Literacy Rate	-.0954 (-2.28)	-.1002 (-2.20)	-.1037 (-2.20)	-.0749 (-1.94)	-.0948 (-2.28)
Percentage Urban			.0396 (1.70)		.0203 (.90)
Percentage Non-agricultural		-.0580 (-1.62)		-.0359 (-1.27)	
Rural Industry	-.0378 (-1.71)				
Potato Acreage p.c.	-.0332 (-1.16)		-.0106 (-.32)		
Percentage of acreage in potatoes					-.0543 (-1.44)
Rents p.c.				-.00062 (-.22)	
R^2	.6895	.6736	.6460	.6602	.6560
F (d.f.)	11.55 (5,26)	10.73 (5,26)	9.49 (5,26)	10.10(5,26)	9.92 (5,26)

Table 7
(continued)

Regression#	11	12	13	14	15
Dependent Variable[a]	$Ed_F^L(2)^e$	$Ed_F^U(1)^e$	$Ed_F^U(2)^e$	$Ed_F^U(4)^e$	$Ed_F^U(2)^e$
Form	linear	logarithmic	logarithmic	logarithmic	logarithmic
Constant	.0680 (2.83)	-3.54 (-2.66)	-1.3752 (-.61)	-1.6936 (-.63)	1.8560 (.97)
Income p.c.	-.0019 (-1.75)			-1.7978 (-2.14)	-1.8486 (-2.20)
Labor Income p.c.			-1.64 (-2.31)		
Housing Quality Index[b]		.8767 (2.06)			.9364 (2.38)
Livestock p.c.		-.9071 (-2.00)			
Percentage Small Farms[c]	.0317 (1.84)		.1799 (.34)	.3304 (.98)	.3676 (.66)
Average Farm Size[d]		.2615 (.75)			
Literacy Rate	-.0856 (-2.22)	-.7952 (-1.66)	-1.0202 (-2.20)	-1.0767 (-2.07)	
Percentage Urban			.0633 (.55)	.0594 (.44)	.0137 (.12)
Percentage Non-agricultural					
Rural Industry	-.0332 (-1.63)				
Potato Acreage p.c.	-.0360 (-1.36)			-.5649 (-1.29)	-.4016 (-1.09)
Percentage of acreage in potatoes			-.4231 (-1.58)		
Rents p.c.		.2098 (.67)			.4160 (1.42)
R^2	.6644	.5669	.5854	.5629	.6043
F (d.f.)	10.29 (5,26)	6.54 (5,25)	7.05 (5,25)	6.44(5,25)	6.11 (6,24)

Notes to Tables (6) and (7)

a - Legend: the number in parentheses refers to the assumptions used in calculating the α's. Assumptions (1), (2), and (3) correspond to parts I, II, and III in table (3) and (4). Assumption (4) calculates α as an average between the prefamine and extrapolated 1851 values.

b - Measured as the proportion of fourth class (i.e., worst quality) houses.

c - Threshold size: 20 acres.

d - Coefficients multiplied by 100.

e - 31 observations only.

upon request. Secondly, due to the large number of possible independent variables, it proved impracticable to run equations with the entire set of independent variables. After all, with the possible exception of the variable measuring the proportional importance of the potato, all independent variables are in one way or another proxies for one true "unobserved" variable namely "ability to withstand the blight". Clearly, such a variable is purely an imaginary construct, but if we have many variables approximating it, the inclusion of an additional variable which is strongly correlated with a linear combination of the independent variables may raise the explanatory power of the equation a little, but increase the standard errors of the other coefficients considerably. Finally, the sources of the independent variables are summarized in the appendix to this paper.

The regression results presented in tables (6) and (7) are suggestive but not entirely unambiguous due to the inevitable limitations of the data base. As will be noted immediately, the regression equations are all highly significant, statistically speaking. The lowest F-statistics are still well beyond 6.00, while the highest are more than double that number. The critical value of $F_{5,26}$ at the 1% level is 3.82. The various versions of Ed_F correspond to different assumptions about prefamine death rates and the distribution of overseas migration over Ireland. Broadly speaking, the overall explanatory power of the independent variables is fairly robust to these assumptions. At the same time, however, some coefficients on individual variables change from significance to insignificance and back with changes in the assumptions behind Ed_F. Needless to say, this

weakens to some extent the results reported, and the coefficients should be interpreted with some caution. Finally, the equations in which Ed_F^U was the dependent variable performed consistently somewhat better than those in which Ed_F^L was the dependent variable. This result suggests that the decline in fertility during the famine years depended on different factors than the rise in death rates, and should be analyzed separately (see table (8), below).

