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TALL BUT POOR: NUTRITION, HEALTH, AND LIVING STANDARDS IN PRE-FAMINE IRELAND

S. Nicholas

Richard H. Steckel

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ABSTRACT

This paper uses height data recorded on Convict Indents to study temporal patterns and regional differences in living standards in pre-famine Ireland. The approach is explicitly comparative and makes use of information from America and other parts of Europe. The Irish attained roughly the 16th centile of modern height standards and, though smaller than contemporary North Americans, were among the tallest in Europe, including the wealthier English. We suggest that a nutritious diet and epidemiological isolation were important factors in the high nutritional living standards of the Irish.

S. Nicholas
School of Economics
University of New South Wales
Kensington, NSW 2033
and
Research School of Social Sciences
Australian National University
Canberra ACT 2601

Richard H. Steckel
Department of Economics
Ohio State University
Columbus, OH 43210
and NBER

I. INTRODUCTION

Why was Ireland so poor? Over the last decade the work of Joel Mokyr and Cormac O'Grada (1982, 1983, 1988, 1989) has made this question the principal research topic in Irish economic and social history. The emerging consensus among economic historians is that the pre-famine Irish economy was backward and pre-industrial but capable of growth and change. Irish agricultural productivity was impressively high, and improving, before 1845, and livestock yields were quite close to those of England (O'Grada, 1988, pp. 2-24). Ireland's farmers supplied 47 per cent of total English imports of grain, meat and butter by 1804-06 and nearly 70 per cent by 1814-16. The strong economic ties that bound the industrializing counties of England to the eastern counties of Ireland accounted for the success of the pre-1810 cotton industry in Ulster, the thriving proto-industrial linen industry that spanned the northern half of the country, and Belfast's industrialization, which was as 'dramatic and thoroughgoing as anything happening in Preston or Middlesbrough' (O'Grada, 1988, pp. 25-7).

In a pioneering article that placed Irish living standards in a U.K. context, Mokyr and O'Grada (1988) argued that Ireland was poor, but less poor than commonly thought. In the absence of data on real wages or personal incomes, Irish historians have been forced to employ various proxies to measure Irish living standards. Schooling, life expectancy, literacy and the consumption of luxury commodities improved for the whole population. Average incomes probably rose and the average Irish person, while abjectly poor, was getting less poor over time (Mokyr and O'Grada, 1988, p. 231; O'Grada, 1988, pp. 2-24).

But there were losers as well as winners. While it was impossible to state that the rural community as a whole was impoverished in pre-famine

Ireland, Cullen (1972, p. 112) thought that laborers without land were destitute in hard times. Kennedy (1985, p. 36) and Mokyr and O'Grada (1988, p. 230) speculated that the widespread improvements in living standards came at the expense of the bottom half of the population, who faced an increasingly harsh economic environment. Constructing a subjective impoverishment index, Mokyr and O'Grada (1988, pp. 212-5) found that the average score was negative, implying that the lot of the poorer classes in Ireland deteriorated after 1815. On the basis of the subjective impoverishment index, Mokyr and O"Grada (1988, p. 215) did not feel justified in drawing strong conclusions about the trends in Irish living standards after 1815. Here we use new information on heights to provide an index of the living standards of Irish workers before 1815. Combined with Mokyr and O'Grada's work, this new index provides a much clearer picture of the changes in living standards of Irish workers between 1780 and 1845.

Average height is sensitive to environmental conditions, particularly those prevailing for people in the lower portion of the distribution of welfare. Our analysis is explicitly comparative, assembling information on heights for the Irish and for populations in other countries. Below we outline our methodology, explaining the use of height data for comparative studies of living standards before surveying our main data on 7,931 Irish-born and 14,400 English-born male and female convict transportees to New South Wales between 1817 and 1840. Using comparative height data from England, America, Austro-Hungary, Japan and Sweden, we then interpret the information on Irish heights as an index of living standards and welfare in a pre-industrial society. Regression analysis allows us to investigate determinants of individual heights and of regional differences in Irish living standards.

II: METHODOLOGY

Height is a widely accepted measure of living standards and well-being (Steckel, 1978; Fogel et al., 1983; Steckel, 1986; Tanner, 1978; and Eveleth and Tanner, 1991). Because growth rates are a function of food intake minus claims on the diet made by body maintenance, physical activity, and disease, stature is a net rather than a gross measure of net nutrition during the growing years. Human growth rates are especially sensitive to environmental conditions in early childhood and adolescence, when growth rates would ordinarily be high. The historical evidence shows that malnutrition due to wars and harvest failures can impact on the growth spurt and final attained height. Disease during the growing years can also result in slower growth as nutrients are diverted to fight illness. Malnutrition and the disease environment may interact to have an effect on height greater than the effect of either in isolation (Scrimshaw, 1975).

Additional income received by a very poor individual during their growing years would probably be spent on basic necessities such as food, housing, medical care, and possibly the alleviation of work effort. These expenditures would tend to increase stature assuming that the potential for growth had not been attained. At some level of per capita income further additions to income have a diminishing effect on stature, otherwise those who grew up in wealthy families would be physical giants. Therefore, individual heights are a nonlinear function of income, which implies that average height of a population is a function not only of the level of income but also its distribution.

A statistical analysis of height and per capita income in developed and developing countries of the mid-twentieth century confirms that average height is highly correlated with the log of per capita income and that, other things

being equal, average height decreases as the Gini coefficient of income inequality increases (Steckel, 1983). These high correlations suggest that factors correlated with poverty, such as a poor diet, hard work, substandard housing and poor medical care, are the major sources of nutritional deprivation and slow growth.

Interpretations of well-being from height data can be complicated by minimum height standards, age and height heaping, ethnic differences in growth potential, and selectivity of those measured. Age and height heaping in the convict sample were assessed by tabulating frequency distributions of Irish and English male and female convict heights. The results showed no evidence of truncation bias, either shortfalls or overloading of the tails of the distributions. Our height distributions are reasonably smooth and symmetrical, and based on the Jarque-Bera test of normality given in Table 1, one cannot reject the hypothesis that these height distributions are normal or Gaussian.[1] The distributions for the English women and the rural-born Irish women displayed some evidence of heaping on the half and full inch. While undesirable, heaping plagues many data sources but simulations have shown that such rounding errors pose relatively minor problems for estimates of sample means primarily because their effects are largely self-cancelling (see Fogel et al, 1983).

Although we cannot eliminate genetic influences as a factor in the comparisons we make, modern height data indicate that environmental circumstances were primarily responsible for differences observed. Evidence on heights attained under very good environmental conditions by Western Europeans or their descendants indicates that genetic differences in growth potential were relatively unimportant among the populations under study (see data complied in the Appendix of Eveleth and Tanner, 1991).

III: DATA

Our data comprised a sample of 5,005 Irish-born men and 3,370 Irish-born women transported to the penal colony of New South Wales between 1817 and 1840. For comparative purposes, we also analyzed 11,030 English-born men and 2,929 English-born women convicts. In all some 160,00 convicts were sent to Australia, of whom about 16 per cent were female. Our sample is from the 80,000 convicts transported to New South Wales from the First Fleet in 1788 to the end of transportation in 1840. Accompanying each convict ship was an Indent which contained information on age, gender, occupation, conjugal status, literacy, town and county of birth (providing data on urban or rural birthplace), county of trial, occupation, crime, previous convictions, and height.

The fine detail of the Indent information, including over 1,000 distinct occupations and careful physical descriptions, bolster our confidence that the data were accurately and reliably compiled. A survey of 593 of the male convicts tried at the Old Bailey between 1816 and 1834 revealed that over 98 per cent of the sentences and crimes in the Indents corresponded with those in the court records, 87 per cent of the ages recorded in the Indents and the court records were within 2 years of each other and, when occupations were listed, they all agreed with those enumerated in the Indents.

