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THE IMPACT OF EMIGRATION ON REAL WAGES IN IRELAND 1850–1914

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ABSTRACT

The Impact of Emigration on Real Wages in Ireland 1850–1914*

In this paper we evaluate quantitatively the impact of mass emigration from Ireland between the 1850s and the first World War on Irish real wages. We produce new estimates for several occupations which show that, contrary to some accounts, real wage growth in Ireland was respectable by international standards. We find econometric evidence of an inverse relationship between real wage growth and labour force growth. Using a computable general equilibrium model of the Irish economy we find that, in the absence of emigration, faster labour force growth would have resulted in lower real wage growth, reducing real wage convergence on United Kingdom and the United States.

JEL classification: D58, J31, J61, N33
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NON-TECHNICAL SUMMARY

Between the Famine and the First World War, emigration from Ireland reached unparalleled heights and by 1911 the Irish population had fallen to three quarters of its 1851 level. Despite its large scale impact on the population and labour force, there has been little attempt to quantify the economic impact of emigration. In this paper we argue that the reduction in the labour force raised the real wage and per capita income above the level that would have existed in the absence of emigration.

In order to assess real wage growth, we have constructed real wage series for four occupations: agricultural labourers, building labourers, carpenters and fitters. The two unskilled wage rates grew at a healthy 1.5% per annum, while skilled wage rates grew a little more slowly. Compared with the United Kingdom, Irish unskilled wage rates grew more rapidly over the whole period; they also converged with wages in the United States in the period up to the 1890s, before falling back somewhat in the last two decades. Thus, despite very slow industrialization, the growth of Irish living standards looks respectable by international comparisons, a finding which is confirmed by other evidence.

How much did emigration contribute to this? Time-series evidence indicates a negative relationship between the agricultural product wage and the male population. This suggests that emigration contributed to real wage growth. Using a panel of county-level data we were unable to find an inverse relation between wage growth and labour force growth. We suggest that this is due to our inability to identify the labour demand curve at the county level. We argue that in any case, the best way to evaluate the effects of emigration is to assess its general equilibrium effects at the aggregate level.

In order to do this we first estimate what population growth would have been without emigration. Depending on the demographic assumptions made, we suggest that in 1911 the Irish population would have been either equal to its 1851 level or half as large again as in 1851. We then construct a computable general equilibrium model of the Irish economy in 1908. The model has three factor inputs and three classes of output, and treats Ireland as a price taker in international markets except for manufactured goods.

Armed with this model we then examine the effects of having a larger population and labour force in 1908. Critical to this assessment is whether we assume there was perfect international capital mobility or complete immobility of capital. Under the first assumption we estimate that the real unskilled urban wage would have been between 66% and 81% of its actual 1908 level, depending on the scale of the labour force increase. Under the second assumption the unskilled wage would have been between 89% and 94% of the actual. These estimates imply

that emigration could have accounted for a significant amount of the real wage gain relative to the United Kingdom and for all of the gain relative to the United States.

Introduction

Ireland's post-famine economic history presents an unusual picture. Largely as a result of mass emigration the Irish population fell to little over half its prefamine level by 1914. Though the proportion of the labour force in agriculture fell, Ireland failed to industrialise as rapidly as other western European countries. Total national income grew slowly although there was a substantial rise in national income per capita.

The effects of mass emigration and falling population on the Irish economy have been debated. Some have seen the mass emigration as depriving Ireland of its brightest and best citizens, reducing Ireland's economic vitality and condemning it to retarded economic development. Others have argued that the emigration acted as a vent for surplus population and permitted a growth in per capita incomes and wages which otherwise would not have been possible. In this paper we argue for the latter view. In terms of the growth rates of real wages, Ireland's performance in the late nineteenth century looks reasonably good by international standards. We maintain that this impressive performance in the absence of rapid industrialisation owes much to the decline in the labour force caused by emigration. The key link was the mobility of the Irish population. Integration into the Atlantic labour market meant that the Irish were responsive to relative wage signals. Consequently the large relative wage gap between Ireland and the countries which received Irish immigrants led to mass emigration. The emigration itself tended to relieve pressure on the land and raise Irish wages relative to the receiving countries.

The paper is organised as follows. In Section I we examine the growth of Irish wages and living standards in comparison with other

countries. Section II examines the hypothesis that the Irish agricultural wage was responsive to movements in the male population. Section III investigates the impact of emigration on the Irish labour force and Irish rural wages at the county level. In Section IV we attempt to estimate the effect of emigration on the population and labour force of Ireland from 1851 to 1911. In order to estimate the impact of faster labour force growth we specify a computable general equilibrium model of the Irish economy in Section V. The effects of emigration are evaluated in a general equilibrium framework in Section VI. Finally we summarise the main findings of the paper in a short conclusion.

I Irish Wages and Living Standards, 1850-1914

There have been both optimistic and pessimistic views of Ireland's economic progress after the famine. In both cases Ireland's performance is seen as having been closely linked with mass emigration and the fall in population. On the pessimistic side, Joseph Lee (1973, p.35) has pointed to the slow growth of Irish national income, which at about 0.5 percent per annum was the slowest in Europe. He associates this with the failure of industrial development to spread as widely as in other countries. He concludes that:

> "Although the average standard of living increased sharply between 1848 and 1877, the actual standard of living rose only slowly. The increase in per capita incomes reflects the artificial impact of the disappearance of the poorest quarter of the population, whose presence had depressed the pre-famine averages, without resulting in a remotely comparable increase in the income of the survivors" (1973, p.12).

Similarly, Fitzpatrick (1984, p.37) has argued that:

> "emigration from the poorest districts was seldom sufficient to eliminate underemployment; and wage levels

for those actually employed rose only slowly and unevenly during the second half of the century."

On the optimistic side Arnold Schrier (1958, p. 82) concluded that:

> "there can be little doubt that the over-all impact ofemigration on the Irish economy was generally favourable. To some extent it relieved the pressure of unemployment and improved the condition of the labourers and tenantry by raising wages and leading to better living accommodations for a larger proportion of the population. It also facilitated the consolidation of small holdings and helped place agriculture on a more economic basis. In addition it made possible a transition in Irish agriculture which can justly be described as revolutionary. Whether in itself it appreciably retarded the development of Irish industry is doubtful since the fiscal and commercial policy of Great Britain operated as a far greater deterrent."

To some extent differing views of Irish economic performance and the link with emigration can be reconciled. The pessimists would argue that backward agriculture and stunted industrial development drove many Irish men and women abroad and the effects of their emigration was simply to mitigate conditions in Ireland. The optimists would no doubt stress that in the absence of emigration things would have been very much worse. In both cases two key issues are raised. First, how good or bad was the growth in Irish real wages and living standards? Here we suggest that international comparisons can shed additional light on the issue. Second, what would wages and living standards have looked like in the absence of mass emigration? We investigate this issue in later sections of the paper.

Let us turn to the growth of Irish living standards. Though estimates of Irish national income for the late nineteenth century are somewhat sketchy Cormac O'Grada (1993, Ch. 8) has recently suggested that Irish national income per capita rose threefold between 1845 and 1913. While total national income grew at about 0.7

percent per annum, per capita income grew by 1.6 percent. Thus Irish income per capita rose over the period from about two fifths that of Britain to about three fifths. He also notes substantial improvements in a number of other measures of well being. The proportion of the population in poverty declined and the proportion of families living in lower quality housing (third and fourth class) fell from 63 percent in 1861 to 29 percent 50 years later. Furthermore, increasing prosperity is reflected in the growing commercialisation and the increasing variety of consumer goods sold in the shops. The volume of bank deposits increased sharply and small savings, as reflected in post office and trustee savings accounts, grew by a factor of four between 1881 and 1912.

Though the indicators of GNP per capita and other measures of well being suggest significant improvement over the period, we can examine labour market conditions more closely through real wage indices, which are more relevant to the labour market situation. Furthermore they afford direct comparison with other countries, specifically, the countries to which most Irish emigrants went, the United States and Britain[1] We have constructed wage indices for four occupations, two skilled and two unskilled. The skilled occupations are fitters and carpenters and the unskilled are bricklayers labourers and agricultural labourers. The construction of these series is discussed in detail in Appendix 1.

Using an index for the cost of living we can measure the growth of real wage rates from 1860 on. The striking result is that real agricultural wage rates doubled between 1860 and 1913, with most of the increase occurring before 1895. From 1860 to 1895

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[1] For comparison with a larger set of countries and over a longer period of time see Williamson (1993).

the average annual growth rate was 1.9 percent and for the whole period to 1913 it was 1.6 percent. But it was not only agricultural wages which grew rapidly. Unskilled building wages doubled between 1860 and the early 1890s, exhibiting an annual growth rate of 2.2 percent. Again, wage growth was slower after 1895 and the average growth rate up to 1913 was 1.5 percent. Taking the comparison back to 1850, the data for unskilled building workers reported by Williamson (1993, Appendix 1.11) indicate that between 1850 and 1913 real wage rates increased by a factor of 2.4, an average growth rate of 1.4 percent per annum.

Our wage series for the skilled trades, carpenters and fitters, begin only in 1866 and exhibit somewhat slower growth than the unskilled wage rates. For carpenters the real wage increased by 56 percent between 1866 and 1895 and, for fitters, 58 percent. The real wage for both groups declined slightly from the mid 1890s to 1913 so that, although both real wages grew by a healthy 1.5 percent annually up to 1895, they grew by only 0.9 percent over the whole period from 1866 to 1913. Despite the slow growth of all real wages after 1895 and somewhat slower growth of skilled wages, the wage growth for the bulk of workers, the unskilled, was dramatic over the whole period and especially up to the turn of the century. This contrasts sharply with some of the more pessimistic statements about Irish living standards.