To start with, a number of independent variables were clearly unimportant in determining the vulnerability of any given county. First and foremost, the prefamine acreage of potatoes fails to show any significance in any specification, whether the variable is defined as acreage per capita or acreage as a percentage of total land under cultivation. Surprising as this may seem, the inevitable conclusion is that the degree of dependency on potatoes mattered little in determining the excess death rates. How is that possible? One possibility is that the 1844-45 constable survey on which Bourke (15) based his data was deficient and cannot be trusted. Far more likely, however, is the possibility that the dependency on potatoes before the famine was so extensive and the destruction of the crops in 1846 so complete, that variations in the potato acreage per capita or per acre hardly mattered. The reduction in nutrition was so large that it made little difference whether a county cultivated .46 acres per capita (as was the case in the county most dependent on potatoes, Waterford), or .17 acres per capita (in county Leitrim, the lowest besides Dublin). Finally, the independent variable used is potato acreage, not potato crops. Little is known about prefamine productivity per acre, but if high yields per acre were associated with low

acreage and vice versa (as would be the case if the potato consumption per capita were relatively constant), the acreage data are simply poor proxies for the "degree of dependency on potatoes."

Among the other variables which appear totally unrelated to a county's vulnerability to the blight, rents per capita appear the most unexpected for the reasons stated above. In spite of the a priori plausibility of a negative relation between rents per capita and the weakness of the economic structure, this hypothesis cannot be accepted at any level of statistical confidence. The percentage of population living in cities, too, does not display a very consistent association with the excess death rates. While the coefficient of the proportion urban population is significant in some regressions, the significance is highly sensitive to the specification of prefamine death rates. It can be said safely, however, that no evidence whatsoever was found that the degree of urbanization was in any way a protection against the famine. If anything, the evidence points the other way. Apparently, the effect of cities' greater sensitivity to contagious disease and malnutrition was stronger than the effect of the greater economic resilience of towns. Finally, no significant relation between the relative importance of cottage industry and excess deaths was found.[32]

The coefficient of income per capita (labor income or total income) is in most cases between -.0015 and -.0030. Thus, for each additional pound sterling of income per capita, the annual average excess death rate for five years would have been lower by something between .15% and .3%. For the entire period this means that between 63,000 and 125,000 less peo-

ple would have died from famine-related causes (and who would not have died otherwise) for each pound increase in national income per capita.[33] If we assume - somewhat unreasonably, it appears - that the linearity assumption can be maintained even for non-marginal changes, we could speculate what the net cost of relative backwardness was for Ireland. Income in Great Britain in 1841 was about £9 higher than in Ireland. Taking the lower bound of our estimate, it can thus be seen that poverty (in the narrow sense of low income) accounted for <u>at least</u> 600,000 famine deaths.

A second variable which seems to do well in accounting for the impact of the disaster is literacy. The coefficient on this variable is between -.06 and -.10, indicating thus that a one percent increase in the literacy rates would cause excess death rates to fall by .1 percent. Again, the magnitudes involved can best be clarified by means of a simple example. The average literacy rate (defined as the proportion of those aged 5 and over who could both read and write) in Ireland was 28.3% according to the 1841 census. If this rate had been half as high again (which would probably have brought Ireland up to British levels, though such comparisons remain extremely hazardous), and we take the lower coefficient of -.06, the excess death rate would have fallen from .033 to about .024. This would have meant approximately 500,000 less famine deaths. It can thus be concluded that literacy and the unobserved variables correlated with it were major determinants of vulnerability.

The argument that farm size was a major determinant of excess mortality finds limited support in the data. Average farm size, as defined by

total land under cultivation divided by the number of farms, negatively related to excess death rates (as it should), but the relation is weak and highly sensitive to specifications and assumptions. More important is the result that excess death rates are positively correlated with the proportion farms under a given level. The results suggest that the critical level was about 20 acres: the proportion farms under that level is generally significantly and positively related to excess death rates. The livestock and housing quality variables which serve as proxies for the overall capital stock (with the reservations noted) perform, on the whole, well and have the expected signs. It seems injudicious to analyze the magnitude of the coefficients, since the two variables are not unambiguous indicators of the ability of a county to cushion a disaster like the Great Famine. The housing quality variable is the proportion of fourth class houses, and as such it is an inaccurate proxy for the overall quality of housing even if we believe that the classification schemes used in the 1841 Census were consistently adhered to. The difficulties with the livestock variables have been pointed out above. Still, the overall size of the coefficients, between .006 and .009 is consistent with our earlier findings. The value of livestock per capita in 1841 was about £2.5. Increasing this by £1 (or 40%) would have reduced the death toll by at least 250,000. Finally, the coefficient of the variable measuring the proportion of population engaged in non-agricultural activity has the expected sign, but its magnitude and level of significance are reduced if income variables are included. While the variable may have affected excess death rates in more than one way, it is at this stage not possible

to distinguish meaningfully between other (and unobserved) variables for which the % in nonagricultural occupations may be a proxy, and the straight effect of industrialization on income.[34]