To further assess the representativeness of our data, and any selectivity bias, the occupational structure of the convict sample and the 1841 Irish census were both coded using six broad occupational categories employed by Mokyr and O'Grada (1982, p. 379) in their study of Irish emigrants to Boston. The occupational breakdown of the male convicts, male population enumerated in the 1841 census and male Boston emigrants differ in Table 2 with respect to farmers. The differences are not as great as they

first appear. Farm laborers and farmers were often confused in the emigrant lists, convict indents and census because the border line between cottier, farm laborer and farmer was not well-defined in pre-industrial Ireland. Mokyr (1983, p. 17) noted that 'Both rich and poor were landholders in Ireland, and terms like "farmer" and "laborer" had become fuzzy'. Many "farmers" had no capital, owned little land and frequently worked as farm laborers. It is hard to adjust for this mis-reporting, and following Mokyr and O'Grada (1982, p. 378) no adjustment is attempted here to reapportion some of the farm laborers as farmers. Taking farmer and farm laborer together, there was a close fit with 72 per cent of the male Irish convicts falling into this aggregate category compared with 76 per cent of the 1841 Irish population.

A similar problem arises for the female convicts in Table 2. The 1841 Irish census grouped women into two categories: laborer (34 per cent) and textile workers (60 per cent), while the female convicts were classified as laborers (92 percent). These apparent differences disappear once it is remembered that female textile workers identified in the census were listed as farm servants in the Indents because they worked at home as domestic workers and were classified as laborers in the Mokyr and O'Grada scheme. Table 2 suggests that both the men and women transported from Ireland were broadly coincident with the working class population at home.[2]

We also assessed the representativeness of the convict sample by comparing the transported convicts with offenders left at home. Recent work by historians of crime in England have shown that the great majority of crime was committed by ordinary men and women, who worked at jobs normally but also stole articles on occasion (Rude, 1985; Jones,1982; Philips, 1977). Unfortunately, similar studies for crimes and criminals in Ireland do not exist. But data do exist on the types of crimes committed by the Irish

transported to Australia. Relative to their transported English counterparts, Irish convicts were overrepresented in the theft of small or inexpensive articles and in animal theft, largely pigs and horned cattle (Robson, 1965, p. 16). They were underrepresented in burglary and housebreaking, and, when committed, those crimes mostly involved making away with kitchen utensils, meal and food (Robson, 1965, pp. 43-5). Overall, the crime of larceny predominated, much of it at the expense of employers and masters. Since the theft of small and inexpensive articles requiring little planning or organization dominated the Irish offenses, there is no support for the thesis that the Irish convicts were members of a criminal class, separate and distinct from the working class.

Transportation for riots, affrays, whiteboyism, threatening letters, and vagrancy were particularly (or exclusively) Irish offenses, but accounted for less than 6 per cent of all Irish crimes (Robson, 1965, pp. 186-98). While agrarian protest, including incendiarism and animal maiming, involved rudimentary organization and secret oaths, the participants were not professional criminals. Agrarian protest was the 'moral economy' of the peasant masses, aimed at economic and political change (MacDonagh, 1968, pp. 144-8). More recently, Mokyr (1983, Ch. 5) has placed rural unrest firmly within the economic conflict between pasturage and arable farming. While Ireland was a violent society, its violence was 'regulated' and sanctioned, allowing the growth of extra-legal or alternative government. Most Irish convicts had no previous convictions. The transported Irish were not significantly different from their friends and relatives who remained in Ireland. On the bases of all these tests, it seems fair to argue that the Irish convicts transported to Australia were coincident with the Irish working class at home.

IV. HEIGHT-BY-AGE PROFILES

The height-by-age profiles in Figure 1 suggest that the rural-born Irish boys spurted before the urban-born Irish or the English. The urban Irish and rural English were between 1 and 1.5 inches shorter than the rural Irish at age 16, a gap only closed at about age 19. There was a significant and persistent gap between the heights of the urban English boys and the other males in our sample. Urban English boys were about 2 inches shorter than the rural-born English and the Irish at age 16 in Figure 1, a gap which urban boys failed to close. At maturity, Irish urban-born boys were significantly taller (0.5 inches) than the urban English, and nearly the same height as the rural-born English; rural-born Irish boys at maturity were significantly taller (0.75 inches) than the urban-born English, and taller (although the difference was not significant) than the rural-born English (see Table 4).

Compared with well-nourished boys today, the boys of the Industrial Revolution spurted at least one year later and continued to grow until age 23, well beyond the modern standards of final attained height at about age 18 (see Tanner, Whitehouse, and Takaishi, 1966). This later and longer spurt in Figure 1 suggests that English and urban-born Irish boys, and to a lesser extent the rural-born Irish, experienced "insults" due either to inadequate food intake, a poor environment, an increased work demand or some combination of these factors during their growing years.

"Hard times" were confirmed by the height-by age profiles of the Irish and English girls in Figure 2, which displayed a similar delayed and dampened growth spurt. Although the sample sizes for the convict women are small before age 16, Figure 2 shows that the growth spurt started around age 14 (about 3 to 4 years later than that for well-nourished female children today) and lasted until 16.5 or 17.5, well beyond the average of age 13 for girls

now. Age at attained terminal height for the Irish and English women was 21, nearly three years later than the modern average at about age 17. At maturity Irish women were significantly taller (over 1 inch) than urban-born English women, but significantly shorter (about 0.34 inches) than the rural-born (see Table 4). Our data show that both Irish and English males and females faced "hard times" during their growing years.

V. TIME PATTERNS

The five year moving averages of final attained heights of cohorts by year of birth in Figures 3 and 4 show that the height advantage of the Irish over the English was more complex than suggested by the point estimates of final attained heights in Table 4, which averaged height over all births between 1770 and 1820. From their 1780s peak (about 66.6 inches, or centile 20.3 of modern height standards), the height of Irish rural male cohorts fell 1 inch to a trough in 1800 that reached centile 11.2 of modern height standards (see Figure 3).[3] This height fall saw the Irish rural-born lose their height advantage over the rural English, although the heights of rural English men also fell about 0.75 inches between the early 1780s and 1805. For the urban-born Irish and English, heights also fell. Urban Irish cohorts born in 1797 were about 1.5 inches below their late 1770s peak, while the urban English cohorts born in 1805 were nearly 2 inches below their late 1770s peak. But the Irish urban-born males maintained a height advantage over the English urban-born for most of the period. The height profiles in Figure 3 confirm that Irish males faced 'hard times', at least in the years before 1800. Given the sensitivity of average heights to the conditions of the poor, the fall in the heights of the Irish males in Figure 3 provides clear evidence that the

well-being of the bottom half of the Irish male population declined. Irish working class men were poor and became poorer before 1800.

The moving average of height of Irish women in Figure 4 shows that the changes in Irish living standards were even more complex than that suggested by the time pattern of male heights. Rural and urban-born females in the bottom half of the female population improved their stature. This not only contrasts with the pattern of Irish male heights that fell before 1800, but also with that of English females. Following a similar pattern to that of English males, the heights of rural-born English females fell from a peak of 61.75 inches (centile 18.6 of modern standards) in 1800 to just under 61 inches (the 11th centile of modern standards) by 1818 and urban-born English cohorts declined 0.5 inches between 1795 and 1814.