In order to compare Irish real wages with those for Britain and the United States, weekly wage rates for each country were adjusted for the absolute difference in price levels between them. The real wage ratios were constructed using methods similar to those used by Williamson (1993), although the individual series used here are different.

Figure 1 plots Irish real wages relative to British for the four occupations. For both carpenters and fitters the Irish real wage hovered around 90 percent of the British between 1870 and 1913. The fact that the ratio was so high and the fact that there was so little trend in it suggests that the Irish skilled labour market was closely integrated with the British. What difference remained in real wages might be explained as a compensating differential for the greater attraction to Irish skilled workers of remaining in Ireland rather than moving to Britain. As has often been noted skilled workers in Ireland can be viewed as circulating in the wider labour market for skilled labour in the United Kingdom as a whole. By contrast, both unskilled building and agricultural real wages were much lower in Ireland than in Britain, although they showed a steady advance over time on the British wage. Between 1860 and 1913 the unskilled building wage rose from 58 to 72 percent of the British and the agricultural wage rose from 61 to 75 percent of the British.

Because it has not been viewed in international perspective this dramatic growth in unskilled wages has often been neglected in discussions of progress in living standards. The gradual convergence of unskilled wage rates on the British suggests that unskilled labour markets were not as well integrated within the United Kingdom as skilled. However, the fact that the wage ratios for unskilled workers in building and agriculture were at similar levels during most of the period, and advanced at a similar rate in the long run, is suggestive of a closer degree of integration within the unskilled labour market in Ireland. Relative to Britain at least, these data are consistent with the idea of a gradually declining unskilled labour 'surplus' both in rural and urban areas.

Figure 2 shows real wage ratios for the four occupations between Ireland and the United States. These present a somewhat mixed picture. In the 1860s they are dominated by the sharp rise in American real wages after the Civil War. Between the early 1870s and the late 1890s, Irish real wages rose relative to American wages for each of the four occupations, although the extent of this increase varied across occupations. It was largest for urban unskilled labour, where the Irish/American real wage ratio increased from 0.39 in 1870-3 to 0.54 in 1896-9, and lowest for carpenters, where the ratio increased from 0.59 in 1870-3 to 0.64 in 1893-7. However, from the late 1890s until the outbreak of World War I the Irish/American wage ratio declined for each occupation. Again, the extent of the decline varied across occupations, being largest for agricultural labourers, where the ratio declined from 0.70 in 1894-6 to 0.50 in 1910-13, and smallest for urban unskilled labourers. Thus it was not until a significant gap in productivity trends opened up between the United States and the United Kingdom in the 1890s that Irish real wages began to grow more slowly than American wages.

In sum, Irish real wages grew faster than British wages between the 1860s and 1913, and faster than American wages between the early 1870s and the late 1890s. This convergence was part of the general trend identified by Williamson (1993), though it was attenuated towards the end of the period. Over the whole period from 1850 to 1915 he finds that Irish unskilled urban real wages rose from 61 to 83 percent of British and from 44 to 54 percent of American (1993, Table A2.1). Given that Ireland did not industrialise rapidly during this period and that its population declined, it is tempting to conclude that the fall in the labour

force, by raising the marginal product of labour, particularly in agriculture, underpinned much of the observed real wage growth. This would also be consistent with the rapid growth of unskilled wage rates and a declining rural labour surplus. However, further evidence is needed to support such a conclusion.

II Growth in the Agricultural Real Wage over Time

Most of the decline in the population and labour force from the famine up to 1913 came in rural areas and in the agricultural sector of the economy. Between 1851 and 1913 the population living in towns of five thousand or more rose by about half a million; as a proportion of total population it grew from 12 percent in 1851 to 29 percent in 1911. Even more striking is the fact that only two of the 32 Irish counties experienced an increase in population over the period. These were Co. Dublin and Co. Antrim which included the two major Irish cities of Dublin and Belfast; indeed about half of the growth in urban population can be accounted for by Belfast alone.

The consequence of these trends was that the rural population fell by over 2.6 million, almost halving its 1851 level by 1911. However, due to the decline in population and labour force as a whole, the proportion of occupied males engaged in farming fell only gradually, from 66.3 percent to 54.7 percent between 1851 and 1911 (Fitzpatrick, 1980, p. 87). The most severe decline occurred among agricultural labourers. The ratio of farm labourers to farmers declined over the period from 2.3 to 1.3. Hence farm labourers were becoming an increasingly small minority of the workforce. However, as Fitzpatrick emphasises the line between farm labourer and farmer was extremely blurred. Many farm families

particularly on small holdings combined work on their own farm with some wage labour. The agricultural wage should therefore accurately reflect the opportunity cost of labour, even where little wage labour was employed directly.

Figure 3 plots the weekly agricultural wage divided by an index of the price of farm output[2] In relation to the output price, farm wages rose considerably over the period. The rise in the agricultural product wage could be due either to a sustained upward shift in the marginal product of labour due to improved techniques or more capital or because of a movement along the marginal productivity schedule due to the declining labour force. We cannot compare this with the trend in the agricultural labour force or with the labour force as a whole because we lack annual data for these. Instead the graph shows an index of the total male population, which declined gradually from 2.9 million to 2.2 million over the period.

One might conclude from the opposite trends in the real wage and male population that this inverse relation reflects a movement along the marginal productivity schedule. However, Irish agriculture underwent substantial change over this period. Most impressive was the shift in the composition of output away from relatively labour intensive arable production towards relatively land intensive livestock[3]. Using a multi-sector computable general equilibrium model of Irish agriculture O'Rourke (1991) has shown that almost all of this shift in the composition of output between

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2 The agricultural price index is taken from Turner, 1987, p. 135-6.

3 For discussions of agricultural output and its composition, see Staehle (1950-1), Crotty (1966), and O'Grada (1988).

1856 and 1876 was due to the increasing scarcity of labour. These trends continued later in the century but this was not the only source of rising agricultural productivity. As a number of agricultural historians have shown, there was also steady progress in agricultural techniques[4].

To what extent can the rise in the product wage be attributed to declining rural population and labour force? As a first step we investigate the time series relationship between the agricultural product wage and the male population. Both these series were tested for a unit root and in neither case could the unit root be rejected. For the real wage and male population respectively the cointegrating regression Durbin Watson statistics (CRDW) were 0.225 and 0.005 and the augmented Dickey Fuller test statistics were 1.949 and 0.760. Both series appear to be integrated of order 1 so it is legitimate to run a regression on the variables in levels. We also include a time trend in the regression and the result is as follows:

$$\log(W/P) = \underset{(5.27)}{21.22} - \underset{(3.36)}{0.01t} - \underset{(5.33)}{2.69}\log(MPOP)$$

$$R^2 = 0.72 \quad DW = 0.82$$

The relation between population and the real wage is negative, with a long run elasticity of -2.7. Of course the 't' statistics are biased upwards in the presence of serial correlation in the error

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[4] O'Grada (1988, Ch.4) points to the diffusion of a number of innovations including the use of new potato varieties, crop spraying, the diffusion of the milk separator, and towards the end of the period, the introduction of mechanisation in the form of threshers and tractors. He estimates that between 1854 and 1908 total factor productivity in agriculture grew by 34 percent, or about half of one percent per annum.

term. The test statistics for cointegration are CRDW = 0.82, ADF = 3.30. These confirm at the 5 percent level that these three variables form a cointegrating vector.

An alternative approach is to estimate a dynamic model of the relationship between the real wage and male population. In order to account for the short run fluctuations in labour demand in agriculture we include a variable for the deviation of agricultural output from its logarithmic trend. We also include population lagged one period as well as the lagged dependent variable in order to avoid simultaneous equations bias. The model was estimated for the period 1867 to 1913; the results appear as the first column of Table 1.

The results support the finding of an inverse relation between the real agricultural wage and population with an elasticity of -3.2, which is comparable with that obtained in the cointegrating regression above. Two other points should be noted. First, as in the cointegrating regression the time trend is negative, indicating that in the absence of population decline the real wage would have fallen. On the face of it, this would suggest an absence of technical progress and capital accumulation which would normally be expected to raise the real wage. However, population fell more slowly than the labour force in agriculture, so the time trend may be compensating for the understated decline in the agricultural labour force. Second, the agricultural output term takes a negative sign rather than the positive sign that might have been associated with demand shocks.

The first equation excludes any variable representing the current change in the labour force; the second equation includes the current male emigration rate in place of the agricultural

production variable. When this equation was estimated by ordinary least squares the male emigration variable gave a negative and insignificant coefficient. This is not surprising since emigration is found to be inversely related to the Irish wage in the emigration function (see Hatton and Williamson, 1993). When instrumental variables are used, the emigration variable gives a positive sign though it is only significant at the ten percent level. Consistent with its importance in the emigration function, the lagged output variable is used as an instrument for the migration variable.

The point estimate for the emigration rate suggests a large short run effect of emigration on labour supply which acted to drive up the real wage in agriculture. But this just reflects the current outflow of labour. In the long run the cumulative effect of emigration is still reflected in the declining population. It is worth noting therefore that the lagged population variable remains negative and significant even in the presence of the emigration term. The long run elasticity is even higher than before at -3.8. These results are certainly very suggestive of a powerful impact of emigration-driven population decline on the real wage in Irish agriculture. However, we cannot be very certain of the magnitudes both because the trend in population was different from the trend in the agricultural labour force and because we have not yet studied the long run impact of emigration on either the population or the labour force.

