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Height and Health in The United Kingdom

1815 - 1860

Evidence From the East India Company Army

by

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HEIGHT AND HEALTH IN THE UNITED KINGDOM 1815-1860:
EVIDENCE FROM THE EAST INDIA COMPANY ARMY

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May, 1994

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For nearly half a century after the collapse of Napoleon's *grande armée* in 1813, the army of the East India Company was probably the world's largest. Native *sepoy* recruits accounted for the bulk of the Company's forces, but its army also included several European regiments, manned largely from the different regions of the United Kingdom. Between 1802 and the quelling of the Great Sepoy Revolt of 1857-8, almost ninety thousand Europeans embarked on the journey from the Company's barracks on the Isle of Wight to India as private soldiers in the Company's army. These men were born between the 1780s and the 1840s, decades straddling the era of the first Industrial Revolution. This study uses information in Company archives on their ages, their heights, their regional origins, and their occupations for insight into the health and welfare of the working classes in Britain and Ireland during the crucial period after 1815.¹ In companion pieces (Mokyr and Ó Gráda, 1989, 1994) we have analyzed the data on men and lads recruited in the 1770s and during the Napoleonic Wars (1802-1815). Here the analysis focuses on the post-1815 period, where the standard of living debate has been most intense, and where the economic picture is less distorted by the disruptions and exigencies of major wars. We also compare the outcomes for different sub-periods, and relate our findings to those of other workers in the field.

We first seek to establish the place of the East India Army recruits in the economy and the labor force that produced them (Part I). We then subject them to anthropometric analysis, noting shifting variations across regions and occupations (Parts II and III). We finally consider the implications of the outcome for the enduring debate about the welfare implications of early industrialization for British and Irish workers (Part IV).

1. THE INSTITUTIONAL AND ECONOMIC CONTEXT:

The European recruits of 'John Company' faced a tough life characterized by poor pay, disease, and a diet dominated by meat and massive drinking. The boredom of barrack life in India

was punctuated by campaigns of pacification and conquest such as the subjugation of the Marathas, the Burmese, the Sikhs, the Afghans and the ruthless suppression of the Great Mutiny of native recruits in 1857-8. The Sepoy Mutiny spelt the end of the East India Company and its great army. Its European regiments were quickly absorbed by her Majesty's forces. Predominantly Irish units in the Company's ranks would form the core of the famous Munster and the Dublin Fusiliers (McCanse, 1927; Mainwaring, 1911; Wylly, 1924; Cadell, 1950/1).

The pace and quality of enlistment in the Company's regiments varied with military requirements in India and labor market conditions back in the United Kingdom. This is reflected in the age distribution of the recruits, as described in Figure 1.

Figure 1: Age Distribution of Recruits, 1802-1860

During the Revolutionary and Napoleonic Wars the Company faced tough competition for men from His Majesty's forces throughout the United Kingdom (compare Chart, 1917), with the result that it was forced to relax its minimum entry requirements drastically.² Hardly surprising, then,

that between 1800 and 1815 the Company's was forced to rely heavily on adolescents, in effect indentured laborers, and very small adult men, although mean age was clearly increasing over time, possibly because of the ineffectiveness of teenagers as soldiers.³ Many of the teenagers would become victims of "the climate and their own imprudence" before seeing military action. In the depressed labor markets of the 1820s, the Company could have its pick of prime-aged men. Much later, in the wake of the Mutiny of the 1850s, the Company again raised the bounty offered to recruits and reduced its minimum height requirement in a desperate - and successful - attempt to attract men. At times during the interim, by way of contrast, the Company could afford to raise the minimum height requirement to sixty-six inches (McCance, 1927, p. 96).

As in all studies using data from volunteer armies, the question of selection bias must be paramount. How typical were these ninety thousand men of the population whence they sprung? Contemporary opinion seemed to describe them in terms that remind one of the French foreign legion: less the very dregs of society than individuals from a variety of backgrounds evading personal problems.⁴ The nicknames of their regiments - "the Dirty Shirts", "the Old Toughs", "the Lambs" - reinforce the recruits' reputation as "hard men". Yet if some of them were indeed adventurers or "black sheep", the previous occupations and birth-places of those recruited suggest a broad cross-section of the male labor force in these years. The recruits were by no means an undifferentiated mass of the very poorest unskilled laborers. The Company's enlistment registers contain some twelve hundred occupations between 1802-60, underlying the heterogeneity both of its intake and of the labor force during the Industrial Revolution. Though 'labourer' was the most common designation in the registers - accounting for about one-third of British and over half of Irish recruits - other occupations accounted for a majority of all job descriptions given. In this regard at least the representativeness seems confirmed: slightly over fifty per cent of Irish adults were identified as "labourers" in the 1841 census.

It is also striking that casualties of the Industrial Revolution such as handloom weavers and framework knitters featured prominently; the framework knitters largely in the 1800s and the 1810s, the weavers throughout.⁵ Occupations requiring a modicum of literacy such as 'clerk' or 'printer' also featured prominently. Movements in the proportion of recruits declaring employments that required literacy are a reasonably good proxy for fluctuations in the quality of the recruits (Figure 2). Thus former clerks, printers, teachers, and the like accounted for only five per cent of the total in the 1800s, when recruits were scarce, but they accounted for about one-fifth of the total in 1836, in 1843-4, and in 1848, years when the labor market was a buyer's market. Again, their share dropped from over ten per cent in 1854-6 to seven per cent in 1857-9. Curiously, perhaps, literate workers accounted for a higher share of Irish than British recruits before 1820, and Ireland's share continued to be high relative to its economic status, although a gap opened up between the two Kingdoms in the late 1820s and gradually widened over the next three decades. However, the shares of occupations requiring literacy in Ireland and Great Britain moved very closely in line at least until the disruptions of the 1840s. Thus, if we believe that the occupational structure of the recruits reflects market conditions, this suggests a high degree of economic integration between the two islands.⁶

Figure 2: Recruits declaring occupations requiring literacy

The Company found recruits in almost every corner of the United Kingdom. The registers indicate the parish or town and county in most cases. Irishmen were typically over-represented: for most of the pre-Famine period Ireland, though accounting for less than one-third of the population of the United Kingdom, they supplied nearly half of the intake (compare Carsten, 1983; Cadell, 1950/1). However, the proportion of Irish recruits declined markedly at readily identifiable points in time: after the Napoleonic Wars and after the Great Famine. As the Irish data move in opposite direction to the Scottish and English data, it seems that the data clearly indicate that labor market considerations ruled recruitment scene (Figure 3).

Figure 3: Recruits by Origin

If we define towns as places containing over ten thousand inhabitants in 1800, then urban populations were always over-represented in the Company's army (Figure 4). Dublin stands out in this respect. Throughout this period less than three per cent of Ireland's population lived in Dublin, but the Irish capital's share of Irish eighteenth century recruitment was twelve per cent during the Napoleonic Wars and still nine per cent in the early 1840s.