We checked the time profiles in Figures 3 and 4 for possible composition effects, which might result in trends which were mere artifacts of the changing skill and class composition of our sample. Heights, for example, may vary by occupation if taller individuals were attracted to jobs for which strength is an asset while smaller people sought positions for which size and strength was unimportant. Women might have been apprenticed or encouraged to work in the same trades as their mothers. To test for occupational influences Armstrong's (1972) skill-class scheme was adapted to generate five occupational groups for the males (unskilled, skilled, public service, domestic service and professional/dealers) and four groups for the females (rural unskilled, manufacturing and transport, domestic service and 'all other occupations'). These variables were included as regressors in a model that also included dummy variables for five-year birth cohorts. Those born before 1790 and professional and dealers occupations for the men and those born before 1795 and 'all other occupations' for the women were the excluded

categories. Since the height profiles for the urban and rural-born displayed different time paths in Figures 3 and 4, separate regressions in Table 5 were run for men and women from each location.

The time profiles in Figures 3 and 4 persist in the year-of-birth dummies in Table 5. The late 1790s height fall and the dip around 1810 for the male urban Irish are identified in our regression results. For the male rural Irish, all the year-of-birth dummies were insignificant. The birth dummies for the females also track the height profiles for the rural and urban-born in Figure 4. Generally, the regressions show that occupational effects were unimportant. None of the male occupational dummies were significant, except for public service of the rural-born. Those employed in public service occupations were the tallest men in our sample due to the large number of soldiers in the public service category who had to attain a minimum height before recruitment. The other occupational groups were not significantly different in height from the excluded class (professionals and dealers). Unskilled rural and domestic service occupations were significant in the rural female regression equation. These jobs required extra strength and endurance, and there is some evidence of self-selection by women in these jobs. Since employment in domestic service (especially general servant, chambermaid, laundress and kitchenhand) and rural unskilled jobs (diaryhand and farm servant) accounted for the overwhelming employment opportunities for rural Irish females, there were no significant shifts in occupational categories in our data. Generally, the regressions in Table 5 show that height profiles in Figures 3 and 4 were not artifacts of a changing occupational structure in the convict sample.

VI. COMPARISONS

Although the more rapid fall in Irish than English male heights before 1800 wiped out the height advantage of the Irish over the rural-born English, Irish males were at least as tall as the rural English after 1800 and were taller than the urban-born English during the whole period. Further, the rural-born Irish boys spurted earlier than the English boys and Irish females improved their height while English women experienced declining stature for births beyond 1790. These patterns of changing Irish heights raise something of an anomaly. The Irish economy was much poorer than the English, and its workers enjoyed a significantly lower material standard of living with a per capita income level little more than half that of England. Yet the poor Irish were as tall or taller than the wealthier English.

This finding is confirmed by data on the heights of recruits into the army. From information on the heights of over 11 thousand Irish and British recruits into the East India Company army between 1800 and 1815, Mokyr and O'Grada (1988, pp. 227-9; O'Grada, 1988, pp. 16-7; Mokyr and O'Grada, 1990, p. 11) discovered that Irish recruits were as tall as those of any other European nation, and possibly growing taller themselves. Irish recruits born in urban locations between 1802 and 1809 were significantly taller than those born in England and Wales, although Irish urban recruits were shorter than their British urban counterparts (Mokyr and O'Grada, 1990, p. 11).[4] In the first anthropometric history of the United Kingdom, Floud, Wachter and Gregory (1990, pp. 200-1) found that Irish recruits into the British army born around 1815 were 0.45 to 0.59 inches taller than recruits born in England.

The height advantage of the poor Irish over the wealthier English shares similarities with the puzzling evidence that the working class boys born in the highest nominal wage area in the U.K., London, were the shortest of all recruits born in England (Floud, Wachter and Gregory, 1990, p. 202).

Floud, Wachter and Gregory suggested that urban disamenities, disease, unemployment, over crowding and high costs of living accounted for the short stature of the London boys. It is true that Irish urban dwellers, except those born in Dublin, escaped many of the worst features of overcrowding, poor housing and inadequate public health typical of the burgeoning towns in the industrializing regions of England. Also the smaller size of the Irish towns and their closer links to the countryside meant that the urban Irish had better access to food supplies than workers in London or Manchester. But even if urban location accounted for all of the height advantage of the urban-born Irish, the anomaly of the rural-born Irish males being taller than the far wealthier rural-born English remains.

This anomaly also holds for the Scots. Scotland was poorer than England, but the 519 male convict Scots transported to Australia were taller (65.82 inches for urban-born and 66.89 inches for the rural-born) than the English, and as tall or taller than the Irish.[5] Extending comparisons to the continent, army recruits from Lower Austria and Bohemia, the most economically developed regions of the Austro-Hungarian Monarchy, were generally the shortest, while those from Hungary and Galicia, the least developed provinces, were taller (Komlos, pp. 96-7). The regional patterns of stature by level of development in the UK shows a common element with other isolated, pre-industrial populations such as the United States, Sweden, and Japan. For example, at ages 27 to 30 Union troops from less developed Kentucky and Tennessee were tallest (69.1) followed by other slave states and the Midwest (at approximately 68.7), while troops from the more developed New England (68.3) and the Middle Atlantic states (68.0) were shortest (Gould, 1869, p. 123). Among southern whites who signed amnesty oaths during the 1860s those from the interior states of Kentucky, Tennessee, Missouri, and Arkansas tended

to be 0.3 to 0.7 inches taller than residents from the more densely settled lower coastal states. A similar but less pronounced regional pattern existed among ex-slave recruits (Margo and Steckel, 1992). In the mid-nineteenth century Swedish soldiers from the less densely settled regions (North and East) were 1.2 to 2 inches taller than those from the more densely settled western areas (Sandberg and Steckel, 1988). Ted Shay (1985) found that Japanese soldiers of the late nineteenth century were 1.2 to 1.6 inches taller from outlying prefectures such as Tottori and Iwate compared with those from the wealthier, more central and developed regions.

The anomaly of the poor Irish being taller than the wealthy English was not, then, unique to the United Kingdom. Pre-industrial populations were frequently taller than those experiencing industrialization, although they were materially poorer. This led Mokyr and O'Grada (1988, p. 228) to warn that the connection between height and per capita income should not be pushed too far. While the warning is apt, it is important to investigate what insights into living standards height data provide for pre-industrial populations. Frequently these pre-industrial populations do not have conventional wage and income data on living standards, which makes the question of the interpretation of height data for pre-industrial populations all the more important. We argue that height data provide a good guide to changing living standards of pre-industrial populations. Secondly, we show that height comparisons between pre-industrial societies and richer and more economically advanced regions can be especially useful when height estimates are immersed in the economic and social history of each region.

VII. POSSIBLE EXPLANATIONS

Diet and claims on the diet made by disease and physical exertion during the growing years were major factors explaining the height advantage of the Irish over the English given the poverty of the Irish and the wealth of the English. The mid-18th century Irish diet consisted of dairy products, oatmeal and meats, and in some regions fish and eggs. The spread of the potato had at first supplemented and added variety to the diet, which meant that the Irish peasant was often better fed than the English laborer (Burnett, 1966, p.20). But by 1800 the potato had become the lynch-pin of the average working man's diet and of the whole system of tillage (O'Grada, 1989, p.112).