III Demographic Change and Wage Change at the County Level

If emigration had large and significant effects on the population and the labour force then this should be reflected at the local

level. There were large variations in emigration rates and in the rates of decline of population across counties. Emigration rates and rates of population deline were highest in the south and west of Ireland. Between 1851 and 1911 the population of Munster fell by 44.3 percent and that of Connaught by 39.5 percent, compared with 30.5 percent for Leinster and 21.4 percent for Ulster. For some counties in the south-west such as Clare, Kerry and Tipperary the population fell by over half.

Of course the changes in population were also influenced by differences in fertility across counties and by internal migration. Cormac O'Grada (1988, p.164) has shown that in 1911 cross county marital fertility was strongly and positively influenced by the depletion of earlier cohorts largely through emigration as well as by the proportion of the county population who were Catholic. This suggests that to some extent previous emigrants were 'replaced' or compensated for. O'Grada suggests that the rate of replacement was less than half. Internal migration was mainly from rural to urban counties. As late as 1911 over 90 percent of the residents of the counties of Connaught were still living in the county of their birth, but the ratio was much lower in the northern and eastern counties which experienced greater in migration.

In order to examine the impact of emigration on the male population and labour force we measure the proportionate change in each over the twenty year periods 1851-71, 1871-91 and 1891-1911 at the county level, yielding a total of 32 counties by three intervals, or 96 observations in all. The change in male population is explained by the total male emigration divided by the mid-period population and by the share of the male labour force in agriculture in the initial year. The latter variable is intended to reflect

internal migration from the rural areas. The model also includes period and county dummies (the latter not reported) for the full set of fixed effects.

The result in the first equation of Table 2 gives a strong negative coefficient on the emigration term, indicating that over a 20 year period male population typically fell by two thirds of the amount of emigration. However, the coefficient for the share in agriculture has the 'wrong' sign and is not significant. The two period dummies also are not significant, suggesting that this regime was relatively constant over time. In the equation for the male labour force there is also a strong negative relation with emigration, indicating that nearly half the labour force was 'replaced'. This result suggests that another force was at work, namely that, in rural counties, higher rates of emigration were partially compensated for by lower rates of outmigration to destinations within Ireland. In contrast to the result for tha total population there are significant period effects on labour force growth indicating some upward trend independent of the rate of emigration.

To what extent did the differing rates of emigration across counties affect labour supply and wage rates? If migration was heavier from counties where wage rates and other aspects of the standard of living were lower then we would expect wage rates to increase most rapidly in these counties (in absence of offsetting demand forces). Emigration should therefore help bring about a convergence of wage rates across counties. Hatton and Williamson (1993) have recently found that county-level wage rates do help explain cross-county emigration rates, though a number of other variables including average family size were also important. In

addition, there is evidence of a trend decline in the dispersion of agricultural wages at the county level. The coefficient of variation of these wage rates declined from 0.151 in 1860 to 0.113 in 1886, and then to 0.074 in 1911[5]

In order to examine these links further, we have taken county-level agricultural wage rates from Bowley (1899) and Fitzpatrick (1984) for the census years 1851, 1871, 1891 and 1911 (or as near to these years as we can get) and use these to measure the rate of change of the agricultural wage for each of the three twenty-year intervals. Combining these three periods as before we can test for the impact of demographic changes on wages at the county level. As before we include the share of the labour force in agriculture at the beginning of the period, as a (negative) proxy for the growth of labour demand, and the full set of fixed effects.

The results are presented in Table 3. They provide little evidence that we can identify a labour supply effect on wages at the county level. In the first equation, the male emigration rate has a positive sign but is highly insignificant.[6] In the second equation, the change in the total labour force has a negative, but not significant, effect on wages. In both equations the share of the male labour force in agriculture has the expected negative, but not significant, effect on wages. By contrast, the most of the equation's explanatory power comes from the dummy variables, which

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5 Similar results are reported by O'Grada (1992, p. 41). This contrasts with the experience of England and Wales where the dispersion of county level agricultural wage rates did not decline. The coefficient of variation was 0.131 in 1860, 0.135 in 1879-81 and 0.134 in 1907 (Boyer and Hatton, 1993).

6 This contrasts with the findings of O'Grada and Walsh (1993, p.32) who obtained a (weakly) significant positive effect of the emigration rate on wage change at the county level for the single cross section for 1893-1911.

indicate a progressive slowing down of nominal wage growth over the three periods.

These results suggest we should reject the hypothesis that emigration or the growth of labour supply had any effect on the wage. Such findings are quite common in cross-sectional studies of contemporary U.S. data (for example Butcher and Card, 1991). However, there may be another explanation. If local labour markets within Ireland were well integrated then cross-sectional results will give downward biased estimates of the impact of labour supply on the wage. Consider the diagram in Figure 4, drawn for two local labour markets, back to back. With initial labour supply levels S1 and S2, M1 migrants move from region 2 to region 1, equalising the wage in each region and leading to employment E1 and E2 respectively. If the labour force in region 2 falls to S'2 internal migration declines and the wage rises in both regions.

This simple example suggests that it may be hard to identify any relationship between cross-county labour supply and the wage. Rather, the effect of a significant drop in labour supply would be to raise the wage in all regions equally. Indeed the significance of the period dummies suggests that the overwhelming proportion of the variance in wage changes is due to the common element over time rather than the differences accross counties. We should concentrate therefore on the change over time of the total labour supply and its effects through general equilibrium channels on wages and living standards

IV Demographic Trends and Emigration

An appropriate way to examine the effects of emigration on the real wage and other variables over a long period of time is to use a

computable general equilibrium model of the economy to consider the counterfactual outcome if there had been no emigration. In order to do this we therefore need to estimate how the Irish population and labour force would have grown if there had been no emigration from 1851 to 1911. Such estimates can be little more than controlled conjectures since it is likely that a series of demographic adjustments would have been set in train had there been no emigration. Our objective then is to suggest a range of plausible values rather than to arrive at a definitive estimate.

It is useful to begin by looking at the number of Irish born enumerated in receiving countries between 1851 and 1911. This is displayed in Table 4. The stock of Irish born living abroad fell after 1881 as the emigration flow declined to a level which was insufficient to replace deaths of the previous emigrants. In 1911 the total stock of Irish born living abroad was 1,878,000, or 30 percent of the total population of Irish born. Had they been living in Ireland the Irish population would have been 6,259,000, a little below the actual population in 1851. A few of these would have been pre-1851 emigrants but this number would have been dwarfed by the number of second generation Irish living abroad. In the United States alone in 1910 there were 2,141,000 of Irish parentage and 1,010,000 with one Irish parent. Though many of these would have been the children of pre-1851 emigrants the numbers are sufficiently large to suggest that if the same births had occurred in Ireland from 1851 on, the Irish population might have been double its actual level in 1911.

In order to produce a more concrete estimate of the counterfactual Irish population in 1911 we consider a simple

demographic model[7]. Population change from one year to the next depends on the birth rate (B), the death rate (D), and the emigration rate (E). Hence we have:

$$P_t = P_{t-1}(1 + B_{t-1} - D_{t-1} - E_{t-1} + Z_{t-1})$$

where Z is the residual error. Such errors might be considerable. It has been shown that from the beginning of civil registration in 1864 recorded birth and death rates substantially underestimate the true rates (see Walsh, 1970; Coward, 1982; O'Grada, 1991). The degree of under registration appears to have decreased over time but was still about 3 percent for births and 5 percent for deaths in 1911. O'Grada (1975) has shown that emigration to Britain also was underenumerated although to a decreasing degree over time.

We can use the relationship above to simulate the Irish population from 1851 to 1911 in the absence of emigration (but leaving in Z)[8]. The result of this exercise indicates that the Irish population would have been more than double its actual level in 1911 at 9,773,000 and exactly 1.5 times the 1851 level. However, this takes no account of the demographic response to lower emigration. As we have seen there is some evidence that as many as

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7 An alternative method of estimating the counterfactual population and labour force would be to work from the stock of emigrants reported in Table 4. Such methods have been used by Williamson (1990, Ch 6) to measure the labour force impact of Irish emigration to Britain, and by O'Rourke, Williamson and Hatton (1993) to estimate the impact of immigration to the United States and emigration from the United Kingdom.

8 The vital rates used for this simulation were taken from Mitchell and Deane, (1962, pp. 32-3, 36-7). Prior to the beginning of civil registration in 1864, the birth rate was assumed to be 26.7 per thousand and the death rate 16.9 per thousand.

half of the Irish emigrants were 'replaced' by increased fertility. An alternative simulation therefore reduces births by half of the emigration rate. The result gives a 1911 population of 6,527,000, close to the actual population level in 1851. These conjectures, though crude, suggest a counterfactual population in 1911 either the same as the 1851 population (low estimate) or one and a half times the 1851 population (high estimate). In terms of growth rates the population increased by 0.675 percent per year on the high estimate and zero on the low estimate, compared with the actual rate of -0.661 percent per year. Though these estimates are for the total population growth, it is likely that, over a period as long as 60 years, the labour force effects would be of a similar magnitude.[9]

V A General Equilibrium Model of the Irish Economy in 1907-8

An appropriate way to assess such large scale effects is through a general equilibrium approach which allows for the full set of interrelationships within the economy. Such methods have been used successfully to estimate the effects of Irish immigration to Great Britain, 1821-1861 (Williamson, 1990, Ch. 6), to assess the effects of emigration on Irish agriculture, 1856-1876 (O'Rourke, 1991), and to evaluate the effects of immigration to the U.S. and emigration from the U.K., 1870-1910 (O'Rourke, Williamson and Hatton, 1993). What follows is a summary description of a simple model of the Irish economy in 1907-8, designed to address the issue of the

[9] Using different methods to calculate the impact of the Irish on the labour force in Britain, Williamson (1990, p.143) estimates that between 1821 and 1871 the Irish born population grew at 2.9 percent per annum, the total Irish population grew at 2.8 percent per annum, and the Irish labour force by 3.0 percent per annum

effects of post-famine emigration on Irish living standards. A more detailed description of the model is available in Appendix 2.