We finally turn to an attempt to explain the decline in fertility during the famine. From the outset it has to be pointed out that the dependent variable used, U_{51}/U_{41}, is equal to the true ratio of fertility rates only under the assumption that the excess death rate relative to the normal death rate was the same for infants and toddlers as it was for their mothers. If it was higher, for instance, some excess mortality among children aged 0-5 would erroneously be attributed to a decline in fertility. In other words, if the famine affected children relatively more than adults, some children who were born after 1845 but died before 1851 would be counted as "not born". One the one hand, it seems reasonable that infants and toddlers would be more susceptible to starvation and disease than their mothers who were likely in extremis to sacrifice their children's needs for food in order to stay alive themselves. But it is important to remember that the prefamine death rates for children were already extremely high, while those for adults aged 17-45 were low by comparison. If, for instance, the probability of dying in any one year rose by 2%, this would have meant a tripling of the death rate for adults in the reproductive years, but for children aged less than five, this would have meant an increase of 37% only.[35]

The results indicate that the decline in fertility was largely determined by three factors: income per capita , housing quality, and potato acreage. It is surprising that no relation was found between potato acreage and excess mortality rates, but that there is a stronger relation between potato acreage and the decline in fertility. Note also that neither farm size nor literacy

Table 8: Regression Analysis of Fertility Rates in 1851 relative to 1841.

(t - values in parentheses)

Regression #	1	2	3	4
Dependent Variable	U_{51}/U_{41}	U_{51}/U_{41}	$M(U_{51}/U_{41})^a$	$M(U_{51}/U_{41})^a$
Form	linear	linear	linear	linear
Constant	.7741 (6.62)	.9795 (7.09)	2.5470 (.56)	1.9231 (.56)
Income p.c.	.0077 (1.21)		.4126 (2.67)	.3802 (2.02)
Labor Income p.c.		.0075 (1.36)		
Housing Quality Index		-.3615 (-3.17)	-6.29 (-1.61)	
Livestock p.c.	-.0078 (-.48)			-.5313 (-1.12)
Percentage Small Farms[b]		-.0106 (-.15)	1.58 (.58)	
Literacy Rate	-.1189 (-.55)	-.2298 (-1.27)		.1699 (.03)
Percentage Urban	.0491 (.42)	-.0469 (-.57)		9.1563 (2.69)
Percentage Non-agricultural	.248 (1.43)		5.77 (.85)	2.5731 (.50)
Rural Industry			-6.35 (-1.27)	
Potato Acreage p.c.		-.192 (-1.85)	-10.70 (-2.73)	-13.5480 (-2.39)
Percentage of acreage in potatoes	-.4142 (-2.15)			
Ed^F	-.9149 [c] (-1.05)	-.8763 [d] (-1.19)	15.99 [c] (.58)	.1426 [c] (.006)
R^2	.6395	.7376	.7722	.7980
F (d.f.)	6.08 (7,24)	9.64 (7,24)	11.62 (7,24)	13.54 (7,24)

Table 8
(continued)

Regression #	5	6
Dependent Variable	$M(U_{51}/U_{41})^a$	$M(U_{51}/U_{41})^a$
Form	linear	linear
Constant	4.6875 (1.09)	2.7285 (.67)
Income p.c.		.6299 (3.63)
Labor Income p.c.	.3562 (2.09)	
Housing Quality Index	-6.2488 (-1.82)	-.7672 (-.17)
Livestock p.c.		-1.3417 (-2.63)
Percentage Small Farms	-.2002 (-.09)	
Literacy Rate	-.2543 (-.04)	1.1482 (.17)
Percentage Urban	6.9668 (2.68)	
Percentage Non-agricultural		
Rural Industry		-5.3015 (-1.46)
Potato Acreage p.c.	-9.2115 (-2.89)	
Percentage of acreage in potatoes		-8.7514 (-1.51)
Ed_F	9.8625[c] (.4237)	-16.9538[d] (-.60)
R^2	.8376	.7540
F (d.f.)	17.69 (7,24)	10.51 (7,24)

Notes to table 8.

a - M(x) is defined as $\frac{1}{1-x}$

b - Threshold level = 20 acres

c - Version used corresponds to table 3 part II.

d - Version used corresponds to table 4 part II.

seem to have had a strong influence on the decline in fertility. It is thus quite clear that the decline in fertility and the excess mortality were determined by quite different factors. There is, however, no evidence that fertility decline itself depended on excess death rates.[36]

V - Conclusions

The Irish potato famine of 1846-51 was - at least so far - the last large-scale natural demographic disaster to strike Europe. As such, it provides an opportunity to study in some detail its impact and the factors determining the magnitude of the excess mortality it inflicted upon Ireland. While the information base for Ireland (both before and after the famine) is far better than for any comparable event in European history, the data should be interpreted with caution. The excess death figures estimated in this paper are calculated on the basis of certain assumptions which have been spelled out explicitly as far as possible. As always, these assumptions are simplifications. All the same, they are superior to previous attempts to estimate (or guess) the number of persons who perished due to famine-related causes.