In Ireland, the vast bulk of the population worked on the land, but did not own it. The conacre system of annual sublettings of small plots involved the exchange of rent or labor services or both by landless laborers for a potato patch, house, garden and perhaps a cow, pig and some chickens (Vaughan, 1989, p. 115; Cullen, 1972, p. 81; Mokyr, 1983, p. 91). From the mid-18th century, the commercialization of subsistence agriculture saw the emergence of a miniature dual economy within the rural household, comprised of a subsistence sector (the production of potatoes and peat) and a cash sector (production of oats, wheat, pigs, cows, dairy products and cottage industry).[6] As early as the 1760s, the marketing of butter and pork by farmers and poorer families meant that meat, butter and milk were not consumed in the same quantities in rural households, and by 1800, when a thriving interregional trade in potatoes, corn and livestock was well established, the consumption of meat, corn and dairy products fell even lower (Kennedy, 1985, p. 16). Except for potatoes and garden produce, cottiers and laborers increasingly became food buyers, especially in the spring, and if their own food supply failed, then income used to purchase whiskey, sugar, tea and tobacco was switched back to staple foods (Cullen, 1981, p. 95).

During the Napoleonic war, the boom in grain, diary and meat exports to England saw the consumption of meat, milk, and butter in Ireland further decline, especially for poor families (Cullen, 1981, pp.99-101). The commercialization of subsistence agriculture and the impact of the Napoleonic war led Dickson (1989, p.108) to argued that the final victory of the potato as the exclusive diet of the laborer and small farmer was achieved by 1800. The fall in Irish male heights in Figure 3 confirms this narrowing of the Irish diet as alternatives to the potato greatly diminished or disappeared (O'Grada, 1989, p. 112). These changes in the Irish diet bolster our confidence that the fall in Irish male heights for cohorts born before 1800 in Figure 3 accurately reveal declining living standards for the lower portion of the male population.

The anomaly of the Irish height advantage over the English urban-born, and the evidence in Figure 3 that the Irish were as tall as the rural-born English after 1800, can also be explained, in part, by the Irish diet, especially the nutritional value of the potato. Mokyr (1983, p.7) estimated that the potato yielded 1400 calories per day, based on the consumption of 4.5 lbs. of potatoes per day per person, and O'Grada (1989, p.12) thought that potato consumption for the bottom third of the population reached 12 lbs daily. Not only rich in calories, the potato was abundant in protein, calcium, iron, thiamine, niacin and vitamin C (Mokyr, p. 10). In part, the Irish height advantage after 1800 was due to the ability of a considerable proportion of the population to keep chickens or a pig and grow vegetables in garden plots to supplemented the staple potato diet. The Irish were also lucky before 1845 in that most 'famines' which affected the whole country were cereal crises, and only in 1765-6, 1783-4 and in 1800 did shortfalls in potato yields coincide with grain failures (Dickson, 1989, p. 105). Other potato

famines in the 1810s and 1820s were local, affecting regions and specific classes (Dickson, 1989, p. 107). The potato based dual economy and the 'gap in famines' help explain why the poor Irish were so tall during a period of commercialization of agriculture and exports of foodstuffs to England.

The English diet is also important in understanding why the poor Irish were as tall or taller than the wealthier English. While more varied, the English diet was less nutritious than the Irish and displayed significant regional variations. The wheaten loaf had triumphed in the south and west of England, while in the north and east oatmeal, made palatable by some milk, potatoes, eggs and vegetables, made up the average diet. Based on sample rural diets for 1795-97, Shammas (1984, pp. 256-7) estimated that the different patterns of food consumption meant that the typical northern diet yielded 2823 calories per day, but only 2109 in the south. The diet of the English town laborer was inferior to that of the rural worker. The urban dwellers had poorer access to food supplies, a smaller chance of owning a plot to grow food supplements, and employment which precluded payment in kind while exposing workers to truck where they were liable to over-charging and short-measure for store bought food. Towns also increased the dependence on the professional services of bakers, brewers and food retailers, which increased the chance of food adulteration, a phenomenon of urban, but not rural, life (Burnett, pp. 72-89).

War, blockade and harvest failures also explain the inadequate rural and urban diet for the English population after 1790 and the reliance of England on the Irish 'bread basket' (Mingay, 1977; Jones, 1974; Hueckel, 1976; Mokyr and Savin, 1976). The number of English harvest failures were significantly higher between 1790 and 1815 than before or since, and the closing of continental sources of grain imports and the risks and uncertainty

involved in shipping during the Napoleonic wars decreased supplies and forced up grain prices. Only the remarkable elasticity of supplies of meat and grain from Ireland allowed England to avoid starvation (Thomas, 1985, p.143).

Gender was a significant factor in the height advantage of the Irish. Irish female heights rose, while the heights of females born in England fell. Rising heights for Irish women is consistent with co-dependent family based production. In Irish households, all family members performed labor, each was vital in the creation of final output, so each had a claim on the resources generated by the household. Sharing the work was related to sharing the rewards of labor, including access to food and nutrients which afforded Irish women sufficient nutrients to guarantee growth (Nicholas and Oxley, 1993).

In contrast English women grew up in households exposed to the full force of industrialization. There is abundant qualitative evidence that English women ate less well than men (Shorter, 1982). Unequal access to food for English women within common households can be related to expected labor market outcomes. Industrialization saw that employment opportunities for English women decline, leading families to allocate more food to males and less to women who could no longer find jobs in the paid labor market. For developing economies undergoing 'modernization', econometric studies have confirmed probable biases in the distribution of nutrients within the family related to declining job opportunities for women in the paid labor market.

Diet and access to food were not the only factors accounting for the height advantage of the Irish. Neglect of new-born children was not uncommon during the period of the Industrial Revolution, due to ignorant management, bad feeding practices and uncleanliness. There were significant differences in child-rearing practices between the Irish and the English (Smith, 1990, pp.71-88). The Irish were much more likely to breastfeed than the English,

and it was common for English children to be "reared artificially' (Smith, 1990, p. 71, p. 84). The Irish also had greater access to fresh milk for their children than the English, whose store-bought milk had a high probability of adulteration. Breastfeeding also meant fewer illnesses for Irish children with the diversion of fewer nutrients to fight disease.

Recently, Komlos (1991, 1989) cast the Irish height experience against a European wide erosion of nutritional intake that saw the heights of rural populations decline in line with the commercialization and market integration of subsistence agriculture. Our discussion of the impact on male heights of a narrowing Irish diet parallels the thrust of Komlos' argument that commercialization can reduce height. Komlos (1989, pp. 104-5) argued that while height and per capita income do not correlate well for subsistence economies, height correlated well with per capita food production. This hypothesis raises several problems when applied to the Irish economy. Per capita food production in Ireland was high, but meat, dairy and wheat consumption were low due to exports. Commercialization and integration did cause Irish heights to fall, but the Irish remained as tall or taller than the wealthier English well after market integration. The higher level of market integration after 1800 saw Irish heights stabilize near those for the tallest populations in Europe. Finally, the Irish economy had a complex mix of subsistence and market agriculture, and we show below that the Irish economy can not be partitioned into a subsistence sector with tall Irish and a market region with short Irish.

VIII. REGRESSION ANALYSIS

We further explore possible influences on height patterns using regression analysis. Following the discussion in the Methodology section,

attained height of an individual was a function of personal characteristics such as occupation and literacy, and environmental features such as the disease environment. Personal characteristics are available from the Indents and county-level environmental variables were gathered from the 1821 Census (Department of Industry and Commerce, 1936).

Ideally we would have liked data that measured the quantity and quality of the diet, income per capita of the household in which an individual grew up, a measure of exposure to disease, and a measure of work effort. However, we were able to construct proxies for some of these variables. Failure to find significant relationships for our proxy variables in the reported regression equations may be attributable to inadequacies of the proxies for the desired variables or to lack of association between the desired variables and stature.