There are three production sectors in the model: agriculture (A), manufacturing (M), and services (S). The agriculture sector produces food (A), using agricultural labor (L_A), capital (K), land (R), and imported manufactures (M_F; representing imported fertilizers). The manufacturing sector produces manufactured goods (M), using non-agricultural labor (L_{NA}), capital, agricultural goods (food-processing was an important sector in Ireland at the time), imported manufactured goods (M_F, for example, yarns), and 'exotic imports' (F), goods for which no domestically produced substitutes are available (for example, raw cotton). Services (S) are produced with non-agricultural labor, capital, and agricultural goods (horses and horse-feed sold to the sector). We write:

$$A = A(L_A, K_A, R, M_{FA}) \quad (1)$$

$$M = M(L_{NAM}, K_M, A_M, M_{FM}, F_M) \quad (2)$$

$$S = S(L_{NAS}, K_S, A_S) \quad (3)$$

All production functions are C.E.S. Elasticities of substitution in manufacturing and services are 0.5, and in agriculture 1.0 (the Cobb-Douglas case). To each production function there corresponds a cost function, which depends only on factor prices due to the assumption of constant returns; competition assures that price equals to cost in each sector.

Food and manufactures are internationallytraded: Ireland exports domestic manufactures and food, and imports foreign manufactures and exotic imports. Prices of these goods are taken as exogenous, with the exception of domestic manufactured goods prices. As is standard in the literature, Irish manufactured exports face a

constant elasticity demand function abroad. Services, by contrast, are non-traded, and their price is endogenously determined.

Agricultural exports are treated as a process whereby a unit of food is transformed into a quantity of 'foreign exchange' via a fictitious production function, at a fixed ratio reflecting the exogenous export price. Manufactured exports also convert domestic manufactures into foreign exchange via a production function. Details of how this is done are relegated to Appendix 2. Imports convert foreign exchange into import goods through further artificial production functions, again at a constant exogenous ratio reflecting exogenous import prices.

Irish and foreign manufactures are treated as distinct goods. However, they substitute closely with each other in consumption. The representative consumer has a nested utility function: an upper-level Cobb-Douglas utility function defined over food, aggregate manufactures, services and exotic imports (for example tea); and a lower level C.E.S. utility function in which Irish and foreign manufactures substitute with each other in the 'production' of the aggregate manufactured good, with an elasticity of substitution of 10.

The consumer is endowed with enough of the numeraire good to allow him to run the (tiny) trade deficit that was observed in 1908. The consumer is also endowed with capital, land, and raw labor (L_R). Land is only used in agriculture. Capital is freely mobile between sectors. The raw labor is transformed into agricultural and non-agricultural labour via a further pseudo-production function:

$$(L_A,\ L_{NA}) = L(L_R) \qquad (4)$$

This function is of the constant elasticity of transformation form. The elasticity of transformation reflects the sensitivity of the distribution of labor between town and country to rural-urban wage gaps. This formulation allows labor to be mobile between town and country, while at the same time allowing for the existence of persistent rural-urban wage gaps.

To each sector there corresponds an activity level to be determined; for each sector, price equals cost. (This also holds for the artificial sectors reflecting trade and rural-urban migration. The price-cost equations for the trade sectors tie down the exogenous goods prices.) For each commodity, there is a price to be determined, as well as a demand-equals-supply equation. The consumer's income (and hence utility) have to be determined; income and expenditure are constrained to be equal. There are thus as many equations in the model as there are unknowns; as usual, Walras' Law implies that one can only solve for relative prices. The 'foreign exchange' good, whose only purpose in the model is to facilitate international trade, is taken to be the numeraire. This is analogous to fixing the nominal trade deficit (at its actual insignificant level).

VI General Equilibrium Results

In order to evaluate the effects of emigration from Ireland in the post famine era we take our model for 1907-8 and examine the effects of increasing the population and labour force by an amount which reflects the no-emigration counterfactual. We then compare the magnitudes of the model's endogenous variables with the actual

values for 1907-8. In light of our discussion of the demographic impact of emigration we evaluate two alternatives: the low estimate in which population and labour force in 1907-8 are set at their 1851 levels, and the high estimate where these are set at one and a half times the 1851 levels. We also examine two alternative assumptions about international capital mobility; in the first, capital is completely immobile so that the capital stock in the counterfactual is held at its actual level in 1907-8; in the second, capital is completely mobile at the ruling world interest rate.[11]

The counterfactual values of some of the key variables in the model as a proportion of the actual values in 1907-8 are reported in Table 5. Turning first to the results with immobile capital, the two real wage rates (nominal wages divided by the cost of living index) not surprisingly would have been lower in the absence of emigration. The agricultural wage would have been 16 (29) percent lower had the labour force been 49 (123) percent higher. The non-agricultural wage would have been 19-34 percent lower with no emigration. The elasticity of the real agricultural wage with respect to the labour force is between minus a quarter and minus a third. Though these effects are large, they are not nearly as large as the effects of population on the product wage estimated earlier.

The overall change in national income is quite substantial, rising by two thirds in the upper estimate, but per capita income

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11 This assumption would evidently have been preferred by the Commission on Population who observed: "Irish capital formed part of the world market and Irish industrial projects had to compete for capital with the opportunities for investment, not only in Great Britain but throughout the world that were freely offered to the investor" (1954, p.26).

would have fallen by up to 25 percent. Would this have involved a massive shift in the labour force into manufacturing and services? Given our assumption about relatively high internal labour mobility, the results suggest that a greater proportion of the labour force would have been in agriculture and the manufacturing labour force would have been only slightly higher.

The bottom two rows indicate that more labour would have dramatically increased marginal productivity and therefore the real rental rates on both land and capital. However, with internationally mobile capital as in columns 3 and 4 of the Table, the return on capital rises only slightly (because of the fall in consumer prices) but that on land still nearly doubles on the upper estimate. With a substantial capital inflow, the marginal productivity of labour in services and especially manufacturing is higher than otherwise and more labour is shifted into the manufacturing and service sectors. The results suggest that with mobile capital, the share of the labour force in the non agricultural sectors would have been slightly higher than the actual share in 1907-8.

The fall in real wages is much attenuated under international capital mobility. Both the agricultural and non-agricultural wage would have declined by a modest 11 percent under the upper estimate, and by only 6 percent under the lower estimate. Gross national product would also have been substantially higher, more than doubling on the upper estimate, and accordingly the decline in per capita income would have been smaller. These results indicate the importance of the capital mobility assumption. Changing other important assumptions appears to have less quantitative impact on

the results[12]

To give a perspective on the results in growth terms, in Table 6, we compare actual with counterfactual growth rates of wages and income from 1858 to 1908. To do this we use the real wage indices discussed earlier, using the unskilled building wage to represent the non-agricultural wage[13]. Not surprisingly, in the case where capital is immobile there are sharp declines in the rates of real wage growth, in the upper estimate reducing agricultural wage growth from 1.1 percent per annum to only 0.4 percent. However, with mobile capital the rate of growth of agricultural wages only would have declined by about a quarter and the non-agricultural wage by less than a fifth.

For the growth of GNP, we assume a benchmark of 0.7 percent per annum based on O'Grada's estimate for the period from 1845. The counterfactual estimates suggest that the growth rate would have been a little less than double the actual on the lowest estimate and about three times the actual on the highest estimate. GNP per capita growth would have fallen by a little less than a quarter on the lowest estimate and by only 7 percent in the case with the lower emigration effect and mobile capital.

Finally, in the lower panel of Table 6 we examine the effects

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12 Two assumptions in particular were examined. First, the elasticity of substitution between Irish and foreign manufactured goods was reduced from 10 to 2. With capital mobile, this gave a fall of 12 percent in the agricultural real wage on the upper estimate compared with the 11 percent in Table 5. Second, we tried an alternative estimate of industrial output in 1907 which is 25 percent lower (see Appendix 3). With mobile capital, this gave a fall in the agricultural wage of 6 percent compared to the 11 percent estimate in Table 5.

13 For the building labourers wage growth we take the 1860 real wage as representing 1858.

of the alternative growth rates of real wages on the real wage ratios between Ireland and Great Britain and the United States respectively. With immobile capital, the Irish/British real wage ratio would have remained constant or declined from 1858 to 1908. With capital mobile, there was still room for some gains in relative real wages, although the higher emigration estimate suggests that the gain over the whole 50 year period would have been cut by more than half. Each counterfactual estimate suggests that the Irish/United States real agricultural wage ratio would have fallen by more that the actual 10 point[14]. The Irish/United States non-agricultural wage ratio would have still increased slightly except in the case of the high estimate with immobile capital.

The results can be compared with those obtained in a recent paper using general equilibrium models for both the United States and the U.K. (O'Rourke, Williamson and Hatton, 1993). These suggest that if there had been no emigration from 1871 to 1911 the unskilled urban wage would have been 12.2 percent lower if capital was immobile and 6.6 percent lower with capital mobile. Applying the same approach to the United States (no immigration from 1870 to 1910) indicates that American wages would have been higher by 34.0 and 9.2 percent respectively. Thus with capital immobile there would have been dramatic divergence between British and American wage rates. Even with international capital mobility the British/American real wage ratio would have fallen from about 0.6 to 0.53 between 1870 and 1913.

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[14] We only have an estimate of the agricultural wage for the United States back to 1870. The figure of 0.36 in parentheses was obtained by extrapolating the real agricultural wage back to 1858 using the non-agricultural unskilled wage.