Within Ireland recruits from Leinster were over-represented, but the changing regional balance within Ireland is interesting. East Ulster, the cradle of Ireland's industrial revolution, provided relatively few men throughout, very similar to the industrializing counties in Britain. The share of recruits supplied by the western and southern counties of Ireland (defined as Regions 13 and 15 in the appendix) rose over time: this could indicate either relative impoverishment or commercialization. Scotland was usually not a fertile field for the Company, though Scots were over-

represented in the 1840s. Table A.1 in the appendix provides the details decade by decade.

Figure 4 Recruits from urban areas

Despite the misgivings of contemporaries on the recruitment methods, the records suggest that supply was sensitive to labor market conditions.⁷ This means that shifts in pay and conditions in 'civvy street' affected the quality of the Company's military intake and their heights. How did soldiers fare in these decades relative to the majority who opted for civilian life? Trends in unskilled and semi-skilled wage levels should provide a benchmark. In Britain, farm laborers saw little increase in their nominal wages during the decades considered here, but the nominal wages of blue collar labor rose by about one-third between the 1800s and the 1850s. Such changes would have been subject to considerable regional variation; the wages of skilled workers rose more (Lindert and Williamson, 1983, Table 2; Hunt, 1986). In Ireland in the 1840s the average worker would have been quite happy with the shilling a day reported by Wakefield for the late 1800s (1812, II, p. 229), but nominal wages certainly rose in the wake of the Great Famine. Wage data are only one, imperfect

gauge of the trend in living standards (Mokyr, 1993, pp. 123-5; Mokyr and Ó Gráda, 1988); nevertheless, they offer a plausible 'first cut' guide to the relative status of soldiering.

Pay and conditions in the army are more difficult to pin down. The East India Company divided the territory under its jurisdiction into three 'presidencies'. It paid men serving in its Bengal presidency, deemed the least arduous, less than those in the Madras or Bombay presidencies. In the 1830s a Bengal private with over seven years service obtained 9 rupees and 10 annas, considerably less than the 13-14 rupees earned by his colleagues in Madras and Bombay (British Parliamentary Papers, 1841). Conditions improved thereafter, yet still "in the 1840s and 1850s... a British soldier in India after stoppages and deductions was paid at the end of the month less than 9 rupees in cash". Since the Company always competed with the regular army for men, its terms mirrored those offered by H.M. forces, so information on terms in the regular army is also apposite. The record on the daily pay of private infantrymen in the regular army is straightforward. Between 1660 and 1792 it had remained steady at sixpence. In 1793, at the onset of the French Revolutionary wars, it rose to 12d, where it remained until the 1850s (British Parliamentary Papers, 1830, p. 8; Skelley, 1977, p. 182).⁸

These were gross sums, however; the cost of food and clothing provided in barracks was deducted at source.⁹ In India in the 1840s and 1850s, after such deductions a soldier was left 'at the end of the month less than nine rupees in cash' (Mason, 1974, p. 201). Working conditions, minimum periods of service, bounties, promotion prospects, and other perquisites also varied over time (Glover, 1963, p. 214). Above all, what attracted people to recruit must have been the security of the pay that survivors could count on, and the bounties received. In the mid-1800s, when the war against Napoleon was its height, huge bounties could be had, and men could also earn large lump sums as substitutes (Fortescue, 1897-1930, V, pp. 200-2; Floud *et al.*, 1990, p. 40n; McAnally, 1949, p. 233). Bounties faithfully reflected demand and supply. Good conduct pay beginning at one penny

a day after three years service was introduced in 1836 (Laffin, 1966, p. 153). In 1846 the minimum period of service was reduced to ten years for infantrymen (Bayley, 1977, pp. 19-20). It is such changes that make evaluating the trend in soldiers' living standards so difficult. Floud *et al.* (1990, pp. 39-40) doubt whether the problem 'can ever be resolved'.

Shifts in the occupational profile of the recruits are consistent with the hypothesis of relative decline in the quality of recruits. First, as noted, the proportion of recruits declaring employments requiring literacy fluctuated considerably from decade to decade, but it failed to register any sustained increase after 1815, and there are some signs of a decline in the proportion towards the end of the period under review (Figure 2 above). How does this crude, lower-bound guide to literacy among recruits compare the trend in literacy among the young male population as a whole? Trends in literacy in Ireland and Britain in this period have still not been firmly established. However, though there is no evidence for marked change in Britain or in Ireland before mid-century, the indications are for some improvement (Mitch, 1993; Logan, 1993; Ó Gráda, 1994). By this criterion, the 'quality' of Company recruits was hardly keeping pace. Secondly, the proportion of

Figure 5: Proportion "labourers" by Kingdom

those returned as 'labourers' - presumably men without much training or skill - increased from the late 1820s on, with the only exception the Irish after the Famine (presumably because the demographic effects were most severe among the poorest (Figure 5)).

Thirdly, after the 1820s the proportion from a (presumably healthier) rural background declined faster than the rural proportion of the population at large (Figure 4). In the 1820s the share of recruits from rural backgrounds still exceeded seventy per cent in Great Britain and eighty per cent in Ireland; by the 1850s the respective percentages were sixty and forty. Fourthly, another sign of poorer quality in the 1850s is the substantial number of recruits passed fit despite physical defects. For example, of 7,106 men recruited between 1853 and 1856, 264 had ailments ranging from scars and leech bites to varicose veins, ulcers, and a defective heart. The final four thousand or so to pass through the Company's recruiting stations included thirty-three with flat feet, twenty-one with curved spines, three with squints, one with an eyecast, one 'paralysed', one 'emaciated', and dozens with other marks or ailments.

II. HEIGHTS AND NUTRITIONAL STATUS: A FIRST APPROXIMATION

Several recent studies have used historical information of the heights of population subsets such as soldiers, cadets, slaves, and prisoners for insight into the nutritional status and living conditions of the population at large (Le Roy Ladurie, 1973; Komlos, 1985; Floud *et al.*, 1990; Komlos, ed., 1994). The East India Company registers are a rich source of data on the heights of its recruits, which we now exploit.

The records used here contain information on nearly ninety thousand men and boys. Heights are usually given to the nearest quarter or eighth of an inch, ages in years. There clearly was some scope for unscrupulous recruits to lie about age, height, and background.¹⁰ Nor could the Company prevent some young men from exaggerating their ages and older men from hiding theirs. As expected, our EIC data also revealed some obvious age- and height-heaping, a common problem in

this kind of source. This does not bias our estimates but it reduces their precision. More serious are the signs of age mis-reporting: for example, the imposition of an age-minimum such as twenty years was regarded by an unknown number of candidates as an invitation to exaggerate their ages.¹¹ All the same, we have found no evidence that such errors and biases systematically invalidate the cautious use of these data.