The occupational groups (unskilled, skilled, public service, domestic service, professional/dealers) used to test for composition effects were employed here. Occupational height differences may have existed in part because occupational choice was governed by one's size and strength. Taller individuals, for example, may have selected jobs for which size was an asset while smaller people sought positions for which this attribute was unimportant. In addition, to the extent that positive intergenerational correlations existed for the occupations of fathers and sons, the occupational categories may reveal income or wealth differences that affected proximate determinants of growth such as diet, housing, and work effort. If the unskilled tended to have fathers who were also unskilled, for example, their stature may inform us about the net nutrition of children from laboring families.

Literacy may be a useful proxy for living conditions during the growing years. Because literacy was costly to the parents in terms of foregone income and direct outlays, one would expect that investments in literacy were one component of family resource allocation (Nicholas and Oxley, 1993). In good circumstances one would expect that parents invested heavily in child growth and education while in bad circumstances they economized on both. The relationship between literacy and net nutrition may be complicated by time lags, occupational structure, the demand for skilled jobs, the cost of education, public health measures, density of settlement, and other factors. Nevertheless, it is reasonable to suppose that a positive correlation existed between literacy and net nutrition during the growing years.

The frequency with which an individual is exposed to contagious diseases and the potency of the disease-causing organisms are hard to measure in the best of experimental circumstances that approximate the way people live simply because the organisms in question are not readily observable. Therefore, researchers usually resort to various proxies for the frequency of contact between people such as population density or rates of geographic mobility. We employ three such variables: (1) The proportion of each county's population involved in manufacturing or handicraft activities, which we argue approximates the frequency of interpersonal contact brought about by trade; (2) The migration rate of convicts as measured by the ratio of the number of convicts who moved into or out of a particular county divided by the convict population of the county, which approximates the rate of interpersonal contact through migration; (3) The average number of children under age 5 per house in each county. In view of Steckel's (1988) finding that the number of siblings in the household significantly reduced the chances of a child's

survival from 1850 to 1860, we argue that the number of children per house is a proxy for the probability of the spread of contagious childhood diseases.

We also experimented with a crude proxy for the diet--the average number of acres of land per house in each county (HOUSEDEN). This variable could measure the amount of land available for growing food, but we recognize its limitations in measuring diet: land may be of uneven quality or fertility, we do not know whether the land was in fact available to households for raising food, and if it was available for raising food we do not have information on foods produced that contributed to the diet.

Table 6 presents the results of the regression on individual heights. The table shows that individuals in public service--a class that includes military personnel recruited with minimum height standards--were systematically taller (1.52 inches) than professionals or dealers. Individuals in domestic service were systematically shorter (1.23 inches), possibly due to disadvantageous environmental backgrounds and selection into an occupation that did not require size or strength. Literate people had a modest height advantage (0.43 inches) over the illiterate, which is consistent with the hypothesis that parents who made investments in their children's education also invested in their growth and development.

Our crude measure of diet--house density--is statistically insignificant. Given that it is difficult to believe that diet was unimportant for growth, the result may be due to the poor quality of the proxy.[7]

The trade variable was statistically significant and reasonably large--increasing the proportion of the county's population involved in manufacturing or handicraft by 0.1 increased average height by 0.15 inches. This result is robust to other specifications including alternative measure of density such

as population per acre or number of people per square mile. Because it is an indirect measure of trade we note that other interpretations of the variable are possible. For example, this measure of occupational structure was probably positively correlated with income. However, one would expect that if income rose, other things being equal, heights would also rise. Given that the coefficient is negative, other things must not have been equal. We suggest that the trade involved with this type of economic activity probably increased interpersonal contact in ways that spread communicable diseases, which more than outweighed the health benefits from command over other resources made possible by the higher incomes from that trade. These environmental and disease factors help explain why an economically poor population such as the Irish were as tall or taller than the population of a much richer region.

Public health programs substantially reduced the adverse health consequences of interpersonal contact, thereby lowering the costs to society of migration and trade. We suspect, but obviously cannot conclude with the data at hand, that the inverse relationship we find between trade (or occupational structure) and health may apply only to societies that do not understand the germ theory of disease, or otherwise have in place effective measures of public health and personal hygiene. However, this conjecture is consistent with Floud's (1984) work on height and income in Europe and with work on child mortality in the United States by Steckel (1988) and by Preston and Haines (1991). Using a large sample of European countries for the period from 1880 to 1971, Floud found that the height and per capita income relationship was similar to that reported by Steckel (1983) for developed and developing countries of the mid-twentieth century. Yet, the child mortality studies for the mid and late nineteenth century (just before the germ theory

of disease became widely accepted) report that socio-economic status as measured by father's occupation and family wealth had little affect on the chances of a child's survival. The germ-theory revolution in medicine beginning in the late nineteenth-century may have helped to forge a relationship between socio-economic status and child health.

IX. REGIONAL PATTERNS

Marked regional variations in living standards are typical of many traditional and industrializing countries. In 1960 Lynch and Vaisey characterized pre-Famine Ireland as a dual economy split between a monetized East and a subsistence West. This thesis has been heavily attacked (Lee, 1971; Johnson, 1970; Mokyr, 1983) and Lee (1971) proposed an alternative characterization. Rather than a geographical split, he suggested two distinct but intertwined and mutual dependent economies, not separated either geographically or economically. To assess these completing dual economy hypotheses, and to uncover the existence of regional differences in living standards, we offer a new test which regresses final attained height of each transported convict on dummy variables for each convict's county, region and urban-rural location. Table 7 and 8 present a set of nested hypotheses regarding attained height and location. In the most general model, at the top left of each table, final attained height depends on whether a man or women was born in an urban or rural part of a specific Irish county, while the model at the bottom predicts one height for the whole country. Formally, the table tests whether the coefficients on the additional variables in the more general models (but excluded from the less general models directly below) are significantly different from zero. If the coefficients in the more general model are not significant (the F value is less than the critical value in

brackets immediately beneath), the reader should proceed to the next, less general, model. When the F value is greater than the critical value in brackets immediately beneath, the coefficients in the more general model are significant and should be accepted. For example, the most general interaction model on the left in the Table 7, which predicts that male Irish heights depended on whether a man was born in a rural or urban part of a particular Irish county, should be rejected. Similarly, the noninteraction model, which tests whether height depended on the county of birth and the urban-rural location of birth, can also be rejected. This is also true of the females in Table 8.

Counties were grouped together into specific regions based on Mokyr and O'Grada (1990, p. 28) scheme: Dublin and east Ulster; west Ulster; Connacht, Kerry and Clare; Munster less Kerry and Clare; and Leinster excluding Dublin. All the regional models can be rejected. The preferred model for Irish men and women is the urban-rural model, where height depended on whether a man or women was born in the rural or urban location. The urban-rural location model supports the dual economy hypothesis that the Irish cash and subsistence economy were intertwined and mutually dependent rather than two geographically separate sectors. If the subsistence and cash economies were continuous, living alongside each other, then urban-rural height differences, not regional ones, would explain male and female stature.

X. CONCLUDING REMARKS

Pre-famine Irish working men were poor and becoming poorer. The delayed growth spurt for Irish men and the downward trend in male heights for births between 1780 and 1800 indicate that the bottom half of the Irish population suffered declining living standards. Combined with Mokyr and

O'Grada's (1988) subjective poverty index, this suggests that the well-being of the bottom half of the male population declined over the whole period 1780-1845. But Irish women did not suffer a similar decline in living standards before 1820. Although the delayed growth spurt for women confirmed that females faced the same "hard times" as the males, females slightly improved their stature for births after 1790. This improvement can be explained by the distribution of food resources within pre-industrial family households.