VII Conclusion

During the period 1850-1913 Irish real wages and per capita income increased at a rate that was quite respectable compared to wage and income growth in Great Britain and the United States. The Irish/British unskilled real wage ratio increased sharply, while the skilled real wage ratio remained roughly constant at 0.90 throughout the period. Irish/United States skilled and unskilled wage ratios increased from the early 1870s to the mid 1890s, then declined somewhat to 1913. The increase in Irish living standards took place despite very slow industrialization.

This paper has attempted to determine the extent to which Ireland's strong wage performance was a result of its unparalleled emigration rates. From 1851 to 1911 the Irish population declined by 25 percent. We estimate that, in the absence of emigration, the Irish population and labor force in 1911 would have been either equal to or 50 percent greater than their 1951 levels.

We construct a computable general equilibrium model of the Irish economy in 1908, and use it to examine the effects of increasing the population and labor force by an amount which reflects the no-emigration counterfactual. Our results indicate that real wages and per capita income would have been lower in 1908 in the absence of emigration. The magnitude of the decline is strongly affected by our assumptions about international capital mobility. If capital was completely immobile, we estimate that the real unskilled urban wage would have been 66-81 percent of its actual 1908 level, and per capita income 75-87 percent of its actual level. If capital was internationally mobile, the unskilled urban wage would have been 89-94 percent of its actual 1908 level, and per

capita income 91-95 percent of its actual level. The estimates imply that emigration could have account for a significant amount of Ireland's real wage gain relative to Britain and for all of the gain relative to the United States.

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APPENDIX 1

Time Series Wage Date: International Comparisons

The sources of the wage data used in the empirical analysis are listed below.

Agriculture: For Ireland, wage data for 1880-1913 were obtained from the Board of Trade's Seventeenth Abstract of Labour Statistics of the United Kingdom (1915, p.67). The series consists of an unweighted average of weekly wages on 27 Irish farms. For 1855-80 wage data for 10 Irish farms were obtained from the Second Report ... on the Wages, Earnings, and Conditions of Employment of Agricultural Labourers in the United Kingdom (1905, p.137), written by A. Wilson Fox for the Board of Trade. The two series were spliced together in 1880.

For England and Wales, wage data for 156 farms from 1880 to 1913 were obtained from the Seventeenth Abstract of Labour Statistics of the United Kingdom (1915, p.67). For 1855-80, wage data for 69 farms were obtained from the Second Report ... on the Wages, Earnings, and Conditions of Employment of Agricultural Labourers in the United Kingdom (1905, p.68). The two series were spliced together in 1880.

For the United States, wage data for 1890-1913 were obtained from Paul Douglas, Real Wages in the United States 1890-1925 (1930, p.186). Wage data for 1869, 1875, 1879-82, 1885, and 1888 were obtained from the U.S. Department of Labor, Bureau of Agricultural Economics, Farm Wage Rates, Farm Employment and Related Data (1943, p.3). We estimated wage rates for 1883-84, 1886-7, and 1889 using linear interpolation, to obtain a continuous series for 1879-90. The two series were spliced together in 1890.

Unskilled labour, building trades: For Ireland, the wage series for 1860-1913 consists of a weighted average of labourers' weekly wages in Dublin and Cork. The weights used were the populations of the cities in 1891. Wage data for "general labourers" in Dublin were obtained from Fergus D'Arcy, "Wages of Labourers in the Dublin Building Industry, 1667-1918". Saothar (1989, pp.24, 26). Wage data for Cork bricklayers' labourers were obtained from an unpublished Board of Trade document, Rates of Wages and Hours of Labour in Various Industries in the United Kingdom (1908). We adjusted for differences in the cost of living between Dublin and Cork by deflating the wage for each city by town-level cost-of-living estimates reported in the Board of Trade's Enquiry ... into Working-Class Rents and Retail Prices (1913, p.1).

For England and Wales, the wage series for 1880-1913 consists of a weighted average of bricklayers' labourers' weekly wages in ten cities: Birmingham, Bradford, Bristol, Hull, Leeds, Liverpool, London, Manchester, Nottingham, and Sheffield. The weights used were the populations of the cities in 1891. For 1860-80, the wage series consists of a weighted average of bricklayers' labourers' weekly wages in four cities: Birmingham, Leeds, London, and Manchester. The weights used were the populations of the cities in 1871. The two series were spliced together in 1880. All wage data were obtained from the Board of Trade's Rates of Wages and Hours of Labour in Various Industries in the United Kingdom

(1908). We adjusted for differences in the cost of living across cities by deflating the reported wage for each city by the town-level cost-of-living estimates for 1905 contained in the Board of Trade's Enquiry into Working Class Rents, Housing and Retail Prices (1908, p.xxxi).

For the United States, we used the index of nominal wages for "common or unskilled labor" constructed by Paul David and Peter Solar, contained in "A Bicentenary Contribution to the History of the Cost of Living in America", Research in Economic History (1977, p.59). We transformed the index into a weekly wage series by setting the weekly wage in 1860 at $6.36 and adjusting all other index numbers for 1860-1913 accordingly. The weekly wage in 1860 was obtained from Stanley Lebergott, Manpower in Economic Growth (1964, p.298).

Carpenters: For Ireland, the wage series for 1866-1913 consists of a weighted average of carpenters' weekly wages in Belfast, Dublin, and Cork. The weights used were the populations of the cities in 1891. Wage data were obtained from the Board of Trade's Rates of Wages and Hours of Labour in Various Industries in the United Kingdom (1908). We adjusted for cost-of-living differences across towns using town-level cost-of-living estimates reported in the Board of Trade's Enquiry ... into Working-Class Rents and Retail Prices (1913, p.1).

For England and Wales, the wage series for 1866-1913 consists of a weighted average of carpenters' weekly wages in ten cities: Birmingham, Bradford, Bristol, Hull, Leeds, Liverpool, London, Manchester, Nottingham, and Sheffield. The weights used were the populations of the cities in 1891. Wage data were obtained from Rates of Wages and Hours of Labour in Various Industries in the United Kingdom (1908). We adjusted for cost-of-living differences across cities using the town-level cost-of-living estimates in the Board of Trade's Enquiry into Working Class Rents, Housing and Retail Prices (1908, p.xxxi).

For the United States, the wage series for 1870-1913 consists of a weighted average of carpenters' weekly wages in four cities: Boston, Chicago, New York, and Philadelphia. The weights used are the populations of the cities in 1891. Wage data for 1890-1913 were obtained from History of Wages in the United States from Colonial Times to 1928, U.S. Bureau of Labor, Bulletin No.449 (October 1929, pp.165-7). Wage data for 1870-90 were obtained from Wages in the United States and Europe, 1870-1898, U.S. Bureau of Labor, Bulletin No.18 (September 1898, p.673). The two series were spliced together in 1890. We adjusted for cost of living differences across cities using the town-level cost-of-living estimates for 1909 in the Board of Trade's Enquiry ... into Working Class Rents, Housing and Retail Prices... in the Principal Industrial Towns of the United States of America (1911, p.xxxvi).

Fitters, Machinists: For Ireland, the wage series for 1866-1913 consists of a weighted average of fitters' weekly wages in Belfast, Dublin, and Cork. The weights used were the populations of the cities in 1891. Wage data were obtained from the Board of Trade's Rates of Wages and Hours of Labour in Various Industries in the United Kingdom (1908). We adjusted for cost-of-living differences across cities using town-level cost-of-living estimates in the Board of Trade's Enquiry ... into Working-Class Rents and Retail Prices (1913, p.1).

For England and Wales, the wage series for 1866-1913 consists of a weighted average of fitters' weekly wages in Birmingham, Bradford, Bristol, Hull, Leeds, London, Manchester, Newcastle, Nottingham and Sheffield. Wage data were obtained from Rates of Wages and Hours of Labour in Various Industries in the Untied Kingdom (1908). We adjusted for cost-of-living differences across cities using the town-level cost-of-living estimates in the Board of Trade's Enquiry into Working Class Rents, Housing and Retail Prices (1908, p.xxxi).

For the United States, the wage series for 1870-1913 consists of a weighted average of machinists' weekly wages in four cities: Boston, Chicago, New York, and Philadelphia. The weights used are the populations of the cities in 1891. Wage data for 1890-1913 were obtained from History of Wages in the United States from Colonial Times to 1928, U.S. Department of Labor, Bulletin No.499 (October 1929, pp.304-6). Wage data for 1870-90 were obtained from Wages in the United States and Europe, 1870 to 1898, U.S. Bureau of Labor, Bulletin No.18 (September 1898, p.678). The two series were spliced together in 1890. We adjusted for cost-of-living differences across cities using the town-level cost-of-living estimates in the Board of Trade's Enquiry ... into Working Class Rents, Housing and Retail Prices ... in the Principal Industrial Towns of the United States of America (1911, p.xxxvi).

APPENDIX 2

The Computable General Equilibrium Model in Detail

The model is a standard neoclassical one. There are 4 components of a neoclassical GE model. Production sectors are characterized by a production function; to each sector there corresponds an activity level, which is endogenously determined by the model. Commodities each have a price, which may or may not be endogenous, depending on whether or not the good is given by world market conditions. Consumers are characterized by endowments and a utility function; their income and utility are endogenous. Finally, a model may also incorporate side constraints (e.g. a minimum wage), to which there correspond 'rationing variables' which move so as to ensure that the constraint is fulfilled (e.g. unemployment).