The estimates leave no doubt that the actual number of famine casualties has been underestimated by historians. Even the lower bound of the present estimates exceeds the only other estimate which is based on research (rather than on "back of the envelope" calculations) by 300,000. The upper bound of the present estimates is almost twice as high. Rather than exaggerated - as some current views imply - the dimensions of the impact of the blight were actually larger than is usually believed.

The factors which made Ireland so vulnerable to the famine have been identified with some certainty. The actual acreage devoted to potatoes was in itself insignificant. Far more important were general economic variables such as income, literacy, and capital/labor ratios. While farm size seems to have played a role too, it is clear that the famine struck down not only the smallest farmers (cottagers and landless laborers) but also those whose

farms were somewhat larger, up to 20 acres. Rents per capita, whether they reflected generally the pressure of labor on the land or more specifically the ability of landowners to pay poor rates, were unimportant.

Furthermore, fertility rates declined as well during the famine. While it is debatable whether "averted deaths" should be counted as famine casualties, it is interesting to note that the factors determining fertility decline differed to some extent from those determining excess mortality. This suggests that the data and methods developed in this paper can be extended to attack the impact of the famine further. One could envisage the demographic impact of the famine as an approach in two stages. First, measure the blight's effect on gross population decline (relative to a level it would have reached in 1851 in the absence of the famine). Secondly, examine the relative importance of the three components of population decline: excess mortality, reduced fertility, and net outward migration. This approach, which is somewhat more general than the one taken here, will be the subject of a forthcoming paper. A further hypothesis which needs to be tested is Cousens's (1) speculation that two institutional factors, namely tenant eviction and Poor Law administration were important factors in the determination of mortality rates, especially in the later years of the famine.

What can be learned from the Irish experience in the famine years that would be of use to economic historians concerned with other countries? The Irish experience in the 1840s, as in so many other instances of Irish history, was a sui generis, unlike anything experienced by any other country in Europe. Since the basis of the conclusions drawn in this paper is an analysis of the cross-sectional variance within Ireland, one is naturally hesitant to extrapolate the relations estimated far outside the sample

space. Nonetheless, it is hopefully not presumptuous to conjecture at this stage that while the statement "Ireland starved because Ireland was poor" is not a tautology, it may all the same be true. The prefamine Irish economy was far less equipped to deal with anything on the order of magnitude of the 1846-51 cataclysm than other Western European economies, whose higher degree of development saved them from a similar fate. Certainly, within Ireland the counties which were relatively wealthy, educated, and industrialized, had a better chance to cope with the disaster and to cut their losses. Sadly enough, there were very few of them.

1. The case lies different as far as Asia is concerned. See for example (1) for some fascinating details on famines in India.

2. A somewhat dated but still generally very valuable collection is (2). Salaman's classic history of the potato [(3), ch.XVI] is also useful. Somewhat uneven but yet far above the average scholarly level of the "popular" genre is (4).

3. For a similar view, see [(6), p.46].

4. It seems rather contrived to argue [(5), p.132] that "the famine and famine fever should not be blamed exclusively for the abnormal mortality of the period. The cholera epidemic in 1849...accounted for many deaths..." Such an artificial dichotimization of death-causes ignores the indirect effect of malnutrition and deterioration in hygienic standards due to the blight, leading to reduced resistance to disease. In fact, it seems that relatively few people died of "starvation" proper compared to "famine fever," typhus, dysentery, and scurvy. Cholera deaths appear comparatively unimportant [(7),p.307], and "proved most fatal in those counties in which the peasantry was already weakened by the deprivations of the preceding two years" [(7a), p.143].

5. For details on the debate see for instance (8), (9), and (10).

6. According to Green, population declined by about a quarter, three quarters of which was accounted for by emigration to North America. As population on the eve of the famine was about 8.3 million, this im-

plies an excess death figure of 519,000.

7. A recent study, however, conjectures that "possibly as many as 1.5 million died directly or indirectly as a result of starvation." [(8),p.421].