The army always imposed some minimum height requirement on its recruits, but this minimum varied according the labor supply conditions and the Company's need for soldiers. Because some of the estimates we use depend on where the height data are truncated, the minimum height dictated how to divide the data into sub-periods each applying a common minimum height requirement. Sixty-five inches was the most common standard, but during 1802-14 the Company applied a standard of sixty inches, and during the Sepoy Revolt sixty-two and sixty-three inches. Thus in all periods the recruits' heights distribution was deficient at the lower end. Wachter and Trussell (1982) developed an algorithm devised to 'restore' missing height observations and produce an estimate of the population mean known as the quantile bend estimator (QBE). In an earlier study of the Company's intake during the Napoleonic Wars (Mokyr and Ó Gráda, 1994), we made extensive use of the QBE; however, applying it in subsequent sub-periods proved impracticable. When the minimum height was raised and the truncation point moved up to a value around the mean of the population, estimating the population mean became increasingly unreliable. The QBE in such circumstances failed to converge, or converged to a number of local likelihood maxima.

In this section we apply two simple procedures to the data. Though these procedures do not yield estimates of the mean heights of each subpopulation, they allow comparisons based on men who were drafted in a given period. First, we simply computed changes over time in the raw mean heights of adult recruits (aged 21 and over) for different subgroups, and compared them. The results of this exercise are given below in Figures 6-8 (in five-year moving averages). Clearly, not much

should be made of changes in the *size* of the gap between groups, given the fluctuations in minimum entry standards and labor market conditions. However, since all groups faced the same minimum at any point in time, the *sign* of the gap is significant. Thus the implication of Figure 6 is that the population supplying Scottish recruits was taller than that supplying either Irishmen or Englishmen, and that the corresponding Irish population had the edge over the English. Similarly, rural areas provided taller recruits than urban throughout (Figure 7), and occupations requiring literacy also conferred a height advantage (Figure 8).

Figure 6: Raw Height of adult recruits by kingdom, five-year moving averages.

Figure 7: Raw Height of adult recruits by area of origin, five-year moving averages.

Figure 8: Raw Height of adult recruits by occupation, five-year moving averages.

The shortcoming of raw height data is that they do not adjust for all variables simultaneously.

For some purposes this may not be desirable: it may be the case that the Scottish were better educated which was correlated with unobserved variables relating to their height. Correcting for occupational breakdowns, then, would give us the "net" and not the "gross" effect. Our second exercise with uncorrected heights data therefore involved running a regression for each year of the form:

$$HEIGHT = a + b_1 \cdot AGE + b_2 \cdot AGESQ + b_3 \cdot AGECUB + b_4 \cdot IRL + b_5 \cdot SCOT + b_6 \cdot LABOR + b_7 \cdot TRADE + b_8 \cdot LITER + b_9 \cdot RURAL$$

where *AGE* is age in years and *AGESQ* and *AGECUB* are age squared and cubed respectively, *HEIGHT* is height in inches, *IRL* and *SCOT* nationality dummies, *LABOR*, *WEAVER*, *LITER*, and *TRADE* occupation dummies, and *RURAL* a dummy for rural origin. This involved using the English

and Welsh as the control on nationality, and an assortment of workers in the clothing, construction, and miscellaneous sectors, as the control on occupation. The procedure does not yield unbiased estimators as the left hand variable is clearly truncated and the specification suffers both from omitted variables and errors in variables problems (especially misreporting and heaping in the heights and ages). All the same, the dummies reflect the *net* effects of each variable. Thus, for example the dummy variable on Ireland reflects the difference in height between Irish recruits and the control group, holding age and occupational structure constant.

The estimates of the annual gap (in five-year moving averages) for the period 1815-1860 are presented in Figures 9-11.

Figure 9: Irish and Scottish relative heights, 1815-1860 (regression coefficients on Kingdom dummies)

Figure 10: Relative Heights of Rural recruits (regression coefficients on rural dummy variable)

Figure 11: Relative height of various occupations (regression coefficients of dummy variables).

The results indicate that relative to England, the Irish and especially Scottish recruits were consistently taller, whether we employ a gross measure (Figure 6) or a net one (Figure 9). With the exception of the 1820s, this trend persists through our period and seems to pick up again toward its very end. It seems plausible that the temporary diminution of the gap in the 1820s reflects particularly poor conditions in English labor markets, inducing higher quality English recruits to join in for a few years. Excepting those years, the regressions confirm what much recent research has stressed, which is that the poorer and less developed areas in the Celtic fringes supplied taller recruits. This casts serious doubts on the easy nexus between nutritional status and standard of living as conventionally defined. A similar picture emerges from Figures 7 and 10, showing that rural areas tended throughout the period to supply somewhat taller recruits than urban areas. Finally, Figure 11 demonstrates, however, that the nexus between height and socioeconomic status more broadly defined holds: recruits with occupations that required some literacy were consistently taller than the reference group. Laborers were somewhat shorter than the reference group in the first decades of our period, but the difference disappears after 1830.

Similar regressions can be used to analyze the different kingdoms and look at regional breakdowns. The analysis for England, unfortunately, provides rather inconsistent results, and despite the large sample sizes, many of the coefficients are small and insignificant. The one result that seems to be consistent is that recruits from rural areas are taller than those from urban areas, and that London and Southern recruits were in most cases smaller than the reference group and that recruits from the industrializing counties were on the whole taller than the rest for most of the period. For Ireland, the results suggest the regional dimension was important there too. Using Leinster (excluding Dublin) as a control, all regional dummies yielded negative coefficients in 1802-4. But over the period as a whole, the poorest regions by this criterion were the south and west. Ex-

weavers were typically about half an inch shorter than the control occupation, while literacy conferred an advantage of nearly an inch. Recruits from Dublin were consistently 0.2-0.3 inches shorter than the rest.

The results are presented in Table 1.