The package which we use, MPS\GE, forces the modeller to use this standard framework. Production and utility functions are specified by the modeller; the package then calculates cost, factor demand and demand functions for all sectors and commodities. Equilibrium is defined by a set of prices, activity levels and incomes such that (i) no sector earns a positive profit; (ii) supply minus demand for each commodity is nonnegative; (iii) income from factor endowments is fully distributed.[14]

Production

There are 3 production sectors in the model: the food sector (A); the manufacturing sector (M); and the service sector (S). In addition to the three commodities produced by the above sectors, there are three primary factors of production [land (R), raw labor (L_R) and capital (K)]; two 'produced' factors of production [agricultural labor (L_A) and non-agricultural labor (L_{NA})]; and two imported goods [exotic goods (T) and imported manufactures (M_F)]. Finally, an artificial good, 'foreign exchange', is used in modelling trade flows, and serves as the numeraire.

MPS\GE constrains production functions to be C.E.S., of which the Cobb-Douglas function is a special case. (The reason for this is that, given the elasticity of substitution, all the parameters of such functions can be estimated from a micro-consistent data set.) Production in the agricultural sector is Cobb-Douglas, production in the other two sectors C.E.S.:

$$A = L_{AA}^{\theta_{AL}} K_A^{\theta_{AK}} R_A^{\theta_{AR}} \tag{1}$$

$$M = \left[a_{HL} L_{NAM}^{\tau_M} + a_{HK} K_M^{\tau_M} + a_{HH} M_{FM}^{\tau_M} + a_{MF} F_M^{\tau_M} + a_{HA} A_M^{\tau_M}\right]^{1/\tau_M} \tag{2}$$

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[14] See Thomas Rutherford (1988), General Equilibrium Modeling with MPS/GE, Department of Economics, University of Western Ontario.

$$S = [a_{SL}L_{NAS}^{\tau S} + a_{SK}K_S^{\tau S} + a_{SA}A_S^{\tau S}]^{1/\tau S} \quad (3)$$

where the left-hand side variables are outputs, Xi is the input of commodity X into sector i, the θ_{Ai}'s and θ_{Ii}'s both sum to one; the a_{ij}'s are constants; and

$$\tau_H = (\sigma_H - 1)/\sigma_H \quad (4)$$

$$\tau_S = (\sigma_S - 1)/\sigma_S \quad (5)$$

where the σ's are the pairwise elasticities of substitution.

Firms in all sectors minimize costs, which generates factor demand and cost functions. It is a standard problem to generate these functions in the Cobb-Dougias and C.E.S. cases. In the general Cobb-Dougias case where Q is output, X_i is the input of factor i, w_i is the price of factor i, and production is described by

$$Q = \Sigma_i X_i^{\theta i} \quad (6)$$

the demand for factor i equals

$$X_i(\{w_j\}, Q) = Q(\theta_i/w_i)\Sigma_j(w_j/\theta_j)^{\theta j} \quad (7)$$

and the cost function is given by

$$c(\{w_i\}, Q) = Q\Sigma_i(w_i/\theta_i)^{\theta i} \quad (8)$$

In the general C.E.S. case, where production is given by

$$Q = [\Sigma_i a_i X_i^{\tau}]^{1/\tau} \quad (9)$$

where $\tau = (\sigma-1)/\sigma$, factor demands are given by

$$X_i(\{w_j\}, Q) = Q[(a_i/w_i)\{\Sigma_j(a_j^{\sigma}w_j^{1-\sigma})\}^{1/1-\sigma}]^{\sigma} \quad (10)$$

and the cost function is

$$c(\{w_i\}, Q) = Q[\Sigma_i(w_i/a_i)^{1-\sigma}]^{1/1-\sigma} \quad (11)$$

The model assumes perfect competition; thus, in each sector price equals unit cost (which depends uniquely on factor prices, given constant returns to scale):

$$p_A = C_A(w_A, r, d, p_{MF}) \quad (12)$$

$$p_M = c_M(w_{NA}, r, p_{MF}, p_F, p_A) \quad (13)$$

$$p_S = c_S(w_{NA}, r, p_A) \qquad (14)$$

Here p_i stands for the price of good i; w_A and w_{NA} are the wages of agricultural and non-agricultural labor respectively; r and d are the returns to capital and land respectively; and the c_i functions are unit cost functions as in (8) and (11) above.

Equations (12) through (14) incorporate the model's assumptions about factor mobility across sectors. Capital is perfectly mobile across all sectors. Land and agricultural labor are only used in A. Non- agricultural labor is perfectly mobile between manufacturing and services. Labor is however imperfectly mobile between the agricultural sector and the rest of the economy (see next section).

Rural-Urban Migration

The model allows for rural-urban wage gaps to be endogenously determined, by letting labor be less than perfectly mobile between sectors. As mentioned above, the consumer is endowed with 'raw' labor. Raw labor is then transformed into agricultural and non-agricultural labor via a pseudo-production function, $(L_A, L_{NA}) = f(L_R)$. The migration 'sector' solves the following problem:

$$\text{maximize } w_A L_A + w_{NA} L_{NA} \text{ s.t.}$$

$$[\delta_A L_A^{(\mu-1)\mu} + \sigma N_A L_{NA}^{(\mu-1)/\mu}]^{\mu/\mu-1} = L_R$$

where L_R is the fixed endowment of raw labor, and f is the constant elasticity of transformation of this joint production function, which determines how sensitive is the intersectoral allocation of labor to changes in the urban-rural wage gap. The solution to this problem is:

$$L_A = L_R[w_A/\delta_A \Gamma]^{\mu}; \quad L_{NA} = L_R[w_{NA}/\delta_{NA} \Gamma]^{\mu} \qquad (15)$$

where $\Gamma = [\sigma_A^{\mu} w_A^{1-\mu} + \delta_{NA}^{\mu} w_{NA}^{1-\mu}]^{1/1-\mu}$

Since the consumer is endowed with raw labor, we need to determine the price of raw labor, w_R, given w_A and w_{NA} (and hence, via (15), L_A and L_{NA}), we can calculate it from the zero-profit condition in the migration 'sector':

$$w_R L_R = w_A L_A + w_{NA} L_{NA} \qquad (16)$$

Trade flows

Pseudo-production functions are also used to model trade flows. Export 'sectors' convert the export good into foreign exchange. Import 'sectors' convert foreign exchange into the import good. In the benchmark equilibrium, Ireland ran a trade deficit. The representative consumer is therefore endowed with enough foreign exchange to allow her to finance this deficit.

This (together with the assumption that 'foreign exchange' is the numeraire good) amounts to assuming that the nominal trade deficit is exogenous. This is of course unsatisfactory; but it is no more convincing (and more complicated) to assume, for example, that trade is always balanced, or that the real value of the deficit is exogenous. As is well known, an intertemporal model would be required to model the current account rigorously; in the context of a static model, some ad hoc assumption is required.

Ireland is assumed to be 'small' in the markets for food, foreign manufactures, and exotic goods; thus their prices are exogenous. This is modelled by allowing exports or imports of these goods to exchange for foreign exchange at a fixed ratio. Let E_i and I_i stand for exports and imports of good i respectively, and let F_i denote the amount of foreign exchange used as an input into, or derived as an output from, the relevant trade sector:

Sector	Output		Input
Food exports	F_A	=	$p_A E_A$
Manufactured imports	I_{MF}	=	F_{MF}/p_{MF}
Exotic good imports	I_F	=	F_F/p_F

The price-cost equations for these three sectors tie down the exogenous prices of these three goods; it remains to determine the level of exports or imports of the goods.

As is standard practice, Ireland is assumed to be 'big' in world markets for its manufactured exports, so manufactured exports cannot be modelled in this way. The more manufactures Ireland exports, the lower will be their price. Thus, the production function converting manufactured exports into foreign exchange will exhibit decreasing rather than constant returns to scale. This is done by modelling the sector in a Cobb-Douglas fashion:

$$F_M = AE_M^{\alpha} Z^{1-\alpha} \qquad (17)$$

where A is a constant and Z is a fictitious factor of production. The factor is in fixed supply, which is what generates the decreasing returns to scale:

$$Z = \bar{Z} \qquad (18)$$

By 'minimizing costs' in this sector, a foreign demand function for Irish manufactured goods[15] is generated, which exhibits a constant elasticity of demand:

$$E_M = Cp_M^{\beta} \qquad (19)$$

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[15] Ownership of the fictitious fixed factor generates income which corresponds to nothing in the real world; so a fictitious consumer is introduced, endowed with the fixed factor, who spends all his income on foreign exchange.

where C is a constant, and β is the elasticity of demand.

Finally, services are non-traded; domestic demand equals domestic supply.

Demand

There is one consumer in the model. The consumer is endowed with all the raw labor, capital, and land in the economy. In addition, as mentioned above, he is endowed with enough foreign exchange to run the exogenous trade deficit. The consumer consumes manufactured goods (both foreign and domestic), food, services and exotic goods. The consumer maximizes

$$U(C_H, C_S, C_A, C_F) = C_H^{\Theta_H} C_S^{\Theta_S} C_A^{\Theta_A} C_F^{\Theta_F} \tag{20}$$

subject to $\Sigma_i p_i C_i = Y$, where M refers to a composite manufactured good. As is well known, Cobb-Douglas utility implies constant expenditure shares; we get

$$C_S = \Theta_S Y / p_S \tag{21}$$

$$C_A = \Theta_A Y / p_A \tag{22}$$

$$C_F = \Theta_F Y / p_F \tag{23}$$

The utility function is a nested one; at a lower level the consumer determines how much of the two manufactured goods (home and foreign) to consume, by solving

$$\max \left[a_I C_H^{s} + a_F C_{HF}^{s}\right]^{1/s}$$

$$\text{s.t. } p_H C_H + p_{HF} C_{HF} = \Theta_H Y \tag{24}$$

which yields the following demand functions for manufactured goods:

$$C_H = \Theta_H Y p_H^{t-1} / a_I^t \left[(p_H/a_I)^t + (p_{HF}/a_F)^t\right] \tag{25}$$

$$C_{HF} = \Theta_H Y p_{HF}^{t-1} / a_F^t \left[(p_H/a_I)^t + (p_{HF}/a_F)^t\right] \tag{26}$$

where $t = s/(s-1)$.