While the Irish were poor, they were also tall. Irish men and women were as tall or taller than the much wealthier English. From a varied diet of mild, butter, meat, corn and potatoes before 1780, the Irish diet came to depend almost exclusively on the potato by 1800. This narrowing of the Irish diet not only explains the fall in the heights of Irish males, but why the Irish were as tall or taller than the English.

The Irish potato diet was nutritious, especially when compared with the diet of the English. Further, the English faced frequent harvest failures and blocked food supplies from the continent during the Napoleonic wars. Probably the English faced a different work effort due to the Industrial Revolution than did the Irish, but the this question needs further study. Our regression analysis suggests that the height advantage of the Irish also depended on the relative isolation of the Irish, measured by migration and trade, compared with the English. While these factors explain the Irish height advantage over the English, more research is required on the relationship between income and health, which is strong for the 20th century but appears weaker, if not inverse, in earlier periods. Studying other societies in transition from pre-industrial to industrial economies and from pre- to post-germ theory of disease will allow economic historians to gain insights into the relationships among height, health, and income as a measure of well-being.

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Table 1: Jarque-Bera Test for Normality

Sample	Jarque-Bera[a] (Chi-Square critical value 5.19)[b]
Irish Urban Males	1.88
Irish Rural Males	1.99
Irish Urban Females	3.82
Irish Rural Females	1.37
English Urban Males	2.21
English Rural Males	2.24
English Urban Females	2.81
English Rural Females	2.37

Source: Calculated from convict Indents.

a. The statistic tests whether the first four moments of the sample distribution are consistent with the normal distribution.

b. At 0.05 level of significance.

Table 2: Occupational Distribution of Transported Convicts, Emigrants to Boston, and the Irish Population, 1841

	Percentage Distribution by Occupational Category					
Sample	Laborers, Servants	Textile Workers	Farmers	Other Artisians	White Collar	Other
Convicts						
Male	72.2	5.9	1.1	15.2	2.6	3.2
Female	92.1	4.9	0.0	1.0	0.0	2.1
1841 Census						
Male	55.4	7.1	20.7	10.5	4.9	1.5
Female	33.7	59.9	1.9	0.7	3.4	0.4
Emigrants						
Male	62.7	3.5	10.4	20.5	2.7	0.2
Female	78.6	11.1	0.5	8.1	1.6	0.7

Source: Convict Indents; Mokyr and O'Grada (1982, p. 379); British Parliamentary Papers (1843, p. 440).

Table 3: Percentage Distribution of Skills, Convicts and Census of 1841.

Group[a]	Female Convicts	Male Convicts	1841 English Males
Professional	0.0	0.3	1.7
Intermediate	0.3	3.1	9.2
Skilled	49.8	45.6	45.2
Semi-Skilled	27.9	26.3	25.7
Unskilled	22.0	24.7	15.5

Source:

a. Armstrong (1972) classification.

Table 4: Adult Heights and T-Tests for Differences in Adult Heights

	English Rural	English Urban	Irish Rural	Irish Urban
		FEMALES		
Height (Inches)	61.65	60.75	61.29	61.14
English Rural		10.71*	5.71*	4.18*
English Urban			8.44*	3.68*
Irish Rural				0.73
		MALES		
Height (Inches)	65.96	65.44	66.10	65.82
English Rural		7.12*	1.94	1.39
English Urban			8.16*	3.57*
Irish Rural				1.09

Source: Convict Indents.

* Significant at 0.05.

Table 5: Explaining Irish Heights by Occupation and Cohort of Birth[a]

	Male[b]		Female[c]	
Variable	Rural	Urban	Rural	Urban
Occupation				
Unskilled	0.217	0.274		
	(0.723)	(0.728)		
Unskilled Rural			0.32	0.03
			(2.24)	(0.06)
Skilled	0.436	0.160		
	(1.411)	(0.427)		
Manuf. & Transport			-0.07	-0.69
			(-0.34)	(-1.11)
Public Service	1.834	0.796		
	(5.036)	(1.758)		
Domestic Service	-0.348	-0.008	0.31	-0.21
	(-1.001)	(-0.017)	(2.53)	(-0.50)
Year of Birth				
1790 - 1794	0.201	-0.253		
	(0.911)	(-0.949)		
1795 - 1799	0.020	-0.692	-0.004	0.48
	(0.096)	(-2.387)	(-0.28)	(0.89)
1800 - 1804	-0.085	-0.143	0.14	0.49
	(-0.400)	(-0.407)	(0.94)	(0.95)
1805 - 1809	-0.267	-0.353	0.05	0.59
	(-1.345)	(-1.136)	(0.03)	(1.18)
1810 - 1814	-0.064	-0.661	0.11	1.02

	(-0.326)	(-2.182)	(0.74)	(2.22)
1815+	-0.302)	-0.100	-0.17	0.24
	(-1.004)	(-0.191)	(-1.05)	(0.51)
Constant	65.84	65.89	61.02	60.23
	(207.88)	(173.41)	(425.13)	(113.22)
R^2	0.03	0.01	0.002	0.03
Observations	2,013	718	2,528	249

Source: Convinct Indents.

a. T-values in parentheses.

b. The omitted class is professional/dealers born before 1790.

c. The omitted class is a professional/dealer born before 1790 (males) or all other occupations born before 1795 (females).

Table 6: Explaining the Heights of Irish Male Convicts by Occupation, Literacy, Trade, Migration, and Density

Variable	Coeficient	T-Value
OCCUPATION[a]		
Unskilled	-0.109	-0.27
Skilled	0.203	0.50
Public Service	1.524	3.20
Domestic Service	-1.234	-2.66
LITERATE	0.426	2.38
TRADE	-1.588	-2.16
MIGRATION	0.211	0.46
CHILD	-3.919	-1.46
HOUSEDEN	0.00158	0.05
CONSTANT	65.877	87.99

Source: Calculated from Convict Indents and Irish Census of 1821 (Department of Industry and Commerce, 1936).

a. Based on Armstrong (1972) classifications. The omitted class is an illiterate professional/dealer.

FOOTNOTES

1. In conducting the tests we rounded heights to the nearest inch for females and the nearest quarter inch for males.

2. See Nicholas and Steckel (1991) and Nicholas and Oxley (1993) for assessments of the English data.

3. We calculated the modern height centiles based on data in Tanner, Whitehouse, and Takaishi (1966).

4. The definition of urban as towns of a population of 10,000 or more biases the urban recruits to the largest cities, underrepresenting smaller cities and towns (Mokyr and O'Grada, 1990, p. 8).

3. Urban-born Scots averaged 65.82 inches and the while the rural-born were 66.89 inches.

5. This dual economy hypothesis is tested in Section IX below.

6. It is also possible that variations in the diet (as measured by the proxy) within the sample were small, which would give a high standard error for the coefficient. However, the standard deviation of House Density was 3.65 compared with a mean of 10.03.