Table 1: REGRESSING NATIONALITY AND OCCUPATION ON HEIGHTS

Period	N	RURAL	IRL	SCOT	LABOR	WEAVER	LITER	TRADE
1802-08	4041	.00	.20*	.05	.05	.13	.15	.14
1809-14	7237	.05	.40*	1.76*	-.22*	-.27*	.86*	-.01
1814-19	6405	.22*	.47*	1.22*	-.30*	-.22*	.65*	.16
1819-23	7667	.19*	.08*	.36*	-.33*	-.22*	.47*	-.11
1824-29	9573	.14*	-.16*	-.02	-.23*	-.28*	.66*	.18*
1829-31	1618	.11	.11	.12	-.16*	-.27	.57*	.23
1831-34	2205	.10	.14*	.47*	-.07	-.19	.34*	-.01
1835-38	1188	.23*	.08	.12	-.02	-.02	.23	.05
1839-41	6834	.20*	.01	.39*	-.10*	-1.4	.61*	.11
1841-45	4701	.13*	.02	.19*	-.07	-.24	.49*	.11
1846-47	2342	.08	.03	.09	-.15	-.47*	.56*	-.13
1847-50	4347	.12*	.21*	.37	-.11	-.65*	.45*	-.10
1850-53	4471	.19*	.16*	.23*	-.05	-.53*	.42*	-.16
1853-56	7105	.08*	.07	.09	.03	-.19	.59*	.03
1856-57	2117	.03	.09	.26*	.16*	.25	.30*	.03
1857	1926	.53*	.09	.10	.15	.53*	1.16*	.41
1858	4419	.31*	-.22*	.03	-.02	-.33*	1.52*	.14
1858-60	8328	.17*	.38*	.55*	-.06	-.41*	1.12*	.28*

Note: an asterisk denotes statistically significant at five per cent

The outcome reported in Table 1 prompts several conclusions:

1. The coefficient on *IRL* is small but positive in most periods, suggesting that being Irish conferred some height advantage. This can plausibly be linked to the superior quality of the pre-Famine Irish staples of potatoes and buttermilk. However, averaged out over the entire period, the gap (weighted by sample size) was small - just over one-tenth of an inch. Though the Irish height advantage shows some signs of having declined after 1814, being minimal between the late 1830s and the later 1840s (i.e.

for recruits born c. 1815-35), it was never quite whittled away.

2. Again, Scottish recruits were taller than either the English or the Irish virtually throughout.

3. The negative coefficients on *WEAVER*, usually in the 0.2-0.5 inch range, fit the historiographical consensus that handloom weaving, typically an occupation that was passed on from father to son, fell on hard times and suffered from steeply declining living standards in this period (e.g. Thompson, 1968, ch. 9).

4. Workers in occupations requiring literacy were consistently taller than the rest. Their height advantage usually exceeded half an inch, but exceeded an inch in the intake recruited to quell the Sepoy Rebellion. Such large coefficients suggest that parents who obtained schooling for their children also had the resources to feed them better. Other data confirm this pattern of higher parental income generating both better schooling and healthier physiques (e.g. Ó Gráda, 1992).

5. The outcome also is also consistent with another piece of conventional wisdom about social conditions during the Industrial Revolution: the claim that urbanization entailed the sacrifice of a healthier living environment (e.g. Williamson, 1990, ch. 9). During the decades considered here, growing up in a rural area conferred an adult height advantage of 0.1-0.2 inches.

Also of interest are regional patterns within Ireland and Great Britain. In order to examine this question, we divided the United Kingdom into the seventeen areas described in the appendix. We then regressed height on AGE terms, occupational dummies for *LITER* and *WEAVER*, and on a series of regional dummies (eleven for Great Britain, six for Ireland). We carried out separate exercises on each island.

Table 2 describes the outcome for England. The coefficients on the rural dummy are generally positive, and those on London negative. This outcome is consistent with the view that urban environments during the Industrial Revolution were relatively unhealthy. The coefficients on the 'South' dummy imply that men recruited north of a line stretching from the Severn to the Mouth of the Thames between the

1820s and the 1850s were taller than southerners. However, the coefficients on the 'industrial' dummy, set = 1 for Lancashire, the West Riding of Yorkshire and Cheshire show no consistent pattern over the period.

TABLE 2: EXPLAINING THE VARIATION IN ENGLISH HEIGHTS

Years	n	Rural Dummy	Industr. Dummy	London Dummy	South Dummy
1814-19	2431	-.0055	.369	.119	.229*
1819-29	7755	.083*	-.078	-.165*	-.100
1831-38	1560	.080	.088	-.262*	-.102
1839-41	3075	.202*	.154*	-.061	-.025
1841-45	2465	.103	-.159	.272*	.027
1846-47	905	.038	-.161	-.257	-.206
1847-50	1235	.187	.166	.005	-.199*
1850-53	1295	.434*	.275*	-.147	-.344*
1853-56	2875	-.003	.082	.088	.211*
1857	980	.717*	.604*	-.216	-.239
1858	2142	.252*	.216*	-.049	-.088
1858-60	4588	.094	-.104	-.340*	-.037

As Table 3 shows, the regional dimension was important in Ireland too. Using Leinster (excluding Dublin) as a control, all regional dummies yielded negative coefficients in 1802-4. But over the period as a whole, the poorest regions by this criterion were the south and west. Ex-weavers were typically about half an inch shorter than the control occupation, while literacy conferred an advantage of nearly an inch. Recruits from Dublin were consistently 0.2-0.3 inches shorter than the rest.

Table 3: EXPLAINING THE VARIATION IN IRISH HEIGHTS

Period	N	DUB	EU	WU	WEST	EMUNST	LITER	WEAVER
1802-14	5598	-.24*	.03	-.30*	-.41*	-.36*	1.05*	-.39*
1802-09	2259	-.19	-.07	-.37*	-.27*	-.47*	.30	-.19
1810-14	3339	-.29*	.24	-.15	-.52*	-.29*	1.05*	-.51*
1814-19	3094	-.30*	.14	.01	-.31*	.16	.83*	-.21
1819-29	7857	-.10	.29*	.09	-.00	-.00	.80*	-.31*
1847-50	2575	-.37*	-.36*	-.32*	-.19*	-.19*	.72*	-.46*
1850-53	2352	-.25*	-.33*	-.07	-.13	-.23*	.50*	-.46*
1856-57	953	-.25	.08	-.06	-.38*	-.11	.31	-.05
1858-60	2786	-.28*	.07	.26	-.09	.46*	1.33*	-.49*

Note: asterisks imply .05 statistical significance

EU = East Ulster WU = West Ulster DUB = Dublin
 West = Connacht plus Clare and Kerry EMUNST = rest of Munster

Tables 2 and 3 underline the hazards in drawing inferences from this kind of source: There are patterns in the data, such as the regional differences, above all the lower stature of recruits from London and Dublin, and the occupational differences, the gaps tend to fluctuate rather strongly from period to period, and disappear at times. What is obviously happening is that the *composition* of the sample of recruits is determined by market forces affecting the characteristics of each regional sample without necessarily having similar effects on the population.

III: HEIGHTS AND NUTRITIONAL STATUS: MAXIMUM LIKELIHOOD

The main shortcoming of the analysis above is that it does not allow us to estimate the population means, because of the changing truncation point over time. What is necessary is a procedure that estimates a population mean from the truncated records such as the QBE estimator mentioned above. Because the QBE could not be used for our data, we exploit the well-known properties of the normal distribution that permit the estimation of a population mean from a normal distribution. For this procedure to work, we need the underlying population to be normally distributed. In practice, this is never fully attained. The deviation from normality is the result of the mixing of

younger recruits (who had not attained their full height) with adults, of heaping and errors in measurement, and of possible truncation on the high-end tail of the distribution. It is also possible that we may be mixing unwittingly samples with different cut-off points (although we have made an effort to avoid this as much as possible, the cut-off points are not declared and had to be inferred from the data).