Equilibrium

Equilibrium is defined by the following conditions: for every sector, price equals cost; for every commodity, demand equals supply; the consumer's income equals the value of endowments.[16] If there are n sectors and m commodities, this implies n + m + 1 equations (and, owing to Walras' Law, n + m independent equations), to solve for n + m + 1 unknowns (n activity levels, m

[16] In the model runs reported here there are no cases where equilibrium prices or activity levels are zero.

prices and the consumer's income). Sectors here include sectors which transform goods into foreign exchange or vice versa, and the sector which transforms raw labor into agricultural and non-agricultural labor.

More concretely/heuristically, there are 11 prices endogenously determined in the model in terms of the numeraire good (foreign exchange): p_M, p_{MF}, p_A, p_F, p_S, p_Z, w_R, w_A, w_{NA}, r, and d. There are 8 activity levels to be determined: M, A, S, E_A, E_M, I_F, I_M and the activity level associated with the migration sector. Finally there is the income of the representative consumer to determine, making 20 endogenous variables in all.

To solve the model there are the following equations. First, there are the zero-profit equations for the three production sectors [(12)-(14)]. Second, there is the zero-profit equation for the migration sector [(16)]. Third, there are the zero-profit conditions for the four trade sectors:

$$p_A = \underline{p}_A \tag{27}$$

$$p_{MF} = \underline{p}_{MF} \tag{28}$$

$$p_F = \underline{p}_F \tag{29}$$

$$1 = K p_M^{\alpha} p_Z^{1-\alpha} \tag{30}$$

where K is a constant.

Fifth, there are the following demand equals supply equations (letting $\underline{X}$ stand for the endowment of factor X):

$$M = E_M + C_M \tag{31}$$

$$S = C_S \tag{32}$$

$$A = C_A + A_M + A_S + E_A \tag{33}$$

$$\underline{L}_R = L_R \tag{34}$$

$$L_{NA} = L_M + L_S \tag{35}$$

$$\underline{K} = K_A + K_M + K_S \tag{36}$$

$$\underline{R} = R \tag{37}$$

$$I_M = C_{MF} + M_{FA} + M_{FM} \tag{38}$$

$$I_T = C_F + F_M \tag{39}$$

$$\underline{Z} = Z \tag{40}$$

as well as an equation saying that all the agricultural labor produced by the migration sector is employed in agriculture; all variables are as defined in the body of the appendix.

Finally there is the equation defining the income of the consumer:

$$Y = w_R \underline{L}_T + r\underline{K} + d\underline{R} + \underline{F} \tag{41}$$

where $\underline{F}$ is the consumer's endowment of the fixed factor. There are thus 20 equations with which to solve 20 unknowns.[17]

[17] In fact, there is one more endogenous variable: the income of the fictitious foreign consumer. To solve for this extra variable we include the equation $Y_F = p_Z \underline{Z}$ defining the income of the fictitious consumer.

APPENDIX 3

Data for the Computable General Equilibrium Model

The model of the Irish economy is calibrated for the period 1907-08. The basis for the calibration is the U.K. Census of Industrial Output in 1907, as amended by later authors,[18] and the official estimate of Irish agricultural output for 1908.

Sectoral inputs and outputs

The official estimate of agricultural output in Ireland in 1908 is £45,574,000. However, this includes all Irish butter production, some of which (worth £3,505,000) took place in creameries (AO p. 14). This sum must therefore be subtracted from the agricultural output total. On the other hand, the official estimate of agricultural output netted out all milk entering into butter, cream and cheese production. Now milk sold to the creameries must be included in agricultural output. The Census of Industrial Production gives the creameries' cost of materials as £3,710,000, and this sum was added to agricultural output.[19] Agricultural output therefore amounted to £45.8 m.

This figure is taken to be value added. To get gross output, the input of imported fertilizers was added. The 1908 trade tables show £0.6m. worth of fertilizers being imported into Ireland. Gross agricultural output was thus £46.4 m.

O'Grada estimates agricultural rents in 1908 at £8 m., and capital's share in agriculture at 8%.[20] Capital income in agriculture therefore amounted to £3.7 m., and labor income in agriculture to £34.1 m.

Finally fishing is included with agriculture in the model. The Census of Production gives the value of fish landed in 1907 as £0.3 m. This figure is arbitrarily divided into a capital income of £0.1 m., and a labor income of £0.2 m. The final figures for agriculture are therefore as follows: a gross output of £46.7 m; a labor input of £34.3 m., a capital input of £3.8 m., a land input of £8 m., and an input of imported manufactures of £0.6 m.

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18 This is contained in The Agricultural Output of Ireland 1908, published for the Department of Agriculture and Technical Instruction for Ireland (DATII), Dublin, 1912; henceforth referred to as AO.

19 Another way of estimating this quantity gives very similar results. 433,000,000 gallons of milk were used to produce butter in 1908. Creameries tended to pay around 4d. per gallon for milk during this period. On the assumption that the milk/butter ratio was the same for creamery and farm-produced butter, the value of milk sold to creameries amounted to £3,762,775. In either case the estimate of the cost of the milk to creameries is greater than the estimate of the value of butter produced in creameries. This is easily explained: creameries sold products other than butter (e.g. cheese and cream). The Industrial Census gives the gross output of creameries as £4,066,000.

20 Cormac O'Grada, Ireland before and after the Famine: Explorations in economic history, 1800-1925, Manchester University Press, 1988; Table 33, p. 130.

The Census of Industrial Production estimates industrial output in 1907 as £23 m. This figure has however been criticized as too low by both Andy Bielenberg and Cormac O'Grada.[21] In what follows we take O Grada's alternative estimate, £40 m. We have also used Bielenberg's estimate of £30.1; as mentioned above, the major conclusions of the paper are not at all affected by industrial output estimate chosen.

Labor and capital shares were taken to be the same in Irish manufacturing as in UK manufacturing generally: 0.68 and 0.32 respectively.[22] Labor income in manufacturing was thus £27.2 m., and capital income £12.8 m.

To get an estimate of gross industrial output, inputs of the other goods entering the model have to be estimated (inputs from industry itself are netted out). Inputs from Irish agriculture are taken from AO; they were taken to be pigs sold to bacon curers, hides sold to tanneries, wool sold to woollen mills, milk sold to creameries, and various crops sold to industry. Valuing the milk sold to creameries as above, and taking the value of other inputs from AO, we reach a total of £9.5 m.[23]

In addition, there are inputs of imported agricultural goods into Irish industry. These data are taken from the DATII's trade statistics for 1908. Imports and exports are broken up, in the summary tables, into three categories: 'farm produce, food and drink stuffs', 'raw materials', and 'manufactured goods'. These categories are then broken down into further sub-categories. The relevant items for the problem at hand are taken to be the raw material categories, 'Hides, skins, wool, hair, feathers, etc.', and 'flax' They amounted to £1.7 m. in 1908, implying a total agricultural input into industry of £11.2 m.

Foreign manufactured goods were also used as inputs into Irish industry. These goods were taken to be the raw material category 'Fats', together with the manufactured goods categories, 'Yarns, thread, rope, cordage, etc.', 'leather', 'metals and metal castings', and 'chemicals, fertilizers and dye stuffs' other than fertilizers. Imports of these categories totalled £6.1 m. in 1908.

Finally, products not produced in Ireland at all were used as inputs into manufacturing. These were taken to be the following raw materials categories: 'coal, coke, etc.', 'wood, hewn and sawn', 'stones, slates, metal ores, etc.', 'other textile raw materials', and 'other raw produce' Imports of these items totalled £7 m. in 1908.

Gross industrial output in 1908 was thus taken to be £64.3 m. (= 40 + 11.2 + 6.1 + 7.0).

Finally, inputs and outputs in the service or non-traded sector have to be estimated. Unfortunately, there are no official estimates of service sector output for the period. I therefore followed O'Grada's guesstimate of £30 m. Labor's share of value

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21 Andy Bielenberg, Industrial growth in Ireland 1790-1910 (Ph.D., LSE, forthcoming); Cormac O'Grada, Ireland: a new economic history 1780-1939 (Oxford University Press, forthcoming).

22 A.L. Bowley, The division of the product of industry, Oxford: The Clarendon Press, 1919; Table VI, p. 45.

23 AO, pp. 17, 22.

added in services was taken to be 0.4932, following Williamson's estimate for Britain in 1911.[24] This implies labor income in services of £14.8 m., and capital income of £15.2 m. Finally, inputs of agriculture into the services sector have to be estimated. These were taken to be horses 'sold for purposes of traffic, recreation, etc., in Ireland', valued at £117,000 (AO, p.17), and oats, hay and straw sold as food for horses in towns, valued at £1.408,000 (AO, p.22). The total input from agriculture into services was thus valued at £31.5 m.

Consumption and trade flows

Total exports amounted to £58.4 m. in 1908, and total imports to £59.0 m., implying a trade deficit of just £0.6 m. Exports of agricultural output totalled £24.0 m. in 1908 (AO, p.6). However, this figure includes exports of butter, valued at £4 m. in 1908. These exports are taken to be from manufacturing, implying genuine agricultural exports of £20 m., and non-agricultural exports of £38.4 m.[25] Moreover, in the model fishing is included with agriculture. Fish exports were worth £0.4 m. in 1908; we therefore take gross agricultural exports as £20.4 m., and gross non-agricultural exports as £38 m.