TABLE 7 REGIONAL MODEL
IRISH MALES

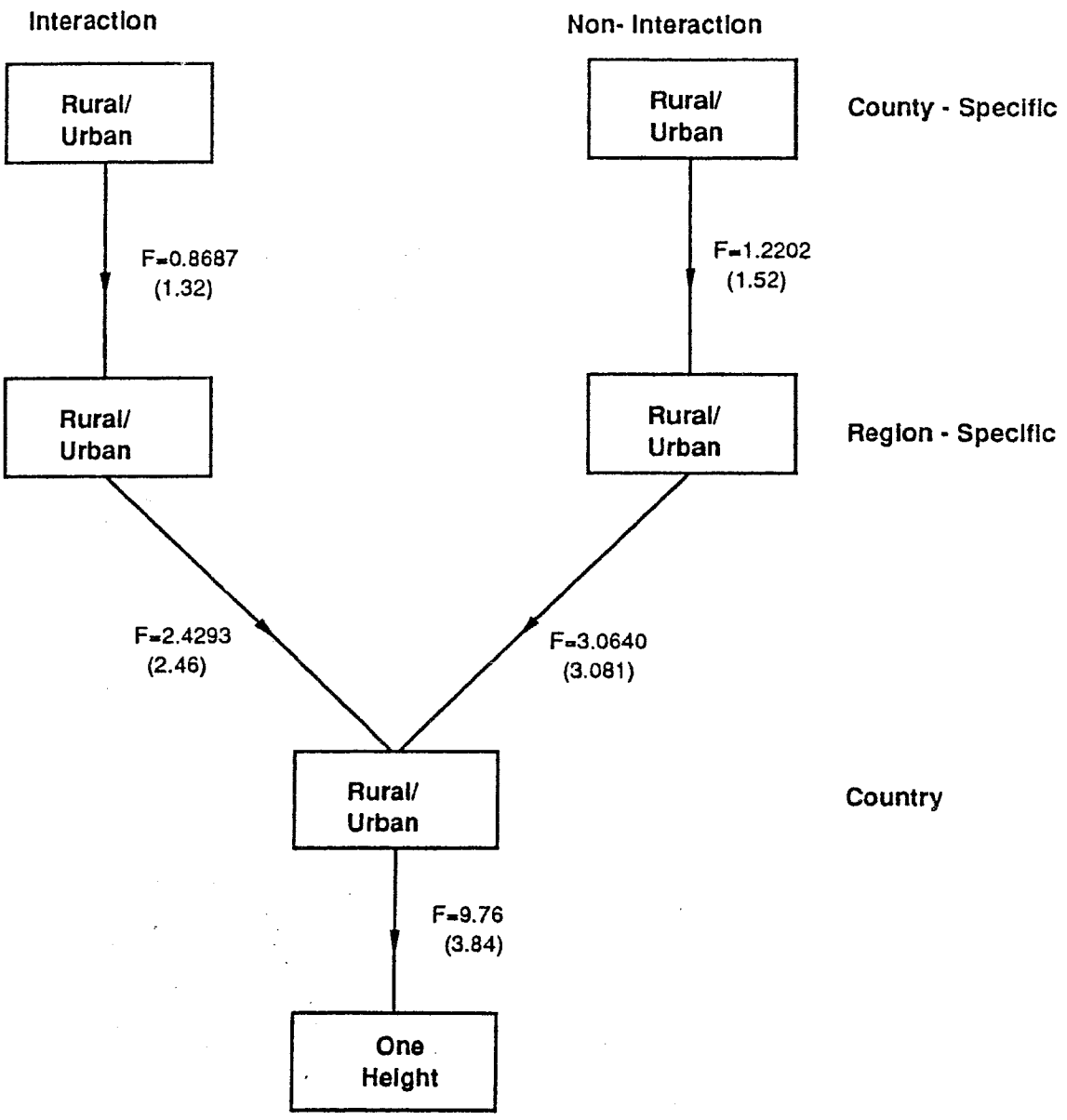

TABLE 8 REGIONAL MODEL

IRISH FEMALES

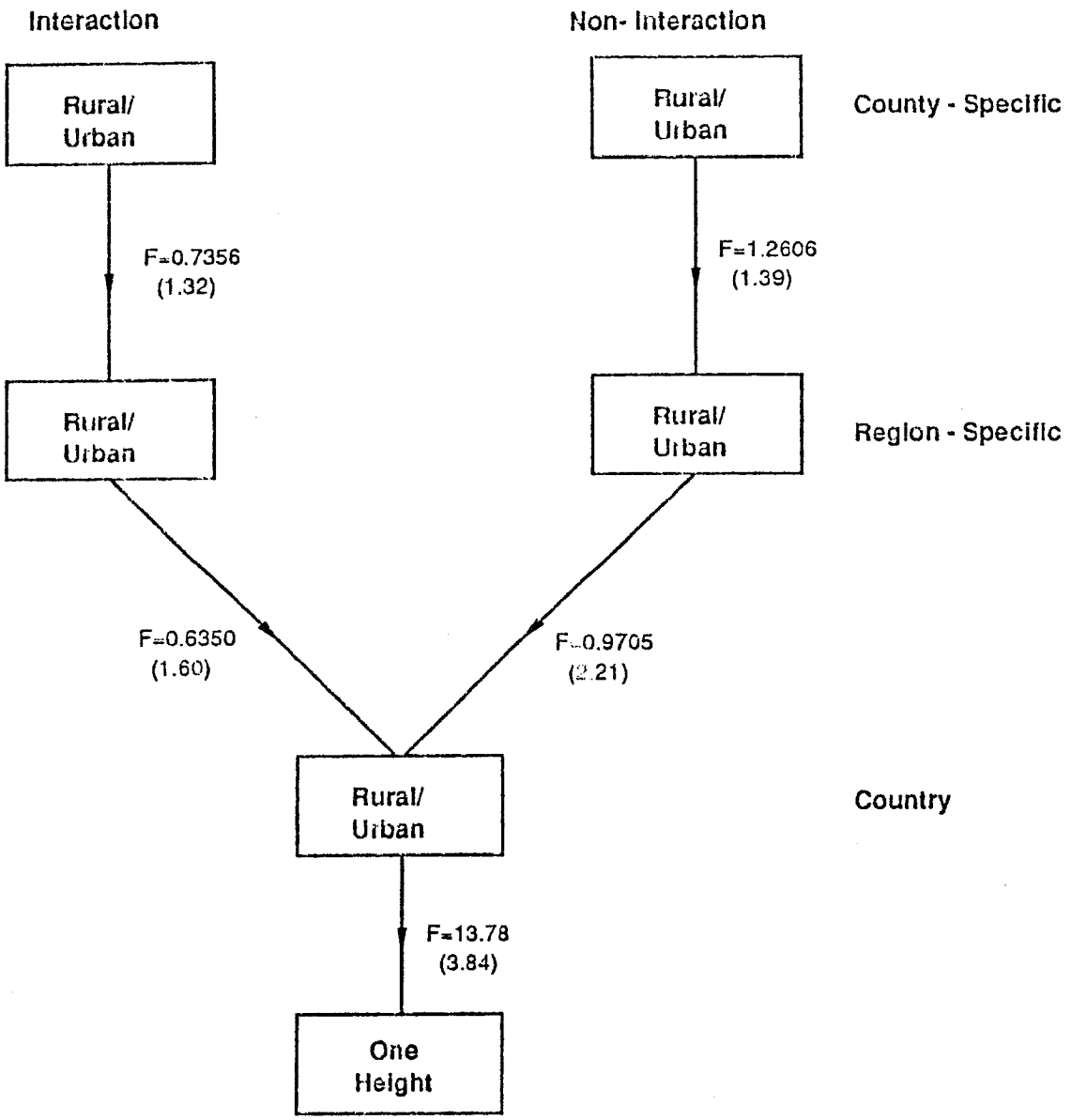

Figure 1. Male Irish and English Height by Age

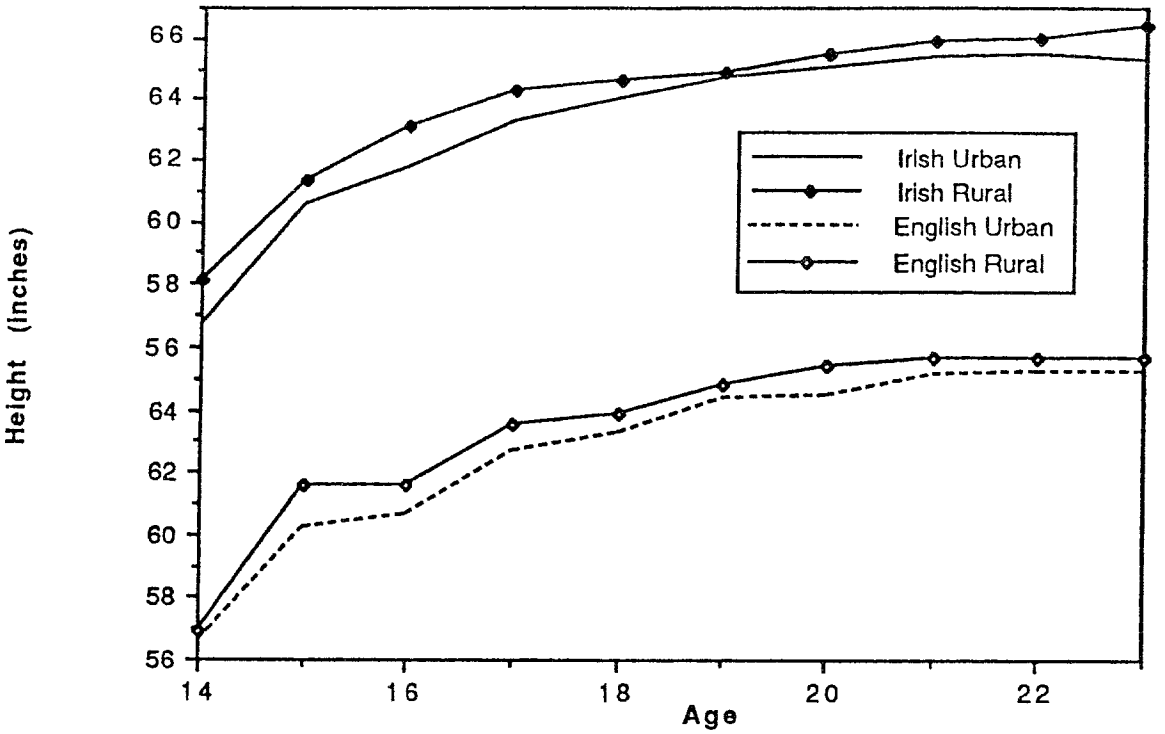

Figure 2. Female Irish and English Height by Age