The technique below is based on a maximum likelihood estimate of truncated normals utilizing the GAUSS software.¹² The idea is simply that if we have a variable $Y \sim N(\mu, \sigma^2)$, the density and distribution functions are given respectively by

$$f(y) = \frac{1}{\sigma} \phi\left(\frac{y-\mu}{\sigma}\right) \quad \text{and}$$

$$F(Y) = \Phi\left(\frac{Y-\mu}{\sigma}\right)$$

and we draw our Y^* only from a point above c^* , the density function of this truncated normal can be written as

$$f(Y) = \frac{f(Y)}{P(Y > c^*)} = \frac{\frac{1}{\sigma} \phi\left(\frac{Y-\mu}{\sigma}\right)}{1 - \Phi\left(\frac{c^*-\mu}{\sigma}\right)} \quad \text{for } Y > c^*$$

$$= 0 \quad \text{for } Y < c^*$$

Which gives the log likelihood function

$$\log L = \sum \log \frac{1}{\sigma} \phi\left(\frac{y_i - \mu}{\sigma}\right) - \log \left[\left(1 - \Phi\left(\frac{c - \mu}{\sigma}\right)\right) \right]$$

$$= -n \log \sigma - \frac{n}{2} \log (2\pi) - \sum \frac{(Y_i - \mu)^2}{2\sigma^2} - \log \Phi\left(\frac{\mu - c}{\sigma}\right)$$

GAUSS calculated the maximum likelihood estimators of the mean of the full normal from the observations from the truncated normal plus a given truncation point.

To test the sensitivity of the estimators to the various problems we mentioned, we tested it on simulated data. Table 4 below provides the results of two such experiments. In the first we created a sample of 10,000 random numbers distributed normally with mean $\mu = 65$ and s.d. $\sigma = 2.50$, approximating observed height data. In the second we created two samples of 5,000 random numbers each, one with $\mu = 65.00$ and $\sigma = 2.50$ and one with $\mu = 63.00$ and $\sigma = 2.50$, and pooled them. The pooled sample will of course be non-normal and have a combined s.d. slightly higher than 2.50.

The results suggest that for the normal distribution the estimates become seriously unreliable at a truncation point that exceeds the mean by about 1" (or slightly less than one half standard deviation). In the mixed distribution, the main difference seems to be that the standard errors are somewhat bigger, but otherwise the procedure seem to work just about as well.

TABLE 4: MAXIMUM LIKELIHOOD ESTIMATIONS OF SIMULATED DATA

	$\mu=65.00, \sigma = 2.50$			Mixed Sample (see text)			
Truncat ion Point	observ includ	$\hat{\mu}$	$\hat{\sigma}$	Truncat ion Point	observ. includ.	$\hat{\mu}$	$\hat{\sigma}$
Full sample	10,000	64.99	2.502	Full sample	10,000	64.019	2.707
60"	9769	64.99 (.027)	2.504 (.022)	59"	9653	64.04 (.031)	2.68 (.025)
61"	9421	65.01 (.031)	2.49 (.026)	60"	9305	64.04 (.036)	2.69 (.029)
62"	8798	65.04 (.040)	2.47 (.030)	61"	8652	64.07 (.041)	2.67 (.034)
63"	7857	65.06 (.057)	2.46 (.038)	62"	7672	64.19 (.062)	2.61 (.041)
64"	6536	65.15 (.088)	2.42 (.049)	63"	6496	64.17 (.099)	2.62 (.054)
65"	5039	65.08 (.158)	2.44 (.070)	64"	5049	64.36 (.149)	2.54 (.069)
65.5"	4235	65.16 (.201)	2.41 (.082)	64.5"	4350	64.33 (.200)	2.55 (.084)
66"	3460	65.29 (.252)	2.37 (.095)	65"	3643	64.37 (.262)	2.54 (.101)
66.5"	2724	65.90 (.247)	2.18 (.092)	65.5"	2956	64.63 (.312)	2.45 (.113)
67	2113	66.25 (.282)	2.07 (.099)	66"	2363	64.56 (.442)	2.47 (.145)
68	1159	66.74 (.439)	1.95 (.132)	67"	1364	65.36 (.600)	2.26 (.183)
69	560	63.29 (3.11)	2.63 (.55)	68"	698	66.18 (.872)	2.06 (.247)
70	208	38.41 (90.16)	5.11 (6.94)	69"	322	64.83 (3.56)	2.34 (.724)

Given the standard problems of shortfall and truncation, a loss of data is inevitable. For this reason, only the results for Ireland and England can be deemed reliable for many periods, though Table 6 contains comparisons between Ireland and Scotland.

The results of this exercise, using a common truncation and period, are reported in Tables 5 and 6. We adopted the following rules for exclusion. First, all comparisons use a common truncation point (T). Second, only comparisons using a sample size of 200 or more are used. Third, where in one or both countries the estimated standard deviation of the mean height of the reference population is outside the range of 1.95-2.99 inches or where the standard deviation of the mean is greater than one, the results were rejected. These conditions ruled out data for the most of the 1830s and for part of the 1850s. We look at adults and young men (aged 20 or 21 years) separately.

There is a clear connection between T and h' . This does not necessarily mean that the procedure is defective. In years when the height limit was low, the mean height of men in the pool supplying recruits was also low. For this reason, time series inferences about the Irish or the English alone are perhaps risky. Nevertheless, broad comparisons are warranted. The results confirm that Irish heights are generally greater than English, though the gap between estimated heights (GAP) is sometimes negative. Minus signs are most noticeable in the 1840s, referring to men born in the 1820s. Yet on this evidence, it would be difficult to reject the claim that the Irish poor born between the 1780s and the 1840s were at least as tall as the English. Table 6 shows that Scottish workers were taller than either Irish or English (confirming the findings of Floud *et al.*, 1990, pp. 202-9).