The following import categories were taken to represent imports of agricultural products destined for consumption: 'live stock', 'fish', 'fruit and vegetables', as well as the eggs and butter component of 'eggs, poultry, butter, etc.' (£76,756), and the grains component of 'grain, flour, meals, etc.' (£4,513,362).[26] The total was £6.1 m. in 1908. In addition there were imports of agricultural products destined for use in manufacturing, mentioned earlier, and worth £1.7 m. Total agricultural imports were thus £7.8 m., and net agricultural exports amounted to £12.6 m.

The following categories were taken to represent imports of exotic goods not produced in Ireland: the raw materials mentioned above, worth £7 m., and 'tea, coffee, cocoa, sugar, etc.' imports of which amounted to £3.3 m. in 1908. Total imports of 'exotic goods' were thus £10.3 m.

The remaining imports were taken to represent imports of

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24 Jeffrey G. Williamson, Did British capitalism breed inequality?, Allen and Unwin, 1985; Appendix Table D.3, p.241.

25 Note an unsatisfactory feature of these estimates: in the data we have, butter is an output partly of the agricultural sector, and partly of the manufacturing sector. The alternative would have been to incorporate the creameries into the agricultural sector; this would however have required data on factor payments in the creameries.

26 Wheat, oats, barley, malt, rye, peas, beans, hops, and 'grains' Not included from the 'grain, flour and feeding stuffs' sub-category in the detailed import tables were maize, tares, lentils, rice, rice flour, sago, sago flour, tapioca, corn food, farina, indian meal, linseed meal, cotton meal, unclassified feeding meal, wheat flour, oatmeal, unclassified meal, bran and pollard, grain offal, feeding stuffs, linseed cake, cotton seed cake, unclassified oil cake, and dog biscuits.

manufactured goods, including the output of food processing industries. The categories concerned were all items listed as 'manufactured goods', together with the raw materials category 'fats', and the farm produce, food and drink categories 'dead meat', 'tobacco and snuff', 'wines, spirits, porter, ale, mineral waters, etc.', 'feeding stuffs', 'other provisions and food stuffs', and those portions of the 'eggs, poultry and butter' and 'grain, flour, meals, etc.' categories not included with agricultural commodities. The total came to £40.9 m. in 1908.

Consumption flows are easily calculated from the foregoing calculations, as residuals. Base year consumption of food was worth £21.4 m., of Irish manufactures £26.3 m., of services £31.5 m., of imported manufactures £34.2 m., and of exotic imports £3.3 m. Total consumption was therefore equal to £116.7 m. Income from labor, capital and land combined equalled £116.1 m.; as expected, consumption exceeded this by the amount of the trade deficit (£0.6 m.).

Table 1

Time Series Equations for the Agricultural Product Wage 1867-1913

	(OLS)	(IV)
Constant	11.35 (2.23)	14.58 (2.38)
Time	-0.006 (1.85)	-0.006 (1.83)
Log male population (t-1)	-1.43 (2.25)	-1.86 (2.39)
Log product wage (t-1)	0.55 (4.27)	0.51 (3.41)
Deviation from trend of log agricultural production (t-1)	-0.30 (1.84)	
Male emigration rate (t)		6.21 (1.70)
R^2	0.80	0.71
DW	1.79	0.14
RSS	0.12	0.14

Table 2

Cross County Regressions for Population and Labor Force Growth

	Proportionate Change in Population	Proportionate Change in Labour Force
Constant	-0.09 (0.43)	-0.43 (2.61)
Male Emigration Rate	-0.66 (4.68)	-0.53 (4.82)
Share of male labour force in agriculture	0.04 (0.12)	0.41 (1.65)
1871-1891 dummy	0.007 (0.39)	0.100 (6.87)
1891 - 1911 dummy	-0.007 (0.24)	0.056 (2.56)
R^2	0.81	0.88
RSS	0.21	0.13

Table 3

Cross County Regressions for Agricultural Wage Growth

	(1)	(2)
Constant	1.00 (2.11)	0.93 (2.11)
Male emigration rate	0.025 (0.08)	
Proportionate change in male labour force		-0.247 (0.78)
Share of male labour force in agriculture	-0.69 (0.97)	-0.068 (1.05)
1871-1891 dummy	-0.26 (6.23)	-0.23 (4.28)
1891-1911 dummy	-2.24 (35.67)	-2.22 (36.78)
R^2	0.99	0.99
RSS	1.10	1.01

Table 4

The Irish Abroad 1851-1911

(000's)

	Irish in Ireland	US	GB	Canada	Australia	NZ	S. Africa
1851	6514	1611	727	-	-	-	-
1861	5788	1859	806	-	177	28	-
1871	5398	1855	775	233	214	49	-
1881	5146	1872	781	186	215	48	-
1891	4680	1615	653	149	229	44	-
1901	4447	1352	632	102	186	44	18
1911	4381	1037	550	93	142	41	15

Table 5

Results of Computable General Equilibrium Analysis for 1907-8

	Capital Immobile		Capital Mobile	
	lower	upper	lower	upper
Counterfactural labour force increase	1.49	2.23	1.49	2.23
Agricultural real wage	0.84	0.71	0.94	0.89
Non-agricultural real wage	0.81	0.66	0.94	0.89
Gross National Product	1.29	1.66	1.42	2.02
G.N.P. per capita	0.87	0.75	0.95	0.91
Labour force in:				
Agriculture	1.54	2.35	1.37	1.90
Manufacturing	1.08	1.08	1.48	2.20
Services	1.20	1.41	1.44	2.09
Real rental rates				
Land	1.50	2.20	1.39	1.96
Capital	1.38	1.83	1.02	1.03

Table 6

Counterfactual Growth Rates of Wages and Income 1858-1908

	Actual	Counterfactual			
		Capital Immobile		Capital Mobile	
		lower	upper	lower	upper
Labour force	-0.59	0.20	1.01	0.20	1.01
Agricultural real wage	1.07	0.73	0.39	0.96	0.84
Non-agricultural real wage	1.60	1.19	0.78	1.49	1.37
GNP	0.70	1.21	1.71	1.40	2.11
GNP per capita	1.29	1.01	0.70	1.20	1.10

Counterfactual Changes in Real Wage Ratios 1858-1908

	Actual	Counterfactual			
		Capital Immobile		Capital Mobile	
		lower	upper	lower	upper
Ireland/GB					
Agricultural real wage	0.14	0.02	-0.07	0.10	0.06
Non-agricultural real wage	0.15	0.01	-0.10	0.11	0.07
Ireland/US					
Agricultural real wage	-0.10	-0.23	-0.34	-0.13	-0.17
Non-agricultural real wage	0.15	0.01	-0.10	0.11	0.07

Figure 1

Figure 2

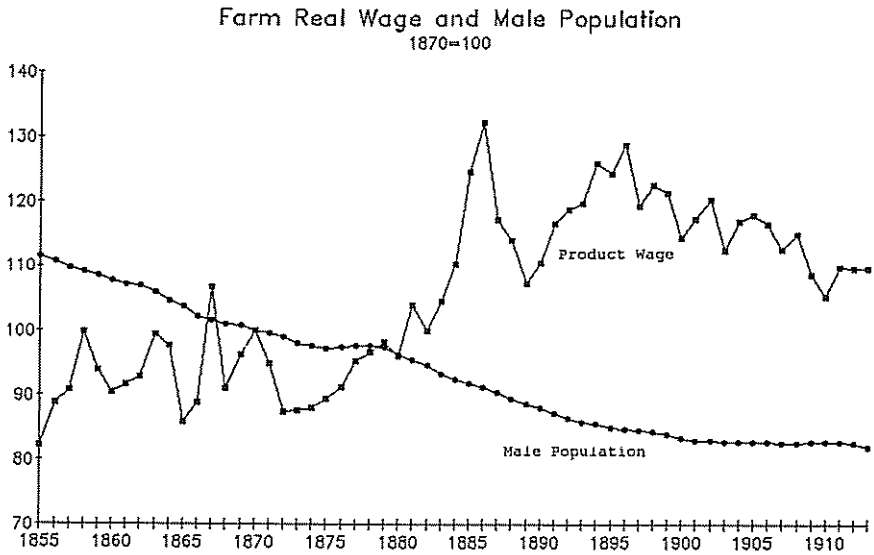

Figure 3

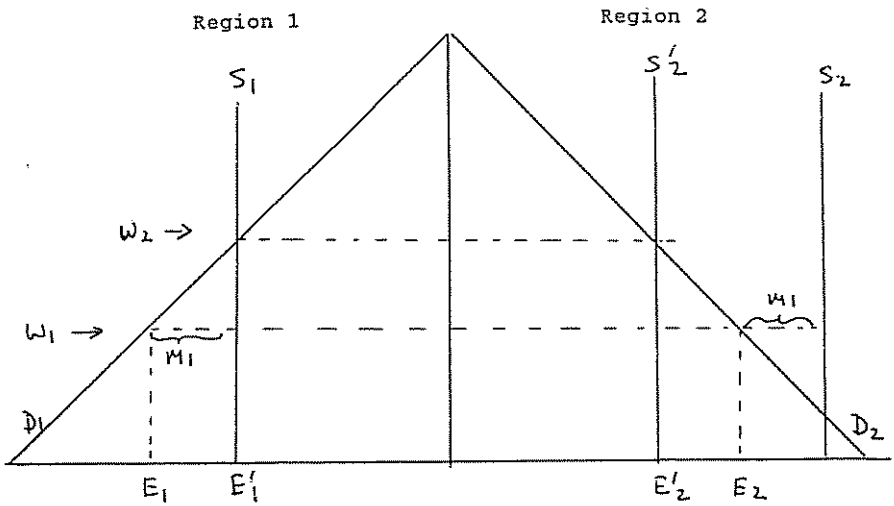

Figure 4