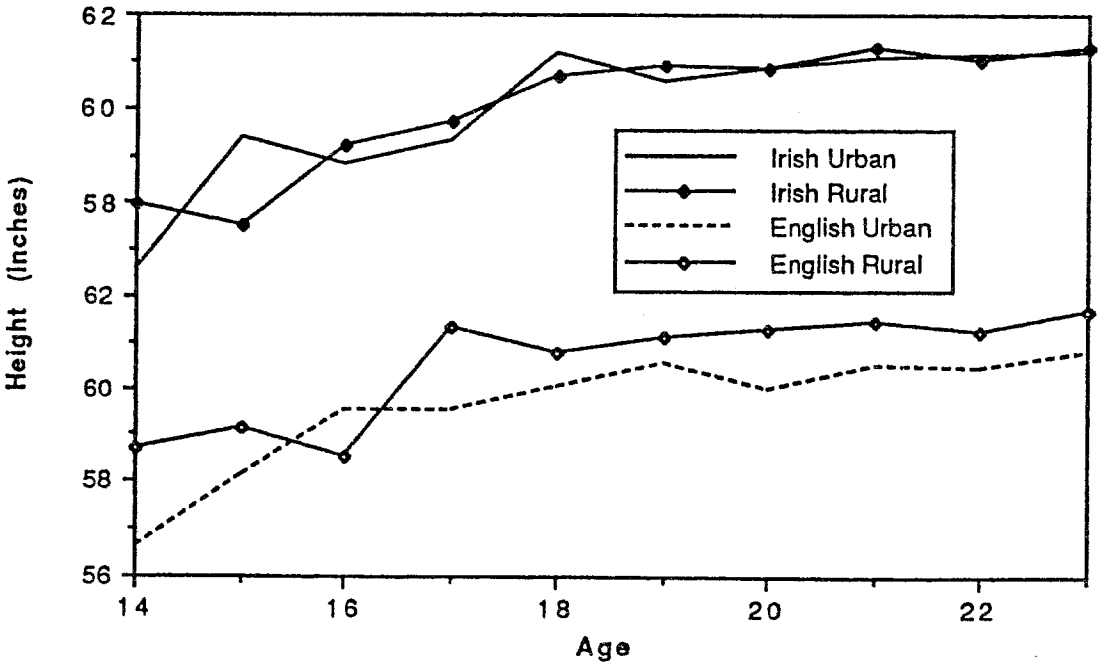

Figure 3 Irish and English Male Height Profile
(5 year moving average
for ages 23-49 years)

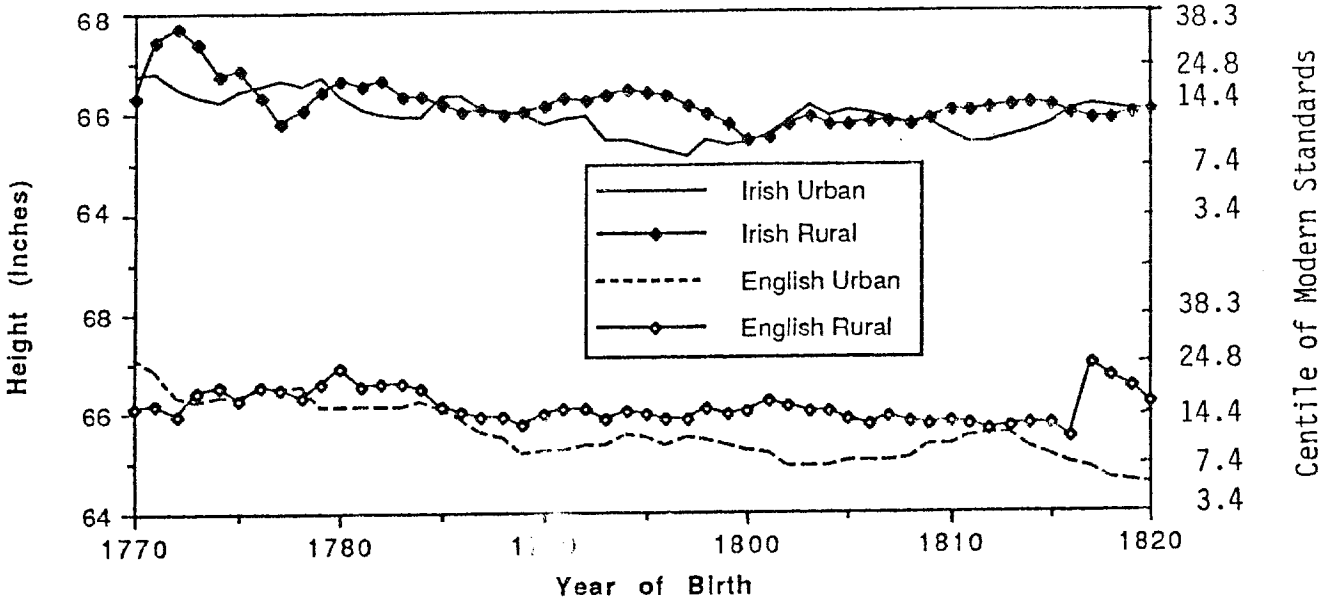

Figure 4 Irish and English Female Height Profile
(5 year moving average
for ages 21-49 years)