TABLE 5: ESTIMATED MEAN HEIGHT (h') OF IRISHMEN AND ENGLISHMEN c. 1800-1860

		<u>Ireland</u>		<u>England</u>		
Period	T	h'	N	h'	N	GAP
<u>A. YOUNG MEN:</u>						
1801-10	63.0	65.68	245	64.14	213	+ 1.34
1811-4/1814	63.5	65.95	292	65.22	227	+ 0.73
5/1814-2/1819	64.0	67.64	505	66.85	352	+ 0.79
3/1819-9/1829	65.0	65.91	1235	65.44	1334	+ 0.47
10/1829-3/1831	66.25	66.17	492	65.44	318	+ 0.73
4/1839-12/1839	65.5	65.89	234	65.64	180	+ 0.25
6/1841-12/1845	66.0	64.62	735	66.47	1109	- 1.85
7/1847-1/1850	66.0	65.09	1523	66.20	648	- 1.11
9/1853-1854	65.5	65.02	382	64.19	344	+ 0.83
1855-8/1856	65.5	66.80	386	66.36	397	+ 0.44
1860	63.0	63.11	437	62.58	470	+ 0.53
<u>B. ADULTS:</u>						
1801-9	63.0	65.48	486	64.80	386	+ 0.68
1810-11	63.5	65.91	506	65.04	355	+ 0.87
1812	63.0	65.70	467	65.12	353	+ 0.58
1813-4/1814	63.0	65.17	452	64.87	319	+ 0.30
5/1814-2/1819	66.0	67.30	843	67.52	505	- 0.22
1822-3	65.0	66.27	425	65.77	299	+ 0.50
1824-5	65.5	65.07	253	66.67	232	- 1.60
1826	65.0	65.48	279	65.99	216	- 0.51
1827-9/1829	65.0	66.37	389	65.15	397	+ 1.22
10/1829-3/1831	66.0	67.06	175	66.96	204	+ 0.10
1840-5/1841	65.0	64.78	453	65.14	506	- 0.36
6/1841-1842	66.0	66.54	326	66.73	532	- 0.19
3/1846-1/1847	65.5	66.50	202	66.23	207	+ 0.27
7/1847-1850	66.0	67.60	833	67.44	439	+ 0.16
1855-8/1856	65.5	66.07	424	66.04	548	+ 0.03
9/1856-7/1857	66.0	66.66	235			
9/1858-1860	63.0	64.48	786	62.31	1271	+ 2.17
<u>C. ADULT LABORERS:</u>						
1801-10	63.50	65.17	379	64.67	210	+ 0.50
1810-4/1814	63.25	65.31	693	64.18	385	+ 1.13
5/1814-2/1819	64.25	67.43	482	66.77	240	+ 0.66
3/1819-9/1829	65.25	66.11	915	66.02	408	+ 0.09
6/1841-12/1845	66.25	67.08	285	66.26	260	+ 0.82
9/1853-8/1856	65.75	66.05	373	66.30	313	- 0.25
1859-60	63.0	65.33	330			

TABLE 5, continuedD. YOUNG LABORERS:

1810-4/1814	63.0	65.48	201			
3/1819-9/1829	65.5	66.49	570	65.59	255	+ 0.90
6/1841-12/1845	66.5	66.12	317	66.09	318	+ 0.03
7/1847-1/1850	66.25	66.00	969	66.10	252	- 0.10
9/1853-8/1856	65.75	67.10	422	65.72	234	+ 1.38

Note: T refers to the truncation height, N to the number of observations.

TABLE 6: COMPARING IRISH AND SCOTTISH HEIGHTS c. 1800-1860

Period	<u>Scotland</u>			<u>Ireland</u>		GAP
	T	h'	N	h'	N	
5/1814-2/1819	66.0	67.72	225	67.30	843	+ 0.42
3/1819-1822	66.0	67.91	210			
1823-9/1829	65.5	66.53	213	66.41	937	+ 0.12
4/1839-5/1841	65.0	65.87	239	63.60	848	+ 2.27
6/1841-1845	66.0	66.81	316	67.15	615	- 0.34
7/1847-1850	66.0	68.08	197	67.60	833	+ 0.48
9/1853-1854	66.0	66.51	190	66.27	318	+ 0.24
1855-8/1856	65.5	66.71	347	66.07	424	+ 0.64
9/1858-1860	63.25	65.66	245	65.19	723	+ 0.47

IV. ANTHROPOMETRIC HISTORY AND THE STANDARD OF LIVING DEBATE:

Over the last decade or so, the anthropometric approach to the standard of living debate has yielded some fascinating and unsuspected findings. Yet it could hardly claim to have produced a consensus on the key issue of working-class immiseration or betterment in the United Kingdom during the Industrial Revolution. Floud, Wachter, and Gregory, authors of by far the most ambitious study of historical heights to date, found that heights in the United Kingdom "rose from the middle of the eighteenth century and into the late 1820s, though with a possible check for those just born before and thus growing up in the Napoleonic Wars". That implied "substantial though gradual improvement which would be hard to discern on the evidence of mortality, morbidity, diet or housing alone" (Floud, Wachter, and Gregory, 1989, pp. 275, 304). But applying an alternative statistical procedure to the same data, John Komlos claimed that "the nutritional status of the British and Irish populations was deteriorating during the second half of the eighteenth century" (Komlos, 1993a, p. 141). Their Australian convict indent data constrained Stephen Nicholas and his associates to inferences based on the heights of individuals born before the mid-1810s, but they have also argued for immiseration in that period. They find that falling heights and a delayed growth spurt revealed "declining living standards among English workers during the Industrial Revolution", a finding buttressed by "the falling English workers' heights compared to that of convicts transported from Ireland" (Nicholas and Steckel, 1991, p. 937). Women's living standards also fell by the same measures (Nicholas and Oxley, 1993). Both Floud-Wachter-Gregory and Komlos report a drop in average male heights for the generations born between the 1830s and the early 1850s (Floud, Wachter, and Gregory, 1989, p. 275; Komlos, 1993a).

Our own best estimates of the trend - reduced sample maximum likelihood estimates of the height of adult male laborers, correcting for changing truncation points and compositional effects - may be found in Panel C in Table 5, which adjusts for age, occupation, and kingdom. The data fail to reveal any sustained improvement in observed height from the end of the Napoleonic Wars (birth cohorts of

about 1790-1800) to the end of the 1850s (birth cohort of about 1835-1840). The other results produced in Table 5 are in agreement. This 'pessimist' finding must be weighed against more 'optimistic' claims based on estimates of the trends in real wages (e.g. Lindert and Williamson, 1983).

All the same, great caution should be exercised in utilizing anthropometric data for purposes of economic welfare comparisons. For example, comparing our results based on men recruited during the 1770s and during the Napoleonic Wars would seem to indicate that those born in the 1780s and 1790s were worse off than those born in the 1750s and 1760s. However, a possible reduction in the relative quality of soldiers in the interim due to changing selection procedures makes such inferences hazardous.¹³ If the army was forced to draw upon lower-skill, lower-quality segments of the working class, some deterioration of observed heights in the sample may not reflect what happens in the population. An even sharper example emerges from our ML estimates in Table 5, which seem to indicate a very sharp decline of heights in the very last years of our sample. Clearly, however, the decline of almost two inches between the mid- and late 1850s was a result of the increased demand-pressure on recruitment during the Sepoy rebellion. Even correcting for the reduced truncation point, this increase has a marked influence on our estimates of h' . We therefore believe that the debate between Komlos and Floud-Wachter-Gregory about measurement problems masks a more serious self selection problem.¹⁴