8. It has been maintained, e.g. (10),p.31 that the 1841 Census was highly defective and severely understated the population size. That some errors and underreporting may have been the case is undeniably true; yet the evidence that this attained - like the 1831 Census - proportions that would invalidate the population figures is lacking.

9. The birth rate thus computed is almost certainly a slight underestimate. The biases due to seasonality of conception, heaping of reported ages at the various age brackets, and underestimating infant mortality are not very important, however. For some more details see (12).

10. Tucker (13) has argued that the children aged zero to one month were omitted from the 1841 Census. This is a misinterpretation of the data. See (12).

11. Data for emigration to North America are provided in (14). In addition, a somewhat rough estimate of Irish migration to Great Britain was obtained in the following manner. In 1841, the British

Census reported that 419,256 persons born in Ireland lived in Great Britain. It was assumed that all of these people migrated in the years 1821-41 in equal portions. This is an oversimplification, since Irish migration quite obviously started before 1821 (15). On the other hand, death rates for the Irish in Britain must have been considerably higher than for those remaining home since a large proportion of them lived in British towns. Liverpool, Manchester, London and Glasgow accounted for over 43% of all Irish in Britain [(11), p. lxxxix].

12. Cousens ignored internal migration and assumed uniform death rates for Ireland as a whole.

13. This is the only way the Census's reported death rate enters the calculation. Since the death rates were low for the cohort aged 10-21, the figures are little sensitive to this coefficient.

14. The weights used are the probabilities of a random member of the cohort to be in a given age group in a random year between 1821-41. Thus the weights are: 11-15: .075; 16-20: .200; 21-25: .250; 26-30: .250; 31-35: .175; 36-40: .050.

15. The number of immigrants to Ireland was negligible, so net and gross overseas migration coincide.

16. The 1851 census has a similar internal migration table as the one mentioned on p.(10). See (4).

17. A minor problem is that the death rates are not the same for each county. For that reason ΣI_i is not strictly zero (as it ought to be theoretically) but positive (though small) since the receiving counties (for whom I_i is negative) had higher values of d_N than the sending counties. The order of magnitude of the error is small, however.

18. The neglect of prefamine internal emigration is a slight simplification which facilitates the computation and does not affect the results significantly. There is no way to calculate how many of the people who migrated to another county between 1841 and 1851, did so before the onset of the famine.

19. The only writer who places adequate emphasis on emigration to Great Britain seems to be O'Brien [(5),pp. 253-54]. Unfortunately, O'Brien's estimates are confused and unreliable.

20. It might be thought that it is not proper to use the population of 1846 as the basis for computing total loss figures, since the base is rapidly shrinking. This would be incorrect, since eq. (10) is set up to compute d_F such as to make actual population plus excess deaths equal to a hypothetical population which is the same except for the abnormal death rates.

21. Intuitively this can be seen as follows. Let P_1 be population at the beginning of the famine, P_2 population at the end of the famine and E emigration in the famine years. The rate of population decline can be estimated by assuming that all emigration occurred at the end of the period, as has been done in eq. (10). Then the rate of population decline x is computed from $\log \left(\frac{P_2 + E}{P_1}\right)$. An alternative is to assume that all emigration occurred on the first day of the famine. In that case the rate of population decline is $x' = \log \left(\frac{P_2}{P_1 - E} \right)$. The "correct" rate of decline is of course somewhere in between. Since $(P_2 + E)/P_1 > P_2/(P_1 - E)$, the absolute value of the rate of population decline $|x|$ is smaller than $|x'|$ and smaller than any value between x and x' including the "true" rate of population decline.

22. For some details see (8), p.467; (9),p.4; (10),p.100. A similar view is expressed by Taylor (11) who warns, quite reasonably, that the reported death figures may be deliberate understatements by shippers and captains of ships.

23. McDonagh [(13),n. 52] cites a figure of 17% for the U. S. as well, which he interprets to pertain to mean both on board and after arrival. The same witness cited states that the following year the death rates of emigrants fell from 17% to 1% and remained low.

24. In 1846 the abnormally small crops of cereals contributed to the distress. Oats, the main alternative to potatoes, were considerably below average. In counties Antrim, Armagh, Cavan, Londonderry, Down, and Meath, in which oats production was particularly important, the harvests were 10%-15% below average, while in Wexford more than half the oats harvest was lost. The wheat harvest was only marginally below its normal level, but wheat was not nearly as important a crop as oats. [(1),p.57]. On the other hand, the cereal crops of 1847 were abnormally good, and those of 1848 were about average. [(2),p.99].

25. Since all tests employ multivariate regression analysis, the effect of income (and all other independent variables) is the net effect, holding everything else constant. Needless to say, income and potato acreage per capita are likely to be correlated, but not to the extent as to endanger the accuracy of the estimates.