The great strength of the convict indent data invoked by Nicholas and his co-workers is that they seem free from the sample selection biases just described. Criminality recognized no minimum height limit, and Nicholas has argued repeatedly that his convicts were neither the agrarian redressers of traditional historiography nor the habitual, hardened criminals of revisionist writing, but 'ordinary British and Irish working-class men and women who stole' (Nicholas, 1989, p. 7; Nicholas and Steckel, 1991, pp. 943-4; Nicholas and Oxley, 1993, p. 729). However, the convict data are not free of selection biases either despite the assurance that convicts' backgrounds were "coincident with the broad skill-social-class mix of the working class" (Nicholas and Steckel, 1991, p. 944). For Ireland, at least, it was not quite that

simple. First, although in rural Ireland transportation may have been used as a deterrent against petty theft, the Dublin convicts were much more likely to have been habitual criminals (Reece, 1989, p. 21; Robinson, 1993, pp. 131-35). Second, for much of the period, parts of Ireland lacked an effective police force so that being a first-time offender was consistent with having spent a considerable spell at criminal activity (Broeker, 1970; McCabe, 1991). Third, certain regions were disproportionately over- or under-represented among the convicts.¹⁵ Scotland was also underrepresented. Fourth, those selected for and surviving the long voyage to New South Wales were likely to have been healthier than the average convict (Robinson, 1993, pp. 138-9). Fifth, the literacy levels implied by the convicts also raise questions about the representativeness of the indent data.¹⁶

Moreover, since the convict data bring the story up to the 1810s only, they cannot pronounce on the post Waterloo years which are more crucial in the standard of living debate than the 1780-1815 period. The inferences based on them about trends in height and living standards are based on regression analysis that includes birth-cohort dummies as explanatory variables. The signs and sizes of the resultant coefficients move erratically, and the accompanying levels of significance are too weak to reject a broad range of hypotheses about time trends, including hypotheses that run counter to the authors' claims.

These shortcomings, and the inconclusive statistical outcome of the analysis based on the convicts' heights, make claims that the convict evidence have demonstrated 'definitively' a decline in English living standards in the pre-1820 period 'particularly among the urban population', but 'slowly improved nutritional standards in Ireland' (Komlos, 1993, p. 363; Nicholas and Steckel, 1991, p. 949; Nicholas and Steckel, 1993, p. 746-7) premature.

Time-series inferences from height data therefore remain, in our view, hazardous; anthropometric evidence alone cannot decide the long-simmering standard of living controversies. Cross sectional comparisons across groups and regions are more valuable. All research so far has pointed to a significant gap between Ireland and England in favor of the Irish, a gap that declines from the mid-

eighteenth century to the Famine. Furthermore, the Scots were generally taller than either the Irish and the English. It is reassuring here to find convict, military, and admiralty records all pointing in the same direction. Other information, too, suggests that the pre-Famine Irish were relatively tall and well-fed (e.g. Ó Gráda, 1992). We have also been able to establish that the unhealthy effects of cities seem to translate into the somewhat lower height of urban recruits, though, again, we cannot rule out the possibility that the growing absence of employment opportunities was more serious in rural areas, causing a different selection bias between urban and rural regions.

It may be time to tone down some of the overly hopeful claims made for the anthropometric approach to economic history made in the earlier stages of the literature. In 1983 Steckel (1983, p. 5) claimed that "height data can be used to analyze questions traditionally posed with income data." Floud (1984, 19-20) went even further, claiming that "height data are superior to other measures of welfare", because they "*already include* the effects of environmental and exogenous influences on welfare which are not included within conventional measures of income". Now, a decade later, a more sober appraisal is in order. The ingenious statistical techniques developed by Wachter and Trussell (1982) were aimed at eliminating one source of bias in height measurement suffering from fuzzy truncation problems. But even where their algorithm works well, it cannot account for the more serious selection bias problems. A further set of problems goes beyond selection biases and focuses on differences in social structures that could affect the outcomes. Dependence on the potato and other low-value but high-calorie foods in poorer countries, and the often accidental relationship between desirable and wholesome diets create a host of problems for those who would infer living standards from nutritional status alone. We are far from counselling an end to the anthropometric approach to the past, however. On the contrary, allied to data on wages, consumption, mortality, morbidity, and work habits, anthropometric analysis certainly adds insight to the continuing research into living standards in history, not least in the United Kingdom during the years of the Industrial Revolution.

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APPENDIX TABLES

Table A.1: THE REGIONAL ORIGINS OF THE RECRUITS BY DECADE

(percentage)

REGION	1802-9	1810-9	1820-9	1830-9	1840-9	1850-
1	3.4	1.7	2.1	2.3	2.5	2.2
2	7.3	6.9	11.9	9.6	6.0	11.6
3	8.0	6.0	4.1	3.7	4.3	6.5
4	6.5	4.7	3.5	3.5	4.3	4.0
5	9.6	9.5	7.6	8.3	10.3	7.6
6	5.7	5.5	5.8	5.8	5.5	4.5
7	3.3	6.9	8.2	10.4	7.4	8.1
<u>England</u>	<u>43.7</u>	<u>41.2</u>	<u>43.3</u>	<u>43.6</u>	<u>40.3</u>	<u>44.5</u>
8	2.0	3.0	2.4	1.8	4.8	8.2
9	1.3	3.2	3.5	2.0	3.7	3.5
10	4.1	2.8	3.0	1.5	3.2	3.1
<u>Scotland</u>	<u>7.4</u>	<u>9.0</u>	<u>8.9</u>	<u>5.3</u>	<u>11.7</u>	<u>14.8</u>
11	5.1	3.7	2.0	1.8	4.8	5.5
12	10.1	6.1	3.0	2.4	5.0	2.7
13	6.1	7.0	8.1	9.1	10.3	6.3
14	5.6	8.8	5.8	6.0	3.1	5.7
15	8.8	8.7	15.1	19.2	14.6	12.1
16	11.7	14.2	12.6	11.2	8.8	7.0
<u>Ireland</u>	<u>47.4</u>	<u>48.5</u>	<u>47.8</u>	<u>49.7</u>	<u>46.6</u>	<u>39.3</u>
<u>Wales</u>	<u>1.3</u>	<u>1.4</u>	<u>1.2</u>	<u>1.4</u>	<u>1.0</u>	<u>1.4</u>

Table A.2: THE OCCUPATIONAL ORIGINS OF THE RECRUITS BY DECADE

(in percentages)

Group	1802-9	1810-9	1820-9	1830-9	1840-9	1850-

<u>a. Ireland:</u>						
Labor	59	50	61	56	66	63
Weaver	14	8	5	2	2	3
Cloth	9	12	8	10	7	10
Constr	2	6	3	4	3	4
Agr	0	2	3	2	1	1
Liter	2	11	10	11	10	7
Trade	2	4	3	3	2	3
Metal	2	3	3	3	4	4
Other	10	5	4	9	4	6
 <u>b. Great Britain:</u>						
Labor	49	36	28	27	35	37
Weaver	12	8	8	3	2	3
Cloth	16	15	15	12	9	10
Constr	3	6	7	8	8	7
Agr	1	2	4	3	2	1
Liter	2	11	12	14	17	10
Trade	2	4	8	9	6	5
Metal	6	7	8	8	10	14
Other	8	10	12	16	12	14

<i>OCCUPATIONAL CODE</i>	<i>TYPICAL OCCUPATIONS</i>
1 Laborers	laborer, servant, groom
2 Weavers	weaver, cotton weaver, etc.
3 Clothing	cordwainer, tanner, spinner, tailor
4 Construction	painter, carpenter, mason, plasterer
5 Farming	farmer, gardener, shepherd, gamekeeper
6 Literate	clerk, student, architect, printer, teacher, surgeon, clockmaker
7 Trade	dealer, hawker, jeweler, publican, hostler, merchant, apothecary
8 Metallurgy, Mining	miner, blacksmith, joiner, gunsmith, collier, nailor
9 Other	basketmaker, carman, cooper, etc.

REGIONS

1	Cumberland, Northumberland, Westmoreland, Yorkshire (North and East Ridings)
2	Lancashire, Yorkshire (West Riding), Cheshire
3	Notts, Derby, Stafford, Salop, Leicester, Warwick, Northampton
4	Herts, Worcester, Gloucester, Oxford, Buckingham, Bedford, Hereford
5	Cornwall, Devon, Somerset, Dorset, Wilts, Berkshire, Hampshire, Sussex, Surrey
6	Essex, Norfolk, Cambridge, Suffolk, Lincoln, Rutland, Kent, Huntingdon
7	Middlesex
8	Lanarkshire
9	The Highlands
10	All other Scottish counties
11	East Ulster (Antrim, Armagh, Down)
12	West Ulster (the rest of Ulster)
13	Connacht, plus Kerry and Clare
14	Dublin
15	Munster (less Kerry and Clare)
16	Leinster excluding Dublin
17	Wales

NOTES

1. The project is based on records to be found in the archives of the East India Company, East India Library, London. They were drawn from files L/MIL/9/29 - L/MIL/9/46.
2. Those charged with recruiting men blamed the high wages obtainable both on the land and in manufacturing; in Ireland members of the militia were put through 'tedious and oppressive' drill exercises in the hope that they would opt for the regular army (McAnally, 1949, p. 290).
3. For a full analysis of the East India Company recruitment data for the 1800-1814 period, see Mokyr and Ó Gráda (1994).
4. In 1843 the German traveller von Orlich described the Company's European's as "a mixture of all the lowest classes of Great Britain, but hardy adventurous men, who in hope of a better condition, have sold their lives for twenty years" (cited in Bhatia, 1977, p. 100). One military historian describes them thus (Heathcote, 1974, p. 156):

The Company's army was frequently chosen by men who wished to cut themselves off from their own world... As a haven for soldiers of fortune, adventurers, rogues, and petty criminals, where few questions were asked about a recruit's background, and where the authorities were not too fussy about the answers, the Company's European regiments were very much, in their day, what the French Foreign Legion was to a later generation. They produced, too, much the same sort of hard-bitten, tough soldier.

5. In 1802-14, for example, the Company's eleven thousand recruits included over a thousand weavers, 364 tailors, 471 cordwainers, 197 carpenters, and 86 miners and colliers. The seven thousand men recruited in 1853-6 included 265 shoemakers, 210 smiths of various descriptions, 126 miners, and 123 carpenters; the literate intake included twenty-one schoolmasters and teachers, 546 clerks, six compositors, five surveyors, and sixty-five printers, and an assortment of

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'clicker', 'gold and silver engine turner', 'leghorn presser', and 'snaffle maker', and surprising ones such as 'gentleman' and 'home missionary'.

6. The correlation between the two series without the years 1846-50 is .768 ($F=71.9$) and somewhat lower with the full series.

7. A critic of army recruitment methods in the 1840s claimed that "it begins in falsehood, continues in intemperance, and ends in remorse" (cited in Bayley, 1977, p. 19).

8. On evolving conditions in the army see Houlding, 1981; Fortescue, 1923, vol. XI, pp. 436-446.

9. In the 1850s messing expenses, uniforms, washing, haircuts, and other deductions accounted for well over half of the 13d: 'even experienced men were lucky to see 3d a day' (Skelley, 1977, pp. 183-4).

10. Others might connive in a lie: "it is well known that a man who is scarcely the prescribed height can be made so by being kept in bed for a certain time, immediately before being taken before the inspecting field officer for approval, and which is frequently practiced by recruiting sergeants" (L/MIL/9/54, p. 426, 22 May 1850).

11. A Cork slater who had passed himself off as aged twenty-four to the recruiting sergeant in 1858 was deemed to be forty when he reached by the Company's barracks. Recruiting sergeants also sometimes managed to pass men just below the prescribed height "by [keeping them] in bed for a certain time, immediately before being taken before the inspecting field officer for approval" (L/MIL/9/54, p. 426, 22 May 1850).

12. For more detail see for instance Maddala (1983), pp. 165ff. The estimator here is identical in concept to the Reduced Sample Maximum Likelihood (RSML) Estimator, developed by Trussell and Wachter (1982, pp. 282-83) except that ours actually carries out the ML estimation rather than using the approximation they propose.

13. The relative wages of soldiers fell sharply during the century, because the nominal pay had remained fixed at 6d for over a century, whereas money wages in England rose in the eighteenth century, in part to compensate for inflation.

14. Komlos concedes the point in a footnote elsewhere (1993b, 769): "the estimated decline in average height among the soldiers coincided with the expansion of all European armies as a consequence of the Napoleonic Wars; *one cannot be absolutely sure that the decline was in now way related to recruiting those elements of the lower classes that would not have been considered in peacetime*" (emphasis added).

15. Nearly one-half of the women sent out between 1791 and 1828 had stood trial in Dublin, while the province of Connacht, which contained one Irishwoman in six, supplied only one-twentieth of the female convicts (Robinson, 1993, pp. 437-68).

16. Nicholas and Oxley claim that "the Irish [women] transportees were at least as literate as the Irish left at home," but there is little correspondence between their illiteracy rates for female Irish convicts born between 1790 and 1825 and the age-cohort data in the 1841 Irish Census. For most of the period the rural illiteracy rates of the convicts are lower than the Census implies, and the urban rates higher. Specifically, the convict indents implies that illiteracy in Irish urban areas was rising for the years of birth from 1810 on and were flat before; they also imply that before 1810 female illiteracy in Ireland was higher in urban areas than in rural. These claims are not supported by the 1841 Census (Nicholas and Oxley, 1993, pp. 729-30; Parliamentary Papers, 1843, p. 438).