26. All values are computed using a fixed set of prices.

27. The 1841 Census data on farm size are, unfortunately, highly suspect, though it is unclear how that affects the present calculations. Cf. (7).

28. Crotty (8) has argued that livestock was growing rapidly already before the famine. This view has been criticized by Lee (9) and Solow (10). The available evidence does not appear at this stage of research

to be sufficient to resolve this controversy.

29. Almquist [(12),pp.161,210] maintains that as the ratio population to effective land rises, total rental payments per capita will decline. This can be shown to hold under certain conditions in the following manner: let $Q = f(N,L)$ denote the aggregate production function, where Q is output, N is land in efficiency units, and L is labor. If the rental rate $r = \frac{dQ}{dN}$, rental payments per capita are given by rN/L, which is equal to $\frac{rN}{Q} \cdot \frac{Q}{L}$, or the share of land times the average product of labor. As population pressure on the land rises, the average product of labor falls. The share of land in total output could be constant (if the production function is Cobb-Douglass for example), but if the elasticity of substitution is less than one, the share of land will rise with L/N and if it is very low, the relation could be reversed.

30. On all this see (14).

31. These conclusions are of course only true holding other things constant. The "raw" correlations between potato acreage and the Ed_F values is, however, equally weak.

32. In contrast with this finding, experimental regressions in which S. H. Cousens's excess death figures were used as the dependent variable show a strong and negative relation between rural industry and excess death rates. This is hardly surprising if we recall that Cousens's excess death rates are particularly low for Ulster and Connaught

in which rural industry was more developed.

33. Assuming that the distribution of income would not change dramatically.

34. For evidence about the strong correlation between income per capita and occupational variables, see (16).

35. The number of children aged less than 5 who were reported to have died in one prefamine year (1840) was 50,517. Applying the same correction factor for underreporting as used for the rest of the population leads to a figure of about 68,000 deaths. Out of a population of about 1.25 million persons aged less than 5, the death rate is about 5.44% for this age group.

36. This can be interpreted as circumstantial evidence that the assumption made in calculating the fertility ratio is not unrealistic. If excess mortality relative to normal mortality had been far higher among children than among women in the reproductive ages, the coefficients on the Ed_F variables in table (8) should have been positive, reflecting an attempt of families to "catch up". If the reverse had been the case, the coefficients would have been excepted to be negative.

Chapter I

1. McAlpin, Michelle B. "Dearth, Famine, and Changes in Risk: A preliminary Exploration of the Changing Impact of Crop Failures in Bombay Residency." MS prepared for a workshop on the Effects of Risk and Uncertainty on Economic and Social Processes in South Asia, University of Pennsylvania, Sept. 1977, unpublished.

2. Edwards, R. Dudley and Williams, T. Desmond, eds., The Great Famine, Studies in Irish History 1845-52. New York: New York University Press, 1957.

3. Salaman, Redcliffe, N., The History and Social Influence of the Potato. Cambridge: At the University Press, 1949.

4. Woodham-Smith, Cecil, The Great Hunger, 1845-49 London: Hamish Hamilton 1962.

5. Cullen, L M., An Economic History of Ireland from 1660. London: B. T. Batsford, Ltd. 1972.

6. Crotty, Raymond D., Irish Agricultural Production: Its Volume and Structure. Cork: Cork University Press, 1966.

7. MacArthur, William P., "Medical History of the Famine," in Edwards and Williams, eds., The Great Famine, pp. 263-315

7a. Cousens, S.H., "The Regional Variation in Mortality During the Great Irish Famine," Proceedings of the Royal Irish Academy, Vol. 63, Section C, No. 3 (Feb. 1963), pp. 127-149.

8. Drake, Michael, "Marriage and Population Growth in Ireland, 1750-1845," E.H.R. 2nd series, vol. XVI, no. 2 Dec. 1963, 301-312.

9. Drake, Michael, "Population Growth and the Irish Economy," in L. M. Cullen, The Formation of the Irish Economy, 65-76.

10. Lee, Joseph, "Marriage and Population in Pre-Famine Ireland," E.H.R., 2nd series, vol.XXI (1968) 283-295.

Chapter II

1. Great Britain, Parliamentary Papers, Vol. XXIX, (The Census of Ireland for the year 1851, pt. V: Tables of Death Vol. 1), 1856.

2. Green, E.R.R., "Agriculture," in R. Dudley Edwards and T. Desmond Williams (eds.), The Great Famine, pp. 89-128. New York: New York University Press, 1957.

3. O'Neill, T.P., "The Organization and Administration of Relief, 1845-1852," in Edwards and Williams, eds., The Great Famine, pp. 209-258.

4. MacArthur, William P., "Medical History of the Famine," in Edwards and Williams, eds., The Great Famine, pp. 263-315.

5. Cousens, S. H., "Regional Death Rates in Ireland during the Great Famine from 1846 to 1851," Population Studies vol. 14, No. 1 (July 1960), 55-74.

6. Donnelly, James S., Landlord and Tenant in Nineteenth Century Ireland. Dublin: Gill and Macmillan, 1973.

7. Lee, Joseph, The Modernization of Irish Society. Dublin: Gill and MacMillan, 1973.

7a. Cullen, L. M., An Economic History of Ireland from 1660. London: B. T. Batsford, Ltd. 1972.

8. Flinn, Michael, Scottish Population History. Cambridge: at the University Press, 1977.

9. Edwards, R. Dudley and Williams, T. Desmond, "Foreword," in R. D. Edwards and T. D. Williams, eds., The Great Famine, pp. vii-xvi.

10. Woodham-Smith, Cecil, The Great Hunger, 1845-49. London: Hamish Hamilton, 1962.

11. Great Britain, Parliamentary Papers, Vol. XXIV. (Report of the Commissioners Appointed to take the Census of Ireland for the year 1841), 1843.

12. Mokyr, Joel, "Poverty and Population in Prefamine Ireland: Old Issues and New Data," unpublished MS, Northwestern University, March 1978.

13. Tucker, G.S.L., "Irish Fertility Ratios before the Famine," E.H.R., 2nd series, Vol. XXIII, No. 2 (May 1970), 267-84.

14. Adams, W.F., Ireland and Irish Emigration to the New World from 1815 to the Famine. New York: Russell and Russell, 1967. (originally published in 1932).

15. Handley, James Edmund, The Irish in Scotland, 1798-1845. Cork: Cork University Press, 1945.

16. Cousens, S.H., "The Regional Variation in Emigration from Ireland Between 1821 and 1841," Institute of British Geographers, Transactions and Papers, No. 37, Dec. 1965, 15-30.

Chapter III

1. Cousens, S.H., "Regional Death Rates in Ireland during the Great Famine from 1846 to 1851," Population Studies vol. 14, No. 1 (July 1960), 55-74.

2. Cousens, S.H., "Regional Pattern of Emigration During the Great Irish Famine, 1846-51," Institute of British Geographers, Transactions and Papers No. 28, 1960, pp. 119-134.

3. Great Britain, Parliamentary Papers, Vol. XXX (The Census of Ireland for the Year 1851, pt. V: Tables of Death vol. 2), 1856.

4. Great Britain, Parliamentary Papers Vol. XXXI (The Census of Ireland for the Year 1851, pt. VI: General Report), 1856.

5. O'Brien, W. P., The Great Famine in Ireland. London: Downey and Co., 1896.

5a. Great Britain, Parliamentary Papers Vol. XXIX, (The Census of Ireland for the Year 1851, pt. V: Tables of Death Vol. 1), 1856.

6. MacArthur, William P., "Medical History of the Famine," in Edwards and Williams, eds., The Great Famine, pp. 263-315.

7. Woodham-Smith, Cecil, The Great Hunger, 1845-49. London: Hamish Hamilton, 1962.

8. Great Britain, Parliamentary Papers, Vol. XIX (Report from the Select Committee of the House of Lords on Colonization from Ireland), 1847.

9. Great Britain, Parliamentary Papers, Vol. XIX (Report from the Select Committee on Passengers' Acts), 1851.

10. Great Britain, Parliamentary Papers Vol. XIII (First Report from the Select Committee on Emigrant Ships), 1854.

11. Taylor, Philip, The Distant Magnet, European Emigration to the U. S. A; New York: Harper and Row, 1971.

12. Great Britain, Parliamentary Papers Vol. XLVII (Papers Relative to Emigration to the British Provinces in North America), 1847-48.

13. McDonagh, Oliver, "Irish Emigration to the United States of American and the British Colonies During the Famine," in Edwards and Williams, eds., The Great Famine, pp. 319-388.

Chapter IV

1. Great Britain, Parliamentary Papers, Vol. LI (Accounts and Papers Pertaining to the Relief of the Distress in Ireland), 1847.

2. O'Neill, T. P., "Food Problems During the Great Irish Famine." Journal of the Royal Society of Antiquaries of Ireland, LXXXII (1952), pp. 99-108.

3. Mokyr, Joel, Industrialization in the Low Countries, 1795-1850, New Haven and London: Yale University Press, 1976.

4. Green, E.R.R., "Agriculture " in R. Dudley Edwards and T. Desmond Williams (eds.), The Great Famine, pp. 89-128. New York: New York University Press, 1957.

5. Great Britain, Parliamentary Papers, Vol. XXIV. (Report of the Commissioners Appointed to take the Census of Ireland for the year 1841),1843.

6. Great Britain, Parliamentary Papers, Vol. XLIX (Returns of Agricultural Produce in Ireland in the year 1848), 1849.

7. Bourke, P.M. Austin, "The Agricultural Statistics of the 1841 Census of Ireland, A Critical Review," E.H.R., 2nd series. vol. XVIII no. 2 (Aug. 1965), 376-91.

8. Crotty, Raymond D., Irish Agricultural Production: Its Volume and Structure. Cork: Cork University Press, 1966.

9. Lee, Joseph, "Irish Agriculture." Agricultural History Review, vol. 17 (1969), 64-76.

10. Solow, Barbara L., The Land Question and the Irish Economy, 1870-1903. Cambridge, Mass.: Harvard University Press, 1971.

11. Cousens, S.H., "The Regional Variation in Mortality During the Great Irish Famine," Proceedings of the Royal Irish Academy, Vol. 63, Section C, No. 3 (Feb. 1963), pp. 127-149.

12. Almquist, Eric, Mayo and Beyond: Land, Domestic Industry, and Rural Transformation in the Irish West. Unpublished Ph.D. Dissertation, Boston University, 1977.

13. Woodham-Smith, Cecil, The Great Hunger, 1845-49. London: Hamish Hamilton, 1962.

14. O'Neill, Thomas P., "The Organization and Administration of Relief, 1845-1852," in Edwards and Williams, eds., The Great Famine, pp. 209-258.

15. Bourke, P.M. Austin, "The Extent of the Potato Crop in Ireland at the Time of the Famine," Journal of Stat. and Soc. Inq. Society of Ireland, vol.XX, part III (1959/60), 1-35.

16. Mokyr, Joel, "Poverty and Population in Prefamine Ireland: Old Issues and New Data," unpublished MS, Northwestern University, March 1978.

Chapter V

1. Cousens, S.H., "The Regional Variation in Mortality During the Great Irish Famine," Proceedings of the Royal Irish Academy, Vol. 63, Section C, No. 3 (Feb. 1963), pp. 127-149.

Appendix

1. Great Britain, Parliamentary Papers, vol. XXX-XXXIV (Reports of the Commissioners for inquiring into the Condition of the Poorer Classes in Ireland), 1835-36.

2. Mokyr, Joel, "Poverty and Population in Prefamine Ireland: Old Issues and New Data," unpublished MS, Northwestern University, March 1978.

3. Great Britain, Parliamentary Papers, Vol. XXIV. (Report of the Commissioners Appointed to take the Census of Ireland for the year 1841), 1843.

4. Bourke, P.M. Austin, "The Agricultural Statistics of the 1841

Census of Ireland, A Critical Review," E.H.R., 2nd series. vol. XVIII no. 2 (Aug. 1965), 376-91.

5. Great Britain, Parliamentary Papers, vols. XIX-XXIII (Report from Her Majesty's Commissioners of Inquiry into the State of the Law and Practice in Relation to the Occupation of Land in Ireland), 1845.

6. Bourke, P.M. Austin, "The Extent of the Potato Crop in Ireland at the Time of the Famine," Journal of Stat. and Soc. Inq. Society of Ireland, vol.XX, part III (1959/60), 1-35.

APPENDIX

Income: Estimates based on three components. Labor income estimated from evidence presented in (1). Rent income based largely on Poor Law Valuation and Government Valuation data. Capital income computed by applying a uniform net rate of return to aggregate capital stock approximated by value of livestock in 1841. For details see (2).

Housing Quality: Equals the ratio of houses of the fourth class to total houses, as provided in (3).

Livestock p.c.: Taken from (3).

Percentage Small Farms: As argued by (4), the 1841 Census data cannot be used here. Instead, data from (5) were used, converted from Poor Law Unions to counties.

Average Farm Size: Equals land under cultivation from (3), divided by number of farms from (5).

Literacy Rate: Equals number of persons who could both read and write divided by population aged over 5.

Percentage Urban: Follows 1841 Census classification of "civic" and "rural" districts.

Percentage Nonagricultural: Based on the division of families "according to pursuits" as given in (3), p. xvii.

Rural Industry: Based on the division of persons according to the "wants" they are ministering to. The index is computed as the ratio persons in rural districts ministering to clothing as a proportion of all persons aged fifteen and over having a specified occupation. From (3). The appropriate tables are the provincial summaries of the general tables.

Potato acreage: Average of 1844 and 1845 acreages planted with potatoes (statute acres), as given in (6).